SN8765

Technical Reference

Literature Number: SLUUA11
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Contents

Preface

Read this First

This manual discusses the modules and peripherals of the SN8765 device, and how the SN8765 device helps to provide a complete battery pack gas gauge and protection solution.

Notational Conventions

The following notation is used, if SBS commands and data flash values are mentioned within a text block:

- SBS commands: italics with parentheses and no breaking spaces, e.g., *RemainingCapacity()*.
- Data Flash: italics, bold and breaking spaces, e.g. ***Design Capacity***
- Register Bits and Flags: italics and brackets, e.g. *[TDA]*
- Data Flash Bits: italic and bold e.g. ***[LED1]***
- Modes and states: ALL CAPITALS, e.g. UNSEALED

The reference format for SBS commands is: SBS:Command Name(Command No.): Manufacturer Access(MA No.)[Flag], for example:

SBS:Voltage(0x09), or SBS:ManufacturerAccess(0x00): Seal Device(0x0020).

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Detailed Description

1.1 JEITA Temperature Ranges

The SN8765 follows the JEITA guidelines, which specify that charging voltage and charging current depend on the temperature. Temperature ranges are used for specifying what should be the charging voltage and charging current.

There are three temperature ranges in which charging is allowed and they are defined as:

- T1 – T2: Low charging temperature range (T1 ≤ Temperature < T2)
- T2 – T3: Standard charging temperature range (T2 ≤ Temperature < T3)
- T3 – T4: High charging temperature range (T3 ≤ Temperature < T4)

For added flexibility, the standard temperature range is divided into two sub-ranges: standard range 1 and standard range 2. An additional temperature value (T2a) is needed to specify these two ranges. These temperature ranges will be configurable in the gas gauge through the following data flash (DF) constants.

- ***JT1:*** Lower bound of low charging temperature range, in °C.
- ***JT2:*** Upper bound of low charging temperature range and lower bound of standard charging temperature range 1, in °C.
- ***JT2a:*** Upper bound of standard charging temperature range 1 and lower bound of standard charging temperature range 2, in °C
- ***JT3:*** Upper bound of standard charging temperature range 2 and lower bound of high charging temperature range, in °C.
- ***JT4:*** Upper bound of high charging temperature range, in °C.

The SN8765 implements hysteresis for the temperature ranges above, using the DF variable (***Temp Hys***). This variable specifies the number of degrees of hysteresis that should be used before switching charging temperature ranges.

The active temperature range is indicated using a set of flags. Since hysteresis is implemented for the temperature ranges, determining the active temperature range depends on the previous state, in addition to the actual temperature. These flags reside in a status register called *TempRange*.

Table 1-1. Temperature Ranges in SN8765

Flag	JEITA Temperature Range	Charging Mode
TR1	Temp < ***JT1***	Charge Suspend or Charge Inhibit
TR2	***JT1*** < Temp < ***JT2***	Low Temp Charge
TR2A	***JT2*** < Temp < ***JT2a***	Standard Temp Charge 1
TR3	***JT2a*** < Temp < ***JT3***	Standard Temp Charge 2
TR4	***JT3*** < Temp < ***JT4***	High Temp Charge or Charge Inhibit
TR5	***JT4*** < Temp	Charge Suspend or Charge Inhibit

1.2 1st Level Protection Features

The SN8765 supports a wide range of battery and system protection features that are easily configured or enabled via the integrated data flash.

1.2.1 Cell Overvoltage (COV) and Cell Undervoltage (CUV)

The SN8765 can detect cell overvoltage/undervoltage and protect battery cells from damage from battery cell overvoltage/undervoltage. If the over/undervoltage remains over a period of 2 s, the SN8765 goes into overvoltage/undervoltage condition and switches off the CHG/DSG FET. The SN8765 recovers from a cell overvoltage condition if all the cell voltages drop below the cell overvoltage recovery threshold. The SN8765 recovers from cell undervoltage condition if all the cell voltages rise above the cell undervoltage recovery threshold.

Per JEITA guidelines, the cell overvoltage threshold changes depending on the temperature. A separate cell overvoltage threshold is specified for each operating temperature range.

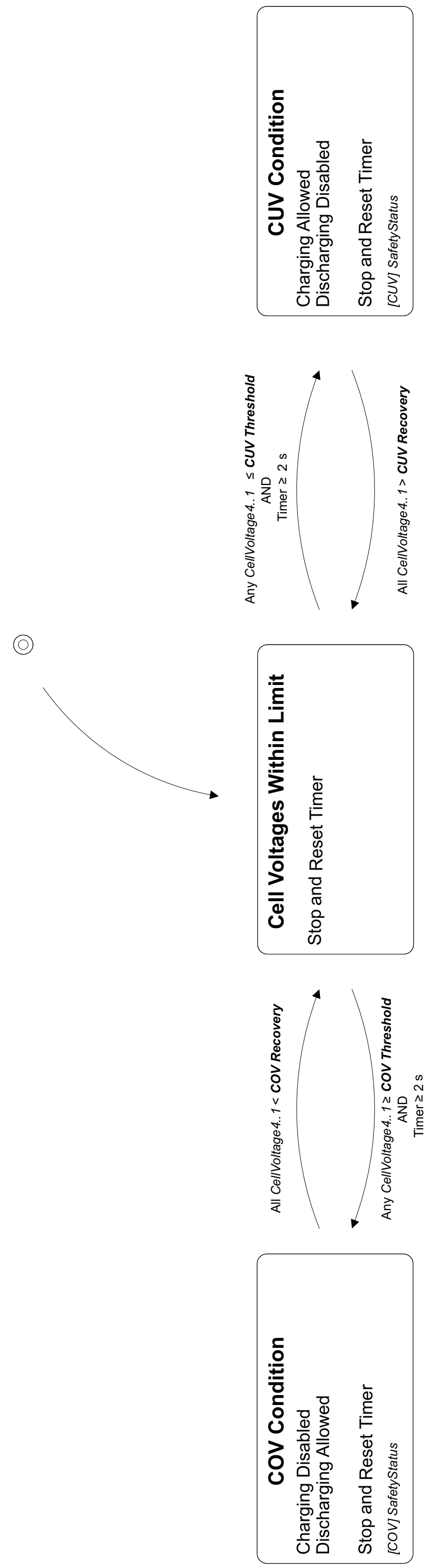


Figure 1-1. COV and CUV

Table 1-2. COV and CUV

Condition:		COV Condition	Normal	CUV Condition
Flags:	*BatteryStatus*	*[TCA]*		*[TDA], [FD]*
	SafetyStatus	*[COV]*		*[CUV]*
	OperationStatus			*[XDSG]*
FET:		CHG FET disabled, enabled during discharge	Normal	DSG FET disabled, enabled during charge
SBS Command:	*ChargingCurrent*	0	Charging algorithm	Charging algorithm
	ChargingVoltage	0	Charging algorithm	Charging algorithm

The SN8765 indicates cell overvoltage condition by setting the *[COV]* flag in *SafetyStatus* if any *CellVoltage4..1* reaches or surpasses the cell overvoltage limit (***LT COV Threshold, ST COV Threshold***, or ***HT COV Threshold***, depending on the current temperature range) and stays above the threshold for period of 2 s.

In cell overvoltage condition charging is disabled and CHG FET and ZVCHG FET (if used) are turned off, *ChargingCurrent* and *ChargingVoltage* are set to zero, *[TCA]* flag in *BatteryStatus* and *[COV]* flag in *SafetyStatus* are set.

The SN8765 recovers from a cell overvoltage condition if all *CellVoltages4..1* are equal to or lower than the appropriate COV Recovery limit (***LT COV Recovery***, ***ST COV Recovery***, or ***HT COV Recovery***) . On recovery the *[COV]* and *[TCA]* flags are reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate values per the charging algorithm.

In a cell overvoltage condition, the CHG FET is turned on during discharging to prevent overheating of the CHG FET body diode.

The SN8765 indicates cell undervoltage by setting the *[CUV]* flag in *SafetyStatus* if any *CellVoltage4..1* reaches or drops below the ***CUV Threshold*** limit during discharging and stays below the threshold for a period of 2 s.

In a cell undervoltage condition, discharging is disabled and DSG FET is turned off, the *[TDA]* and *[FD]* flags in *BatteryStatus* and the *[CUV]* flag in *SafetyStatus* are set.

The SN8765 recovers from cell undervoltage condition if all *CellVoltages4..1* are equal to or higher than ***CUV Recovery*** limit. On recovery, the *[CUV]* flag in *SafetyStatus* is reset, *[XDSG]* flag is reset, the *[TDA]* and *[FD]* flags are reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate values per the charging algorithm.

In cell undervoltage condition, the DSG FET is turned on during charging to prevent overheating of the DSG FET body diode.

1.2.2 Charge and Discharge Overcurrent

The SN8765 has two independent levels of recoverable overcurrent protection, the tier-1 (firmware overcurrent protection, charge and discharge directions) and AFE (hardware overcurrent protection, for discharge only) overcurrent protection. Both levels require the *Current* value to be greater than or equal to a programmed OC Threshold in either charge or discharge current for a period greater than OC Time Limit. In tier-1 only, however, if the OC Time Limit is set to 0, that specific feature is disabled.

Table 1-3. Recoverable Charge and Discharge Overcurrent

Protection	OC Threshold	OC Time Limit	OC Recovery Threshold	*SafetyAlert* Flag	*SafetyStatus* Flag
Tier-1 Charge	***OC (1st Tier)Chg***	***OC (1st Tier) Chg Time***	***OC Chg Recovery*** for ***Current Recovery Time***	*[OCC]*	*[OCC]*
Tier-1 Discharge	***OC (1st Tier) Dsg***	***OC (1st Tier) Dsg Time***	***OC Dsg Recovery*** for ***Current Recovery Time***	*[OCD]*	*[OCD]*

Table 1-3. Recoverable Charge and Discharge Overcurrent (continued)

Protection	OC Threshold	OC Time Limit	OC Recovery Threshold	*SafetyAlert* Flag	*SafetyStatus* Flag
AFE Hardware Discharge	***AFE OC Dsg***	***AFE OC Dsg Time***	***AFE OC Dsg Recovery*** for ***Current Recovery Time***	—	*[AOCD]*

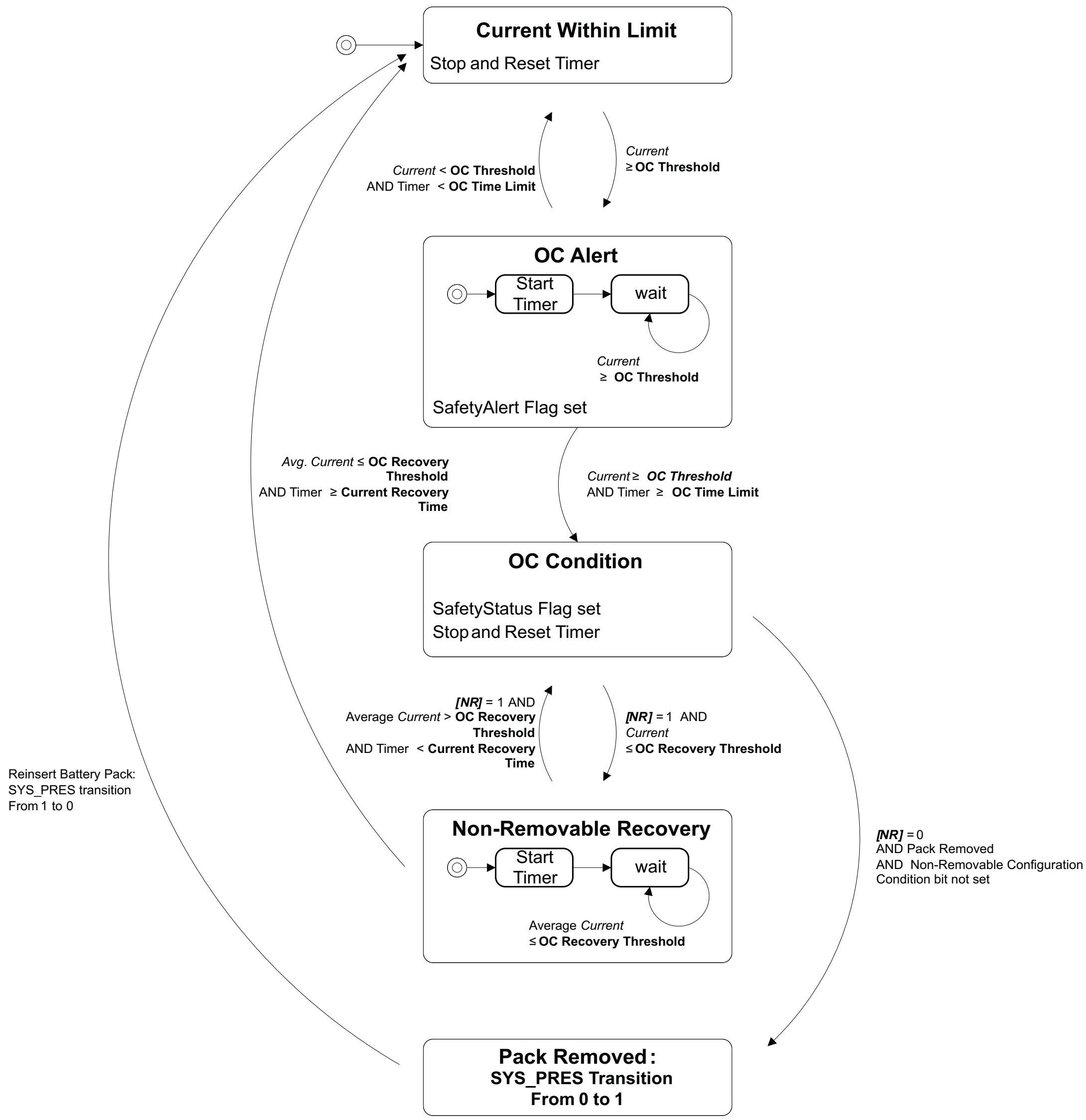


Figure 1-2. Recoverable OC Protection

For the tier-1 overcurrent protection, the specific flag in *SafetyAlert* is set if *Current* exceeds the OC Threshold. The SN8765 changes the specific flag in *SafetyAlert* to the specific flag in *SafetyStatus* if the *Current* stays above the OC Threshold limit for at least OC Time Limit period. This function is disabled if the OC Time Limit is set to zero. The *SafetyStatus* flag is reset if the *Current* falls below the OC Recovery Threshold.

If the tier-1 timer expires during charging, the CHG FET is turned off. When this occurs, the internal current fault timer is reset, *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* flag is set and the *[OCC]* flag is set in *SafetyStatus*.

However, when the SN8765 has the *[OCC]* flag in *SafetyStatus* set, the CHG FET is turned on again during discharge (*Current* ≤ (–) ***Dsg Current Threshold***). This prevents overheating of the CHG FET body diode during discharge. No other flags change state until full recovery is reached. This action is not affected by the setting of ***[NR]*** bit.

If the tier-1 timer expires during discharging, the DSG FET is turned off and the ZVCHG FET is turned on if used. When this occurs the internal current fault timer is reset, *ChargingCurrent* is set to ***Pre-chg Current***, *[PCHG]*, *[XDSG]*, *[XDSGI]*, and *[TDA]* flag are set, and the *[OCD]* flag is set in *SafetyStatus*.

When the current measured by the AFE exceeds the ***AFE OC Dsg*** for longer than ***AFE OC Dsg Time***, the integrated AFE detects a discharge-overcurrent fault, the CHG and DSG FETs are turned off, the internal XALERT signal triggers an interrogation by the SN8765. When the SN8765 identifies the overcurrent condition, the CHG FET is re-enabled, *[TDA]* flag is set, *ChargingCurrent* is set to 0, and *[AOCD]* is set.

However, when either *[OCD]* or *[AOCD]* is set, the discharge-FET is turned on again during charging (*Current* ≥ ***Chg Current Threshold***). This prevents overheating of the discharge-FET body diode during charge. No other flags change state until full recovery is reached. This action is not affected by the state of ***[NR]*** bit.

Table 1-4. Overcurrent Conditions

Protection	Condition	Flags					FET	Charging Current	Charging Voltage
		Safety Alert	*Safety Status*	*Battery Status*	*Operation Status*	*Charging Status*			
Tier-1 Charge	OC Alert	*[OCC]*					normal	charging algorithm	charging algorithm
	OC Condition		*[OCC]*	*[TCA]*			CHG FET disabled, enabled during discharge	0	0
Tier-1 Discharge	OC Alert	*[OCD]*					normal	charging algorithm	charging algorithm
	OC Condition		*[OCD]*	*[TDA]*	*[XDSG],[XDSGI]*	*[PCHG]*	DSG FET disabled, enabled during charge	***Pre-chg Current***	charging algorithm
AFE Discharge	OC Condition		*[AOCD]*	*[TDA]*	*[XDSGI]*		CHG FET and DSG FET disabled; CHG FET will be re-enabled	0	charging algorithm

The SN8765 can individually configure each recoverable overcurrent-protection to recover via two different methods based on ***[NR]*** bit.

Standard Recovery, where ***[NR]*** = 0 and the overcurrent tier is not selected in ***Non-Removable Cfg*** register. When the pack is removed and reinserted the condition is cleared. Pack removal and reinsertion is detected by a low-to-high-to-low transition on the $\overline{\text{PRES}}$ input. When the overcurrent tier is selected in ***Non-Removable Cfg***, that particular feature uses the Non-Removable Battery Mode recovery.

Non-Removable Battery Mode Recovery where ***[NR]*** = 1. The state of ***Non-Removable Cfg*** has no consequence. This recovery requires *AverageCurrent* to be ≤ the respective recovery threshold, and for the *Current_Fault* timer ≥ ***Current Recovery Time***.

When a charging-fault recovery condition is detected, then the CHG FET is allowed to be turned on, if other safety and configuration states permit, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set to the appropriate value per the charging algorithm, and the appropriate *SafetyStatus* flag is reset.

When a discharging-fault recovery condition is detected, the DSG FET is allowed to be turned on if other safety and configuration states permit, *[TDA]* flag is reset, *ChargingCurrent* and *ChargingVoltage* are set to the appropriate value per the charging algorithm, and the *[PCHG]*,*[XDSG]*, *[XDSGI]*, and the appropriate *SafetyStatus* flag are reset.

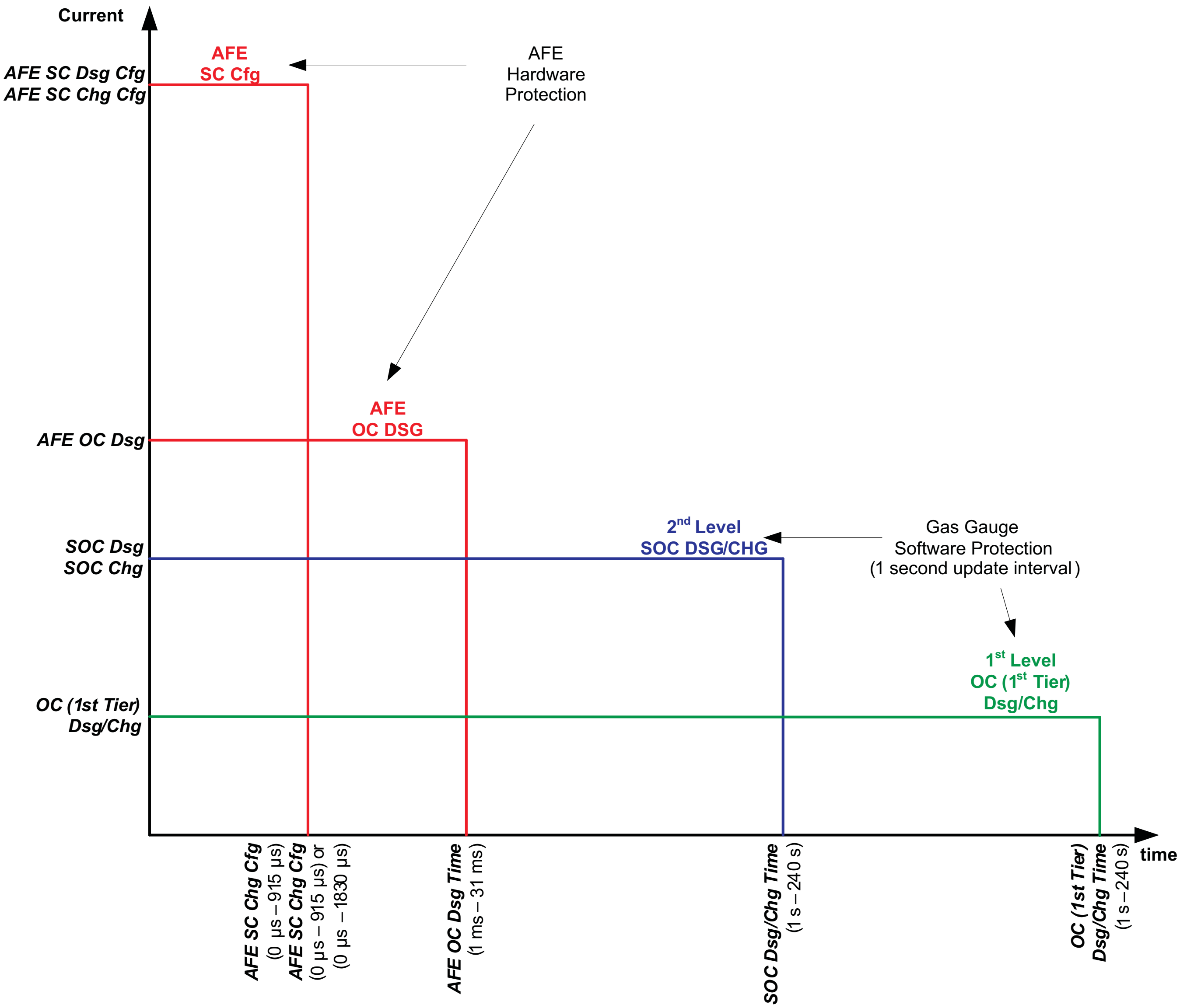


Figure 1-3. Overcurrent Protection Levels

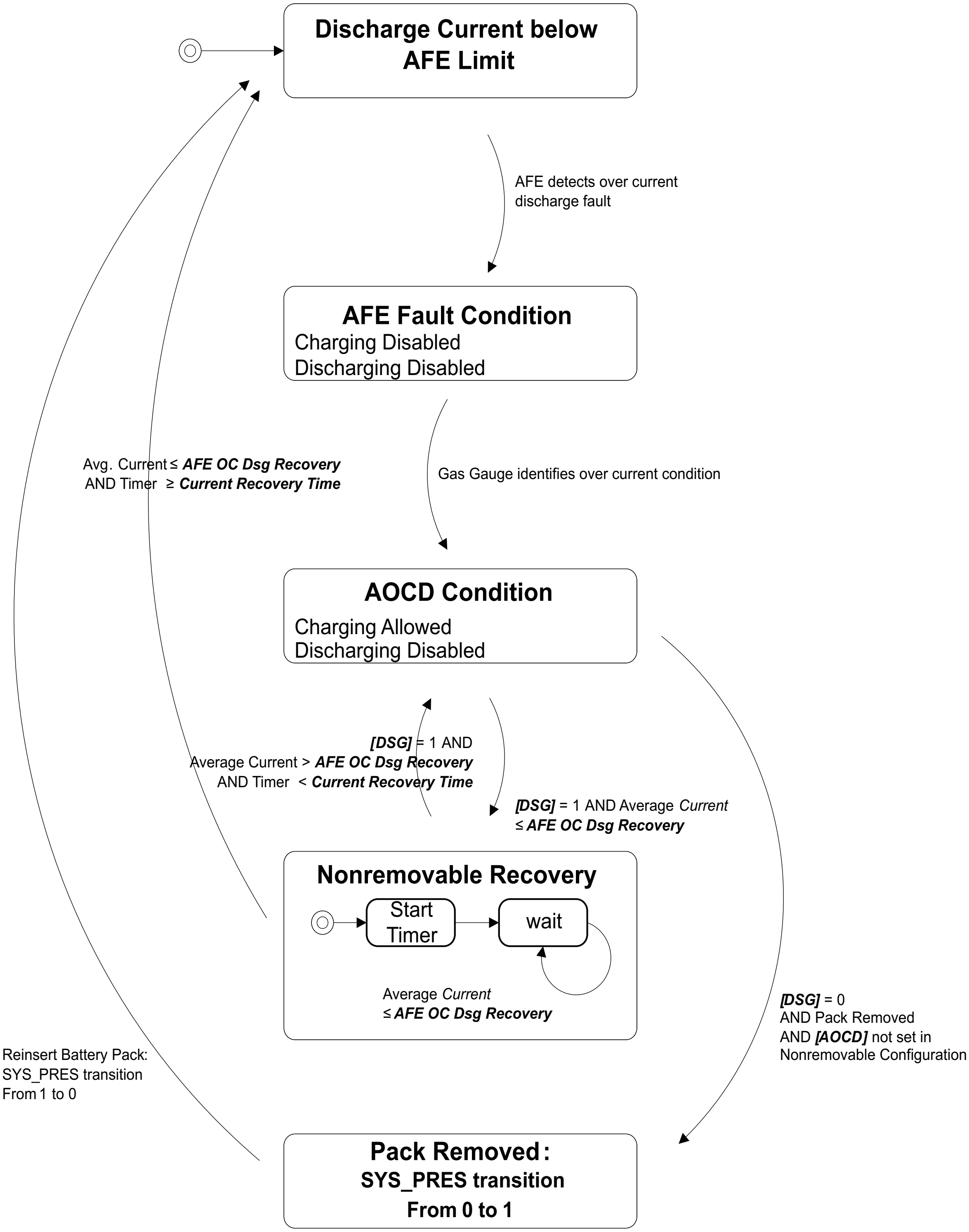


Figure 1-4. AFE Discharge Overcurrent Protection

1.2.3 *Short-Circuit Protection*

The SN8765 short-circuit protection is executed by the integrated AFE, but is recovered by the SN8765. This allows different recovery methods to accommodate various applications.

The integrated AFE charge short-circuit and discharge short-circuit protection are configured by the SN8765 data flash ***AFE SC Chg Cfg*** and ***AFE SC Dsg Cfg*** registers, respectively.

When the integrated AFE detects a short circuit in charge (in discharge) fault, the charge (discharge) FET is turned off, the internal XALERT signal is driven low by the integrated AFE and the SN8765 starts interrogation of the AFE. When the SN8765 identifies the short-circuit in charge (discharge) condition, discharge-FET (charge-FET) is re-enabled, the internal AFE current fault timer is reset, *[TCA]* (*[TDA]*) in battery status is set, *ChargingCurrent* and *ChargingVoltage* is set to 0 and *[SCC]* (*[SCD]*) is set. If the short-circuit condition is in discharge, then *[XDSG]* flag is also set.

Each SN8765 short-circuit protection feature can be individually configured to recover via two different methods, based on ***[NR]*** bit.

Standard Recovery is where ***[NR]*** = 0 and the overcurrent tier is not selected in ***Non-Removable Cfg***. When the pack is removed and re-inserted, the condition is cleared. Pack removal and re-insertion is detected by transition on the $\overline{\text{PRES}}$ input from low to high to low. When the overcurrent tier is selected in ***Non-Removable Cfg***, that particular feature uses the Non-removable Battery Mode recovery.

Non-Removable Battery Mode Recovery is where ***[NR]*** = 1. The state of ***Non-Removable Cfg*** has no consequence when ***[NR]*** bit is set to 1. This recovery requires that *AverageCurrent* be ≤ ***AFE SC Recovery*** threshold and that the internal AFE current recovery timer ≥ ***Current Recovery Time***.

When the recovery condition for a charging fault is detected, the CHG FET is allowed to be turned on if other safety and configuration states permit. The ZVCHG FET also returns to previous state. When this occurs, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set to the appropriate values per the charging algorithm, and the appropriate *SafetyStatus* flag is reset.

When the recovery condition for a discharging fault is detected, the DSG FET is allowed to be turned on if other safety and configuration states permit. The ZVCHG FET also returns to previous state. When this occurs *[TDA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set to the appropriate value per the charging algorithm, and *[XDSG]* and the appropriate *SafetyStatus* flags are reset.

Table 1-5. Short Circuit Protection

Short Circuit	Condition	Flags Set	FET	Charging Current	Charging Voltage	Clear Threshold
Charge	***AFE SC Chg Cfg***	*[SCC] SafetyStatus*, *[TCA]*	CHG FET disabled, enabled during discharge	0	0	***AFE SC Recovery***
Discharge	***AFE SC Dsg Cfg***	*[SCD] SafetyStatus*, *[TDA]*, *[XDSG]*	DSG FET disabled, enabled during charge	0	0	

1.2.4 Overtemperature Protection

The SN8765 has overtemperature protection for both charge and discharge conditions.

The SN8765 sets the over temperature charging *[OTC]* *SafetyAlert* flag, if pack temperature reaches or surpasses ***Over Temp Chg*** limit during charging. The SN8765 changes *[OTC]* *SafetyAlert* to over temperature condition, if pack temperature stays above ***Over Temp Chg*** limit for a time period of ***OT Chg Time***. This function is disabled if ***OT Chg Time*** is set to zero.

If *[OTFET]* is set and SN8765 is in *[OTC]* condition, charging is disabled and CHG FET is turned off, ZVCHG FET is turned off if configured for use, *ChargingCurrent* and *ChargingVoltage* are set to zero, the *[OTC]* flag in *SafetyAlert* is reset, *[TCA]* and *[OTC]* in *SafetyStatus* are set.

The SN8765 recovers from an *[OTC]* condition if *Temperature* is equal to or below ***OTC Chg Recovery*** limit. On recovery the *[OTC]* flag in *SafetyStatus* is reset, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set back to their appropriate value per the charging algorithm, and the CHG FET returns to previous state.

In an *[OTC]* condition, the CHG FET is turned on during discharging to prevent overheating of the CHG FET body diode.

The SN8765 sets the over temperature discharging *[OTD]* *SafetyAlert* flag, if pack temperature reaches or surpasses ***Over Temp Dsg*** limit during discharging. The SN8765 changes *[OTD]* *SafetyAlert* to over temperature condition, if pack temperature stays above ***Over Temp Dsg*** limit for a time period of ***OT Dsg Time***. This function is disabled if ***OT Dsg Time*** is set to zero.

If *[OTFET]* is set and SN8765 is in *[OTD]* condition, discharging is disabled and DSG FET is turned off, *ChargingCurrent* is set to zero, the *[OTD]* *SafetyAlert* flag is reset, *[TDA]* is set, *[XDSG]* flag is set and the *[OTD]* flag in *SafetyStatus* is set.

The SN8765 recovers from an *[OTD]* condition if pack temperature is equal to or below ***OTD Chg Recovery*** limit. On recovery *[OTD]* in *SafetyStatus* is reset, *[TDA]* is reset, *ChargingCurrent* is set back to the appropriate value per the charging algorithm, and the DSG FET is allowed to switch on again.

In an *[OTD]* condition, the DSG FET is turned on during charging to prevent overheating of the DSG FET body diode.

Table 1-6. Overtemperature Protection

	Alert Threshold	Alert Time Limit	*SafetyAlert* Flags Set	Overtemp Condition	Recovery Threshold
Charge	***Over Temp Chg***	***OT Chg Time***	*[OTC]*	*[OTC] SafetyStatus* Flag, *[TCA]* set, ChargingCurrent =0, ChargingVoltage = 0, (CHG FET off if *[OTFET]* set)	***OT Chg Recovery***
Discharge	***Over Temp Dsg***	***OT Dsg Time***	*[OTD]*	*[OTD] SafetyStatus* Flag, *[TDA]* Set, ChargingCurrent =0, (*[XDSG]* set and DSG FET off if *[OTFET]* flag set)	***OT Dsg Recovery***

1.2.5 AFE Watchdog

The integrated AFE automatically turns off the CHG FET, DSG FET and ZVCHG FET (if used), if the integrated AFE does not receive the appropriate frequency on the internal watchdog input (WDI) signal from SN8765. The SN8765 has no warning that this is about to happen, but it can report the occurrence once the SN8765 is able to interrogate the integrated AFE.

When the internal XALERT input of the SN8765 is triggered by the integrated AFE, the SN8765 reads the STATUS register of the integrated AFE. If *[WDF]* is set, the SN8765 also sets *[WDF]* in *SafetyStatus* and periodic verification of the integrated AFE RAM is undertaken. If verification of the integrated AFE RAM fails then the FETs will turn off. Verification of the integrated AFE RAM will continue once every second. If the periodic verification passes, then *[WDF]* in *SafetyStatus* is cleared and the FETs return to normal operation.

1.3 2nd-Level Protection Features

The SN8765 provides features that can be used to indicate a more serious fault via the FUSE output. These outputs can be used to blow an in-line fuse to permanently disable the battery pack from charge or discharge activity.

If any PF Threshold condition is met, the appropriate flag is set in *PFAlert*. If the PF Threshold condition is cleared within the PF time limit, the appropriate PFAlert flag is cleared in *PFAlert*. But if the PF Threshold condition continues over the PF Time Limit or Alert Limit, then the SN8765 goes into permanent failure condition and the appropriate flag is set in *PFStatus* and reset in *PFAlert*.

When any NEW cause of a permanent failure is set in *PFStatus* function, the NEW cause is added to ***PF Flags 1*** register. This allows ***PF Flags 1*** register to show ALL permanent failure conditions that have occurred.

On the first occasion of a permanent failure indicated by *PFStatus* change from 0x00, the *PFStatus* value is stored in ***PF Flags 2***.

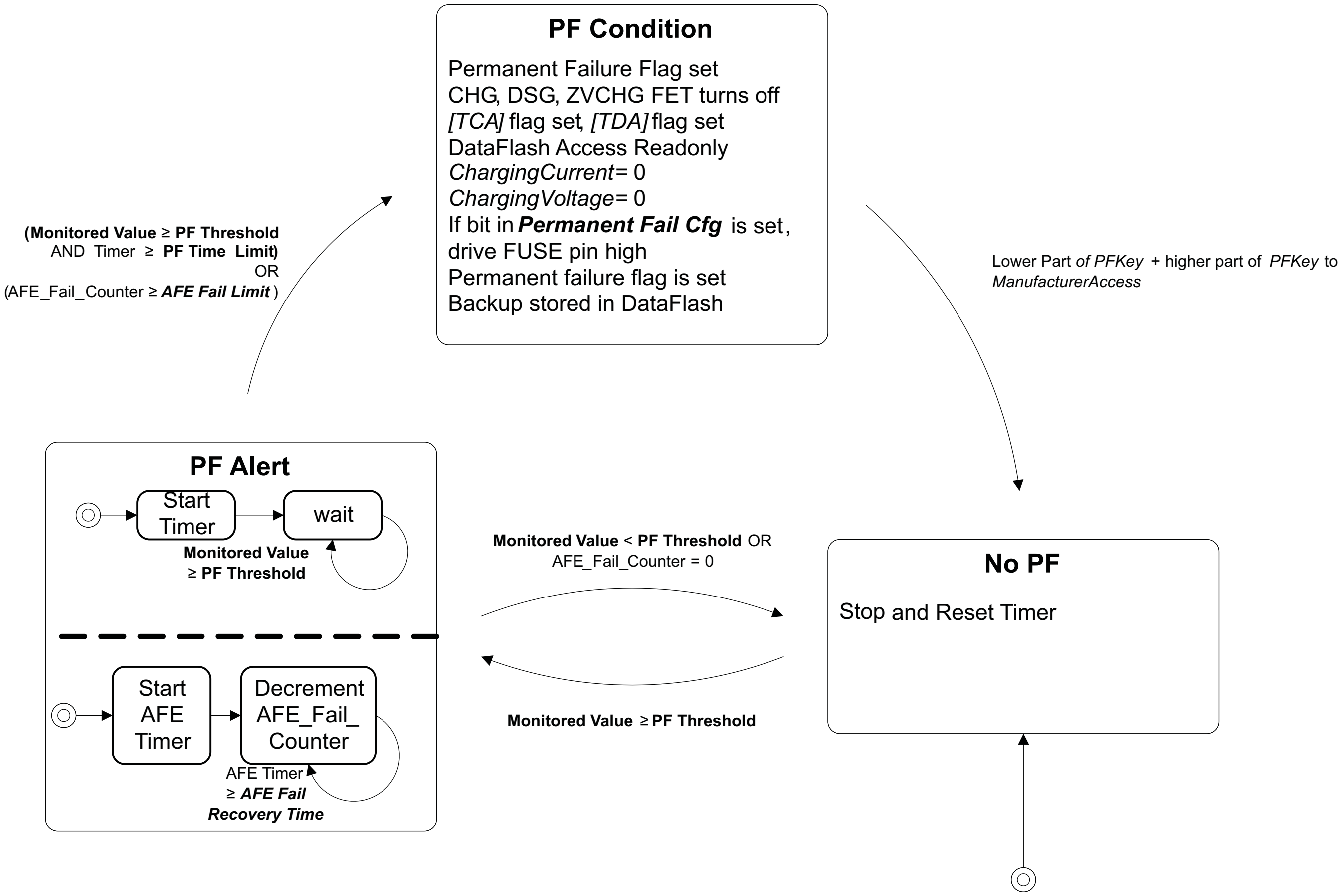


Figure 1-5. 2nd-Level Protection

1.3.1 2nd-Level (Permanent) Failure Actions

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

- CHG, DSG, and ZVCHG FETs are turned OFF.
- *[TCA], [TDA]* flags in *BatteryStatus* are set.
- A backup of SBS data and the complete memory map of the integrated AFE is stored to data flash (if *[LTPF]* is set in *OperationStatus*).
- Data flash write access is disabled, but the data flash can be read (if *[LTPF]* is set in *OperationStatus*).
- *ChargingCurrent* and *ChargingVoltage* are set to 0.
- The appropriate bit in *PF Flags 1* is set (if *[LTPF]* is set in *OperationStatus*).
- If the appropriate bit in ***Permanent Fail Cfg*** is set, then 0x3672 is programmed to ***Fuse Flag***, and the FUSE pin is driven and latched high. The*[PF]* flag in *SafetyStatus* is also set (if *[LTPF]* is set in *OperationStatus*).

For the convenience of production test, If *[LTPF]* is cleared in *OperationStatus*, when permanent failures occur, data flash write is still allowed, there is no PF data logging in DF:PF Status, and the PF can be cleared by resetting the SN8765. *[LTPF]* is set by the *LTPF Enable* ManufacturerAccess command. If *[LTPF]* in *OperationStatus* is already set, to clear this bit and disable PF data logging, clear the DF:Configuration:Registers(64):Operation Cfg C(4)[PROD_LTPF_EN], and then reset the SN8765.

Table 1-7. Permanent Fail Backup

SBS Value	Data Flash Backup
SBS:Voltage(0x09)	DF:PF Status:Device Status Data(96):PF Voltage(4)
SBS:CellVoltage4(0x3c)	DF:PF Status:Device Status Data(96):PF C4 Voltage(6)
SBS:CellVoltage3(0x3d)	DF:PF Status:Device Status Data(96):PF C3 Voltage(8)
SBS:CellVoltage2(0x3e)	DF:PF Status:Device Status Data(96):PF C2 Voltage(10)
SBS:CellVoltage1(0x3f)	DF:PF Status:Device Status Data(96):PF C1 Voltage(12)
SBS:Current(0x0a)	DF:PF Status:Device Status Data(96):PF Current(14)
SBS:Temperature(0x08)	DF:PF Status:Device Status Data(96):PF Temperature(16)
SBS:BatteryStatus(0x16)	DF:PF Status:Device Status Data(96):PF Batt Stat(18)
SBS:RemainingCapacity(0x0f)	DF:PF Status:Device Status Data(96):PF RC-mAh(20)
SBS:FullChargeCapacity(0x10)	DF:PF Status:Device Status Data(96):PF FCC(22)
SBS:ChargingStatus(0x55)	DF:PF Status:Device Status Data(96):PF Chg Status(24)
SBS:SafetyStatus(0x51)	DF:PF Status:Device Status Data(96):PF Safety Status(26)
DOD at EDV2	DF:PF Status:Device Status Data(96):PF DOD(28)
Integrated AFE Memory Map	
	DF:PF Status:AFE Regs(97):AFE Status(0)
	DF:PF Status:AFE Regs(97):AFE State(1)
	DF:PF Status:AFE Regs(97):AFE Output(2)
	DF:PF Status:AFE Regs(97):AFE Output Status(3)
	DF:PF Status:AFE Regs(97):AFE Cell Select(5)
	DF:PF Status:AFE Regs(97):AFE OLV(6)
	DF:PF Status:AFE Regs(97):AFE OLT(7)
	DF:PF Status:AFE Regs(97):AFE SCC(8)
	DF:PF Status:AFE Regs(97):AFE SCD(9)
	DF:PF Status:AFE Regs(97):AFE Function(10)

1.3.2 Time-Limit–Based Protection

SN8765 reports a 2nd level protection alert by setting the appropriate flag in the *PFAlert* function if the monitored value reaches or rises above the Protection Threshold. If the monitored value stays above the Protection Threshold over the Max Alert duration, the SN8765 reports a 2nd level permanent failure, clears the appropriate *PFAlert* flag, and sets the appropriate *PFStatus* flag. See Table 1-8 for all Protection Thresholds and Max Alert durations.

Safety Overvoltage Protection — The SN8765 monitors the individual cell voltages for extreme values. Depending on the temperature range the battery is operating in, either LT, ST, or HT Safety Overvoltage is activated when cells go above these thresholds.

Cell Imbalance Fault — The SN8765 starts cell imbalance fault detection when *Current* is lesser or equal to ***Cell Imbalance Current*** for ***Battery Rest Time*** period AND All (*CellVoltage4..1*) > ***Min CIM-check voltage***. The difference between highest cell voltage and lowest cell voltage is monitored. If ***Battery Rest Time*** is set to zero or ***Cell Imbalance Time*** is set to zero, this function is disabled.

2nd-Level Protection IC Input — The FUSE pin of the SN8765 can be used to determine the output state of an external protection device such as the bq294xx. The SN8765 watches for FUSE pin level when the 2nd level voltage protection IC outputs high.

Safety Overcurrent Protection — The SN8765 monitors the current during charging and discharging. The overcurrent thresholds and time limits can be set independently for charging and discharging.

Safety Overtemperature Protection — The SN8765 monitors the pack temperature during charging and discharging. The overtemperature thresholds and time limits can be set independently for charging and discharging.

Open Thermistor — The SN8765 can detect an open thermistor condition if the temperature function reports extreme temperature values.

CHG and ZVCHG FET Fault Protection — The SN8765 monitors if there is, at any time, an attempt to turn off the CHG FET or ZVCHG FET, or the CHG bit in the *FETStatus* register is clear and the current continues to flow.

Discharge FET Fault Protection — The SN8765 monitors if there is, at any time, an attempt to turn off the DSG FET, or the DSG bit in the *FETStatus* register is clear and the current continues to flow.

Table 1-8. Time-Limit–Based 2nd-Level Protection

Protection	Monitored Value	Requirement	PF Threshold	PF Time Limit (Set to 0 to Disable Protection)	*PFAlert* and *PFStatus* Flag	*Permanent Fail Cfg* Flag
Safety Cell Overvoltage	Cell voltage	—	***LT SOV Threshold***, ST SOV Threshold, or HT SOV Threshold	***SOV Time***	*[SOV]*	*[XSOV]*
Cell Imbalance Fault	Difference of highest and lowest of *CellVoltage4..1*	*Current* ≤ ***Cell Imbalance Current*** for ***Battery Rest Time*** AND All (*CellVoltage4..1*) > ***Min CIM-check voltage***	***Cell Imbalance Fail Voltage***	***Cell Imbalance Time***	*[CIM]*	*[XCIM]*
2nd-Level Protection IC Input	FUSE pin voltage	—	FUSE pin voltage > 2 V (typical)	***PFIN Detect Time***	*[PFIN]*	*[XPFIN]*
Safety Overcurrent Charge	*Current*	*Current* > 0	***SOC Chg***	***SOC Chg Time***	*[SOCC]*	*[XSOCC]*
Safety Overcurrent Discharge	(–)*Current*	*Current* < 0	***SOC Dsg***	***SOC Dsg Time***	*[SOCD]*	*[XSOCD]*
Safety Overtemperature Chg	*Temperature*	*Current* > 0	***SOT Chg***	***SOT Chg Time***	*[SOTC]*	*[XSOTC]*
Safety Overtemperature Dsg	*Temperature*	*Current* < 0	***SOT Dsg***	***SOT Dsg Time***	*[SOTD]*	*[XSOTD]*
Open Thermistor	*Temperature*	—	***Open Thermistor***	***Open Time***	*[OTS]*	*[XOTS]*
Charge and ZVCHG FET Fault	*Current*	(CHG FET or ZVCHG FET turn off attempt or CHG Flag in *FETStatus* clear) and *Current* >0	***FET Fail Limit***	***FET Fail Time***	*[CFETF]*	*[XCFETF]*
Discharge FET Fault	(–)*Current*	(DSG FET turn off attempt or DSG Flag in *FETStatus* clear) and *Current* < 0	***FET Fail Limit***	***FET Fail Time***	*[DFETF]*	*[XDFETF]*

1.3.3 Limit-Based Protection

The SN8765 reports a 2nd-level permanent failure and sets the appropriate *PFStatus* flag if the internal error counter reaches the max error limit. The internal error counter is incremented by one if the error happens and decremented by one each fail recovery period.

Integrated AFE Communication Fault Protection — The SN8765 periodically validates its read and write communications with the integrated AFE. If either a read or write verify fails, an internal AFE_Fail_Counter is incremented. If the AFE_Fail_Counter reaches ***AFE Fail Limit***, the SN8765 reports a *[AFE_C]* permanent failure. If the ***AFE Fail Limit*** is set to 0, this feature is disabled. An *[AFE_C]* fault can also be declared if, after a full reset, the initial gain and offset values read from the AFE cannot be verified. These values are A/D readings of the integrated AFE VCELL output. The integrated AFE offset values are verified by reading the values twice and confirming that the readings are within acceptable limits. The max difference between 2 readings is set with ***AFE Init Limit***. The maximum number of read retries, if offset and gain value verification fails and *[AFE_C]* fault is declared, is set in ***AFE Fail Limit***.

Periodic AFE Verification — The SN8765 periodically (***AFE Check Time***) compares certain RAM content of the integrated AFE with that of the SN8765 data flash and the expected control-bit states. This function is disabled if ***AFE Check Time*** is set to 0. If an error is detected, the internal AFE_Fail_Counter is incremented. If the internal AFE_Fail_Counter reaches the ***AFE Fail Limit***, the SN8765 reports a permanent failure.

Integrated AFE Init Verification — After a full reset the SN8765 and the AFE offset and gain values are read twice and compared. The ***AFE Init Limit*** sets the maximum difference in A/D counts of two successful readings of offset and gain, which the SN8765 still considers as the same value. If the gain and offset values are still not considered the same after ***AFE Init Retry Limit*** comparison retries, the SN8765 reports a permanent failure error.

Data Flash Failure — The SN8765 can detect if the data flash is not operating correctly. A permanent failure is reported when either: (I) After a full reset the instruction flash checksum does not verify; (ii) if any data flash write does not verify; or (iii) if any data flash erase does not verify.

Table 1-9. Limit Based-2nd Level Protection

Protection	Monitored Value	Fail Recovery	Max Error Limit (Set to 0 to Disable Protection)	*PFAlert* Flag, *PFStatus* Flag	*Permanent Fail Cfg* Flag
AFE Communication Fault	Periodic Communication with integrated AFE	Decrement of internal AFE_Fail_Counter by one per ***AFE Fail Recovery Time*** period	***AFE Fail Limit***	*[AFE_C]*	***[XAFE_C]***
Periodic AFE Verification	Check RAM of integrated AFE with ***AFE Check Time*** period	Decrement of internal AFE_Fail_Counter by one per ***AFE Fail Recovery Time*** period	***AFE Fail Limit***	*[AFE_P]*	***[XAFE_P]***
AFE Initialization	Initial gain and offset values from integrated AFE after full reset	—	***AFE Init Retry Limit***	*[AFE_C]*	***[XAFE_C]***
Data Flash Failure	Data Flash	—	False flash checksum after reset, data flash write not verified, data flash erase not verified	*[DFF]*	***[XDFF]***

1.3.4 Clearing Permanent Failure

The SN8765 permanent failure can be cleared by sending two *ManufacturerAccess* commands in sequence: the first word of the *PFKey* followed by the second word of the *PFKey*. After sending these two commands in sequence, *PFStatus* flags are cleared. Refer to Permanent Fail Clear (*PFKey*) Manufacturer access for further details.

1.4 Gas Gauging

The SN8765 features the Compensated End of Discharge Voltage (CEDV) gauging algorithm, capable of gauging a maximum capacity of 32 Ah.

The operational overview in Figure 1-6 illustrates the gas gauge operation of the SN8765.

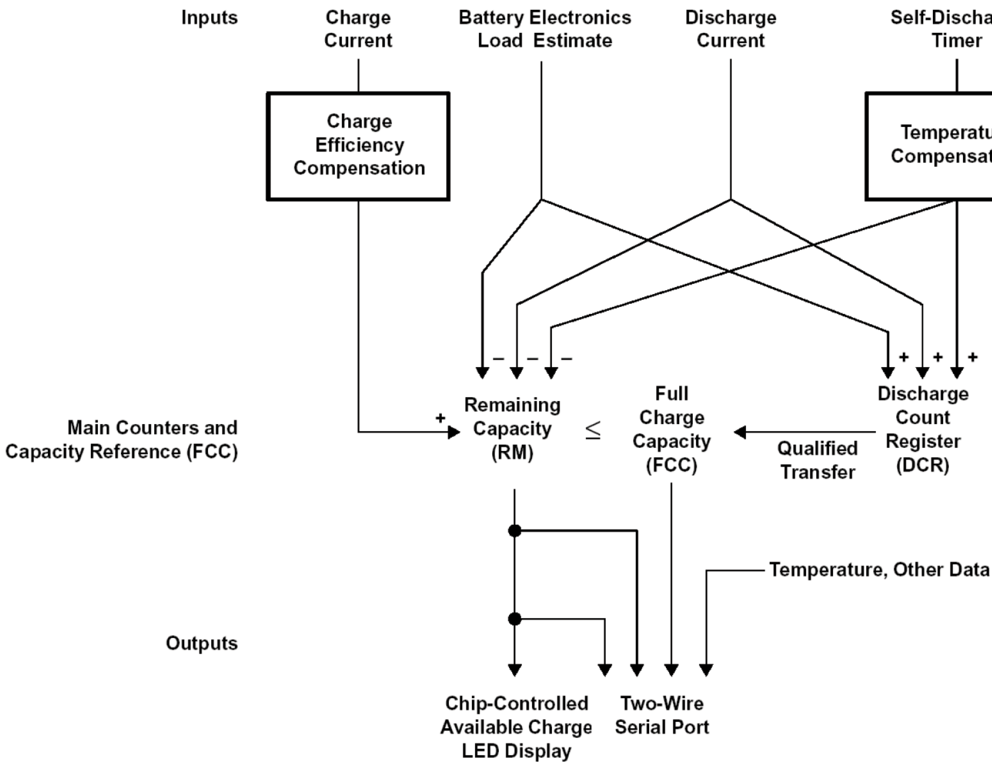


Figure 1-6. SN8765 Gas Gauging Operational Overview

1.4.1 CEDV Gas Gauging Operational Overview

The SN8765 accumulates the measured quantities of charge and discharge and estimates self-discharge of the battery. The SN8765 compensates the charge current measurement for temperature and state-of-charge of the battery. The SN8765 also adjusts the self-discharge estimation based on temperature.

The main charge counter *RemainingCapacity* (RM) represents the available capacity or energy in the battery at any given time. The SN8765 adjusts RM for charge, self-discharge, and other compensation factors. The information in the RM register is accessible through the SMBus interface. The *FullChargeCapacity* (FCC) register represents the initial or last measured full discharge of the battery. It is used as the battery full-charge reference for relative capacity indication. The SN8765 updates FCC after the battery undergoes a qualified discharge from nearly full to a low battery level. FCC is accessible through the SMBus interface.

The Discharge Count Register (DCR) is a non-accessible register that tracks discharge of the battery. The SN8765 uses the DCR register to update the FCC register if the battery undergoes a qualified discharge from nearly full to a low battery level. In this way, the SN8765 learns the true discharge capacity of the battery under system use conditions.

1.4.2 Main Gas Gauge Registers

RemainingCapacity (RM) — Remaining capacity in the battery

RM represents the remaining capacity in the battery. The SN8765 computes RM in units of either mAh or 10 mWh depending on the selected capacity mode. See Section A.4 for unit configuration.

RM counts up during charge to a maximum value of *FCC* and down during discharge and self-discharge to a minimum of 0. In addition to charge and self-discharge compensation, the SN8765 calibrates RM at three low-battery-voltage thresholds, EDV2, EDV1, and EDV0. This provides a voltage-based calibration to the RM counter.

DesignCapacity (DC) — User-specified battery full capacity

DC is the user-specified battery full capacity. It is calculated from ***Design Capacity*** and is represented in units of mAh or 10 mWh. It also represents the full-battery reference for the absolute display mode.

FullChargeCapacity (FCC) — Last measured discharge capacity of the battery

FCC is the last measured discharge capacity of the battery. It is represented in units of either mAh or 10 mWh, depending on the selected capacity mode. On initialization, the SN8765 sets *FullChargeCapacity* to the data flash value stored in ***Full Charge Capacity*** (*FCC*). During subsequent discharges, the SN8765 updates *FullChargeCapacity* with the last measured discharge capacity of the battery. The last measured discharge of the battery is based on the value in the DCR register after a qualified discharge occurs. Once updated, the SN8765 writes the new *FullChargeCapacity* value to data flash in mAh to ***Full Charge Capacity***. *FullChargeCapacity* represents the full battery reference for the relative display mode and relative state of charge calculations.

Discharge Count Register (DCR) — The DCR register counts up during discharge, independent of RM. DCR counts discharge activity, battery load estimation, and self-discharge increment. The SN8765 initializes DCR, at the beginning of a discharge, to FCC – RM when RM is within the programmed value in ***Near Full***. The DCR initial value of *FCC* – RM is reduced by *FCC*/128 if SC = 1 (bit 5 in ***CEDV Config***) and is not reduced if SC = 0. DCR stops counting when the battery voltage reaches the EDV2 threshold on discharge.

1.4.3 Capacity Learning (FCC Update) and Qualified Discharge

The SN8765 updates *FCC* with an amount based on the value in DCR if a qualified discharge occurs. The new value for *FCC* equals the DCR value plus the programmable nearly full and low battery levels, according to the following equation:

FCC (new) = DCR (final) = DCR (initial) + Measured Discharge to EDV2 + (FCC x Battery_Low%)

Where Battery_Low % = (***Battery Low %*** value in data flash) ÷ 2.56

A qualified discharge occurs if the battery discharges from *RM* ≥ *FCC*—***Near Full*** to the EDV2 voltage threshold with the following conditions:

- No valid charge activity occurs during the discharge period. A valid charge is defined as a charge of 10 mAh into the battery.
- No more than 256 mAh of self-discharge or battery load estimation occurs during the discharge period.
- The temperature does not drop below the low temperature thresholds programmed in ***Low Temp*** during the discharge period.
- The battery voltage reaches the EDV2 threshold during the discharge period and the voltage is greater than or equal to the EDV2 threshold minus 256 mV when the SN8765 detected EDV2.
- Current remains ≥3C/32 when EDV2 is reached.
- No overload condition exists when EDV2 threshold is reached, or if RM has dropped to Battery_Low % x *FCC*.

The SN8765 sets *[VDQ]* = 1 in ***Operation Status*** when a qualified discharge begins. The SN8765 sets *[VDQ]* = 0 if any disqualifying condition occurs. One complication may arise regarding the state of *[VDQ]* if ***[CSYNC]*** is set in ***Operation Cfg B***. When ***[CSYNC]*** is enabled, *RemainingCapacity* is written to equal *FullChargeCapacity* on valid primary charge termination and the charge deficit (difference between FCC and RM) is stored; and when discharge begins, the charge deficit is subtracted from RM. This capacity synchronization is done even if the condition *RM* ≥ *FCC*—***Near Full*** is NOT satisfied at charge termination.

FCC cannot be reduced by more than 256 mAh or increased by more than 512 mAh during any single update cycle. The SN8765 saves the new *FCC* value to the data flash within 4 seconds of being updated.

1.4.4 End-of-Discharge Thresholds and Capacity Correction

The SN8765 monitors the battery for three low-voltage thresholds, EDV0, EDV1, and EDV2. The ***[EDVV]*** bit in ***CEDV Config*** configures the SN8765 for single-cell EDV thresholds.

If the ***[CEDV]*** bit in ***CEDV Config*** is clear, fixed EDV thresholds may be programmed in ***Fixed EDV0***, ***Fixed EDV1*** , and ***Fixed EDV2*** in mV.

If the ***[CEDV]*** bit in ***CEDV Config*** is set, automatic EDV compensation is enabled and the SN8765 computes the EDV0, EDV1, and EDV2 thresholds based on values stored in the CEDV subclass data-flash from address offsets of 1 through 13 and the battery's current discharge rate and temperature.

The SN8765 disables EDV detection if Current exceeds the ***Overload Current*** threshold. The SN8765 resumes EDV threshold detection after Current drops below the ***Overload Current*** threshold. Any EDV threshold detected is reset after charge is applied and *[VDQ]* is cleared after 10 mAh of charge.

The SN8765 uses the EDV thresholds to apply voltage-based corrections to the RM register according to Table 1-10.

Table 1-10. State of Charge Based on Low Battery Voltage

THRESHOLD	RELATIVE STATE OF CHARGE
EDV0	0%
EDV1	3%
EDV2	*Battery Low %*

The SN8765 performs EDV-based RM adjustments with Current ≥C/32. No EDVs are set if Current <C/32. The SN8765 adjusts RM as it detects each threshold. If the voltage threshold is reached before the corresponding capacity on discharge, the SN8765 reduces RM to the appropriate amount as shown in Table 1-10.

If an RM % level is reached on discharge before the voltage reaches the corresponding threshold, then RM is held at that % level until the threshold is reached. RM is only held if *[VDQ]* = 1, indicating a valid learning cycle is in progress. If ***Battery Low %*** is set to zero, EDV1 and EDV0 corrections are disabled.

1.4.5 EDV Discharge Rate and Temperature Compensation

If EDV compensation is enabled, the SN8765 calculates battery voltage to determine EDV0, EDV1, and EDV2 thresholds as a function of battery capacity, temperature, and discharge load. The general equation for EDV0, EDV1, and EDV2 calculation is:

$$\text{EDV0,1,2} = n\,(\text{EMF} \times \text{FBL} - |\text{ILOAD}| \times \text{R0} \times \text{FTZ}) \quad (1)$$

- EMF is a no-load cell voltage higher than the highest cell EDV threshold computed. EMF is programmed in mV in ***EMF***.
- ILOAD is the current discharge load magnitude.
- n = the number of series cells. In the SN8765 case n = 1.
- FBL is the factor that adjusts the EDV voltage for battery capacity and temperature to match the no-load characteristics of the battery.

$$\text{FBL} = f\,(\text{C0},\ \text{C} + \text{C1},\ \text{T}) \quad (2)$$

- C (either 0%, 3%, or Battery Low % for EDV0, EDV1, and EDV2, respectively) and C0 are the capacity related EDV adjustment factors. C0 is programmed in ***EDV C0 Factor***. C1 is the desired residual battery capacity remaining at EDV0 (RM = 0). The C1 factor is stored in ***EDV C1 Factor***.
- T is the current temperature in °K.
- R0•FTZ represents the resistance of a cell as a function of temperature and capacity.

$$\text{FTZ} = f\,(\text{R1},\ \text{T0},\ \text{C} + \text{C1},\ \text{TC}) \quad (3)$$

- R0 is the first order rate dependency factor stored in ***EDV R0 Factor*** (DF).
- T is the current temperature; C is the battery capacity relating to EDV0, EDV1, and EDV2.
- R1 adjusts the variation of impedance with battery capacity. R1 is programmed in ***EDV R1 Rate Factor***.
- T0 adjusts the variation of impedance with battery temperature. T0 is programmed in ***EDV T0 Rate Factor***.
- TC adjusts the variation of impedance for cold temperatures (T < 23°C). TC is programmed in ***EDV TC***

Factor .

- Typical values for the EDV compensation factors, based on overall pack voltages for a 3s2p Li-Ion 18650 pack, are
  - EMF = 11550/3
  - T0 = 4475
  - C0 = 235
  - C1 = 0
  - R0 = 5350/3
  - R1 = 250
  - TC = 3

The graphs below show the calculated EDV0, EDV1, and EDV2 thresholds versus capacity using the typical compensation values for different temperatures and loads for a Li-Ion 18650 cell. The compensation values vary widely for different cell types and manufacturers and must be matched exactly to the unique characteristics for optimal performance.

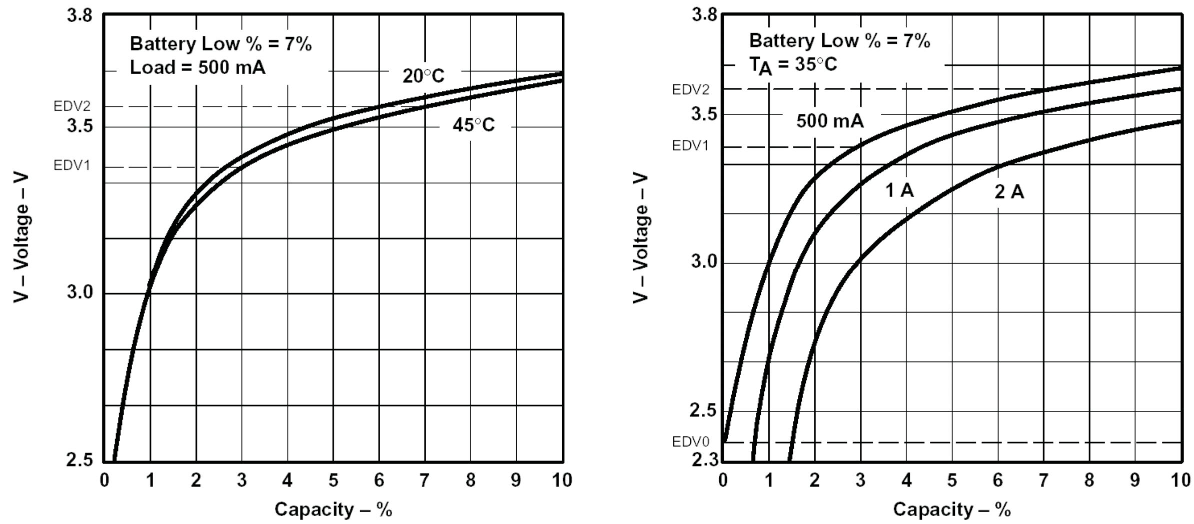


Figure 1-7. (a) EDV Calculations vs Capacity for Various Temperatures, (b) EDV Calculations vs Capacity for Various Loads

1.4.6 EDV Age Factor

EDV Age Factor allows the SN8765 to correct the EDV detection algorithm to compensate for cell aging. This parameter scales cell impedances as the cycle count increases. This new factor is used to accommodate for much higher impedances observed in larger capacity and/or aged cells. For most applications the default value of zero is sufficient. However, for some very specific applications, this new aging factor may be required. In those cases, experimental data must be taken at the 0, 100, 200, and 300 cycle read points using a typical discharge rate while at ambient temperature. Entering this data into a TI provided MathCAD™ program will yield the appropriate ***EDV Age Factor*** value. Contact TI Applications Support @ http://www-k.ext.ti.com/sc/technical-support/email-tech-support.asp?AAP for more detailed information.

1.4.7 Self-Discharge

The SN8765 estimates the self-discharge of the battery to maintain an accurate measure of the battery capacity during periods of inactivity. The SN8765 makes self-discharge adjustments to RM every 1/4 second when awake and periodically when in SLEEP mode. The period is determined by ***Sleep Time***.

The self-discharge estimation rate for 25°C is doubled for each 10 degrees above 25°C or halved for each 10 degrees below 25°C. Table 1-11 shows the relation of the self-discharge estimation at a given temperature to the rate programmed for 25°C.

Table 1-11. Self Discharge for Rate Programmed

TEMPERATURE (°C)	SELF-DISCHARGE RATE
Temp < 10	¼Y% per day
10 ≤ Temp <20	½Y% per day
20 ≤ Temp <30	Y% per day
30 ≤ Temp <40	2Y% per day
40 ≤ Temp <50	4Y% per day
50 ≤ Temp <60	8Y% per day
60 ≤ Temp <70	16Y% per day
70 ≤ Temp	32Y% per day

The nominal self-discharge rate, %PERDAY (% per day), is programmed in an 8-bit value ***Self-Discharge Rate*** by the following relation:

Self-Discharge Rate = %PERDAY/ 0.01

1.4.8 Battery Electronic Load Compensation

The SN8765 can be configured to compensate for a constant load (as from battery electronics) present in the battery pack at all times. The SN8765 applies the compensation continuously when the charge or discharge is below the digital filter. The SN8765 applies the compensation in addition to self-discharge. The compensation occurs at a rate determined by the value stored in *Electronics Load*. The compensation range is 0 µA–765 µA in steps of approximately 3 µA.

The amount of internal battery electronics load estimate in µA, BEL, is stored as follows:

Electronics Load = BEL / 3

1.4.9 CEDV Configuration

Various gas gauging features can be configured by the ***CEDV Config*** register.

Table 1-12. CEDV Configuration

Feature	Description
SC	The SC bit enables learning cycle optimization for a Smart Charger or independent charge. 1 Learning cycle optimized for independent charger 0 Learning cycle optimized for Smart Charger
CEDV	The CEDV bit determines whether the SN8765 implements automatic EDV compensation to calculate the EDV0, EDV1, and EDV2 thresholds base on rate, temperature, and capacity. If the bit is cleared, the SN8765 uses the fixed values programmed in data flash for EDV0, EDV1, and EDV2. If the bit is set, the SN8765 calculates EDV0, EDV1, and EDV2. 0 EDV compensation disabled 1 EDV compensation enabled
EDVV	The EDVV bit selects whether EDV termination is to be done with regard to voltage or the lowest single-cell voltage. 0 EDV conditions determined on the basis of the lowest single-cell voltage 1 EDV conditions determined on the basis of *Voltage*

1.4.10 Initial Battery Capacity at Device Reset

The SN8765 estimates the initial capacity of a battery pack at device reset, which is the case when battery cells are first attached to the application circuit. The initial *FullChargeCapacity* (FCC) is a direct copy of the data flash parameter ***Full Charge Capacity***. The initial RM and RSOC are estimated using the open-circuit voltage (OCV) characteristics of the programmed Li-ion chemistry (default ID0100), ***DOD at EDV2***, and ***Qmax Pack***. This gives a reasonably accurate RM and RSOC, however, battery capacity learning is required in order to find the accurate FCC, RM and RSOC. During battery capacity learning, ***Full Charge Capacity*** and ***DOD at EDV2*** will be learned and updated.

The data flash parameter *Full Charge Capacity* should be initialized to the ***DesignCapacity***. ***DOD at EDV2*** should be initialized to (1–Battery_Low%) x 16384, where Battery_Low% = ***Battery Low %*** ÷ 2.56.

1.4.11 Gas Gauge Operating Modes

Entry and exit of each mode is controlled by data flash parameters in the subclass "Gas Gauging: Current Thresholds" section. In Relaxation Mode or Discharge Mode, the DSG flag in *BatteryStatus* is set.

Charge mode is exited and Relaxation mode is entered when *Current* goes below ***Quit Current*** for a period of ***Chg Relax Time***. Discharge mode is entered when *Current* goes below ***(–)Dsg Current Threshold***. Discharge mode is exited and Relaxation mode is entered when *Current* goes above ***(–)Quit Current*** threshold for a period of ***Dsg Relax Time***. Charge mode is entered when *Current* goes above ***Chg Current Threshold***.

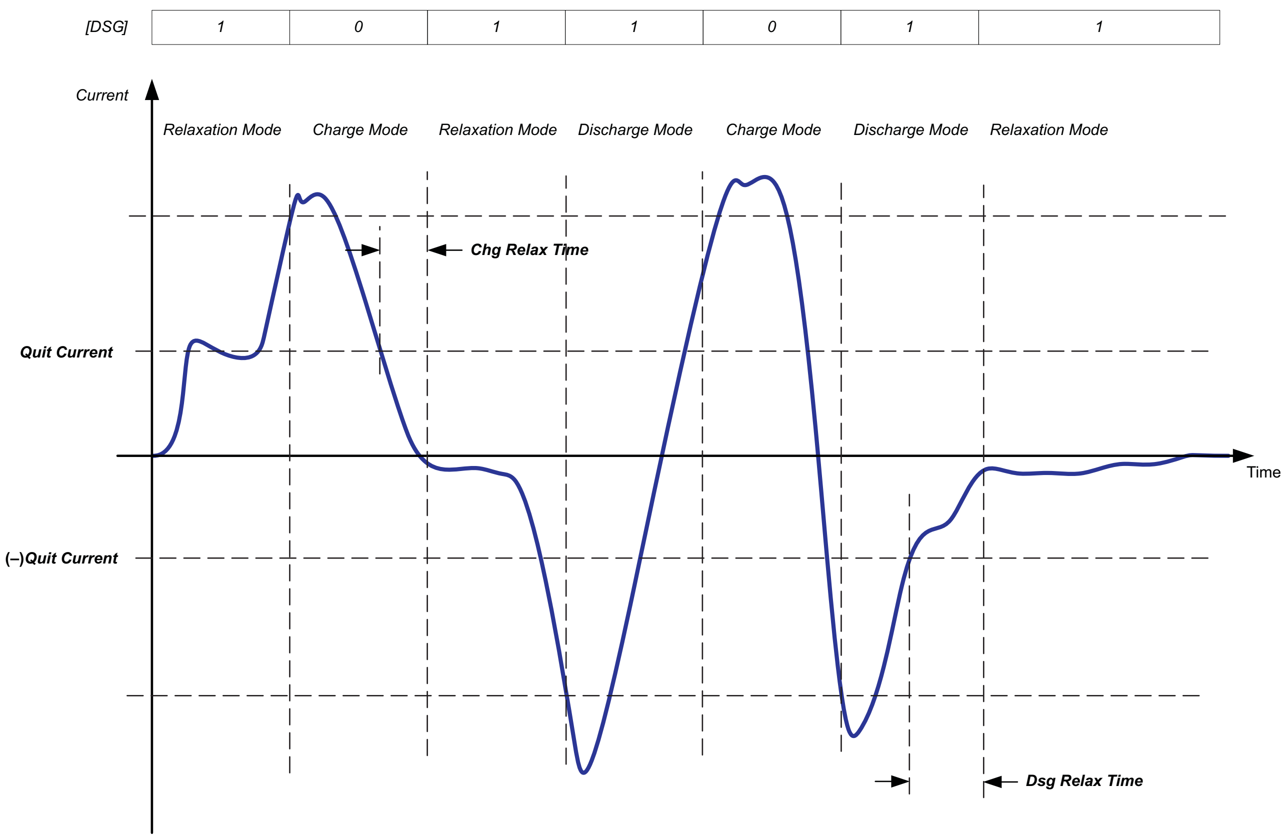


Figure 1-8. Gas Gauge Operating Mode Example

1.4.12 Qmax

Qmax is used for initial capacity (RM and RSOC) estimate in conjunction with the cell voltages and programmed chemistry information when device resets. The ***Qmax Pack***, ***Qmax Cell 0***, ***Qmax Cell 1***, ***Qmax Cell 2***, and ***Qmax Cell 3*** values should be taken from the cell manufacturers' data sheet multiplied by the number of parallel cells. This is also used for the *DesignCapacity* function and the ***Design Capacity*** data flash value.

1.5 Charge Control

The SN8765 can report the appropriate charging current needed for the constant charging current and the charging voltage needed for constant voltage charging per charging algorithm to a smart charger using the *ChargingCurrent* and the *ChargingVoltage* functions. The actual charging status of SN8765 is indicated with flags and can be read out with the *ChargingStatus* function.

1.5.1 Charge Control SMBus Broadcasts

All broadcasts to a host or a smart charger are enabled by the ***[BCAST]*** bit. If the ***[HPE]*** bit is enabled, Master-Mode broadcasts to the Host address are PEC enabled. If the ***[CPE]*** bit is enabled, Master-Mode broadcasts to the Smart-Charger address are PEC enabled. When broadcast is enabled, the following broadcasts are sent:

- *ChargingVoltage* and *ChargingCurrent* broadcasts are sent to the Smart-Charger device address (0x12) every 10 to 60 seconds.
- If any of the *[OCA], [TCA], [OTA], [TDA], [RCA], [RTA]* flags are set, the *AlarmWarning* broadcast is sent to the host device address (0x14) every 10 seconds. Broadcasts stop when all flags above have been cleared.
- If any of the *[OCA], [TCA], [OTA] or [TDA]* flags are set, the *AlarmWarning* broadcast is sent to Smart-Charger device address every 10 seconds. Broadcasts stop when all flags above have been cleared.

1.5.2 Charging and Temperature Ranges

The SN8765 requests different charging current and charging voltage for each of the temperature ranges defined in Section 1.1, through the *ChargingVoltage* and *ChargingCurrent* commands.

Additionally, the charging current can be set differently depending on the cell voltage. Three ranges of cell voltage are defined using two cell voltage thresholds: ***Cell Voltage Threshold 1*** and ***Cell Voltage Threshold 2*** (see Table 1-13). During charging, as cell voltage increases *ChargingCurrent* is set to the appropriate value when cell voltage crosses one of the cell voltage thresholds. However, if cell voltage decreases below the threshold *ChargingCurrent* is not set back to the previous value unless discharge or relax state is detected. This is done to avoid the situation where charging current being changed back and forth due to the voltage drop that results form changing the charging current value. In addition, ***Cell Voltage Thresh Hys*** is used to make sure that transitions between cell voltage ranges are not affected by small transients.

Table 1-13. Cell Voltage Ranges

Condition	Cell Voltage Range
max(*CellVoltage4..1*) < ***Cell Voltage Threshold 1***	CVR1
Cell Voltage Threshold 1 < max(*CellVoltage4..1*) < ***Cell Voltage Threshold 2***	CVR2
Cell Voltage Threshold 2 < max(*CellVoltage4..1*)	CVR3

The dependency of the *Charging Voltage* and *Charging Current* on temperature range and cell voltage range is summarized in Table 1-14 and illustrated in Figure 1-9 and Figure 1-10.

Table 1-14. Charging Voltage and Charging Current Dependency on Temperature Range and Cell Voltage Range

Temp Range	Cell Voltage	Charging Voltage	Charging Current
TR1	—	0	0
TR2	CVR1	***LT Chg Voltage***	***LT Chg Current 1***
	CVR2		***LT Chg Current 2***
	CVR3		***LT Chg Current 3***
TR2A	CVR1	***ST1 Chg Voltage***	***ST1 Chg Current 1***
	CVR2		***ST1 Chg Current 2***
	CVR3		***ST1 Chg Current 3***
TR3	CVR1	***ST2 Chg Voltage***	***ST2 Chg Current 1***
	CVR2		***ST2 Chg Current 2***
	CVR3		***ST2 Chg Current 3***
TR4	CVR1	***HT Chg Voltage***	***HT Chg Current 1***
	CVR2		***HT Chg Current 2***
	CVR3		***HT Chg Current 3***
TR5	—	0	0

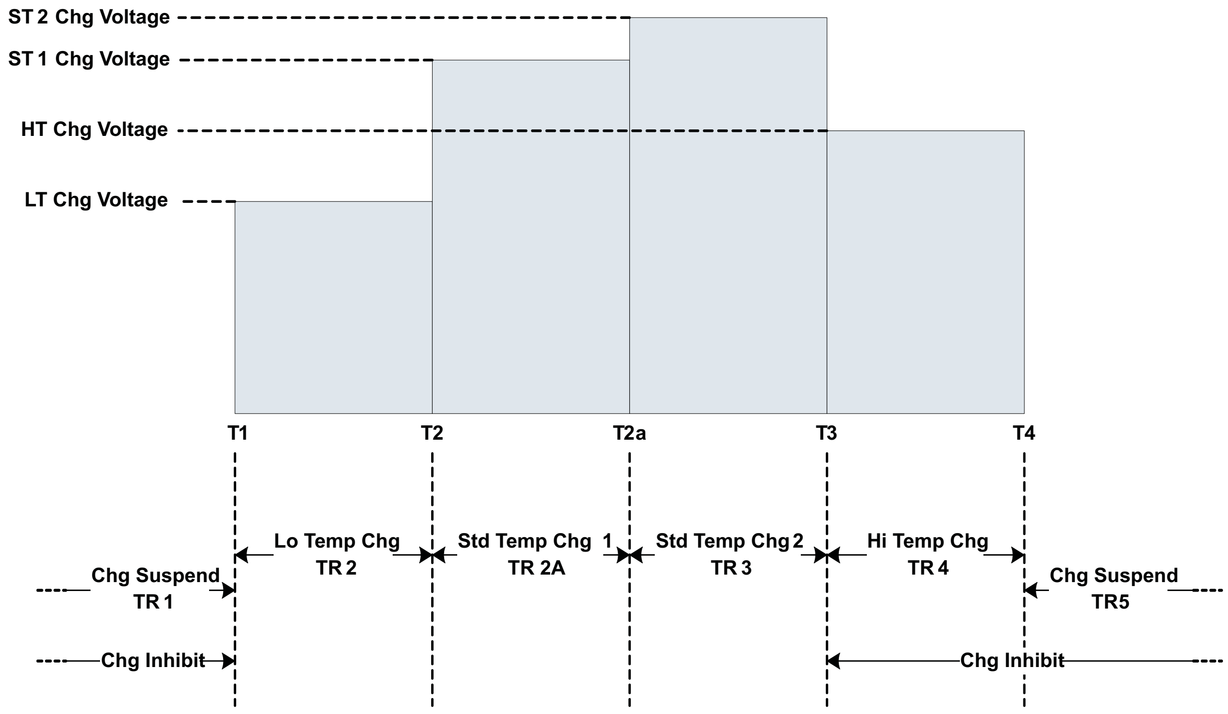


Figure 1-9. Temp Ranges and Charge Voltage for JEITA with Enhancements for More Complex Charging Profiles

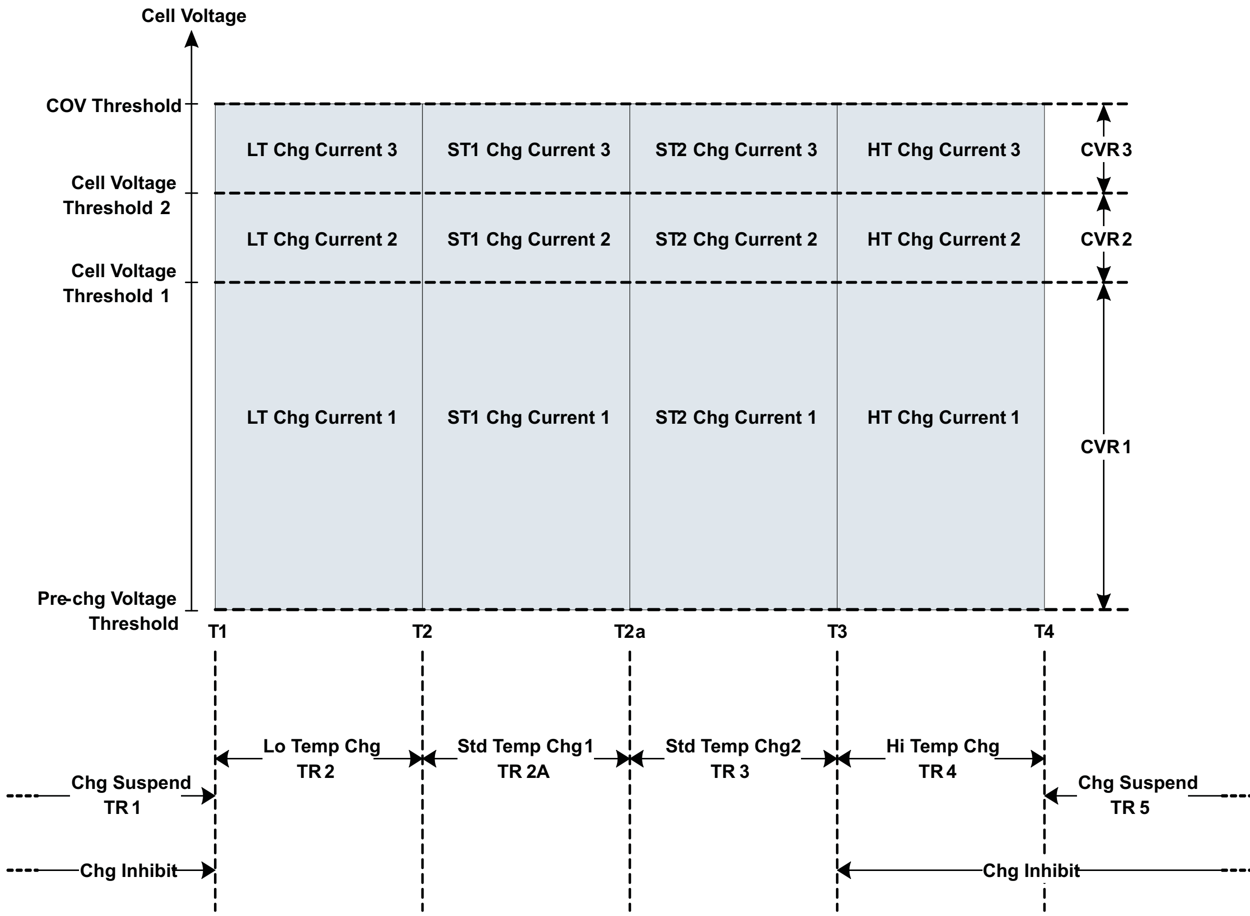


Figure 1-10. Temp Ranges and Charge Current for JEITA with Enhancements for More Complex Charging Profiles

1.5.2.1 Low Temperature Charging

The SN8765 enters this mode when the *Temperature* function reports a temperature in the TR2 range (***JT1*** < *Temperature* < ***JT2***). In this mode [*LTCHG*] flag in *ChargingStatus* is set, the *ChargingVoltage* is set to *LT Chg Voltage*, and the *ChargingCurrent* is set to ***LT Chg Current 1***, ***LT Chg Current 2***, or ***LT Chg Current 3*** depending on the active cell voltage range. The charging current dataflash values for low temp charging should be set to low current values similar to precharge mode. The SN8765 leaves this mode and clears the *[LTCHG]* flag if the *Temperature* goes below ***JT1*** or above ***JT2*** + *Temp Hys*.

1.5.2.2 Standard Temperature Charging 1

The SN8765 enters this mode when the *Temperature* function reports a temperature in the TR2A range (***JT2*** < *Temperature* < ***JT2a***). In this mode the *[ST1CHG]* flag in *ChargingStatus* is set, *ChargingVoltage* is set to ***ST1 Chg Voltage***, and the *ChargingCurrent* is set to ***ST1 Chg Current***, ***ST1 Chg Current 2***, or ***ST1 Chg Current 3*** depending on the active cell voltage range. The SN8765 leaves this mode and clears the *[ST1CHG]* flag if the *Temperature* goes below ***JT2*** or above ***JT2a***.

1.5.2.3 Standard Temperature Charging 2

The SN8765 enters this mode when the *Temperature* function reports a temperature in the TR3 range (***JT2a*** < Temperature < ***JT3***). In this mode the *[ST2CHG]* flag in *ChargingStatus* is set, *ChargingVoltage* is set to ***ST2 Chg Voltage***, and the *ChargingCurrent* is set to ***ST2 Chg Current 1*** or ***ST2 Chg Current 2*** or ***ST2 Chg Current 3*** depending on the active cell voltage. The SN8765 leaves this mode and clears the *[ST2CHG]* flag if the *Temperature* goes below ***JT2a – Temp Hys*** or above ***JT3***.

1.5.2.4 High Temperature Charging

The SN8765 enters this mode when the *Temperature* function reports a temperature in the TR4 range (***JT3*** < *Temperature* < ***JT4***). In this mode the *[HTCHG]* flag in *ChargingStatus* is set, ChargingVoltage is set to ***HT Chg Voltage***, and the *ChargingCurrent* is set to ***HT Chg Current 1***, ***HT Chg Current 2***, or ***HT Chg Current 3*** depending on the active cell voltage. The SN8765 leaves this mode and clears the *[HTCHG]* flag if the *Temperature* goes below ***JT3 – Temp Hys*** or above ***JT4***.

1.5.3 Charge-Inhibit Mode

If the SN8765 is in discharge mode or relaxation mode (*[DSG]* = 1), the SN8765 goes into charge-inhibit mode and sets the *ChargingCurrent* and *ChargingVoltage* values to 0 to inhibit charging if:

- *Temperature* < ***JT1*** limit OR
- *Temperature* > ***JT3*** limit

In charge-inhibit mode, the *[XCHG]* flag in *ChargingStatus* is set. If the ***[CHGIN]*** bit in ***Operation Cfg B*** is set, the CHG FET and ZVCHG FET (if used) are also turned off when the SN8765 is in charge-inhibit mode.

The SN8765 allows charging to resume when:

- *Temperature* ≥ ***JT1*** + ***Temp Hys*** AND
- *Temperature* ≤ ***JT3*** – ***Temp Hys***

The FETs also return to their previous states at that time. The *[XCHG]* flag is cleared when the foregoing conditions are met, when a charge fault condition is detected, or when the battery is removed if in removable mode (***[NR]*** = 0).

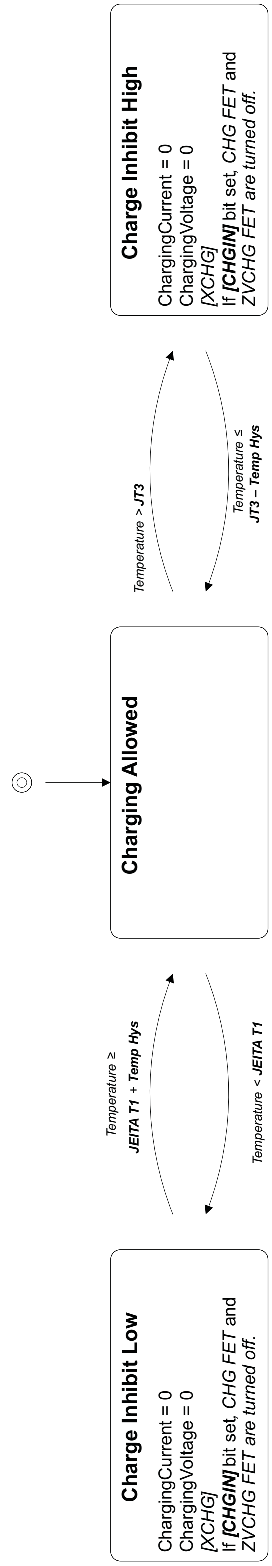


Figure 1-11. Charge Inhibit

1.5.4 Charge-Suspend Mode

The SN8765 suspends charging when:

- *Temperature* < ***JT1***, OR
- *Temperature* > ***JT4***

In charge-suspend mode, the *[CHGSUSP]* flag in *ChargingStatus* is set and *ChargingCurrent* is set to 0. The CHG FET and ZVCHG FET (if used) are also turned off if the ***[CHGSUSP]*** bit in the ***Operation Cfg B*** register is set.

The SN8765 resumes charging if:

- *Temperature* ≥ ***JT1*** + ***Temp Hys***, AND
- *Temperature* ≤ ***JT3*** – ***Temp Hys***.

On resuming, the SN8765 clears the *[CHGSUSP]* status flag and sets *ChargingCurrent* according to the appropriate charging mode entered, and the CHG and ZVCHG FETs (if used) return to their previous state.

The SN8765 also leaves the charge-suspend mode and clears the *[CHGSUSP]* flag when a protection condition is detected or when the battery is removed in removable battery mode (***[NR]*** = 0).

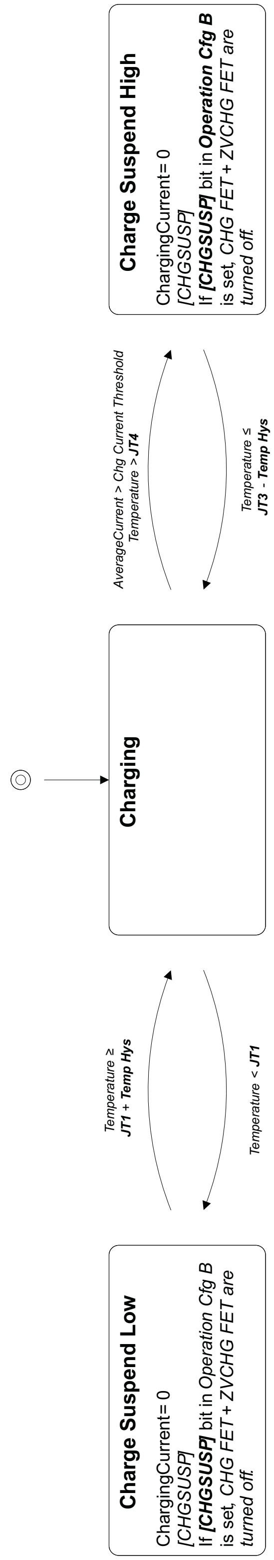


Figure 1-12. Charge Suspend

1.5.5 Pre-Charge Cfg

The SN8765 enters precharge mode during charging if any cell voltage goes below ***Pre-chg Voltage*** limit or if any of the *SafetyStatus* flags, *[CUV]* or *[OCD]*, is set.

Depending on the setting of the ***[PCHG1]*** and ***[PCHG0]*** bits, PCHG FET can be enabled or disabled in PRECHARGE mode.

Table 1-15. Precharge FET

PCHG1	PCHG0	FET Used	Functions Supported
0	0	Not defined	No precharge, both CHG and PCHG FET disabled
0	1	CHG FET	Precharge: Requires smart charger that can output precharge current autonomously, or by receiving broadcast charging current/charging voltage from the SN8765; Does not support zero-volt charge
1	0	PCHG FET	Precharge using the PCHG FET
1	1	Not defined	No precharge, both CHG and PCHG FET disabled

In precharge mode the *[PCHG]* flag is set and *ChargingCurrent* is set to ***Pre-chg Current***.

The SN8765 leaves PRECHARGE mode and clears the *[PCHG]* flag if all cell voltages reach or rise above ***Recovery Voltage***. PRECHARGE mode is also exited if charge suspend mode is entered, any charge fault condition is detected, or the pack is removed in removable mode.

1.5.6 Primary Charge Termination

The SN8765 determines charge termination if:

- Average Charge Current < ***Taper Current*** during 2 consecutive ***Current Taper Window*** time periods, AND
- the accumulated change in capacity must be > 0.25 mAh per period during two consecutive ***Current Taper Window*** time periods, AND
- *Voltage* + ***Taper Voltage*** ≥ ***Charging Voltage***

NOTE: To make sure that the charge terminates properly, it is recommend that ***Taper Current*** be set to a value greater than ***Quit Current***.

The following parameters change the behavior of SN8765 on charge termination:

Table 1-16. Primary Charge Termination

Parameter	Behavior on Primary Charge Termination
TCA Set % = –1	*[TCA]* flag set, *ChargingCurrent* = 0
FC Set % = –1	*[FC]* flag set
[CHGFET] set	CHG FET turned off
[CSYNC] set	*RemainingCapacity* = *FullChargeCapacity* regardless of ***TCA Set %*** value
[RSOCL] set	If the ***[RSOCL]*** bit in ***Operation Cfg C*** is set then *RelativeStateofCharge* and *RemainingCapacity* are held at 99% until primary charge termination occurs and only displays 100% upon entering primary charge termination.
[RSOCL] clear	If the ***[RSOCL]*** bit in ***Operation Cfg C*** is cleared then *RelativeStateofCharge* and *RemainingCapacity* are **not** held at 99% until primary charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.

1.5.7 Discharge and Charge Alarms

The SN8765 enables *[TDA], [FD], [TCA] and [FC]* flags in *BatteryStatus* to be set or cleared on the following thresholds based on *RelativeStateOfCharge*. All thresholds can be disabled by setting them to –1. ***FC Clear %*** should not be disabled by setting to –1.

	Threshold	*BatteryStatus* Flag
RelativeStateOfCharge	≤ ***TDA Set %***	*[TDA]* is set
	≥ ***TDA Clear %***	*[TDA]* is cleared
	≤ ***FD Set %***	*[FD]* is set
	≥ ***FD Clear %***	*[FD]* is cleared
	≥ ***TCA Set %***	*[TCA]* is set
	≤ ***TCA Clear %***	*[TCA]* is cleared
	≥ ***FC Set %***	*[FC]* is set
	≤ ***FC Clear %***	*[FC]* is cleared

The *[TDA]* and *[FD]* flags in *BatteryStatus* can also be set or cleared based on *Voltage*. If the voltage settings are not used then they should be set to extreme range values.

	Threshold	*BatteryStatus* Flag
Voltage	≤ ***TDA Volt Threshold*** for a period of ***TDA Volt Time***	*[TDA]* is set
	≥ ***TDA Clear Volt***	*[TDA]* is cleared
	≤ ***FD Volt Threshold*** for a period of ***FD Volt Time***	*[FD]* is set
	≥ ***FD Clear Volt***	*[FD]* is cleared

1.5.8 Cell Balancing

Cell balancing in SN8765 is accomplished by connecting an external parallel bypass load to each cell, and enable the bypass load depending on each individual cell's charge state. The bypass load is typically formed by a P-ch MOSFET and a resistor connected in series across each battery cell. The filter resistors that connect the cell tabs to VC1~VC4 pins of the SN8765 are required to be 1k ohms. Using this circuit, the SN8765 balances the cells during charge by discharging those cells above the threshold set in *Cell Balance Threshold*, if the maximum difference in cell voltages exceeds the value programmed in *Cell Balance Min*. During cell balancing, the SN8765 measures the cell voltages at an interval set in *Cell Balance Interval*. On the basis of the cell voltages, the SN8765 either selects the appropriate cell to discharge or adjusts the cell balance threshold up by the value programmed in *Cell Balance Window* when all cells exceed the cell balance threshold or the highest cell exceeds the cell balance threshold by the cell balance window.

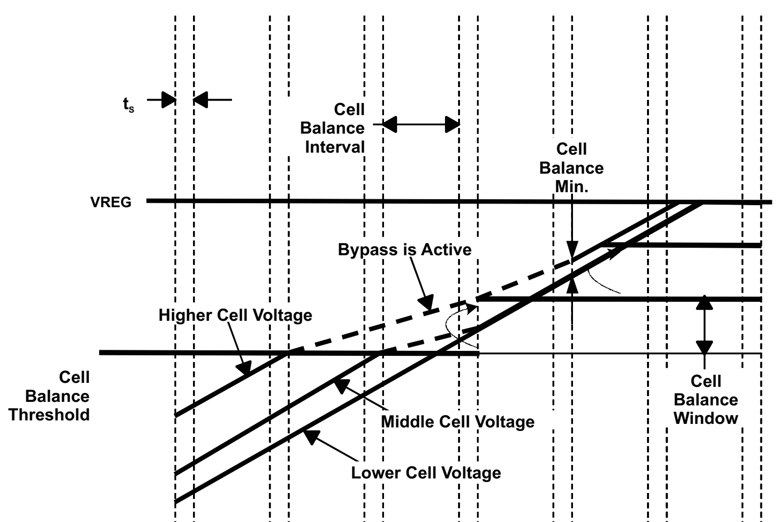


Figure 1-13. Cell Balancing

Cell balancing only occurs when charging current is detected. The cell balance threshold is reset to the value in *Cell Balance Threshold* at the start of every charge cycle. The threshold is only adjusted once during any balance interval.

1.5.9 Charging Faults

The SN8765 can report charging faults in the *ChargingStatus* register.

On occurrence of a FCMTO, PCMTO, OCHGV, and OC charging fault the SN8765 sets:

- The appropriate *ChargingStatus* flag
- If the flags in ***Charge Fault Cfg*** and *ChargingStatus* match, the CHG FET (or the ZVCHG FET if in precharge) is turned off.
- *ChargingCurrent* = 0, *ChargingVoltage* = 0.
- *[TCA]* flag in *BatteryStatus*
- *[OC]* flag in *BatteryStatus* if it's an Overcharge fault

On occurrence of a OCHGI charging fault the SN8765 sets:

- The *[OCHGI] ChargingStatus* flag
- If the ***[OCHGI]*** bit in ***Charge Fault Cfg*** is set, the CHG FET is turned off and the ZVCHG FET (if enabled, i.e. ***[ZVCHG1]:[ZVCHG2]*** = 0:0 in ***Operation Cfg A***) is turned on. If ZVCHG FET is not enabled in ***Operation Cfg A***, CHG FET remains on, regardless of this bit.
- *ChargingCurrent* = 0, *ChargingVoltage* = 0.
- *[TCA]* flag in *BatteryStatus*

On occurrence of a XCHGLV charging fault the SN8765 sets:

- The *[XCHGLVI] ChargingStatus* flag
- If the ***[CS_XCHGLV]*** bit in ***Charge Fault Cfg*** is set, the DSG FET is turned off (if not already turned off by cell under voltage protection); the ZVCHG FET remains on. If the ZVCHG FET is not enabled in ***Operation Cfg A***, CHG FET remains on.
- *ChargingCurrent* = 0; *ChargingVoltage* is not set to zero since it is a Battery Depleted fault.
- *[TCA]* flag in *BatteryStatus*

On Recovery the SN8765:

- Resets the appropriate *ChargingStatus* flags
- CHG FET and ZVCHG FET (if used) return to previous states. In PCMTO, if the SN8765 recovers by discharge current and the discharge current sustains, the CHG FET is turned on even if the device is still in precharge mode. DSG FET is also allowed to turn on again on recovery from Battery Depleted fault.
- Sets *ChargingCurrent* and *ChargingVoltage* back to previous state according to charging algorithm.
- Resets *[TCA]* flag in *BatteryStatus*

Precharge Mode Timeout

When *Current* is ≥ ***Chg Current Threshold*** the SN8765 starts the Precharge Timer. The Precharge Timer is suspended when precharge mode is not active (*[PCHG]* = 0), or when *[DSG]* = 1. The precharge Timer is reset when an amount of discharge greater than ***Over Charge Recovery*** is detected or the pack is removed and reinserted when NR = 0. Set ***PC-MTO*** to zero to disable this feature.

The SN8765 goes into precharge mode charging timeout if:

- Precharge timer ≥ ***PC-MTO***

The SN8765 suspends the precharge timer if:

- *Current* ≤ ***(–)Dsg Current Threshold***

The SN8765 recovers (i.e. timer resets) if:

- ***PC-MTO*** is set, OR
- An amount of discharge greater than ***Over Charge Recovery*** is detected, OR
- Pack is removed and reinserted, if ***[NR]*** = 0

FAST CHARGE Mode Timeout

When *Current* is ≥ ***Chg Current Threshold***, the SN8765 starts the Fast Charge timer. The Fast Charge Timer is suspended when fast charge is not active (*[FCHG]* = 0), or when *[DSG]* = 1. The Fast Charge Timer is reset when an amount of discharge greater than ***Over Charge Recovery*** is detected or the pack is removed and reinserted when NR = 0. Set ***FC-MTO*** to 0 to disable this feature.

The SN8765 goes into FAST CHARGE mode charging timeout if:

- Fast charge timer ≥ ***FC-MTO***

The SN8765 suspends the fast charge timer if:

- *Current* ≤ ***(–)Dsg Current Threshold***

The SN8765 recovers (i.e. timer resets) if:

- ***FC-MTO*** is set, OR
- An amount of discharge greater than ***Over Charge Recovery*** is detected, OR
- Pack is removed and reinserted if ***[NR]*** = 0

Overcharging Voltage

The SN8765 goes into overcharging voltage mode if:

- *Voltage* ≥ ***Charging Voltage*** + ***Over Charging Voltage*** for min. ***Over Charging Volt Time*** period.

The SN8765 recovers, if:

- *Voltage* ≤ ***Charging Voltage***

Overcharging Current

The SN8765 goes into overcharging current mode if:

- *Current* ≥ *ChargingCurrent* + ***Over Charging Current*** for min. ***Over Charging Curr Time*** period.

The SN8765 recovers, if:

- *AverageCurrent* ≤ ***Over Charging Curr Recov***

Overcharge

The SN8765 goes into OVERCHARGE mode if the battery pack is charged in excess of *FullChargeCapacity* by ***Over Charge Capacity***:

The SN8765 recovers if any of the following conditions are met:

- Pack removed and reinserted (***[NR]*** = 0)
- Continuous amount of discharge over ***Over Charge Recovery*** and *AverageCurrent* < 0, when ***[NR]*** = 1
- *RemainingCapacity* ≤ ***FC Clear %***

Battery Depleted

The SN8765 goes into battery depleted mode if:

- *Voltage* ≤ ***Depleted Voltage*** for ***Depleted Voltage Time*** and charger is present.

The SN8765 recovers, if:

- *Voltage* > ***Depleted Voltage Recovery***

Table 1-17. Charging Faults

Charge Fault	Fault Condition	Recovery Condition	***ChargingStatus*** Flag, ***Charge Fault Configuration*** Flag
Precharge Timeout	Precharge Timer ≥ ***PC-MTO***	*Current* ≤ ***(–)Dsg Current Threshold***, OR Pack removed and reinserted if ***[NR]*** = 0	*[PCMTO]*
Fast charge Timeout	Fast charge Timer ≥ ***FC-MTO***		*[FCMTO]*
Overcharging Voltage	*Voltage* ≥ ***Charging Voltage*** + ***Over Charging Voltage*** for min. ***Over Charging Volt Time***	*Voltage* ≤ ***Charging Voltage***	*[OCHGV]*

Table 1-17. Charging Faults (continued)

Charge Fault	Fault Condition	Recovery Condition	***ChargingStatus* Flag, *Charge Fault Configuration* Flag**
Overcharging Current	*Current* ≥ *ChargingCurrent* + ***Over Charging Current*** for min. ***Over Charging Curr Time***	*AverageCurrent* ≤ ***Over Charging Curr Recov***	*[OCHGI]*
Overcharge	*RemainingCapacity* - *FullChargeCapacity* ≥ ***Over Charge Capacity***	Pack removed and reinserted if ***[NR]*** = 0, OR continuous amount of discharge of ***Over Charge Recovery*** if ***[NR]*** = 1, OR *RemainingCapacity* ≤ ***FC Clear %***	*[OC]*
Battery Depleted	*Voltage* ≤ ***Depleted Voltage*** for min ***Depleted Voltage Time***	*Voltage* > ***Depleted Voltage Recovery***	*[XCHGLV]*, ***[CS_XCHGLV]***

1.6 LED Display

1.6.1 Display Activation

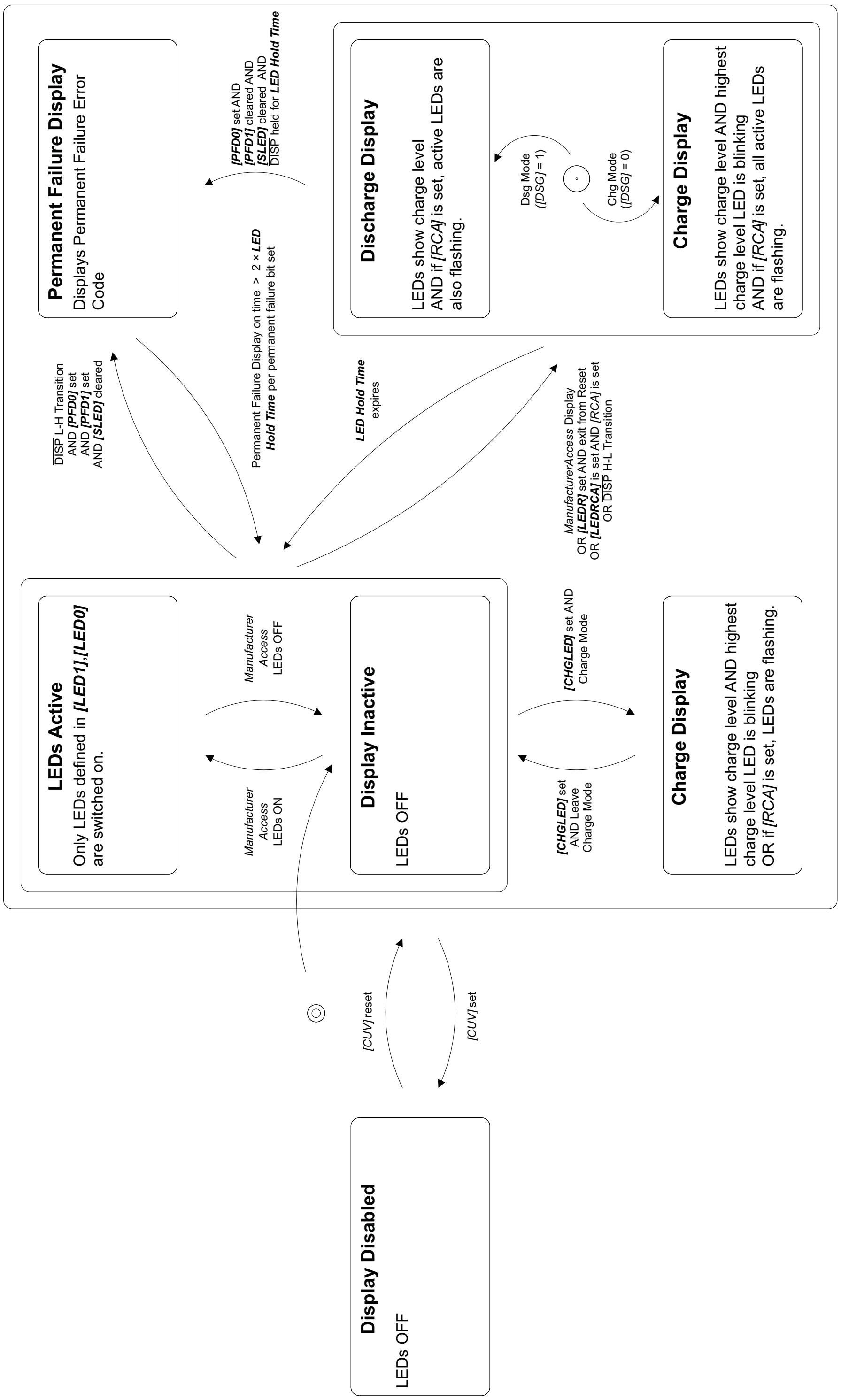


Figure 1-14. Display Activation

The LED display is activated with a High to Low (H-L) transition at the $\overline{\text{DISP}}$ pin. The following flags configure additional display activation settings. If *[CUV]* or *[PUV]* flags are set, the display is disabled.

LEDR — Set this flag to activate the display on exit from reset.

LEDRCA — Set this flag to let all active LEDs flash with ***LED Flash Period*** if *[RCA]* flag is set.

CHGLED — Set this flag to let the display stay activated during charging.

PFD1, PFD0 — If ***[PFD0]*** is set, the permanent failure can be activated in two different ways depending on the ***[PFD1]*** flag. If ***[PFD1]*** is cleared, the permanent failure display is active after normal capacity display, if $\overline{\text{DISP}}$ is held low after H-L transition for ***LED Hold Time*** period. If ***[PFD1]*** is set, the permanent failure display is activated with a H-L transition at $\overline{\text{DISP}}$ pin. The permanent failure display stays active 2 × ***LED Hold Time*** for each flag set in *PFStatus* register. See Section 1.6.4 for available error codes.

LEDs ON, LEDs OFF, Display ON — The display can be tested with these *ManufacturerAccess* commands, *LEDs ON* and *LEDs OFF* switches all configured LEDs on or off. The *Display ON* command simulates a H-L transition at the $\overline{\text{DISP}}$ pin.

1.6.2 Display Configuration

The following parameters configures the display in various ways.

DMODE — The charge level display can be configured to show either relative state of charge or absolute state of charge.

LED1, LED0 — These bits configure the number of LEDs and the charge threshold levels used in the LED display. The SN8765 can use predefined charge levels for 3,4, or 5 LEDs or user defined levels.

SLED — The serial LED option can be used to implement a much brighter display at the expense of additional hardware components. With the parallel connection, the 3.3 V output from the bq29330 is used to power the LEDs. Using that approach, current in each LED should be limited to 3 mA maximum. With the serial option, all LEDs can be powered from the battery voltage and driven in series through a simple constant current regulator. The current is then diverted to ground at the various nodes between the series LEDs in order to program the desired pattern.

LED Blink Period — During charging, the top LED segment flashes with the ***LED Blink Period***; e.g. if battery charge is 36% and the display uses 5 LEDs, LED 2 will blink. ***[LEDRCA]***, ***CHG Flash Alarm*** and ***DSG Flash Alarm*** will override this setting if active.

LED Flash Period — During discharge alarm, the remaining LED segments flash with ***LED Flash Period***; e.g. if battery charge is 36% and the display uses 5 LEDs, LED 1 and LED 2 will blink.

LED Delay — An activation delay from one LED to another LED can be set with this value.

LED Hold Time — After display activation the display will stay on ***LED Hold Time*** period. The permanent failure display will stay on double the ***LED Hold Time*** period for each permanent failure bit set.

1.6.3 Display Format

The SN8765 can show state of charge using the LED display. Predefined levels for 3, 4, or 5 LEDs or user configurable levels can be selected. State of charge levels can be configured for charging and discharging.

If the display is activated during charging the display shows the state of charge and the top LED segment flashes at the rate of ***LED Blink Period*** (eg: if *RelativeStateOfCharge* = 36% and 5 LEDs are being used then LED2 will blink). The blinking is overridden with ***CHG Flash Alarm*** or ***[LEDRCA]***.

If state of charge falls below the flash alarm level, all remaining active LEDs will flash at the ***LED Flash Period***. The flash alarm can be disabled by setting it to –1.

Table 1-18. Display Charge Level Threshold

LED1, LED0 Setting:	3 LED	4 LED	5 LED	USER	
Threshold Level:	**Charge + Discharge Level**			**Charging Level**	**Discharging Level**
Flash Alarm active	0%–10%	0%–10%	0%–10%	0%–***CHG Flash Alarm***	0%–***DSG Flash Alarm***
LED 1 active	0%–100%	0%–100%	0%–100%	***CHG Thresh 1***–100%	***DSG Thresh 1***–100%
LED 2 active	34%–100%	25%–100%	20%–100%	***CHG Thresh 2***–100%	***DSG Thresh 2***–100%
LED 3 active	67%–100%	50%–100%	40%–100%	***CHG Thresh 3***–100%	***DSG Thresh 3***–100%
LED 4 active	—	75%–100%	60%–100%	***CHG Thresh 4***–100%	***DSG Thresh 4***–100%
LED 5 active	—	—	80%–100%	***CHG Thresh 5***–100%	***DSG Thresh 5***–100%

1.6.4 Permanent Failure Error Codes

When a permanent failure occurs, the type of permanent failure error can be shown on the display. The table below shows available error codes. The permanent failure display requires proper setting of ***[PFD1]*** and ***[PFD0]*** bits. The permanent failure code display is disabled if ***[SLED]*** bit is set. The LED Flash Period and LED Blink Period are fixed for these errors and not affected by the LED Data Flash settings.

PFStatus	LED3	LED2	LED1
[FBF]	On	Blink	Flash
[VSHUT]	Off	Blink	Flash
[SOPT]	On	Blink	On
[SOCD]	Off	Blink	On
[SOCC]	Flash	Blink	Off
[AFE_P]	On	Blink	Off
[AFE_C]	Off	Blink	Off
[DFF]	Blink	Flash	Flash
[DFETF]	Blink	On	Flash
[CFETF]	Blink	Off	Flash
[CIM_R]	Blink	Flash	On
[SOT1D]	Blink	On	On
[SOT1C]	Blink	Off	On
[SOV]	Blink	Flash	Off
[PFIN]	Blink	On	Off

1.6.5 LED Current Configuration

The sink current setting of the LED inputs to the SN8765 can be programmed with the following settings. All of the LEDs are programmed with the same current level.

Table 1-19. LED Current Configuration

ILED1	ILED0	Sink Current
0	0	0 mA
0	1	3 mA
1	0	4 mA
1	1	5 mA (default)

1.7 Device Operating Mode

The SN8765 has several device power modes. During these modes, the SN8765 modifies its operation to minimize power consumption from the battery.

1.7.1 Normal Mode

During normal operation, the SN8765 takes *Current*, *Voltage*, and *Temperature* measurements, performs calculations, updates SBS data, and makes protection and status decisions at one-second intervals. Between these periods of activity, the SN8765 is in a reduced power state.

$\overline{\text{PRES}}$ is sampled once per second and if $\overline{\text{PRES}}$ is high, the *OperationStatus [PRES]* flag is cleared. If $\overline{\text{PRES}}$ is low, the *OperationStatus [PRES]* flag is set indicating the system is present (the battery is inserted).

If the ***[NR]*** bit is set, the $\overline{\text{PRES}}$ input can be left floating as it is not monitored.

1.7.2 Battery Pack Removed Mode/System Present Detection

1.7.2.1 Battery Pack Removed

The SN8765 detects the Battery Pack Removed state if ***[NR]*** bit is set to 0 AND the $\overline{\text{PRES}}$ input is high (*[PRES]* = 0).

On entry to the Battery Pack Removed state, *[TCA]* and *[TDA]* flags are set, *ChargingCurrent* and *ChargingVoltage* are set to 0, the CHG and DSG FETs are turned off, and the ZVCHG FET is turned off (if used).

Polling of the $\overline{\text{PRES}}$ pin continues at a rate of once every 1 s.

The SN8765 exits the Battery Pack Removed state if ***[NR]*** flag is set to 0, AND the $\overline{\text{PRES}}$ input is low (*[PRES]* = 1). When this occurs, *[TCA]* and *[TDA]* flags are reset.

1.7.2.2 System Present

$\overline{\text{PRES}}$ is sampled once per second and if $\overline{\text{PRES}}$ is high, the *OperationStatus [PRES]* flag is cleared. If $\overline{\text{PRES}}$ is low, the *OperationStatus [PRES]* flag is set indicating the system is present (the battery is inserted). If the ***[NR]*** bit is set, the PRES input is ignored and can be left floating. The SN8765 turns on both CHG and DSG FET when the *OperationStatus [PRES]* flag is set and the device is operating in the NORMAL mode with no safety conditions.

1.7.3 SLEEP Mode

In SLEEP mode the SN8765 measures Voltage and Temperature in ***Sleep Voltage Time*** intervals and *Current* at ***Sleep Current Time*** intervals. At each interval the SN8765 performs calculations, updates SBS data, and makes protection and status decisions. Between these periods of activity, the SN8765 is in a reduced-power state.

The SN8765 enters SLEEP mode when the following conditions exist:

- If ***[NR]*** bit is set to 0, *[PRES]* must also be cleared for the SN8765 to enter sleep.

  AND one of the following conditions:
- (|*Current*| ≤ ***Sleep Current***) AND (SMBus is low for ***Bus Low Time)*** AND (***[SLEEP]*** bit is set)

  OR
- (|*Current*| ≤ ***Sleep Current***) AND *(ManufacturerAccess* Sleep command is received) AND (***[SLEEP]*** is set).

Entry to SLEEP mode is blocked if any of the *PFStatus* flags are set. If ***Sleep Voltage Time*** = 0 or ***Sleep Current Time*** = 0, SLEEP mode is not entered, and the SN8765 remains in NORMAL mode.

On entry to sleep, if ***[NR]*** = 0, the CHG and DSG FETs are turned off, and the ZVCHG FET is turned off (if used) regardless of ***[NRCHG]*** setting. If ***[NR]*** = 1, the CHG FET is turned off, and the ZVCHG FET is turned off (if used). However, if ***[NRCHG]*** is set then the CHG FET remains on.

Typically, on entry to SLEEP mode, the auto calibration of the A/DC begins. However, if *Temperature* is ≤ ***Cal Inhibit Temp Low*** or *Temperature* ≥ ***Cal Inhibit Temp High***, or if the Sleep is caused by the *ManufacturerAccess* Sleep command, Auto Calibration is not started on entry to SLEEP mode. The activation of auto calibration is not affected by the state of ***[SLEEP]***, ***Sleep Voltage Time***, ***Sleep Current Time***, or *Current*.

The SN8765 exits SLEEP mode when one or more of the following conditions exist:

- If the ***[NR]*** bit is set to 0 and *[PRES]* is set to 1.
- (|*Current*| > ***Sleep Current***
- SMBC or SMBD inputs transition high
- *OperationStatus*, *ChargingStatus* or *SafetyStatus* are set
- Wake function enabled by setting ***Wake Current Reg*** and a voltage across SRP and SRN is detected

The SN8765 exits SLEEP mode if absolute value of *Current* is greater than ***Sleep Current***, OR the SMBC or SMBD inputs transition high, OR any *OperationStatus*, *ChargingStatus*, or *SafetyStatus* flags change state.

In addition, if ***[NR]*** is cleared, the SN8765 exits SLEEP mode when *[PRES]* = 1.

1.7.4 Wake Function

The SN8765 can exit SLEEP mode, if enabled, by the presence of a voltage across SRP and SRN. The level of the current signal needed is programmed in ***Wake Current Reg***.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Low Byte	RSVD	RSVD	RSVD	RSVD	RSVD	IWAKE	RSNS1	RSNS0

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure 1-15. Wake Current Reg

IWAKE — This bit sets the current threshold for the Wake function.

0 = 0.5A (or if RSNS0=RSNS1=0 then this function is disabled)

1 = 1.0A (or if RSNS0=RSNS1=0 then this function is disabled)

Table 1-20. Wake Current Reg

RSNS1	RSNS0	Resistance
0	0	Disabled (default)
0	1	2.5 mΩ
1	0	5 mΩ
1	1	10 mΩ

1.7.5 SHUTDOWN Mode

The SN8765 enters SHUTDOWN mode if the following conditions are met:

- ***[SHUTV]*** in ***Operation Cfg C*** is set to 0 AND*Voltage* ≤ ***Shutdown Voltage*** AND *Current* ≤ 0 for a period of ***Cell Shutdown Time*** AND *PackVoltage* < ***AFE Shutdown Voltage*** threshold.

  OR
- ***[SHUTV]*** in ***Operation Cfg C*** is set to 1 AND Min (*CellVoltage4..1*) ≤ ***Cell Shutdown Voltage*** AND *Current* ≤ 0 for a period of ***Shutdown Time*** AND *PackVoltage* < ***AFE Shutdown Voltage*** threshold.

  OR
- (*ManufacturerAccess* shutdown command received AND *Current* = 0) AND *PackVoltage* < ***AFE Shutdown Voltage*** threshold.

When the SN8765 meets these conditions, the CHG, DSG, and ZVCHG FETs are turned off, and the integrated AFE is commanded to shut down. In SHUTDOWN mode, the SN8765 is completely powered down because its supply is removed.

To exit SHUTDOWN mode the voltage at the PACK pin must be greater than the startup voltage specified in SN8765 datasheet. When this happens, the integrated AFE returns power to the SN8765, the *[WAKE]* flag is set, and the integrated AFE is configured by the AGG. The *[WAKE]* flag is cleared and the *[INIT]* flag is set after approximately 1 s when all SBS parameters have been measured and updated.

1.8 Security (Enables and Disables Features)

There are three levels of secured operation within the SN8765. To switch between the levels, different operations are needed with different codes. The three levels are SEALED, UNSEALED, and FULL ACCESS.

1. **FULL ACCESS or UNSEALED to SEALED —** The use of the *Seal Device* command instructs the SN8765 to limit access to the SBS functions and data flash space and sets the *[SS]* flag. In SEALED mode, standard SBS functions have access per the Smart Battery Data Specification—Appendix A. Extended SBS Functions and data flash are not accessible. Once in SEALED mode, the part can never permanently return to UNSEALED or FULL ACCESS modes.

2. **SEALED to UNSEALED —** Instructs the SN8765 to extend access to the SBS and data flash space and clears the *[SS]* flag. In UNSEALED mode, all data, SBS, and DF have read/write access. Unsealing is a two-step command performed by writing the 1st word of the *UnSealKey* to *ManufacturerAccess* followed by the second word of the *UnSealKey* to *ManufacturerAccess*. The unseal key can be read and changed via the extended SBS block command *UnSealKey* when in FULL ACCESS mode. To return to the SEALED mode, either a hardware reset is needed, or the *ManufacturerAccess* seal device command is needed to transit from FULL ACCESS or UNSEALED to SEALED.

3. **UNSEALED to FULL ACCESS —** Instructs the SN8765 to allow FULL ACCESS to all SBS commands and data flash. The SN8765 is shipped from TI in this mode. The keys for UNSEALED to FULL ACCESS can be read and changed via the extended SBS block command *FullAccessKey* when in FULL ACCESS mode. Changing from UNSEALED to FULL ACCESS is performed by using the *ManufacturerAccess* command, by writing the 1st word of the *FullAccessKey* to *ManufacturerAccess* followed by the second word of the *FullAccessKey* to *ManufacturerAccess*. The full access key can be read and changed via the extended SBS block command *FullAccessKey* when in FULL ACCESS mode. In FULL ACCESS mode, the command to go to Boot ROM can be sent.

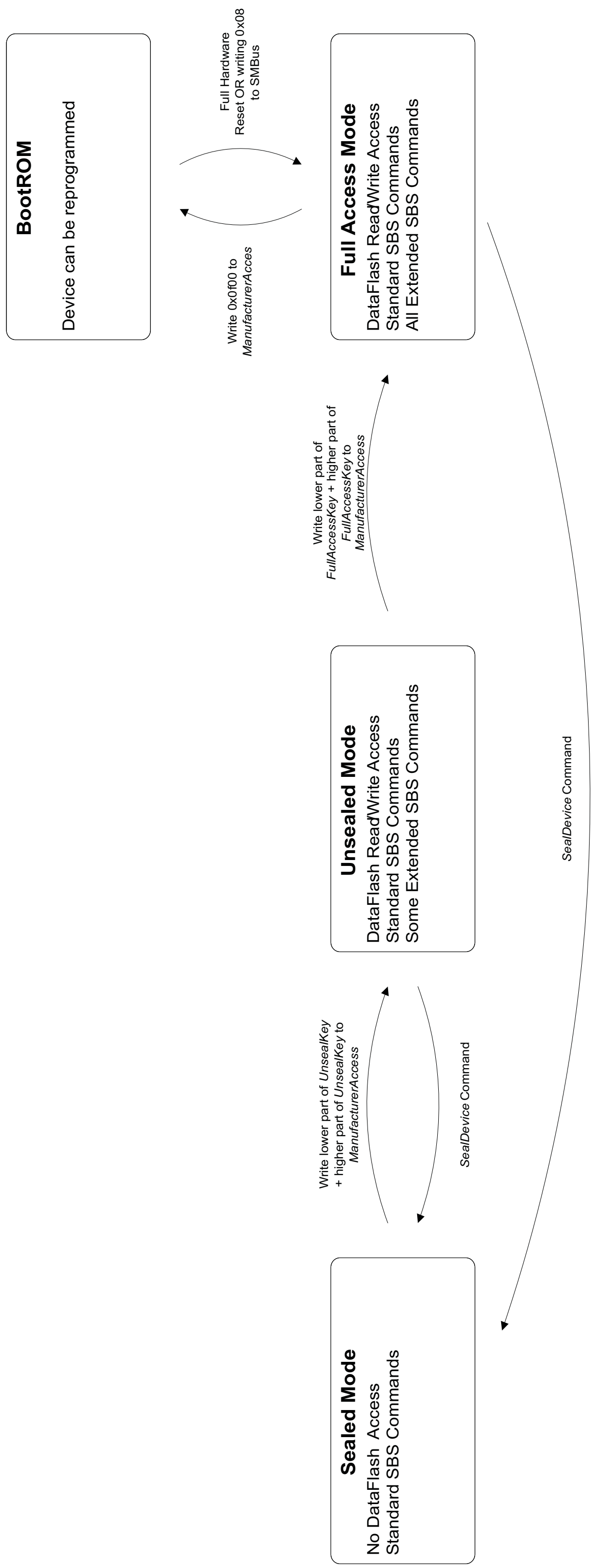


Figure 1-16. Security

1.9 Calibration

The SN8765 has integrated routines that support calibration of current, voltage, and temperature readings, accessible after writing 0xF081 or 0xF082 to ManufacturerAccess().

When the calibration routines are activated, the raw ADC data is available through the ManufacturerData() command, which returns a 26-byte data block.

ManufacturerAccess()	Description
0x002D	Enable/Disable Calibration Mode in ManufacturingStatus()
0xF080	Exit Calibration Mode
0xF081	Output raw ADC data of voltage, current, and temperature on ManufacturerData()
0xF082	Output raw ADC data of voltage, current, and temperature on ManufacturerData(). This mode includes a shunt of the Coulomb Counter input.

The calibration procedure requires writing to the following DF constants:

Table 1-21. Calibration Data Flash Constants

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Calibration	Voltage	Cell Scale 0	I2	0	32767	20500	—
Calibration	Voltage	Cell Scale 1	I2	0	32767	20500	—
Calibration	Voltage	Cell Scale 2	I2	0	32767	20500	—
Calibration	Voltage	Cell Scale 3	I2	0	32767	20500	—
Calibration	Voltage	PACK Gain	U2	0	65535	44100	—
Calibration	Voltage	BAT Gain	U2	0	65535	44100	—
Calibration	Current	CC Gain	F4	1.00E–01	4.00E+00	0.9419	—
Calibration	Current	Capacity Gain	F4	2.98E+04	1.19E+06	280932.625	—
Calibration	Current Offset	CC Offset	I2	–32767	32767	–7744	—
Calibration	Current Offset	Coulomb Counter Offset Samples	U2	0	65535	64	—
Calibration	Current Offset	Board Offset	I2	–32767	32767	0	—
Calibration	Temperature	Internal Temp Offset	I1	–128	127	0	0.1°C
Calibration	Temperature	External 1 Temp Offset	I1	–128	127	0	0.1°C
Calibration	Temperature	External 2 Temp Offset	I1	–128	127	0	0.1°C
Calibration	Temperature	External 3 Temp Offset	I1	–128	127	0	0.1°C
Calibration	Temperature	External 4 Temp Offset	I1	–128	127	0	0.1°C
Calibration	Internal Temp Model	Int Coeff 1	I2	–32768	32767	0	—
Calibration	Internal Temp Model	Int Coeff 2	I2	–32768	32767	0	—
Calibration	Internal Temp Model	Int Coeff 3	I2	–32768	32767	–11136	—
Calibration	Internal Temp Model	Int Coeff 4	I2	–32768	32767	5754	—

Table 1-21. Calibration Data Flash Constants (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Calibration	External Temp Model	Ext Coeff a1	I2	–32768	32767	–14520	—
Calibration	External Temp Model	Ext Coeff a2	I2	–32768	32767	23696	—
Calibration	External Temp Model	Ext Coeff a3	I2	–32768	32767	–20298	—
Calibration	External Temp Model	Ext Coeff a4	I2	–32768	32767	28073	—
Calibration	External Temp Model	Ext Coeff a5	I2	–32768	32767	865	—
Calibration	External Temp Model	Ext Coeff b1	I2	–32768	32767	–694	—
Calibration	External Temp Model	Ext Coeff b2	I2	–32768	32767	1326	—
Calibration	External Temp Model	Ext Coeff b3	I2	–32768	32767	–3880	—
Calibration	External Temp Model	Ext Coeff b4	I2	–32768	32767	5127	—

The ManufacturerData() output format is: ZZYYaaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLL, where:

VALUE	FORMAT	DESCRIPTION
ZZ	Byte	8-bit counter, increments when raw ADC values are refreshed, typically every 250 ms
YY	Byte	Output status:
		0x01 when ManufacturerAccess() = 0xF081
		0x02 when ManufacturerAccess() = 0xF082
AAaa	2's Complement	Coulomb Counter
BBbb	2's Complement	Cell Voltage 1
CCcc	2's Complement	Cell Voltage 2
DDdd	2's Complement	Cell Voltage 3
EEee	2's Complement	Cell Voltage 4
FFff	2's Complement	Internal Temperature
GGgg	2's Complement	External Temperature 1 (TS1)
HHhh	2's Complement	External Temperature 2 (TS2)
IIii	2's Complement	Reserved
JJjj	2's Complement	Reserved
KKkk	2's Complement	PACK Voltage
LLll	2's Complement	BAT Voltage

1.9.1 Cell Voltage Calibration

1. Apply known voltages in mV to the cell voltage inputs:
   - V_{CELL1} between VC4 pin and VSS pin
   - V_{CELL2} between VC3 pin and VC4 pin
   - V_{CELL3} between VC2 pin and VC3 pin
   - V_{CELL4} between VC1 pin and VC2 pin
2. Send 0xF081 or 0xF082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData().

3. Poll ManufacturerData() until ZZ increments by 2 before reading data.
4. Grab ADC conversion readings of cell voltages from ManufacturerData():
   - ADC_{CELL1} = AAaa of ManufacturerData(): Is ADCCELL1 < 0x8000? If yes, use ADC_{CELL1}; otherwise, ADCCELL1 = AAaa – 0xFFFF + 0x0001.
   - ADC_{CELL2} = BBbb of ManufacturerData(): Is ADC_{CELL2} < 0x8000? If yes, use ADC_{CELL2}; otherwise, ADC_{CELL2} = BBbb – 0xFFFF + 0x0001.
   - ADC_{CELL3} = CCcc of ManufacturerData(): Is ADC_{CELL3} < 0x8000? If yes, use ADC_{CELL3}; otherwise, ADC_{CELL3} = CCcc – 0xFFFF + 0x0001.
   - ADC_{CELL4} = DDdd of ManufacturerData(): Is ADC_{CELL4} < 0x8000? If yes, use ADC_{CELL4}; otherwise, ADC_{CELL4} = DDdd – 0xFFFF + 0x0001.
5. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
6. Calculate gain values:

$$Alt\ Cell\ Scale1 = \frac{V_{CELL1}}{ADC_{CELL1}} * 2^{16}$$

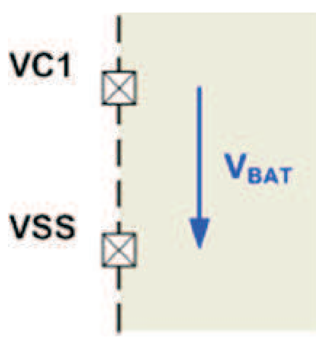
$$Alt\ Cell\ Scale2 = \frac{V_{CELL1} + V_{CELL2}}{ADC_{CELL1} + ADC_{CELL2}} * 2^{16}$$

$$Alt\ Cell\ Scale3 = \frac{V_{CELL1} + V_{CELL2} + V_{CELL3}}{ADC_{CELL1} + ADC_{CELL2} + ADC_{CELL3}} * 2^{16}$$

$$Alt\ Cell\ Scale4 = \frac{V_{CELL1} + V_{CELL2} + V_{CELL3} + V_{CELL4}}{ADC_{CELL1} + ADC_{CELL2} + ADC_{CELL3} + ADC_{CELL4}} * 2^{16}$$

7. Update data flash with Cell Scale 1, Cell Scale 2, Cell Scale 3, Cell Scale 4.
8. Re-check the voltage reading. Repeat the steps if the reading is not accurate.

1.9.2 BAT Voltage Calibration



1. Apply known voltages in mV to the voltage input:
   - V_{BAT} between VC4 pin and VSS pin
2. Enter calibration mode if ManufacturerStatus()[CAL] = 0; send 0x002d to ManufacturerAccess().
3. Send 0xF081 or 0xF082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData().
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of the cell stack voltage from ManufacturerData():
   - ADC_{BAT} = LLll of ManufacturerData(): Is ADC_{BAT} < 0x8000? If yes, use ADC_{BAT}; otherwise, ADC_{BAT} = – (0xFFFF – LLll + 0x0001).
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.

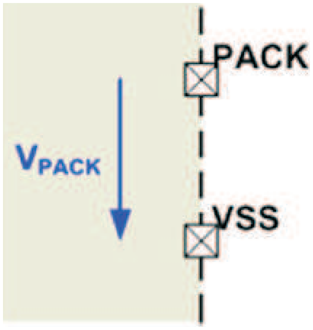
- ADC_{BAT} = [ADC_{BAT}(reading n) + … + ADC_{BAT}(reading 1)]/n

7. Calculate gain value, using the following formula:

$$BAT\ Gain = \frac{V_{BAT}}{ADC_{BAT}} * 2^{16}$$

8. Update the data flash with BAT Gain.
9. Re-check the voltage reading. Repeat the steps if the readings are not accurate.
10. Exit calibration mode by sending 0x002d to ManufacturerAccess() or continue with calibration.

1.9.3 PACK Voltage Calibration

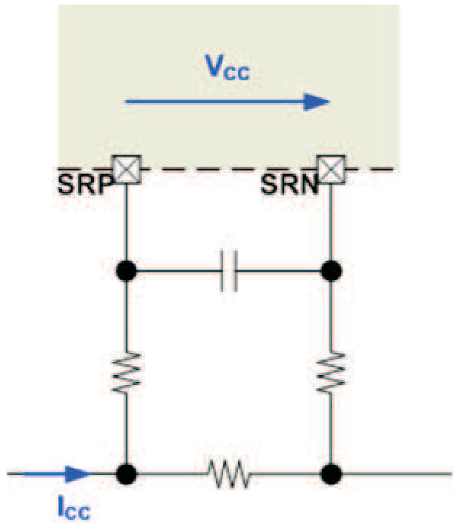


1. Apply known voltages in mV to the voltage input:
   - V_{BAT} between PACK pin and VSS pin
2. Enter calibration mode if ManufacturerStatus()[CAL] = 0; send 0x002d to ManufacturerAccess().
3. Send 0x0081 or 0x0082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData().
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of pack voltage from ManufacturerData():
   - ADC_{PACK} = KKkk of ManufacturerData(): Is ADC_{PACK} < 0x8000? If yes, use ADC_{PACK}; otherwise, ADC_{PACK} = – (0xFFFF – KKkk + 0x0001).
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
   - ADC_{PACK} = [ADC_{PACK}(reading n) + … + ADC_{PACK}(reading 1)]/n
7. Calculate gain value:

$$PACK\ Gain = \frac{V_{PACK}}{ADC_{PACK}} * 2^{16}$$

8. Update data flash with PACK Gain.
9. Re-check the voltage reading. Repeat the steps if the readings are not accurate.
10. Exit calibration mode by sending 0x002d to ManufacturerAccess() or continue with calibration.

1.9.4 Current Calibration



1.9.4.1 Offset Calibration

1. Apply a known current of 0 mA:
   - Make sure no current is flowing through the sense resistor connected between the SRP and SRN pins.
2. Send 0xF082 to ManufacturerAccess() to enable raw CC output on ManufacturerData() with CC shunt.
3. Read *Coulomb Counter Offset Samples* from data flash.
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of current from ManufacturerData():
   - ADC_{CC} = AAaa of ManufacturerData(): Is ADC_{CC} < 0x8000? If yes, use ADC_{CC}; otherwise, ADC_{CC} = AAaa – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
   - ADC_{CC} = [ADC_{CC}(reading n) + … + ADC_{CC}(reading 1)]/n
7. Calculate offset value:
   $CC\ offset = ADC_{CC} * (Coulomb\ Counter\ Offset\ Samples)$
8. Update data flash with *CC Offset*.
9. Re-check the current reading. Repeat the steps if the reading is not accurate.

1.9.4.2 Board Offset Calibration

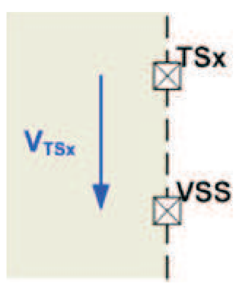
1. Apply a known current of 0 mA:
   - Make sure no current is flowing through the sense resistor connected between SRP pin and SRN pin.
2. Send 0xF081 to ManufacturerAccess() to enable raw CC output on ManufacturerData().
3. Read Coulomb Counter Offset Samples from data flash.
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of current from ManufacturerData():
   - • ADC_{CC} = AAaa of ManufacturerData(): Is ADC_{CC} < 0x8000? If yes, use ADC_{CC}; otherwise, ADC_{CC} = AAaa – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
   - ADC_{CC} = [ADC_{CC}(reading n) + … + ADC_{CC}(reading 1)]/n

7. Calculate offset value:
$$Board\ offset = (ADC_{CC} - CC\ Offset\ /\ (Coulomb\ Counter\ Offset\ Samples)) * (Coulomb\ Counter\ Offset\ Samples)$$
8. Update data flash with *Board Offset*.
9. Re-check the current reading. Repeat the steps if the reading is not accurate.

1.9.4.3 Gain Calibration

1. Apply a known current in mA to the current input.
   - Make sure current I_{CC} is flowing through the sense resistor connected between SRP pin and SRN pin.
2. Send 0xF081 to ManufacturerAccess() to enable raw CC output on ManufacturerData().
3. Read *Coulomb Counter Offset Samples* from data flash.
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of current from ManufacturerData():
   - ADC_{CC} = AAaa of ManufacturerData(): Is ADC_{CC} < 0x8000? If yes, use ADC_{CC}; otherwise, ADC_{CC} = AAaa – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
   - ADC_{CC} = [ADC_{CC}(reading n) + … + ADC_{CC}(reading 1)]/n
7. Calculate gain values:
$$CC\ Gain = \frac{I_{CC}}{ADC_{CC} - \dfrac{(Board\ Offset) + (CC\ Offset)}{(Coulomb\ Counter\ Offset\ Samples)}}$$
$$Capacity\ Gain = CC\ Gain * 298261.6178$$
8. Update data flash with CC Gain, *Capacity Gain*.
9. Re-check the current reading. Repeat the steps if the reading is not accurate.

1.9.5 Temperature Calibration



1.9.5.1 Internal Temperature Sensor Calibration (OPTION 1)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TINT}$ is applied to the device.
2. Enable TINT as the SBS temperature source by setting the Misc Configuration bit 7 to 1.
3. Grab the reported temperature from the SBS temperature.
4. Calculate temperature offset:
$$TINT\ offset = TEMP_{TINT} - TINT$$
5. Update data flash with the calculated value.
6. Re-check the current reading. Repeat the steps if the reading is not accurate.

1.9.5.2 Internal Temperature Sensor Calibration (OPTION 2)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TINT}$ is applied to the device.
2. Read *Int Coeff 1*, *Int Coeff 2*, *Int Coeff 3*, *Int Coeff 4* from data flash.
3. Send 0xF081 or 0xF082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData().
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of temperature from Temperature():
   - ADCTINT = FFff of ManufacturerData(): Is ADC_{INT} < 0x8000? If yes, use ADC_{TINT}; otherwise, ADC_{TINT} = FFff – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
   - ADC_{TINT} = [ADC_{TINT}(reading n) + … + ADC_{TINT}(reading 1)]/n
7. Calculate temperature offset:

$$A = ADC_{TINT} / 2^{16}$$

$$T_{TINT} = ((INT\ Coeff1) * A^3 + (INT\ Coeff2) * A^2 + (INT\ Coeff3) * A + (INT\ Coeff4)) * 0.1 - 273.15$$

$$Internal\ Temperature\ Offset = TEMP_{TINT} - T_{TINT}$$

8. Update data flash with Internal Temperature Offset.
9. Re-check the temperature reading. Repeat the steps if the reading is not accurate.

1.9.5.3 TS1 Calibration (OPTION 1)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TS1}$ is applied to the thermistor connected to the TS1 pin.
2. Enable TS1 as the SBS temperature source by setting the Misc Configuration bit 7 to 0.
3. Grab the reported temperature from the SBS temperature.
4. Calculate temperature offset:

$$TS1\ offset = TEMP_{TS1} - TS1$$

5. Update data flash with calculated value.
6. Re-check the current reading. Repeat the steps if the reading is not accurate.

1.9.5.4 TS1 Calibration (OPTION 2)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TS1}$ is applied to the thermistor connected to the TS1 pin.
2. Read Coeff a1, Coeff a2, Coeff a3, Coeff a4, Coeff b1, Coeff b2, Coeff b3, Coeff b4 from data flash.
3. Send 0xF081 or 0xF082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData().
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab the ADC conversion readings of temperature from ManufacturerData():
   - ADC_{TS1}= GGgg of ManufacturerData(): Is ADC_{TS1} < 0x8000? If yes, use ADC_{TS1}; otherwise, ADC_{TS1} = GGgg – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
   - ADC_{TS1} = [ADC_{TS1}(reading n) + … + ADC_{TS1}(reading 1)]/n
7. Calculate temperature offset:

$$A = \frac{ADC_{TS1}}{2^{15}}$$

$$B = \frac{A}{(Coeff\ A1)*A^{4} + (Coeff\ A2)*A^{3} + (Coeff\ A3)*A^{2} + (Coeff\ A4)*A + (Coeff\ A5)} * 2^{14}$$

$$T_{TS1} = ((Coeff\ B1)*B^{3} + (Coeff\ B2)*B^{2} + (Coeff\ B3)*B^{1} + (Coeff\ B4))*0.1 - 273.15$$

$$External1\ Temperature\ Offset = TEMP_{TS1} - T_{TS1}$$

8. Update data flash with calculated with *External 1 Temperature Offset*.
9. Re-check the temperature reading. Repeat the steps if the reading is not accurate.

1.9.5.5 TS2 Calibration (OPTION 1)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TS2}$ is applied to the thermistor connected to the TS2 pin.
2. Enable TS2 by setting the Secondary Thermistor to 1.
3. Grab the reported temperature from the extended command 0x7D.
4. Calculate temperature offset:
   $TS2\ offset = TEMP_{TS2} - TS2$
5. Update data flash with the calculated value.
6. Re-check the current reading. Repeat the steps if the reading is not accurate.

1.9.5.6 TS2 Calibration (OPTION 2)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TS2}$ is applied to the thermistor connected to the TS2 pin.
2. Read *Coeff a1*, *Coeff a2*, *Coeff a3*, *Coeff a4*, *Coeff b1*, *Coeff b2*, *Coeff b3*, and *Coeff b4* from data flash.
3. Send 0xF081 or 0xF082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData().
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of temperature from ManufacturerData():
   - ADC_{TS2} = HHhh of ManufacturerData(): Is ADC_{TS2} < 0x8000? If yes, use ADC_{TS2}; otherwise, ADC_{TS2} = HHhh – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData() until ZZ increments, which indicates updated values.
   - ADC_{TS2} = [ADC_{TS2}(reading n) + … + ADC_{TS2}(reading 1)]/n
7. Calculate temperature offset:

$$A = \frac{ADC_{TS2}}{2^{15}}$$

$$B = \frac{A}{(CoeffA1)*A^{4} + (CoeffA2)*A^{3} + (CoeffA3)*A^{2} + (CoeffA4)*A + (CoeffA5)} * 2^{14}$$

$$T_{TS2} = ((CoeffB1)*B^{3} + (CoeffB2)*B^{2} + (CoeffB3)*B^{1} + (CoeffB4))*0.1 - 273.15$$

$$External2\ Temperature\ Offset = TEMP_{TS2} - T_{TS2}$$

8. Update the data flash with the calculated External 2 Temperature Offset.
9. Re-check the temperature reading. Repeat the steps if the reading is not accurate.

1.10 Communications

The SN8765 uses SMBus v1.1 with Master Mode and packet error checking (PEC) options per the SBS specification.

1.10.1 SMBus On and Off State

The SN8765 detects an SMBus off state when SMBC and SMBD are logic-low for ≥ 2 seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

1.10.2 Packet Error Checking

The SN8765 can receive or transmit data with or without PEC.

In the write-word protocol, if the host does not support PEC, the last byte of data is followed by a stop condition. If the host does not support PEC, the ***[HPE]*** bit should be set to 0 (default).

In the write-word protocol, the SN8765 receives the PEC after the last byte of data from the host. If the host does not support PEC, the last byte of data is followed by a stop condition. After receipt of the PEC, the SN8765 compares the value to its calculation. If the PEC is correct, the SN8765 responds with an ACKNOWLEDGE. If it is not correct, the SN8765 responds with a NOT ACKNOWLEDGE and sets an error code. If the host supports PEC, the ***[HPE]*** bit should be set to 1.

In the read-word and block-read in master mode, the host generates an ACKNOWLEDGE after the last byte of data sent by the SN8765. The SN8765 then sends the PEC, and the host, acting as a master-receiver, generates a NOT ACKNOWLEDGE and a stop condition.

1.10.3 SN8765 Slave Address

The SN8765 uses the address 0x16 on SMB for communication.

1.10.4 Broadcasts to Smart Charger and Smart Battery Host

The SN8765 can broadcast messages to the smart battery charger and smart battery host. This can be enabled with the ***[BCAST]*** bit.

PEC byte for alarm transmissions in master-mode to charger can be enabled with the ***[CPE]*** bit.

PEC byte for alarm transmissions in master-mode to smart battery host and the PEC byte for receiving communications from all sources in slave-mode can be enabled with the ***[HPE]*** bit.

Standard SBS Commands

The SN8765 SBS command set meets the SBD v1.1 specification. All SBS Values are updated in 1-second intervals.

A.1 ManufacturerAccess (0x00)

This read- or write-word function provides battery-system level data, access to test controls, and security features.

Table A-1. ManufacturerAccess

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x00	R/W	ManufacturerAccess	hex	2	0x0000	0xffff	—	

A.1.1 System Data

The results of these commands need to be read from *ManufacturerAccess* after a write with the command word to *ManufacturerAccess*.

A.1.1.1 Device Type (0x0001)

Returns the IC part number.

Table A-2. Device Type

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0001	R	Device Type	hex	2	—	—	0x0900	

A.1.1.2 Firmware Version (0x0002)

Returns the firmware version. The format is most-significant byte (MSB) = Decimal integer, and the least-significant byte (LSB) = sub-decimal integer, e.g.: 0x0120 = version 01.20.

Table A-3. Firmware Version

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0002	R	Firmware Version	hex	2	—	—	0x0102	

A.1.1.3 Hardware Version (0x0003)

Returns the hardware version stored in a single byte of reserved data flash. e.g.: 0x00a7 = Version A7.

Table A-4. Hardware Version

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0003	R	Hardware Version	hex	2	—	—	0x00a7	

A.1.1.4 DF Checksum (0x0004)

This function is only available when the SN8765 is in UNSEALED mode or FULL ACCESS mode, indicated by the *[SS]* and *[FAS]* flag. A write to this command forces the SN8765 to generate a checksum of the full Data Flash array. The generated checksum is then returned within 45 ms.

NOTE: If another SMBus command is received while the checksum is generated, the DF Checksum is generated but the response may be time out (<25 ms).

Table A-5. DF Checksum

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0004	R	DF Checksum	hex	2	—	—	—	

A.1.1.5 Pending EDV Threshold Voltage (0x0005)

The read-word function returns the predicted EDV2 until EDV2 is reached, then the predicted EDV1 until EDV1 is reached, and then the predicted EDV0. Format is big endian.

Table A-6. Pending EDV Threshold Voltage

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0005	R	Pending EDV Threshold Voltage	hex	2	—	—	—	mV

A.1.1.6 Manufacturer Status (0x0006)

This function is available while the SN8765 is in normal operation. This 16-bit word reports the battery status.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	FET1	FET0	PF1	PF0	STATE3	STATE2	STATE1	STATE0
Low Byte	0	0	0	0	1	0	1	0

LEGEND: All bits are read-only.

Figure A-1. Manufacturer Status

FET1, FET0 — Indicates the state of the charge and discharge FETs

0,0 = Both charge and discharge FETs are on.
0,1 = CHG FET is off, DSG FET is on.
1,0 = Both charge and discharge FETs are off.
1,1 = CHG FET is on, DSG FET is off.

PF1, PF0 — Indicates permanent failure cause when permanent failure is indicated by STATE3..STATE0

0,0 = Fuse is blown if enabled via DF:Configuration:Register(64):Permanent Fail Cfg
0,1 = Cell imbalance failure
1,0 = Safety voltage failure
1,1 = FET failure

STATE3, STATE2, STATE1, STATE0 — Indicates the battery state.

0,0,0,0 = Wake Up
0,0,0,1 = Normal Discharge
0,0,1,1 = Pre-Charge
0,1,0,1 = Charge
0,1,1,1 = Charge Termination
1,0,0,0 = Fault Charge Terminate
1,0,0,1 = Permanent Failure
1,0,1,0 = Overcurrent
1,0,1,1 = Overtemperature
1,1,0,0 = Battery Failure
1,1,0,1 = Sleep
1,1,1,0 = Discharge Prohibited
1,1,1,1 = Battery Removed

A.1.1.7 Chemistry ID (0x0008)

Returns the OCV table chemistry ID of the battery. The default table ID is 0x0100. For a list of OCV chemistry IDs, refer to the application note, *Support of Multiple Li-Ion Chemistries w/Impedance Track(TM) Gas Gauges* (SLUA372).

Table A-7. Chemistry ID

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0008	R	Chemistry ID	hex	2	0x0000	0xffff	0x0100	

A.1.2 System Control

The commands in this section cause the SN8765 to take actions when written. No data is returned.

A.1.2.1 Shutdown (0x0010)

Instructs the SN8765 to verify and enter shutdown mode. This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode. Shutdown will not be entered unless the *PackVoltage* < ***Charger Present*** and *Current* ≤ 0.

A.1.2.2 Sleep (0x0011)

Instructs the SN8765 to verify and enter SLEEP mode if no other command is sent after the *Sleep* command. Any SMB transition will wake up the SN8765. It takes about 1 min. before the device will go to sleep. This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode.

A.1.2.3 Seal Device (0x0020)

Instructs the SN8765 to limit access to the extended SBS functions and data flash space, sets the *[SS]* flag, and clears the *[FAS]* flag.

This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode.

See Section 1.8 in this document for detailed information.

A.1.2.4 LTPF Enable (0x0021)

This command clears any existing PF flags, enables Lifetime Data and PF and sets the *[LTPF]* flag in *Operation Status* and the ***[PROD_LTPF_EN]*** bit in ***Operation Cfg C***. See the description in *Operation Cfg C*.

This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode.

A.1.2.5 Calibration Mode (0x002d)

This command sets or clears permissions to allow the SN8765 to enter calibration mode.

A.1.2.6 FUSE Activation (0x0030)

This command drives the FUSE pin high.

This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode.

A.1.2.7 FUSE Clear (0x0031)

This command sets the FUSE pin back to low.

This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode.

A.1.2.8 Reset (0x0041)

The SN8765 undergoes a full reset. The SN8765 holds the clock line down for a few milliseconds to complete the reset.

This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode.

A.1.2.9 DFRowAddress (0x01yy)

This command sets the current data flash row address (based on yy) prior to block reading or writing.

A.1.2.10 BootRom (0x0f00)

The SN8765 goes into BootRom mode.

This command is only available when the SN8765 is in FULL ACCESS mode.

A.1.2.11 Exit Calibration (0xf080)

This command instructs the SN8765 to exit calibration mode.

A.1.2.12 Output Calibration Data (0xf081)

This command instructs the SN8765 to output 26 bytes of raw ADC and Coulomb Counter data on ManufacturerData (0x23) while in calibration mode.

A.1.2.13 Output Calibration Data (0xf082)

This command instructs the SN8765 to output 26 bytes of raw ADC and Coulomb Counter data on ManufacturerData (0x23) while in calibration mode. This mode also includes an internal short of the Coulomb Counter inputs.

A.1.2.14 Permanent Fail Clear (*PFKey*)

This two-step command needs to be written to *ManufacturerAccess* in following order: 1st word of the *PFKey* first followed by the 2nd word of the *PFKey*. If the command fails 4 seconds must pass before the command can be reissued.

It instructs the SN8765 to clear the *PFStatus*, clear the *[PF]* flag, clear the ***Fuse Flag***, reset the FUSE pin, and unlock the data flash for writes.

This command is only available when the SN8765 is in UNSEALED or FULL ACCESS mode.

NOTE: Higher word must be immediately followed by lower word. If clear command fails, command can only be repeated 4 seconds after previous attempt. If communication other than the lower word occurs after the first word is sent, the *Permanent Fail Clear* command fails.

A.1.2.15 Unseal Device (*UnsealKey*)

Instructs the SN8765 to enable access to the SBS functions and data flash space and clear the *[SS]* flag. This two-step command needs to be written to *ManufacturerAccess* in the following order: 1st word of the *UnSealKey* first followed by the 2nd word of the *UnSealKey*. If the command fails 4 seconds must pass before the command can be reissued.

This command is only available when the SN8765 is in SEALED mode.

See Section 1.8 in this document for detailed information.

A.1.2.16 Full Access Device (*FullAccessKey*)

Instructs the SN8765 to enable full access to all SBS functions and data flash space and set the *[FAS]* flag. This two-step command needs to be written to *ManufacturerAccess* in the following order: 1st word of the *FullAccessKey* first followed by the 2nd word of the *FullAccessKey*.

This command is only available when the SN8765 is in UNSEALED mode.

See Section 1.8 in this document for detailed information.

A.1.3 Extended SBS Commands

Also available via *ManufacturerAccess* in SEALED mode are some of the extended SBS commands. The commands available are listed below.

The result of these commands need to be read from *ManufacturerAccess* after a write to *ManufacturerAccess*.

0x0050 = SBS:SafetyAlert(0x50)
0x0051 = SBS:SafetyStatus(0x51)
0x0052 = SBS:PFAlert(0x52)
0x0053 = SBS:PFStatus(0x53)
0x0054 = SBS:OperationStatus(0x54)
0x0055 = SBS:ChargingStatus(0x55)
0x0057 = SBS:ResetData(0x57)
0x0058 = SBS:WDResetData(0x58)
0x005a = SBS:PackVoltage(0x5a)
0x005d = SBS:AverageVoltage(0x5d)
0x0072 = SBS:TempRange(0x72)

A.2 RemainingCapacityAlarm (0x01)

This read- or write-word function sets or gets a low-capacity alarm threshold unsigned integer value with a range of 0 to 65535 and units of either mAh (*CapM* = 0) or 10 mWh (*CapM = 1*). The default value for *RemainingCapacityAlarm* is stored in ***Rem Cap Alarm***. If *RemainingCapacityAlarm* is set to 0, the alarm is disabled.

If *RemainingCapacity* < *RemainingCapacityAlarm*, the *[RCA]* flag is set and the SN8765 sends an *AlarmWarning* message to the SMBUS host.

If *RemainingCapacity* ≥ *RemainingCapacityAlarm* and *[DSG]* is set, the *[RCA]* flag is cleared.

0 = Remaining capacity alarm is disabled

1..700 = Remaining capacity limit for *[RCA]* flag

Table A-8. RemainingCapacityAlarm

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x01	R/W	RemainingCapacityAlarm	unsigned integer	2	0	700	300	mAh or 10 mWh

A.3 RemainingTimeAlarm (0x02)

This read- or write-word function sets or gets the *RemainingTimeAlarm* unsigned integer value in minutes with a range of 0 to 65535. The default value of *RemainingTimeAlarm* is stored in ***Rem Time Alarm***. If *RemainingTimeAlarm* = 0, this alarm is disabled.

If *AverageTimeToEmpty* < *RemainingTimeAlarm*, the *[RTA]* flag is set and the SN8765 sends an *AlarmWarning* message to the SMBus host.

If *AverageTimeToEmpty* ≥ *RemainingTimeAlarm*, the *[RTA]* flag is reset

0 = Remaining time alarm is disabled

1..30 = Remaining time limit for *[RTA]* flag

Table A-9. RemainingTimeAlarm

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x02	R/W	RemainingTimeAlarm	unsigned integer	2	0	30	10	min

A.4 BatteryMode (0x03)

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

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	CapM	ChgM	AM	RSVD	RSVD	RSVD	PB	CC
Low Byte	CF	RSVD	RSVD	RSVD	RSVD	RSVD	PBS	ICC

LEGEND: High Byte is Read/Write, Low Byte is Read Only; RSVD = Reserved and **must** be programmed to 0.

Figure A-2. BatteryMode

CapM — Sets the units used for capacity information and internal calculation.

0 = Reports in mA or mAh (default)

1 = Reports in 10 mW or 10 mWh

Following functions are instantaneously updated after *[CapM]* change:

SBS:RemainingCapacityAlarm(0x01)

SBS:AtRate(0x04)

SBS:RemainingCapacity(0x0f)

SBS:FullChargeCapacity(0x10)

SBS:DesignCapacity(0x18)

Following functions are recalculated within 1 second after *[CapM]* change:

SBS:RemainingTimeAlarm(0x02)

SBS:AtRateTimeToEmpty(0x06)
SBS:AtRateOK(0x07)
SBS:RunTimeToEmpty(0x11)
SBS:AverageTimeToEmpty(0x12)
SBS:BatteryStatus(0x16)

ChgM: — Enables or disables the SN8765 's transmission of *ChargingCurrent* and *ChargingVoltage* messages to the Smart Battery Charger.

0 = Enable *ChargingVoltage* and *ChargingCurrent* broadcasts to the Smart Battery Charger by setting the ***[BCAST]*** bit in ***Operation Cfg B*** when charging is desired.
1 = Disable *ChargingVoltage* and *ChargingCurrent* broadcasts to the Smart Battery Charger (default)

AM: — Enables or disables *AlarmWarning* broadcasts to the host and Smart Battery Charger

0 = Enable *AlarmWarning* broadcast to host and Smart Battery Charger by setting the ***[BCAST]*** bit in ***Operation Cfg B*** (default). The SN8765 sends the *AlarmWarning* messages to the SMBus Host and the Smart Battery Charger any time an alarm condition is detected.
1 = Disable *AlarmWarning* broadcast to host and Smart Battery Charger. The SN8765 does not master the SMBus, and *AlarmWarning* messages are not sent to the SMBus Host and the Smart Battery Charger for a period of no more than 65 seconds and no less than 45 seconds. *[AM]* is automatically cleared by the SN8765 60 seconds after being set to 1, independent of the ***[BCAST]*** bit.

NOTE: The system, as a minimum, is required to poll the Smart Battery Charger every 10 seconds if the *[AM]* flag is set.

PB: — Sets the role of the battery pack. This flag is not used by SN8765 and should be set to 0.

CC: — Enable or disable internal charge controller. This flag is not used by SN8765 and should be set to 0.

CF: — This flag is set if *MaxError* > ***CF MaxError Limit***

0 = Battery OK
1 = Condition cycle requested

PBS: — Primary battery support is not supported by SN8765 and is fixed to 0.

ICC: — This flag indicates if internal charge controller function is supported or not. This value is fixed to 1.

A.5 AtRate (0x04)

This read- or write-word function is the first half of a two-function call set used to set the *AtRate* value used in calculations made by the *AtRateTimeToFull*, *AtRateTimeToEmpty*, and *AtRateOK* functions. The *AtRate* units are in either mA (*[CapM]* = 0) or 10 mW (*[CapM]* = 1).

When the *AtRate* value is positive, the *AtRateTimeToFull* function returns the predicted time to full-charge at the *AtRate* value of charge. When the *AtRate* value is negative, the *AtRateTimeToEmpty* function returns the predicted operating time at the *AtRate* value of discharge. When the *AtRate* value is negative, the *AtRateOK* function returns a Boolean value that predicts the battery's ability to supply the *AtRate* value of additional discharge energy (current or power) for 10 seconds.

The default value for *AtRate* is zero.

Table A-10. AtRate

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x04	R/W	AtRate	signed integer	2	–32768	32767	0	mA or 10 mW

A.6 AtRateTimeToFull (0x05)

This read-word function returns an unsigned integer value of the predicted remaining time to fully charge the battery using a CC-CV method at the *AtRate* value in minutes, with a range of 0 to 65534. A value of 65535 indicates that the *AtRate* = 0.

AtRateTimeToFull can report time based on constant current (*[CapM]* = 0) or constant power (*[CapM]* = 1), and updates within one second after the SMBus host sets the *AtRate* value. The SN8765 automatically updates *AtRateTimeToFull* based on the *AtRate* function at one-second intervals.

0..65534 = predicted time to full charge, based on *AtRate*
65535 = no charge or discharge (*AtRate* is 0)

Table A-11. AtRateTimeToFull

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x05	R	AtRateTimeToFull	unsigned integer	2	0	65535	—	min

A.7 AtRateTimeToEmpty (0x06)

This read-word function returns an unsigned integer value of the predicted remaining operating time in minutes with a range of 0 to 65534, if the battery is discharged at the *AtRate* value. A value of 65535 indicates that *AtRate* = 0.

AtRateTimeToEmpty can report time based on constant current (*[LDMD]* = 0), or constant power (*[LDMD]* = 1), and is updated within one second after the SMBus host sets the *AtRate* value. The SN8765 updates *AtRateTimeToEmpty* at one-second intervals.

0..65534 = predicted remaining operating time, based on *AtRate*
65535 = no charge or discharge (*AtRate* is 0)

Table A-12. AtRateTimeToEmpty

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x06	R	AtRateTimeToEmpty	unsigned integer	2	0	65535	—	min

A.8 AtRateOK (0x07)

This read-word function returns a boolean value that indicates whether or not the battery can deliver the *AtRate* value of energy for 10 seconds.

The SN8765 updates this value within one second after the SMBus host sets the *AtRate* function value. The SN8765 updates *AtRateOK* at one-second intervals.

If *AtRate* function returns ≥ 0, *AtRateOK* always returns TRUE.

0 = FALSE SN8765 can **not** deliver energy for 10 seconds based on discharge rate indicated in *AtRate*
1..65535 = TRUE SN8765 deliver can energy for 10 seconds based on discharge rate indicated in *AtRate*

Table A-13. AtRateOK

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x07	R	AtRateOK	unsigned integer	2	0	65535	—	min

A.9 Temperature (0x08)

This read-word function returns an unsigned integer value of the temperature in units of 0.1°K, as measured by the SN8765. It has a range of 0 to 6553.5°K.

The source of the measured temperature is configured by ***[TEMP1]***, ***[TEMP0]*** bits in the ***Operation Cfg A*** register.

Table A-14. Temperature

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x08	R	Temperature	unsigned integer	2	0	65535	—	0.1°K

A.10 Voltage (0x09)

This read-word function returns an unsigned integer value of the sum of the individual cell voltage measurements in mV with a range of 0 to 20000 mV.

Table A-15. Voltage

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x09	R	Voltage	unsigned integer	2	0	20000	—	mV

A.11 Current (0x0a)

This read-word function returns a signed integer value of the measured current being supplied (or accepted) by the battery in mA, with a range of –32,768 to 32,767. A positive value indicates charge current and a negative value indicates discharge.

Any current value within the ***Deadband*** will be reported as 0 mA by the *Current* function.

Table A-16. Current

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0a	R	Current	signed integer	2	–32768	32767	—	mA

NOTE: *Current* function is the average of 4 internal current measurements over a one-second period.

A.12 AverageCurrent (0x0b)

This read-word function returns a signed integer value that approximates a one-minute rolling average of the current being supplied (or accepted) through the battery terminals in mA, with a range of –32,768 to 32,767.

AverageCurrent is calculated by a rolling IIR filtered average of *Current* function data with a period of 14.5 s. During the time after a reset and before 14.5 s has elapsed the reported *AverageCurrent* = *Current* function value.

Table A-17. AverageCurrent

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0b	R	AverageCurrent	signed integer	2	–32768	32767	—	mA

A.13 MaxError (0x0c)

This read-word function returns an unsigned integer value of the expected margin of error, in %, in the state-of-charge calculation with a range of 1 to 100%.

For example, when *MaxError* returns 10% and *RelativeStateOfCharge* returns 50%, the *RelativeStateOfCharge* is more likely between 50% and 60%. The SN8765 sets *MaxError* to 100% on a full reset. The SN8765 sets *MaxError* to 2% on completion of a learning cycle, unless the SN8765 limits the learning cycle to the +512/–356 mAh maximum adjustment values. If the learning cycle is limited, the SN8765 sets *MaxError* to 8% unless *MaxError* was already below 8%. In this case, *MaxError* does not change. The SN8765 increments *MaxError* by 1% after four increments of *CycleCount* without a learning cycle.

Event	***MaxError* Setting**
Full Reset	set to 100%
Completion of a learning cycle without limit	set to 2%
Completion of a limited learning cycle	set to a maximum of 8%
Without a learning cycle	Increment by 1% every four cycle

Table A-18. MaxError

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0c	R	MaxError	unsigned integer	1	0	100	—	%

A.14 RelativeStateOfCharge (0x0d)

This read-word 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%, with fractions of % rounded up.

If the ***[RSOCL]*** bit in ***Operation Cfg C*** is set then *RelativeStateofCharge* and *RemainingCapacity* are held at 99% until primary charge termination occurs and only displays 100% upon entering primary charge termination.

If the ***[RSOCL]*** bit in ***Operation Cfg C*** is cleared then *RelativeStateofCharge* and *RemainingCapacity* are **not** held at 99% until primary charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.

Table A-19. RelativeStateOfCharge

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0d	R	RelativeStateOfCharge	unsigned integer	1	0	100	—	%

A.15 AbsoluteStateOfCharge (0x0e)

This read-word function returns an unsigned integer value of the predicted remaining battery capacity expressed in %, with a range of 0 to 100%, with any fractions of % rounded up. The table below shows the calculation used depending on the *[CapM]* flag.

CapM AbsoluteStateOfCharge Calculation
0 = *RemainingCapacity*/***Design Capacity***
1 = *RemainingCapacity*/ ***Design Energy***

NOTE: *AbsoluteStateOfCharge* can return values > 100%.

Table A-20. AbsoluteStateOfCharge

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0e	R	AbsoluteStateOfCharge	unsigned integer	1	0	100+	—	%

A.16 RemainingCapacity (0x0f)

This read- or write-word function returns an unsigned integer value, with a range of 0 to 65535, of the predicted charge or energy remaining in the battery. This value is expressed in either charge (mAh) or energy (10 mWh), depending on the setting of the *[CapM]* flag.

Table A-21. RemainingCapacity

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0f	R/W	RemainingCapacity	unsigned integer	2	0	65535	—	mAh or 10 mWh

A.17 FullChargeCapacity (0x10)

This read-word function returns an unsigned integer value, with a range of 0 to 65535, of the predicted pack capacity when it is fully charged. This value is expressed in either charge (mAh) or power (10 mWh) depending on setting of *[CapM]* flag.

Table A-22. FullChargeCapacity

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x10	R	FullChargeCapacity	unsigned integer	2	0	65535	—	mAh or 10 mWh

A.18 RunTimeToEmpty (0x11)

This read-word function returns an unsigned integer value of the predicted remaining battery life at the present rate of discharge, in minutes, with a range of 0 to 65534 min. A value of 65535 indicates that the battery is not being discharged.

This value is calculated and updated based on current or power, depending on the setting of the *[CapM]* flag.

0..65534 = Predicted remaining battery life, based on *Current*
65535 = Battery is not being discharged.

Table A-23. RunTimeToEmpty

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x11	R	RunTimeToEmpty	unsigned integer	2	0	65535	—	min

A.19 AverageTimeToEmpty (0x12)

This read-word function returns an unsigned integer value of the predicted remaining battery life, in minutes, based upon *AverageCurrent*, with a range of 0 to 65534. A value of 65535 indicates that the battery is not being discharged.

This value is calculated based on current or power, depending on the setting of the *[CapM]* flag.

0..65534 = Predicted remaining battery life, based on *AverageCurrent*
65535 = Battery is not being discharged

Table A-24. AverageTimeToEmpty

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x12	R	AverageTimeToEmpty	unsigned integer	2	0	65535	—	min

A.20 AverageTimeToFull (0x13)

This read-word function returns an unsigned integer value of predicted remaining time until the battery reaches full charge, in minutes, based on *AverageCurrent*, with a range of 0 to 65534. A value of 65535 indicates that the battery is not being charged.

0..65534 = Predicted remaining time until full charge
65535 = Battery is not being charged.

Table A-25. AverageTimeToFull

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x13	R	AverageTimeToFull	unsigned integer	2	0	65535	—	min

A.21 ChargingCurrent (0x14)

This read-word function returns an unsigned integer value of the desired charging current, in mA, with a range of 0 to 65534. A value of 65535 indicates that a charger should operate as a voltage source outside its maximum regulated current range.

0..65534 = Desired charging current in mA
65535 = Charger should operate as voltage source outside its maximum regulated current range

Table A-26. ChargingCurrent

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x14	R	ChargingCurrent	unsigned integer	2	0	65535	—	mA

A.22 ChargingVoltage (0x15)

This read-word function returns an unsigned integer value of the desired charging voltage, in mV, where the range is 0 to 6553. A value of 65535 indicates that the charger should operate as a current source outside its maximum regulated voltage range.

0..65534 = Desired charging voltage in mV
65535 = Charger should operate as current source outside its maximum regulated voltage range

Table A-27. ChargingVoltage

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x15	R	ChargingVoltage	unsigned integer	2	0	65535	—	mV

A.23 BatteryStatus (0x16)

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

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	OCA	TCA	RSVD	OTA	TDA	RSVD	RCA	RTA
Low Byte	INIT	DSG	FC	FD	EC3	EC2	EC1	EC0

LEGEND: All Values Read Only; RSVD = Reserved

Figure A-3. BatteryStatus

OCA — 1 = Over Charged Alarm

TCA — 1 = Terminate Charge Alarm

OTA — 1 = Over Temperature Alarm

TDA — 1 = Terminate Discharge Alarm

RCA — Remaining Capacity Alarm

1 = Remaining Capacity Alarm is set
see:
SBS:RemainingCapacityAlarm(0x01)

RTA — Remaining Time Alarm

1 = Remaining Time Alarm is set
see:
SBS:RemainingTimeAlarm(0x02)

INIT — 1 = Initialization. This flag is cleared approx. 1 second after device reset, after all SBS parameters have been measured and updated

DSG — Discharging

0 = SN8765 is in charging mode.
1 = SN8765 is in discharging mode, relaxation mode, or valid charge termination has occurred.
See:
Section 1.4

FC — 1 = Fully Charged

FD — 1 = Fully Discharged

EC3, EC2, EC1, EC0 — Error Code, returns status of processed SBS function

0,0,0,0 =	OK	SN8765 processed the function code with no errors detected.
0,0,0,1 =	BUSY	SN8765 is unable to process the function code at this time.
0,0,1,0 =	Reserved	SN8765 detected an attempt to read or write to a function code reserved by this version of the specification or SN8765 detected an attempt to access an unsupported optional manufacturer function code.
0,0,1,1 =	Unsupported	SN8765 does not support this function code as defined in this version of the specification.
0,1,0,0 =	AccessDenied	SN8765 detected an attempt to write to a read-only function code.
0,1,0,1 =	Over/Underflow	SN8765 detected a data overflow or underflow.
0,1,1,0 =	BadSize	SN8765 detected an attempt to write to a function code with an incorrect data block.
0,1,1,1 =	UnknownError	SN8765 detected an unidentifiable error.

A.24 CycleCount (0x17)

This read-word function returns, as an unsigned integer value, the number of cycles the battery has experienced, with a range of 0 to 65535. The default value is stored in the data flash value ***Cycle Count***, which is updated each time this variable is incremented. There are 2 different cycle calculations depending on the ***[CCT]*** bit.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

CCT Cycle Count Calculation

0 = one cycle count is the accumulated discharge of ***CC Threshold***

1 = one cycle count is the accumulated discharge of ***CC %*** x *FullChargeCapacity*. If ***CC Threshold*** is greater than ***CC %*** x *FullChargeCapacity*, ***CC Threshold*** is used for the calculation

Table A-28. CycleCount

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x17	R/W	CycleCount	unsigned integer	2	0	65535	0	

A.25 DesignCapacity (0x18)

This read-word function returns, as an unsigned integer value, the theoretical or nominal capacity of a new pack, stored in ***Design Capacity*** or in ***Design Energy***.

The *DesignCapacity* value is expressed in either current (mAh at a C/5 discharge rate) or power, (10 mWh at a P/5 discharge rate) depending on the setting of the *[CapM]* bit.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-29. DesignCapacity

SBS Cmd.	Mode	Name	CapM	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x18	R/W	DesignCapacity	0	unsigned integer	2	0	65535	4400	mAh
			1	unsigned integer	2	0	65535	6336	10 mWh

A.26 DesignVoltage (0x19)

This read-word function returns an unsigned integer value of the theoretical voltage of a new pack, in mV, with a range of 0 to 65535. The default value is stored in ***Design Voltage***.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-30. DesignVoltage

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x19	R/W	DesignVoltage	unsigned integer	2	7000	18000	14400	mV

A.27 SpecificationInfo (0x1a)

This read-word function returns, as an unsigned integer value, the version number of the Smart Battery Specification the battery pack supports, as well as voltage- and current-scaling information.

Power-scaling is the product of the voltage-scaling times the current-scaling. The data is packed in the following fashion:

IPScale x 0x1000 + VScale x 0x0100 + SpecID_H x 0x0010 + SpecID_L

VScale (voltage scaling) and IPScale (current scaling) should always be set to zero. The default setting is stored in ***Spec Info***.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-31. SpecificationInfo

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x1a	R/W	SpecificationInfo	hex	2	0x0000	0xffff	0x0031	

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IPScale (0) (multiplies current by $10^{IPScale}$)				VScale (0) (multiplies voltage by 10^{VScale})				SpecID_H (0..15)				SpecID_L (0..15)			

LEGEND: R/W = Read/Write; R = Read only;–*n* = value after reset

Figure A-4. SpecificationInfo

A.28 ManufactureDate (0x1b)

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

(year–1980) x 512 + month x 32 + day

The default value for this function is stored in ***Manuf Date***.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-32. ManufactureDate

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x1b	R/W	ManufacturerDate	unsigned integer	2	0	65535	0	

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Year biased by 1980 (0..127)							Month (1..12)				Date (0..31)				
MSB						LSB	MSB			LSB	MSB				LSB

Figure A-5. ManufacturerDate

A.29 SerialNumber (0x1c)

This read-word function is used to return an unsigned integer serial number. The default value of this function is stored in ***Ser. Num.***.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-33. SerialNumber

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x1c	R/W	SerialNumber	hex	2	0x0000	0xffff	0x0001	

A.30 ManufacturerName (0x20)

This read-block function returns a character string containing the battery manufacturer's name with a maximum length of 11 characters (11 data + length byte).

The default setting of this function is stored in data flash ***Manuf Name***.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-34. ManufacturerName

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x20	R/W	ManufacturerName	String	11+1	—	—	Texas Inst.	ASCII

A.31 DeviceName (0x21)

This read-block function returns a character string that contains the battery name with a maximum length of 7 characters (7 data + length byte).

The default setting of this function is stored in data flash ***Device Name***.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-35. DeviceName

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x21	R/W	DeviceName	String	7+1	—	—	SN8765	ASCII

A.32 DeviceChemistry (0x22)

This read-block function returns a character string that the manufacturer uses to identify the battery chemistry with a maximum length of 4 characters (4 data + length byte).

The default setting of this function is stored in data flash ***Device Chemistry***, although it has no use for internal charge control or fuel gauging.

When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-36. DeviceChemistry

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x22	R/W	DeviceChemistry	String	4+1	—	—	LION	ASCII

A.33 ManufacturerData/CalibrationData (0x23)

This read-block function returns several configuration data flash elements with an absolute maximum length of 14 Data + 1 length byte (stored in Manufacturer Data Length). The Manufacturing data elements shown below are stored in the Manufacturer Data subclass. When the SN8765 is in UNSEALED or higher security mode, this block is R/W.

Table A-37. ManufacturerData

<table>
<tr><th>Data</th><th>Byte</th><th>Name</th><th>Format</th></tr>
<tr><td rowspan="10">Manufacturer Data</td><td>0</td><td rowspan="2">Pack Lot Code</td><td rowspan="15">Hex</td></tr>
<tr><td>1</td></tr>
<tr><td>2</td><td rowspan="2">PCB Lot Code</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td rowspan="2">Firmware Version</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td rowspan="2">Hardware Revision</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td><td rowspan="2">Cell Revision</td></tr>
<tr><td>9</td></tr>
<tr><td rowspan="4">SN8765 Counter</td><td>10</td><td>Partial Reset Counter</td></tr>
<tr><td>11</td><td>Full Reset Counter</td></tr>
<tr><td>12</td><td>Watchdog Reset Counter</td></tr>
<tr><td>13</td><td>Check Sum</td></tr>
<tr><td>Length</td><td>14</td><td>String Length Byte</td></tr>
</table>

While in calibration mode, this read-block function returns raw ADC and Coulomb Counter data with an absolute maximum length of 26 bytes.

Table A-38. CalibrationData

Data	Byte	Name	Format
Calibration Data	0	8-bit counter, refreshes after every ADC sample, 250 ms	Hex
	1	Output Calibration Data Status, 0x01 if ManufacturerData() = 0xF081 or 0x02 if ManufacturerData() = 0xF082	
	2	Coulomb Counter	2's Complement
	3		
	4	Cell Voltage 1	
	5		
	6	Cell Voltage 2	
	7		
	8	Cell Voltage 3	
	9		
	10	Cell Voltage 4	
	11		
	12	Internal Temperature	
	13		
	14	External Temperature 1 (TS1)	
	15		
	16	External Temperature 2 (TS2)	
	17		
	18	Reserved	
	19		
	20	Reserved	
	21		
	22	PACK Voltage	
	23		
	24	BAT Voltage	
	25		

A.34 Authenticate/ManufacturerInput (0x2f)

This read- or write-block function allows the host to authenticate the SN8765 -based battery using a SHA-1 authentication transform with a length of 20 data bytes + 1 length byte. See *SHA-1 Authentication* chapter and *Using SHA-1 in bq20zxx Family of Gas Gauges* application report (SLUA359) for detailed information.

Table A-39. Authenticate

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x2f	R/W	Authenticate	String	20+1	—	—	—	

While in data flash access mode, this read- or write-block function stores a 32-byte block in data flash at the data flash row address pointed to by ManufacturerAccess (0x01yy).

Similarly, a read to this command will return a 32-byte block from data flash based on Manufacturer Access (0x01yy).

Table A-40. ManufacturerInput

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x2f	R/W	ManufacturerInput	Hex	32	—	—	—	

A.35 CellVoltage4..1 (0x3c..0x3f)

These read-word functions return an unsigned value of the calculated individual cell voltages, in mV, with a range of 0 to 65535. *CellVoltage1* corresponds to the bottom most series cell element, while *CellVoltage4* corresponds to the top most series cell element.

Table A-41. CellVoltage4..1

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x3c	R	CellVoltage4	unsigned integer	2	0	65535	—	mV
0x3d		CellVoltage3					—	
0x3e		CellVoltage2					—	
0x3f		CellVoltage1					—	

A.36 SBS Command Values

Table A-42. SBS COMMANDS

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x00	R/W	ManufacturerAccess	hex	2	0x0000	0xffff	—	
0x01	R/W	RemainingCapacityAlarm	unsigned int	2	0	65535	300	mAh or 10 mWh
0x02	R/W	RemainingTimeAlarm	unsigned int	2	0	65535	10	min
0x03	R/W	BatteryMode	hex	2	0x0000	0xe383	—	
0x04	R/W	AtRate	signed int	2	–32768	32767	—	mA or 10 mW
0x05	R	AtRateTimeToFull	unsigned int	2	0	65534	—	min
0x06	R	AtRateTimeToEmpty	unsigned int	2	0	65534	—	min
0x07	R	AtRateOK	unsigned int	2	0	65535	—	
0x08	R	Temperature	unsigned int	2	0	65535	—	0.1°K
0x09	R	Voltage	unsigned int	2	0	65535	—	mV
0x0a	R	Current	signed int	2	–32768	32767	—	mA
0x0b	R	AverageCurrent	signed int	2	–32768	32767	—	mA
0x0c	R	MaxError	unsigned int	1	0	100	—	%
0x0d	R	RelativeStateOfCharge	unsigned int	1	0	100	—	%
0x0e	R	AbsoluteStateOfCharge	unsigned int	1	0	100+	—	%
0x0f	R/W	RemainingCapacity	unsigned int	2	0	65535	—	mAh or 10 mWh
0x10	R	FullChargeCapacity	unsigned int	2	0	65535	—	mAh or 10 mWh
0x11	R	RunTimeToEmpty	unsigned int	2	0	65534	—	min
0x12	R	AverageTimeToEmpty	unsigned int	2	0	65534	—	min
0x13	R	AverageTimeToFull	unsigned int	2	0	65534	—	min
0x14	R	ChargingCurrent	unsigned int	2	0	65534	—	mA
0x15	R	ChargingVoltage	unsigned int	2	0	65534	—	mV
0x16	R	BatteryStatus	unsigned int	2	0x0000	0xdbff	—	
0x17	R/W	CycleCount	unsigned int	2	0	65535	—	
0x18	R/W	DesignCapacity	unsigned int	2	0	65535	4400	mAh or 10 mWh
0x19	R/W	DesignVoltage	unsigned int	2	0	65535	14400	mV
0x1a	R/W	SpecificationInfo	hex	2	0x0000	0xffff	0x0031	
0x1b	R/W	ManufactureDate	unsigned int	2	—	—	01-Jan–1980	ASCII
0x1c	R/W	SerialNumber	hex	2	0x0000	0xffff	0x0001	

Table A-42. SBS COMMANDS (continued)

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x20	R/W	ManufacturerName	String	11+1	—	—	Texas Inst.	ASCII
0x21	R/W	DeviceName	String	7+1	—	—	SN8765	ASCII
0x22	R/W	DeviceChemistry	String	4+1	—	—	LION	ASCII
0x23	R/W	ManufacturerData/ Calibration Data	String/Hex and 2's Complement	14+1/2 6	—	—	—	ASCII / -
0x2f	R/W	Authenticate/Manufacturer Input	String/Hex	20+1/3 2	—	—	—	ASCII /–
0x3c	R	CellVoltage4	unsigned int	2	0	65535	—	mV
0x3d	R	CellVoltage3	unsigned int	2	0	65535	—	mV
0x3e	R	CellVoltage2	unsigned int	2	0	65535	—	mV
0x3f	R	CellVoltage1	unsigned int	2	0	65535	—	mV

Extended SBS Commands

The extended SBS commands are only available when the SN8765 device is in UNSEALED or FULL ACCESS mode.

B.1 AFEData (0x45)

This read-block function returns a string of 11 data bytes + 1 length byte. The first 9 bytes are the integrated AFE memory map followed by 2 bytes of the internal SN8765 AFE_Fail_Counter.

Table B-1. AFEData

Data	Byte	Name	Format
Integrated AFE	0	AFE Status	hex
	1	AFE State	
	2	AFE Output	
	3	AFE Output Status	
	5	AFE Cell Select	
	6	AFE OLV	
	7	AFE OLT	
	8	AFE SCC	
	9	AFE SCD	
	10	AFE Function	
SN8765	9	Internal AFE_Fail_Counter high byte	
	10	Internal AFE_Fail_Counter low byte	
	11	String Length Byte	

B.2 FETControl (0x46)

This read- or write-word function allows direct control of the FETs for test purposes only. If this command was used to alter current state of the FETs, the gauge can overwrite the FET state depending on gauging and safety conditions. If the FUSE pin is not used in the application circuit, it should be connected to ground directly or the FETs will not be able to turn on.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
FETControl	RSVD	RSVD	RSVD	RSVD	ZVCHG	CHG	DSG	RSVD

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure B-1. FETControl

ZVCHG — (Pre-Charge) charge FET Control

0 = Turn OFF pre-charge FET
1 = Turn ON pre-charge FET

CHG — Charge FET Control

0 = Turn OFF CHG FET. CHG FET does not turn off in discharge mode to protect the FET body diode.
1 = Turn ON CHG FET

DSG — Discharge FET Control

0 = Turn OFF DSG FET. DSG FET does not turn of in charge mode to protect the FET body diode.
1 = Turn ON DSG FET

B.3 PendingEDV (0x47)

This read-word function returns the predicted EDV2 until EDV2 is reached, then the predicted EDV1 until EDV1 is reached, and then the predicted EDV0. Format is little Endian.

Table B-2. PendingEDV

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x47	R	PendingEDV	unsigned integer	2	0	65535	—	mV

B.4 StateOfHealth (0x4f)

This read-word function returns the state of health of the battery in %. The calculation formula depends on the *[CapM]* flag.

CapM ***StateOfHealth***
0 = *FullChargeCapacity*/***Design Capacity***
1 = *FullChargeCapacity*/***Design Energy***

B.5 SafetyAlert (0x50)

This read-word function returns indications of pending safety issues, such as running safety timers, or fail counters that are nonzero but have not reached the required time or value to trigger a *SafetyStatus* failure.

See Section 1.2 for further details.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	OTD	OTC	OCD	OCC	RSVD	RSVD	RSVD	RSVD
Low Byte	CUV	COV	PF	RSVD	WDF	AOCD	SCC	SCD

LEGEND: All Values Read-Only

Figure B-2. SafetyAlert

OTD — 1 = Discharge overtemperature alert

OTC — 1 = Charge overtemperature alert

OCD — 1 = Discharge overcurrent alert

OCC — 1 = Charge overcurrent alert

WDF — 1 = AFE watchdog alert

AOCD — 1 = AFE discharge overcurrent alert

SCC — 1 = Charge short-circuit alert

SCD — 1 = Discharge short-circuit alert

B.6 SafetyStatus (0x51)

This read-word function returns the status of the 1st level safety features.

See Section 1.2 for further details.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	OTD	OTC	OCD	OCC	RSVD	RSVD	RSVD	RSVD
Low Byte	CUV	COV	PF	RSVD	WDF	AOCD	SCC	SCD

LEGEND: All Values Read-Only

Figure B-3. SafetyStatus

OTD — 1 = Discharge overtemperature condition

OTC — 1 = Charge overtemperature condition

OCD — 1 = Discharge overcurrent condition

OCC — 1 = Charge overcurrent condition

CUV — 1 = Cell undervoltage condition

COV — 1 = Cell overvoltage condition

PF — 1 = Permanent failure and FUSE pin has been driven high.

WDF — 1 = AFE watchdog condition

AOCD — 1 = AFE discharge overcurrent condition

SCC — 1 = Charge short-circuit condition

SCD — 1 = Discharge short-circuit condition

B.7 PFAlert (0x52)

This read-word function returns indications of pending safety issues, such as running safety timers that have not reached the required time to trigger a *PFAlert* failure.

See Section 1.3 for further details.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	VSHUT	RSVD	SOPT	SOCD	SOCC	AFE_P	ACE_C
Low Byte	DFF	DFETF	CFETF	CIM	SOTD	SOTC	SOV	PFIN

LEGEND: All Values Read-Only; RSVD = Reserved

Figure B-4. PFAlert

VSHUT — = 1: A permanent failure has occurred AND the device went into shutdown after that event.

SOPT — = 1: Open Thermistor permanent failure alert

SOCD — = 1: Discharge Safety Overcurrent permanent failure alert

SOCC — = 1: Charge Safety-Overcurrent permanent failure alert

AFE_P — = 1: Periodic AFE Communications permanent failure alert

AFE_C — = 1: Permanent AFE Communications failure alert

DFF — 1 = Data Flash Fault permanent failure alert

DFETF — = 1: Discharge-FET-Failure permanent failure alert

CFETF — = 1: Charge-FET-Failure permanent failure alert

CIM — = 1: Cell-Imbalance permanent failure alert

SOTD — = 1: Discharge Safety Overtemperature permanent failure alert

SOTC — = 1: Charge Safety Overtemperature permanent failure alert

SOV — = 1: Safety-Overvoltage permanent failure alert

PFIN — = 1: External Input Indication of permanent failure alert

B.8 PFStatus (0x53)

The permanent failure status register indicates the source of the SN8765 permanent-failure condition.

Any new permanent failure is added to ***PF Flags 1*** register to show all permanent failures that have occurred.

See Section 1.3 for further details.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	VSHUT	RSVD	SOPT	SOCD	SOCC	AFE_P	AFE_C
Low Byte	DFF	DFETF	CFETF	CIM	SOTD	SOTC	SOV	PFIN

LEGEND: All Values Read-Only; RSVD = Reserved

Figure B-5. PFStatus

VSHUT — = 1: A permanent failure has occurred AND the device went into shutdown after that event.

SOPT — 1 = Open Thermistor permanent failure

SOCD — 1 = Discharge Safety Overcurrent permanent failure

SOCC — 1 = Charge Safety-Overcurrent permanent failure

AFE_P — 1 = Periodic AFE Communications permanent failure

AFE_C — 1 = Permanent AFE Communications failure

DFF — 1 = Data Flash Fault permanent failure

DFETF — 1 = Discharge-FET-Failure permanent failure

CFETF — 1 = Charge-FET-Failure permanent failure

CIM — 1 = Cell-Imbalance permanent failure

SOTD — 1 = Discharge Safety Overtemperature permanent failure

SOTC — 1 = Charge Safety Overtemperature permanent failure

SOV — 1 = Safety-Overvoltage permanent failure

PFIN — 1 = External Input Indication of permanent failure

B.9 OperationStatus (0x54)

This read-word function returns the current operation status of the SN8765.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	PRES	FAS	SS	CSV	LTPF	RSVD	RSVD	STATUS
Low Byte	WAKE	DSG	XDSG	XDSGI	EDV2	VDQ	RSVD	RSVD

LEGEND: All Values Read-Only; RSVD = Reserved

Figure B-6. OperationStatus

PRES — 1 = $\overline{\text{PRES}}$ is low, indicating that the system is present (battery inserted).

FAS — 0 = Full access security mode

SS — 1 = Sealed security mode

CSV — 1 = Data Flash checksum value has been generated

LTPF — The LTPF flag indicates if Lifetime Data and PF are enabled
0 = Lifetime Data and PF are not enabled (default).
1 = Lifetime Data and PF is enabled.

STATUS — The STATUS flag indicates if the gauge is in NORMAL mode or calibration mode
0 = Gauge is in normal data acquisition mode.
1 = Gauge is in calibration data acquisition mode.

WAKE — 1 = SN8765 WAKE mode

DSG — Replica of the SBS:BatteryStatus(0x16)[DSG] flag.

XDSG — 1 = Discharge fault

XDSGI — 1 = Discharge disabled due to a current issue

EDV2 — indicates that cell voltage is less than the EDV2 threshold
0 = Voltage > EDV2 threshold (discharging)
1 = Voltage < EDV2 threshold

VDQ — indicates if the present discharge cycle is valid for an FCC update.
0 = Discharge cycle is not valid.
1 = Discharge cycle is valid.

B.10 ChargingStatus (0x55)

This read-word function returns the current status of the charging functions.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	XCHG	CHGSUSP	PCHG	RSVD	LTCHG	ST1CHG	ST2CHG	HTCHG
Low Byte	RSVD	CB	PCMTO	FCMTO	OCHGV	OCHGI	OC	XCHGLV

LEGEND: All Values Read-Only

Figure B-7. ChargingStatus

XCHG — 1 = Charging disabled

CHGSUSP — 1 = Charging suspended

PCHG — 1 = Precharging conditions exist

LTCHG — 1 = Low temperature charging

ST1CHG — 1 = Standard temperature charging 1

ST2CHG — 1 = Standard temperature charging 2

HTCHG — 1 = Low temperature charging

CB — 1 = Cell balancing in progress

PCMTO — 1 = Precharge timeout fault

FCMTO — 1 = Fast-charge timeout fault

OCHGV — 1 = Overcharge voltage fault

OCHGI — 1 = Overcharge current fault

OC — 1 = Overcharge fault

XCHGLV — 1 = Battery is depleted.

B.11 FETStatus (0x56)

This read-word function allows display of the FET status in either UNSEALED or SEALED mode.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
FETControl	RSVD	RSVD	RSVD	RSVD	ZVCHG	CHG	DSG	RSVD

LEGEND: RSVD = Reserved

Figure B-8. FETStatus

ZVCHG — (Pre-Charge) charge FET Status

0 = Pre-charge FET is OFF.
1 = Pre-charge FET is ON.

CHG — Charge FET Status

0 = CHG FET is OFF.
1 = CHG FET is ON.

DSG — Discharge FET Status

0 = DSG FET is OFF.
1 = DSG FET is ON.

B.12 ResetData (0x57)

This read-word function returns the number of partial resets (low byte) and full resets (high byte) the device has experienced.

Table B-3. ResetData

SBS Cmd.	Mode	Name			Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x57	R	ResetData	partial resets	low byte	unsigned integer	1	0	255	—	
			full resets	high byte	unsigned integer	1	0	255	—	

B.13 WDResetData (0x58)

This read-word function returns the number of watchdog resets the device has experienced.

Table B-4. WDResetData

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x58	R	WDResetData	unsigned integer	2	0	65535	—	

B.14 PackVoltage (0x5a)

This read-word function returns an unsigned integer value representing the measure voltage from the PACK pin, in mV, with a range of 0 to 65535. ***AFE Pack Gain*** is the scale factor for the *PackVoltage.*

Table B-5. PackVoltage

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5a	R	PackVoltage	unsigned integer	2	0	65535	—	mV

B.15 AverageVoltage (0x5d)

This read-word function returns an unsigned integer value that approximates a one-minute rolling average of the sum of the cell voltages in mV, with a range of 0 to 65535.

Table B-6. AverageVoltage

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5d	R	AverageVoltage	unsigned integer	2	0	65535	—	mV

B.16 TS1Temperature (0x5E)

This read-block function returns the TS1 temperature reading.

Table B-7. TS1Temperature

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5E	R	TS1Temperature	Integer	2	–400	1200	—	0.1°C

B.17 TS2Temperature (0x5F)

This read-block function returns the TS2 temperature reading.

Table B-8. TS2Temperature

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5F	R	TS2Temperature	Integer	2	–400	1200	—	0.1°C

B.18 UnSealKey (0x60)

This read- or write-block command allows the user to change the Unseal key for the Sealed-to-Unsealed security-state transition. This function is only available when the SN8765 is in the Full-Access mode, indicated by a cleared *[FAS]* flag.

The order of the bytes, when entered in *ManufacturerAccess*, is the reverse of what is written to or read from the part. For example, if the 1st and 2nd word of the *UnSealKey* block read returns 0x1234 and 0x5678, then in *ManufacturerAccess*, 0x3412 and 0x7856 should be entered to unseal the part.

Table B-9. UnSealKey

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x60	R/W	UnSealKey	hex	4	0x00000000	0xffffffff	—	

B.19 FullAccessKey (0x61)

This read- or write-block command allows the user to change the Full-Access security key for the Unsealed-to-Full-Access security-state transition. This function is only available when the SN8765 is in the Full-Access mode, indicated by a cleared *[FAS]* flag.

The order of the bytes, when entered in *ManufacturerAccess*, is the reverse of what is written to or read from the part. For example, if the 1st and 2nd word of the *FullAccessKey* block read returns 0x1234 and 0x5678, then in *ManufacturerAccess*, 0x3412 and 0x7856 should be entered to put the part in FULL ACCESS mode.

Table B-10. FullAccessKey

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x61	R/W	FullAccessKey	hex	4	0x00000000	0xffffffff	—	

B.20 PFKey (0x62)

This read- or write-block command allows the user to change the Permanent-Failure-Clear key. This function is only available when the SN8765 is in the FULL ACCESS mode, indicated by a cleared *[FAS]* flag.

The order of the bytes, when entered in *ManufacturerAccess*, is the reverse of what is written to or read from the part. For example, if the 1st and 2nd word of the *PFKey* block read returns 0x1234 and 0x5678, then in *ManufacturerAccess*, 0x3412 and 0x7856 should be entered to clear a permanent failure.

Table B-11. PFKey

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x62	R/W	PFKey	hex	4	0x00000000	0xffffffff	—	

B.21 AuthenKey3 (0x63)

This read- or write-block command stores Byte 12–Byte 15 of the 16-byte long authentication key. This function is only available when the SN8765 is in the FULL ACCESS mode, indicated by a cleared *[FAS]* flag.

Table B-12. AuthenKey3

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x63	R/W	AuthenKey3	hex	4	0x00000000	0xffffffff	0x10325476	

B.22 AuthenKey2 (0x64)

This read- or write-block command stores Byte 8–Byte 11 of the 16-byte long authentication key. This function is only available when the SN8765 is in the FULL ACCESS mode, indicated by a cleared *[FAS]* flag.

Table B-13. AuthenKey2

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x64	R/W	AuthenKey2	hex	4	0x00000000	0xffffffff	0x98abdcfe	

B.23 AuthenKey1 (0x65)

This read- or write-block command stores Byte 4–Byte 7 of the 16-byte long authentication key. This function is only available when the SN8765 is in the FULL ACCESS mode, indicated by a cleared *[FAS]* flag.

Table B-14. AuthenKey1

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x65	R/W	AuthenKey1	hex	4	0x00000000	0xffffffff	0xdfceab89	

B.24 AuthenKey0 (0x66)

This read- or write-block command stores Byte 0–Byte 3 of the 16-byte long authentication key. This function is only available when the SN8765 is in the FULL ACCESS mode, indicated by a cleared *[FAS]* flag.

Table B-15. AuthenKey0

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x66	R/W	AuthenKey0	hex	4	0x00000000	0xffffffff	0x67452301	

B.25 ManufacturerInfo (0x70)

This read/write block function returns the data stored in ***Manuf. Info*** where byte 0 is the MSB with a maximum length of 31 data + 1 length byte. When the SN8765 is in UNSEALED or FULL ACCESS mode, this block is read/write. When the SN8765 is in SEALED mode, this block is read only.

Table B-16. ManufacturerInfo

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x70	R/W	ManufacturerInfo	String	31+1	—	—	—	

B.26 SenseResistor (0x71)

This read- or write-word command allows the user to change the sense resistor value used in µΩ. The SN8765 automatically updates the respective calibration data on receipt of a new sense resistor value.

Table B-17. SenseResistor

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x71	R/W	SenseResistor	unsigned integer	2	0	65535	10000	µΩ

B.27 TempRange (0x72)

This read-word function returns the present temperature range in effect.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	RSVD	RSVD	TR5	TR4	TR3	TR2A	TR2	TR1

LEGEND: All values read-only. RSVD = Reserved

Figure B-9. TempRange

- **TR1** – 1 = temperature range 1: *Temperature* < ***JT1***
- **TR2** – 1 = temperature range 2: ***JT1*** < *Temperature* < ***JT2***
- **TR2A** – 1 = temperature range 3: ***JT2*** < *Temperature* < ***JT2a***
- **TR3** – 1 = temperature range 4: ***JT2a*** < *Temperature* < ***JT3***
- **TR4** – 1 = temperature range 5: ***JT3*** < *Temperature* < ***JT4***
- **TR5** – 1 = temperature range 6: ***JT4*** < *Temperature*

B.28 ManufacturerStatus (0x74)

This read-word function returns the current operation status of the SN8765.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	CAL STATUS

LEGEND: All Values Read-Only; RSVD = Reserved

Figure B-10. ManufacturerStatus

CAL STATUS — Indicates if permissions are enabled or disabled to allow gauge to enter calibration mode.

0 = Calibration mode is not allowed.

1 = Calibration mode is allowed.

B.29 Extended SBS Command Values

Table B-18. EXTENDED SBS COMMANDS

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x45	R	AFEData	String	11+1	—	—	—	ASCII
0x46	R/W	FETControl	hex	1	0x00	0x1e	—	
0x47	R	PendingEDV	unsigned int	2	0	65535	—	mV
0x4f	R	StateOfHealth	unsigned int	1	0	100	—	%
0x50	R	SafetyAlert	hex	2	0x0000	0xffff	—	
0x51	R	SafetyStatus	hex	2	0x0000	0xffff	—	
0x52	R	PFAlert	hex	2	0x0000	0x9fff	—	
0x53	R	PFStatus	hex	2	0x0000	0x9fff	—	
0x54	R	OperationStatus	hex	2	0x0000	0xffff	—	
0x55	R	ChargingStatus	hex	2	0x0000	0xffff	—	
0x57	R	ResetData	hex	2	0x0000	0xffff	—	
0x58	R	WDResetData	unsigned int	2	0	65535	—	
0x5a	R	PackVoltage	unsigned int	2	0	65535	—	mV
0x5d	R	AverageVoltage	unsigned int	2	0	65535	—	mV
0x60	R/W	UnSealKey	hex	4	0x00000000	0xffffffff	—	
0x61	R/W	FullAccessKey	hex	4	0x00000000	0xffffffff	—	
0x62	R/W	PFKey	hex	4	0x00000000	0xffffffff	—	
0x63	R/W	AuthenKey3	hex	4	0x00000000	0xffffffff	—	
0x64	R/W	AuthenKey2	hex	4	0x00000000	0xffffffff	—	
0x65	R/W	AuthenKey1	hex	4	0x00000000	0xffffffff	—	
0x66	R/W	AuthenKey0	hex	4	0x00000000	0xffffffff	—	
0x70	R/W	ManufacturerInfo	String	8+1	—	—	—	ASCII
0x71	R/W	SenseResistor	unsigned int	2	0	65535	—	μΩ
0x72	R	TempRange	unsigned int	2	0	65535	—	0.1°K
0x74	R	ManufacturerStatus	hex	2	0x0000	0x0001	—	

Data Flash

CAUTION

Care should be taken when mass programming the data flash space using previous versions of data flash memory map files (such as *.gg files) to make sure that all public locations are updated correctly.

Data flash can only be updated if *Voltage* ≥ ***Flash Update OK Voltage*** or *PackVoltage* ≥ ***Flash Update OK Voltage***.

NOTE: Data flash reads and writes are verified according to the method detailed in Section 1.3.

Data flash updates are disabled when the *[PF] SafetyStatus* flag is set.

C.1 Accessing Data Flash

In different security modes, the data flash access conditions change. See Section A.1 and Section 1.8 for further details.

SECURITY MODE	NORMAL DATA FLASH ACCESS
BootROM	N/A
FULL ACCESS	R/W
UNSEALED	R/W
Sealed	N/A

C.1.1 Data Flash Interface

The SN8765 data flash is organized into rows where each data flash variable is assigned an offset within its row.

Data flash commands are NACKed if the SN8765 is in SEALED mode (*[SS]* flag is set).

Reading and writing data flash row data are block operations, which are each 32 bytes long.

None of the values written are bounded by the SN8765 and the values are not rejected by the gas gauge.

Writing an incorrect value may result in hardware failure due to firmware program interpretation of the invalid data. The data written is persistent, so a Power On Reset does resolve the fault.

C.1.2 Reading a Data Flash Row

Information required:

- DFRowAddress
- Variable Offset

Procedure:

1. Write the data flash row address to SN8765 using *DFRowAddress (0x01yy)* command to *ManufacturerAccess (0x00)*.

2. Read a block of data using *ManufacturerInput (0x2f)* command. Each row can hold up to 32 bytes of data.
3. Specific bytes within the block can be parsed or accessed using the correct variable offset.

C.1.3 Writing a Data Flash Row

Information required:

- DFRowAddress
- Variable Offset
- 32- byte data block

Procedure:

1. Write the data flash row address to SN8765 using *DFRowAddress (0x01yy)* command to *ManufacturerAccess (0x00)*.
2. Read a block of data using *ManufacturerInput (0x2f)* command and store in local memory. Each row can hold up to 32 bytes of data.
3. Modify specific bytes within the 32-byte block based on the variable offset noted earlier.
4. Write the modified block of data from local memory back to data flash using *ManufacturerInput (0x2ff* command. A full 32-byte block of data must be written to the selected data flash row address.

C.2 Calibration

C.2.1 Data

C.2.1.1 CC Gain

CC Gain sets the mA current scale factor for the Coulomb Counter. Use calibration routines to set this value.

Table C-1. CC Gain

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Gain	floating point	4	0.1	4	0.9419	

C.2.1.2 CC Delta

CC Delta sets the mAh capacity scale factor for the Coulomb Counter. Use calibration routines to set this value.

Table C-2. CC Delta

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Delta	floating point	4	29826	1193046	280932.6	

C.2.1.3 VC1 K-Factor

This register value stores the ADC voltage translation factor for the bottom cell (Cell 1), which is connected between the VC4 and VSS pins. By default, this value is not used and the factory calibration are in effective. This value overrides the factory calibration when ***K-factor Override Flag*** is set to 0x9669 by the software voltage calibration process.

Table C-3. VC1 K-Factor

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
VC1 K-factor	signed integer	2	0	32767	20500	

C.2.1.4 VC2 K-Factor

This register value stores the ADC voltage translation factor for Cell 2, which is connected between the VC3 and VC4 pins. By default, this value is not used and the factory calibration are in effective. This value overrides the factory calibration when ***K-factor Override Flag*** is set to 0x9669 by the software voltage calibration process.

Table C-4. VC2 K-Factor

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
VC2 K-factor	signed integer	2	0	32767	20500	

C.2.1.5 VC3 K-Factor

This register value stores the ADC voltage translation factor for Cell 3, which is connected between the VC2 and VC3 pins. By default, this value is not used and the factory calibration are in effective. This value overrides the factory calibration when ***K-factor Override Flag*** is set to 0x9669 by the software voltage calibration process.

Table C-5. VC3 K-Factor

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
VC3 K-factor	signed integer	2	0	32767	20500	

C.2.1.6 VC4 K-Factor

This register value stores the ADC voltage translation factor for the top cell (Cell 4), which is connected between the VC1 and VC2 pins. By default, this value is not used and the factory calibration are in effective. This value overrides the factory calibration when ***K-factor Override Flag*** is set to 0x9669 by the software voltage calibration process.

Table C-6. VC4 K-Factor

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
VC4 K-factor	signed integer	2	0	32767	20500	

C.2.1.7 K-Factor Override Flag

This register value is by default 0, indicating that the factory calibrated K-factors are being used. If this register is set to 0x9669, VC1~VC4 K-factors in the data flash are used for voltage translation.

Table C-7. K-Factor Override Flag

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
K-factor Override Flag	Hex	2	0	0xFFFF	0	

C.2.1.8 AFE Pack Gain

This register value stores the scale factor for the *PackVoltage*, voltage measured at the PACK pin of the SN8765.

Table C-8. AFE Pack Gain

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Pack Gain	unsigned integer	2	0	32767	24500	μV/cnt

C.2.1.9 CC Offset

This register value stores the Coulomb Counter offset compensation. It is set during CC Offset calibration, or by automatic calibration of the SN8765 before the gauge enters sleep. It is not recommended to manually change this value.

Table C-9. CC Offset

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Offset	signed integer	2	–32768	32767	–1667	

C.2.1.10 Board Offset

This register value stores the compensation for the PCB dependant Coulomb Counter offset. It is recommended to use characterization data of the actual PCB to set this value.

Table C-10. Board Offset

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Board Offset	signed integer	2	–32768	32767	0	

C.2.1.11 Int Temp Offset

This register value stores the internal temperature sensor offset compensation. Use calibration routines to set this value.

Table C-11. Int Temp Offset

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Int Temp Offset	signed integer	1	–128	127	0	

C.2.1.12 Ext1 Temp Offset

This register value stores the temperature sensor offset compensation for the external temperature sensor 1 connected at the TS1 pin of the SN8765. Use calibration routines to set this value.

Table C-12. Ext1 Temp Offset

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Ext1 Temp Offset	signed integer	1	–128	127	0	

C.2.1.13 Ext2 Temp Offset

This register value stores the temperature sensor offset compensation for the external temperature sensor 2 connected at the TS2 pin of the SN8765. Use calibration routines to set this value.

Table C-13. Ext2 Temp Offset

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Ext2 Temp Offset	signed integer	1	–128	127	0	

C.2.2 Config

C.2.2.1 CC Current

This value sets the current used for the CC calibration when in calibration mode.

Table C-14. CC Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Current	unsigned integer	2	0	32767	3000	mA

C.2.2.2 Voltage Signal

This value sets the voltage used for calibration when in calibration mode.

Table C-15. Voltage Signal

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Voltage Signal	unsigned integer	2	0	32767	12600	mV

C.2.2.3 Temp Signal

This value sets the temperature used for the temperature calibration in calibration mode.

Table C-16. Temp Signal

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Temp Signal	unsigned integer	2	0	32767	2980	0.1K

C.2.2.4 CC Offset Time

This value sets the time used for the CC Offset calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiples of 250. Numbers less than 250 will cause a CC offset calibration error. Numbers greater than 250 will be rounded down to the nearest multiple of 250.

Table C-17. CC Offset Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Offset Time	unsigned integer	2	0	65535	250	ms

C.2.2.5 ADC Offset Time

This constant defines the time for the ADC Offset calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiples of 32. Numbers less than 32 will cause an ADC offset calibration error. Numbers greater than 32 will be rounded down to the nearest multiple of 32.

Table C-18. ADC Offset Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ADC Offset Time	unsigned integer	2	0	65535	32	ms

C.2.2.6 CC Gain Time

This constant defines the time for the CC Gain calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiples of 250. Numbers less than 250 will cause a CC gain calibration error. Numbers greater than 250 will be rounded down to the nearest multiple of 250.

Table C-19. CC Gain Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Gain Time	unsigned integer	2	0	65535	250	ms

C.2.2.7 Voltage Time

This constant defines the time for the voltage calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiples of 1984. Numbers less than 1984 will cause a voltage calibration error. Numbers greater than 1984 will be rounded down to the nearest multiple of 1984.

Table C-20. Voltage Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Voltage Time	unsigned integer	2	0	65535	1888	ms

C.2.2.8 Temperature Time

This constant defines the time for the temperature calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiples of 32. Numbers less than 32 will cause a temperature calibration error. Numbers greater than 32 will be rounded down to the nearest multiple of 32.

Table C-21. Temperature Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Temperature Time	unsigned integer	2	0	65535	32	ms

C.2.2.9 Cal Mode Timeout

The SN8765 will exit calibration mode automatically after a ***Cal Mode Timeout*** period.

Table C-22. Cal Mode Timeout

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cal Mode Timeout	unsigned integer	2	0	65535	38400	s/128

C.2.3 Temp Model

C.2.3.1 Ext Coef a1..a5, b1..b4, Ext rc0, Ext adc0

These values characterize the external thermistor connected to the TS1 pin or the TS2 pin of the SN8765. The default values characterize the Semitec 103AT NTC thermistor. Do not modify these values without consulting TI.

Table C-23. Ext Coef a1..a5, b1..b4, Ext rc0, Ext adc0

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Ext Coef a1	signed integer	2	–32768	32767	–11130	num
Ext Coef a2					19142	
Ext Coef a3					–19262	
Ext Coef a4					28203	
Ext Coef a5					892	
Ext Coef b1					328	
Ext Coef b2					–605	
Ext Coef b3					–3443	
Ext Coef b4					4696	
Ext rc0					87	
Ext adc0					17740	

C.2.3.2 Rpad, Rint

These values characterize the pad and the internal resistance of the SN8765. Do not modify these values without consulting TI.

Table C-24. Pad Resistance and Int Resistance

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Rpad	signed integer	2	–32768	32767	87	num
Rint					17740	

C.2.3.3 Int Coef 1..4, Int Min AD, Int Max Temp

These values characterize the internal thermistor of the SN8765. Do not modify these values without consulting TI.

Table C-25. Int Coef 1..4, Int Min AD, Int Max Temp

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Int Coef 1	signed integer	2	–32768	32767	0	s
Int Coef 2					0	
Int Coef 3					–11136	
Int Coef 4					5754	
Int Min AD					0	
Int Max Temp					5754	

C.2.4 Current

C.2.4.1 Filter

Filter defines the filter constant used in the *AverageCurrent* calculation:

AverageCurrent new = a × *AverageCurrent* old + (1–a) × *Current*

with:

a = <*Filter*> / 256; the time constant = 1 sec/ln(1/a) (default 14.5 s)

Table C-26. Filter

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Filter	unsigned integer	1	0	255	239	mA

C.2.4.2 Deadband

Any current within ± ***Deadband*** will be reported as 0 mA by the *Current* function.

Table C-27. Deadband

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Deadband	unsigned integer	1	0	255	3	mA

C.2.4.3 CC Deadband

This constant defines the deadband voltage for the measured voltage between the SR1 and SR2 pins used for capacity accumulation in units of 294 nV. Any voltages within ±***CC Deadband*** do not contribute to capacity accumulation.

Table C-28. CC Deadband

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Deadband	unsigned integer	1	0	255	34	294 nV

C.3 System Data

C.3.1 Manufacturer Data

C.3.1.1 Pack Lot Code

The *ManufacturerData* function reports ***Pack Lot Code*** as part of its return value.

Table C-29. Pack Lot Code

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Pack Lot Code	hex	2	0x0000	0xffff	0x0000	

C.3.1.2 PCB Lot Code

The *ManufacturerData* function reports ***PCB Lot Code*** as part of its return value.

Table C-30. PCB Lot Code

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PCB Lot Code	hex	2	0x0000	0xffff	0x0000	

C.3.1.3 Firmware Version

The *ManufacturerData* function reports ***Firmware Version*** as part of its return value.

Table C-31. Firmware Version

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Firmware Version	hex	2	0x0000	0xffff	0x0000	

C.3.1.4 Hardware Revision

The *ManufacturerData* function reports ***Hardware Version*** as part of its return value.

Table C-32. Hardware Revision

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Hardware Revision	hex	2	0x0000	0xffff	0x0000	

C.3.1.5 Cell Revision

The *ManufacturerData* function reports ***Cell Revision*** as part of its return value.

Table C-33. Cell Revision

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Revision	hex	2	0x0000	0xffff	0x0000	

C.3.2 Manufacturer Info

C.3.2.1 Manuf. Info

The *ManufacturerInfo* function returns the string stored in ***Manuf. Info***. The maximum text length is 31 characters.

Table C-34. Manuf. Info

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Manuf. Info	string	31 + 1	—	—	0123456789abcdef0123456789abcde	

C.3.3 Lifetime Data

C.3.3.1 Lifetime Max Temp

If the *[LTPF]* flag is set ***Lifetime Max Temp*** value is updated if one of the following conditions are met:

- internal measurement temperature – ***Lifetime Max Temp*** > 1 °C.
- internal measurement temperature > ***Lifetime Max Temp*** for a period > 60 seconds
- internal measurement temperature > ***Lifetime Max Temp*** AND any other lifetime value is updated.

Table C-35. Lifetime Max Temp

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Lifetime Max Temp	signed integer	2	0	1400	300	0.1°C

C.3.3.2 Lifetime Min Temp

If the *[LTPF]* flag is set ***Lifetime Min Temp*** is updated if one of the following conditions are met:

- ***Lifetime Min Temp*** – internal measurement temperature > 1 °C.
- ***Lifetime Min Temp*** > internal measurement temperature for a period > 60 seconds
- ***Lifetime Min Temp*** > internal measurement temperature > AND any other lifetime value is updated.

Table C-36. Lifetime Min Temp

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Lifetime Min Temp	signed integer	2	–600	1400	200	0.1°C

C.3.3.3 Lifetime Max Cell Voltage

If the *[LTPF]* flag is set ***Lifetime Max Cell Voltage*** is updated if one of the following conditions are met:

- Any internally measured cell voltage–***Lifetime Max Cell Voltage*** > 25 mV
- Any internally measured cell voltage > ***Lifetime Max Cell Voltage*** for a period > 60 seconds
- Any internally measured cell voltage ***Lifetime Max Cell Voltage*** AND any other lifetime value is updated.

Table C-37. Lifetime Max Cell Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Lifetime Max Cell Voltage	signed integer	2	–32768	32767	3500	mV

C.3.3.4 Lifetime Min Cell Voltage

If the *[LTPF]* flag is set ***Lifetime Min Cell Voltage*** is updated if one of the following conditions are met:

- ***Lifetime Min Cell Voltage*** – any internally measured cell voltage > 25 mV
- ***Lifetime Min Cell Voltage*** > any internally measured cell voltage for a period > 60 seconds
- ***Lifetime Min Cell Voltage*** > any internally measured cell voltage AND any other lifetime value is updated.

Table C-38. Lifetime Min Cell Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Lifetime Min Cell Voltage	signed integer	2	–32768	32767	3200	mV

C.4 SBS Configuration

C.4.1 Data

C.4.1.1 Rem Cap Alarm

When *[CapM]* in *BatteryStatus* is set to 0, the default value of *RemainingCapacityAlarm* is stored in ***Rem Cap Alarm*** and copied to the SBS value upon SN8765 initialization.

Table C-39. Rem Cap Alarm

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Rem Cap Alarm	unsigned integer	2	0	700	300	mAh

C.4.1.2 Rem Energy Alarm

When *[CapM]* in *BatteryStatus* is set to 1, the default value of *RemainingCapacityAlarm* is stored in ***Rem Energy Alarm*** and copied to the SBS value upon the SN8765 initialization.

Table C-40. Rem Energy Alarm

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Rem Energy Alarm	unsigned integer	2	0	1000	432	10 mWh

C.4.1.3 Rem Time Alarm

The default value of *RemainingTimeAlarm* is stored in ***Rem Time Alarm*** and copied to the SBS value upon SN8765 initialization.

Table C-41. Rem Time Alarm

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Rem Time Alarm	unsigned integer	2	0	30	10	min

C.4.1.4 Init Battery Mode

The default value of *BatteryMode* is stored in ***Init Battery Mode*** and copied to the SBS value upon SN8765 initialization.

Table C-42. Init Battery Mode

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Init Battery Mode	hex	2	0	0xffff	0x0081	

C.4.1.5 Design Voltage

The default value of *DesignVoltage* is stored in ***Design Voltage*** and copied to the SBS value upon SN8765 initialization.

Table C-43. Design Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Design Voltage	unsigned integer	2	7000	18000	10800	mV

C.4.1.6 Spec Info

The default value of *SpecificationInfo* is stored in ***Spec Info*** and copied to the SBS value upon SN8765 initialization.

Table C-44. Spec Info

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Spec Info	hex	2	0x0000	0xffff	0x0031	

C.4.1.7 Manuf Date

The default value of *ManufacturerDate* is stored in ***Manuf Date*** and copied to the SBS value upon SN8765 initialization.

Table C-45. Manuf Date

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Manuf Date	unsigned integer	2	0	65535	0	Day + Mo*32 + (Yr –1980)*512

C.4.1.8 Ser. Num.

The default value of *SerialNumber* is stored in ***Ser. Num.*** and copied to the SBS value upon SN8765 initialization.

Table C-46. Ser. Num.

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Ser. Num.	hex	2	0x0000	0xffff	0x0001	

C.4.1.9 Cycle Count

The default value of *CycleCount* is stored in ***Cycle Count*** and copied to the SBS value upon SN8765 initialization. When the SBS value changes ***Cycle Count*** is also updated.

Table C-47. Cycle Count

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cycle Count	unsigned integer	2	0	65535	0	Count

C.4.1.10 CC Threshold

If the *[CCT]* bit is cleared the cycle count function counts the accumulated discharge of the ***CC Threshold*** value as one cycle.

Table C-48. CC Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC Threshold	signed integer	2	100	32767	4400	mAh

C.4.1.11 CC %

If the *[CCT]* bit is set the cycle count function counts the accumulated discharge of (*FullChargeCapacity* x ***CC %***) as one cycle. If (*FullChargeCapacity* x ***CC %***) is smaller than ***CC Threshold***, ***CC Threshold*** is used for counting.

Table C-49. CC %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CC %	unsigned integer	1	0	100	90	%

C.4.1.12 CF Max Error Limit

If *MaxError* function value is greater than ***CF Max Error Limit***, *[CF]* in *BatteryMode* is set.

Table C-50. CF Max Error Limit

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CF Max Error Limit	unsigned integer	1	0	100	100	%

C.4.1.13 Design Capacity

If *[CapM]* in *BatteryMode* is set to 0, the *DesignCapacity* function reports ***Design Capacity***.

Table C-51. Design Capacity

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Design Capacity	unsigned integer	2	0	65535	4400	mAh

C.4.1.14 Design Energy

If *[CapM]* in *BatteryMode* is set to 1, the *DesignCapacity* function reports ***Design Energy***.

Table C-52. Design Energy

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Design Energy	unsigned integer	2	0	65535	4752	0.1 Wh

C.4.1.15 Full Charge Capacity

This value is used as the *Full Charge Capacity* at device reset. This value is updated by the CEDV gauging algorithm when battery voltage reaches EDV2. Initialize this value to Design Capacity.

Table C-53. Full Charge Capacity

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Full Charge Capacity	unsigned integer	2	0	65535	4400	mAh

C.4.1.16 DOD at EDV2

This value is updated by the CEDV gauging algorithm when battery voltage reaches EDV2. If ***Battery Low %*** is altered, the ***DOD at EDV2*** value should be set to (1–Battery_Low%) x 16384, where Battery_Low% = ***Battery Low %*** ÷ 2.56. The firmware default value is 15232, which corresponds to a ***Battery Low %*** = 18 (%/2.56) (saved to the DF as 18 in unit of %/2.56).

Table C-54. DOD at EDV2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
DOD at EDV2	unsigned integer	2	0	16384	15232	

- DF:Gas Gauging:CEDV Cfg:Battery Low %

C.4.1.17 Manuf Name

The *ManufacturerName* function returns a string stored in ***Manuf Name***. The maximum text length is 11 characters.

Table C-55. Manuf Name

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Manuf Name	string	11 + 1	—	—	Texas Inst.	ASCII

C.4.1.18 Device Name

The *DeviceName* function returns a string stored in ***Device Name***. The maximum text length is 7 characters.

Table C-56. Device Name

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Device Name	string	7 + 1	—	—	SN8765	ASCII

C.4.1.19 Device Chemistry

The *DeviceChemistry* function returns a string stored in ***Device Chemistry***. The maximum text length is 4 characters.

Table C-57. Device Chemistry

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Device Chemistry	string	4 + 1	—	—	LION	ASCII

C.4.2 Configuration

C.4.2.1 TDA Set %

If set between 0% and 100% the SN8765 sets the *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below ***TDA Set %***. Set to –1 to disable this function.

Table C-58. TDA Set %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TDA Set %	signed integer	1	–1	100	6	%

C.4.2.2 TDA Clear %

If set between 0% and 100% the SN8765 clears the *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above ***TDA Clear %***. Set to –1\ to disable this function.

Table C-59. TDA Clear %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TDA Clear %	signed integer	1	–1	100	8	%

C.4.2.3 FD Set %

If set between 0% and 100%, the SN8765 sets the *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below ***FD Set %***. Set to –1 to disable this function.

Table C-60. FD Set %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FD Set %	signed integer	1	–1	100	2	%

C.4.2.4 FD Clear %

If set between 0% and 100% the SN8765 clears the *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above ***FD Clear %***. Set to –1 to disable this function.

Table C-61. FD Clear %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FC Clear %	signed integer	1	–1	100	5	%

C.4.2.5 TDA Set Volt Threshold

The SN8765 sets the *[TDA]* flag in *BatteryStatus* if *Voltage* is equal to or lower than ***TDA Set Volt Threshold*** for a period equal to or greater than ***TDA Set Volt Time***.

Table C-62. TDA Set Volt Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TDA Set Volt Threshold	unsigned integer	2	0	16800	3750	mV

C.4.2.6 TDA Set Volt Time

The SN8765 sets the *[TDA]* flag in *BatteryStatus* if *Voltage* is equal to or lower than ***TDA Set Volt Threshold*** for a period equal to or greater than ***TDA Set Volt Time***. Set to 0 to disable this feature.

Table C-63. TDA Set Volt Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TDA Set Volt Time	unsigned integer	1	0	240	5	s

C.4.2.7 TDA Clear Volt

The SN8765 clears the *[TDA]* flag if *Voltage* is equal to or greater than ***TDA Clear Volt***. ***TDA Clear Volt*** clears *[TDA]* only if *[TDA]* is set by ***TDA Set Volt Threshold***. It will not clear *[TDA]* if *[TDA]* is set by ***TDA Set %*** or any other function.

Table C-64. TDA Clear Volt

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TDA Clear Volt	unsigned integer	2	0	16800	4125	mV

C.4.2.8 FD Set Volt Threshold

The SN8765 sets the *[FD]* flag if *Voltage* is equal to or lower than ***FD Set Volt Threshold*** for a period equal to or greater than ***FD Volt Time***.

Table C-65. FD Set Volt Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FD Set Volt Threshold	unsigned integer	2	0	16800	3750	mV

C.4.2.9 FD Volt Time

The SN8765 sets the *[FD]* flag if *Voltage* is equal to or lower than ***FD Set Volt Threshold*** for a period equal to or greater than ***FD Volt Time***. Set to 0 to disable this feature.

Table C-66. FD Volt Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FD Volt Time	unsigned integer	1	0	240	5	s

C.4.2.10 FD Clear Volt

The SN8765 clears the *[FD]* flag if *Voltage* is equal to or greater than ***FD Clear Volt***.

Table C-67. FD Clear Volt

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FD Clear Volt	unsigned integer	2	0	16800	4125	mV

C.5 PF Status

C.5.1 Device Status Data

C.5.1.1 PF Flags 1

The flags in the ***PF Flags 1*** register indicate the reason that the SN8765 has entered permanent failure. If the failure flag in ***PF Flags 1*** matches the bit in ***Permanent Fail Cfg*** the FUSE pin is driven high and the ***Fuse Flags*** is set to 0x3672. The FUSE pin can be used to blow an optional fuse in a severe failure condition to prevent more damage of the system.

All permanent failure flags in the failure sequence are stored in ***PF Flags 1***. Only the first permanent failure flag in a failure sequence is stored in ***PF Flags 2*** to indicate the cause of the permanent failure.

Table C-68. PF Flags 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Flags 1	hex	2	0x0000	0x8000	0x0000	

C.5.1.2 Fuse Flag

The ***Fuse Flag*** is set to 0x3672 when a 2nd level protection failure occurs and the matching bit is set in the ***Permanent Fail Cfg*** register. The FUSE pin is driven high.

0x0000 = No Failure (default)

0x3672 = ***Permanent Fail Cfg*** flag matches ***PF Flags 1*** flag and FUSE pin is driven low.

Table C-69. Fuse Flag

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Fuse Flag	hex	2	0x0000	0xffff	0x0000	

C.5.1.3 PF Voltage

When a permanent failure is detected *Voltage* is captured and stored into in ***PF Voltage***.

Table C-70. PF Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Voltage	unsigned integer	2	0	32767	0	mV

C.5.1.4 PF C4 Voltage

When a permanent failure is detected *CellVoltage4* is captured and stored in ***PF C4 Voltage***.

Table C-71. PF C4 Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF C4 Voltage	unsigned integer	2	0	9999	0	mV

C.5.1.5 PF C3 Voltage

When a permanent failure is detected *CellVoltage3* is captured and stored in ***PF C3 Voltage***.

Table C-72. PF C3 Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF C3 Voltage	unsigned integer	2	0	9999	0	mV

C.5.1.6 PF C2 Voltage

When a permanent failure is detected *CellVoltage2* is captured and stored in ***PF C2 Voltage***.

Table C-73. PF C2 Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF C2 Voltage	unsigned integer	2	0	9999	0	mV

C.5.1.7 PF C1 Voltage

When a permanent failure is detected *CellVoltage1* is captured and stored in ***PF C1 Voltage***.

Table C-74. PF C1 Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF C1 Voltage	unsigned integer	2	0	9999	0	mV

C.5.1.8 PF Current

When a permanent failure is detected the pack *Current* is captured and stored in ***PF Current***.

Table C-75. PF Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Current	signed integer	2	–32768	32767	0	mA

C.5.1.9 PF Temperature

When a permanent failure is detected the pack *Temperature* is captured and stored in ***PF Temperature***.

Table C-76. PF Temperature

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Temperature	signed integer	2	–9999	9999	0	0.1 K

C.5.1.10 PF Batt Stat

When a permanent failure is detected the *BatteryStatus* flags are captured and stored in ***PF Batt Stat***.

Table C-77. PF Batt Stat

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Batt Stat	unsigned integer	2	0x0000	0xffff	0x0000	

C.5.1.11 PF RC-mAh

When a permanent failure is detected *RemainingCapacity,* in mAh, is captured and stored into in ***PF RC-mAh***.

Table C-78. PF RC-mAh

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF RC-mAh	unsigned integer	2	0	32767	0	mAh

C.5.1.12 PF FCC

When a permanent failure is detected FullChargeCapacity, in mAh, is captured and stored in ***PF FCC***.

Table C-79. PF FCC

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF FCC	unsigned integer	2	0	32767	0	mAh

C.5.1.13 PF Chg Status

When a permanent failure is detected the *ChargingStatus* flags are captured and stored in ***PF Chg Status***.

Table C-80. PF Chg Status

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Chg Status	hex	2	0x0000	0xffff	0x0000	

C.5.1.14 PF Safety Status

When a permanent failure is detected, the *SafetyStatus* flags are captured and stored in ***PF Safety Status***.

Table C-81. PF Safety Status

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Safety Status	hex	2	0x0000	0xffff	0x0000	

C.5.1.15 PF DOD

When a permanent failure is detected, DOD (Depth of Discharge), is captured and stored into ***PF DOD***.

Table C-82. PF DOD

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF DOD	signed integer	2	0	32767	0	

C.5.1.16 PF Flags 2

On the first occurrence of a permanent failure, when PFStatus changes from 0x0000, the *PFStatus* flags will be captured and stored in this value. Only the first permanent failure flag in a failure sequence is stored in ***PF Flags 2*** to indicate the cause of the permanent failure. All permanent failure flags in the failure sequence are stored in ***PF Flags 1***.

Table C-83. PF Flags 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF Flags 2	hex	2	0x0000	0x8000	0x0000	

C.5.2 AFE Regs

When the SN8765 detects a permanent failure a complete copy of the integrated AFE register values is stored ***AFE Regs***.

Table C-84. AFE Regs

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Status	hex	1	0x00	0xff	0x00	
AFE State						
AFE Output						
AFE Output Status						
AFE Cell Select						
AFE OLV						
AFE OLT						
AFE SCC						
AFE SCD						
AFE Function						

C.6 Gas Gauging

C.6.1 CEDV Cfg

C.6.1.1 CEDV Config

This register configures various features of the CEDV gauging.

Table C-85. CEDV Config

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CEDV Config	hex	1	0x00	0x70	0x00	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
CEDV Config	0	RSVD	SC	CEDV	EDVV	RSVD	RSVD	RSVD

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-1. CEDV Config

SC — This bit enables learning cycle optimization for a Smart Charger or independent charge.

0 (default) = Learning cycle is optimized for Smart Charger.
1 = Learning cycle is optimized for independent charger.

CEDV — This bit determines whether the SN8765 implements automatic EDV compensation to calculate the EDV0, EDV1, and EDV2 thresholds base on rate, temperature, and capacity. If the bit is cleared, the SN8765 uses the fixed values programmed in data flash for EDV0, EDV1, and EDV2. If the bit is set, the SN8765 calculates EDV0, EDV1, and EDV2.

0 (default) = EDV compensation is disabled.
1 = EDV compensation is enabled.

EDVV — This bit selects whether EDV termination is to be done with regard to voltage or the lowest single-cell voltage.

0 (default) = EDV conditions are determined on the basis of the lowest single-cell voltage.
1 = EDV conditions are determined on the basis of voltage.

C.6.1.2 EMF

This value is the no-load cell voltage higher than the highest cell EDV threshold computed.

Table C-86. EMF

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
EMF	unsigned integer	2	0	65535	3743	mV

C.6.1.3 EDV C0 Factor

This value is the no-load, capacity related EDV adjustment factor.

Table C-87. C0

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
C0	unsigned integer	2	0	65535	149	

C.6.1.4 EDV R0 Factor

This value is the first order rate dependency factor, accounting for battery impedance adjustment.

Table C-88. R0

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
R0	unsigned integer	2	0	65535	867	

C.6.1.5 EDV T0 Rate Factor

This value adjusts the variation of impedance with battery temperature.

Table C-89. T0

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
T0	unsigned integer	2	0	65535	4030	

C.6.1.6 EDV R1 Rate Factor

This value adjusts the variation of impedance with battery capacity.

Table C-90. R1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
R1	unsigned integer	2	0	65535	316	

C.6.1.7 EDV TC Factor

This value adjusts the variation of impedance for cold temperatures (T<23°C).

Table C-91. TC

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TC	unsigned integer	1	0	255	9	

C.6.1.8 EDV C1 Factor

This value is the desired reserved battery capacity remaining at EDV0.

Table C-92. C1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
C1	unsigned integer	1	0	255	0	

C.6.1.9 EDV Age Factor

This value allows the SN8765 to correct the EDV detection algorithm to compensate for cell aging.

Table C-93. Age Factor

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Age Factor	unsigned integer	1	0	255	0	

C.6.1.10 Fixed EDV0

This value is the EDV0 threshold if ***[CEDV]*** is clear in ***CEDV Config***.

Table C-94. Fixed EDV0

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Fixed EDV0	unsigned integer	2	0	65535	3031	mV

C.6.1.11 Fixed EDV1

This value is the EDV1 threshold if ***[CEDV]*** is clear in ***CEDV Config***.

Table C-95. Fixed EDV1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Fixed EDV1	unsigned integer	2	0	65535	3385	mV

C.6.1.12 Fixed EDV2

This value is the EDV2 threshold if ***[CEDV]*** is clear in ***CEDV Config***.

Table C-96. Fixed EDV2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Fixed EDV2	unsigned integer	2	0	65535	3501	mV

C.6.1.13 Low Temp

This value specifies the minimum temperature above which a discharge must maintain to qualify for capacity learning.

Table C-97. Low Temp

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Low Temp	unsigned integer	1	0	255	119	0.1C

C.6.1.14 Overload Current

This value sets the upper current range for EDV detection, beyond which EDV detection is halted.

Table C-98. Overload Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Overload Current	unsigned integer	2	0	65535	5000	mA

C.6.1.15 Self Discharge Rate

This value is the estimated self-discharge rate of the battery.

Table C-99. Self Discharge Rate

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Self Discharge Rate	unsigned integer	1	0	255	20	0.01%/day

C.6.1.16 Electronics Load

This value should be set to a discharge rate determined by the battery electronics current consumption.

Table C-100. Electronics Load

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Electronics Load	unsigned integer	1	0	255	0	3 μA

C.6.1.17 Battery Low %

This value should be set to be corresponding to a capacity value that correspond to the first or highest voltage point, EDV2. It should be chosen where the capacity sensitivity to voltage is very detectable. It is a non-measured portion of the overall learned *FullChargeCapacity*. This value is an unsigned integer when programmed into the data flash memory, and has a unit of %/2.56/256. When reading/writing this value in the evaluation software, it is in a unit of %/2.56. If the target ***Battery Low %*** is changed in your design, make sure that the initial value of ***DOD at EDV2*** is also adjusted accordingly. See Section C.4.1.16 for more information.

Table C-101. Battery Low %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Battery Low %	unsigned integer	2	0	65535	4608	%/2.56/256

- DF:SBS Configuration:Data(48):DOD at EDV2(28)

C.6.1.18 Near Full

This value sets the start of discharge condition for qualified capacity learning.

Table C-102. Near Full

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Near Full	unsigned integer	2	0	65535	200	mAh

C.6.2 Current Thresholds

C.6.2.1 Dsg Current Threshold

The SN8765 enters discharge mode from relaxation mode or charge mode if *Current* < (–) ***Dsg Current Threshold***.

Table C-103. Dsg Current Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Dsg Current Threshold	unsigned integer	2	0	2000	100	mA

C.6.2.2 Chg Current Threshold

The SN8765 enters charge mode from relaxation mode or discharge mode if *Current* > ***Chg Current Threshold***.

Table C-104. Chg Current Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Chg Current Threshold	unsigned integer	2	0	2000	50	mA

C.6.2.3 Quit Current

The SN8765 enters relaxation mode from charge mode if *Current* goes below ***Quit Current*** for ***Chg Relax Time***. The SN8765 enters relaxation mode from discharge mode if *Current* goes above ***(–)Quit Current*** for ***Dsg Relax Time***.

Table C-105. Quit Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Quit Current	unsigned integer	2	0	1000	10	mA

C.6.2.4 Dsg Relax Time

The SN8765 enters relaxation mode from discharge mode if *Current* goes above ***(–)Quit Current*** for at least ***Dsg Relax Time***.

Table C-106. Dsg Relax Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Dsg Relax Time	unsigned integer	1	0	255	1	s

C.6.2.5 Chg Relax Time

The SN8765 enters relaxation mode from charge mode if *Current* goes below ***Quit Current*** for at least ***Chg Relax Time.***

Table C-107. Chg Relax Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Chg Relax Time	unsigned integer	1	0	255	60	s

C.6.3 State

C.6.3.1 Qmax Cell 0..3

These values define the maximum chemical capacity for each cell used for the capacity calculation. The value should be set to be equal or slightly greater than ***Full Charge Capacity***. Typically, set these values to a room temperature, low-rate (0.2 C ~ 0.5 C) discharge capacity, usually available from the battery cell datasheet. If the data is not available, set this to ***Full Charge Capacity***.

Table C-108. Qmax Cell 0..3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Qmax Cell 0	unsigned integer	2	0	32767	4400	mAh
Qmax Cell 1		2	0	32767	4400	mAh
Qmax Cell 2		2	0	32767	4400	mAh
Qmax Cell 3		2	0	32767	4400	mAh

C.6.3.2 Qmax Pack

This value defines the maximum chemical capacity of the battery pack. Set this value to the smallest value of ***Qmax Cell 0*** .. ***3***. This value is used to calculate the initial remaining capacity of the battery pack upon a full reset.

Table C-109. Qmax Pack

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Qmax Pack	unsigned integer	2	0	32767	4400	mAh

C.7 Charge Control

C.7.1 Charge Control SMBus Broadcasts

All broadcasts to a host or a smart charger are enabled by the ***[BCAST]*** bit. If the ***[HPE]*** bit is enabled, master-mode broadcasts to the host address are PEC enabled. If the ***[CPE]*** bit is enabled, master-mode broadcasts to the Smart-Charger address are PEC enabled. When broadcast is enabled, the following broadcasts are sent:

- *ChargingVoltage* and *ChargingCurrent* broadcasts are sent to the Smart-Charger device address (0x12) every 10 to 60 seconds.
- If any of the *[OCA], [TCA], [OTA], [TDA], [RCA], [RTA]* flags are set, the *AlarmWarning* broadcast is sent to the host device address (0x14) every 10 seconds. Broadcasts stop when all flags above have been cleared.
- If any of the *[OCA], [TCA], [OTA] or [TDA]* flags are set, the *AlarmWarning* broadcast is sent to Smart-Charger device address every 10 seconds. Broadcasts stop when all flags above have been cleared.

C.7.2 Charge Temperature Cfg

C.7.2.1 JT1

JT1 is the lower bound of the low temperature charging range. If *Temperature* is below the ***JT1*** threshold, then *[TR1]* flag in *TempRange* is set and charging is inhibited from starting. If SN8765 is in charge mode (*[DSG]* = 0), then charging is suspended, *[CHGSUSP]* flag in *ChargingStatus* is set, and *ChargingCurrent* and *ChargingVoltage* are set to 0.

Table C-110. JT1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
JT1	Integer	2	–400	1200	0	0.1°C

C.7.2.2 JT2

JT2 is the upper bound of the low temperature charging range and the lower bound of standard temperature charging range 1. If *Temperature* is between ***JT1*** and ***JT2***, then *[TR2]* flag in *TempRange* is set, *Charging Voltage* is set to ***LT Chg Voltage*** and *ChargingCurrent* is set to ***LT Chg Current 1***, ***LT Chg Current 2***, or ***LT Chg Current 3***, depending on cell voltage (see Section 1.5.2).

Table C-111. JT2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
JT2	Integer	2	–400	1200	120	0.1°C

C.7.2.3 JT2a

JT2a is the upper bound of the standard temperature charging range1 and the lower bound of standard temperature charging range 2. If *Temperature* is between ***JT2*** and ***JT2a***, then *[TR2A]* flag in *TempRange* is set, *Charging Voltage* is set to ***ST1 Chg Voltage*** and *ChargingCurrent* is set to ***ST1 Chg Current 1***, ***ST1 Chg Current 2***, or ***ST1 Chg Current 3***, depending on cell voltage (see Section 1.5.2).

Table C-112. JT2a

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
JT2a	Integer	2	–400	1200	300	0.1°C

C.7.2.4 JT3

JT3 is the upper bound of the standard temperature charging range 2, and the lower bound of high temperature charging range. If *Temperature* is between ***JT2a*** and ***JT3***, then *[TR3]* flag in *TempRange* is set, *Charging Voltage* is set to ***ST2 Chg Voltage*** and *ChargingCurrent* is set to ***ST2 Chg Current 1***, ***ST2 Chg Current 2***, or ***ST2 Chg Current 3***, depending on cell voltage (see Section 1.5.2).

If *Temperature* is greater than ***JT3*** and charging did not start ([DSG] = 1), then charging is inhibited from starting.

Table C-113. JT3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
JT3	Integer	2	–400	1200	450	0.1°C

C.7.2.5 JT4

JT4 is the upper bound of the high temperature charging range. If *Temperature* is between ***JT3*** and ***JT4***, then *[TR4]* flag in *TempRange* is set, *Charging Voltage* is set to ***HT Chg Voltage*** and *Charging Current* is set to ***HT Chg Current 1, HT Chg Current 2***, or ***HTChg Current 3***, depending on cell voltage (see Section 1.5.2).

If *Temperature* is greater than ***JT4*** then [*[TR5]*] flag in *TempRange* is set. If SN8765 is in charge mode (*[DSG]* = 0), then charging is suspended, *[CHGSUSP]* flag in *ChargingStatus* is set, and *ChargingCurrent* and *ChargingVoltage* are set to 0.

Table C-114. JT4

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
JT4	Integer	2	–400	1200	550	0.1°C

C.7.2.6 Temp Hys

If, in charge inhibit mode, the *Temperature* rises above ***JT1*** + ***Temp Hys*** or falls below ***JT3–Temp Hys*** charging is allowed to be resumed and *[XCHG]* in *ChargingStatus* is cleared. If the ***[NR]*** flag is cleared the fault condition can be cleared by removing and reinserting the battery pack.

Table C-115. Temp Hys

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Temp Hys	signed integer	2	0	100	10	0.1°C

C.7.3 Pre-Charge Cfg

C.7.3.1 Pre-chg Current

The SN8765 sets the *ChargingCurrent* to the ***Pre-chg Current*** value when in PRECHARGE mode.

Table C-116. Pre-chg Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Pre-chg Current	unsigned integer	2	0	2000	250	mA

C.7.3.2 Pre-chg Voltage

The SN8765 enters PRECHARGE mode and sets the *[PCHG]* flag in *ChargingStatus* if any *CellVoltage4..1* drops below the ***Pre-chg Voltage*** threshold. In this mode, *Charging Voltage* is set to ***LT Chg Voltage***, and *Charging Current* is set to ***Pre-chg Current***.

Table C-117. Pre-chg Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Pre-chg Voltage	unsigned integer	2	0	20000	3000	mV

C.7.3.3 Recovery Voltage

The SN8765 enters FAST CHARGE mode from PRECHARGE mode and sets either the *[LTCHG], [ST1CHG], [ST2CHG], or [HTCHG]* flag in *ChargingStatus* if all *CellVoltage4..1* are equal to or higher than the ***Recovery Voltage***.

Table C-118. Recovery Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Recovery Voltage	unsigned integer	2	0	20000	3100	mV

C.7.4 Charge Cfg

C.7.4.1 LT Chg Voltage

The SN8765 sets *ChargingVoltage* to the ***LT Chg Voltage*** value when *Temperature* in is the low temperature charging range (*[TR2]* = 1).

Table C-119. LT Chg Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LT Chg Voltage	Integer	2	0	20,000	12,000	mV

C.7.4.2 LT Chg Current 1

The SN8765 sets *ChargingCurrent* to the ***LT Chg Current 1*** value when *Temperature* is in the low temperature charging range (*[TR2]* = 1) and max(*CellVoltage4..1*) is in the CVR1 range.

Table C-120. LT Chg Current 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LT Chg Current 1	Integer	2	0	20,000	2,000	mA

C.7.4.3 LT Chg Current 2

The SN8765 sets *ChargingCurrent* to the ***LT Chg Current 2*** value when *Temperature* in the low temperature charging range (*[TR2]* = 1) and max(*CellVoltage4..1*) is in the CVR2 range.

Table C-121. LT Chg Current 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LT Chg Current 2	Integer	2	0	20,000	2,000	mA

C.7.4.4 LT Chg Current 3

The SN8765 sets *ChargingCurrent* to the ***LT Chg Current 3*** value when *Temperature* in the low temperature charging range (*[TR2]* = 1) and max(*CellVoltage4..1*) is in the CVR3 range.

Table C-122. LT Chg Current 3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LT Chg Current 3	Integer	2	0	20,000	2,000	mA

C.7.4.5 ST1 Chg Voltage

The SN8765 sets *ChargingVoltage* to the ***ST1 Chg Voltage*** value when *Temperature* is in the standard temperature charging range 1 (*[TR2A]* = 1).

Table C-123. ST1 Chg Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST1 Chg Voltage	Integer	2	0	20,000	12,600	mV

C.7.4.6 ST1 Chg Current 1

The SN8765 sets *ChargingCurrent* to the ***ST1 Chg Current 1*** value when *Temperature* is in the standard temperature charging range 1 (*[TR2A]* = 1) and max(*CellVoltage4..1*) is in the CVR1 range.

Table C-124. ST1 Chg Current 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST1 Chg Current 1	Integer	2	0	20,000	4,000	mA

C.7.4.7 ST1 Chg Current 2

The SN8765 sets *ChargingCurrent* to the ***ST1 Chg Current 2*** value when *Temperature* is in the standard temperature charging range 1 (*[TR2A]* = 1) and max(*CellVoltage4..1*) is in the CVR2 range.

Table C-125. ST1 Chg Current 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST1 Chg Current 2	Integer	2	0	20,000	4,000	mA

C.7.4.8 ST1 Chg Current 3

The SN8765 sets *ChargingCurrent* to the ***ST1 Chg Current 3*** value when *Temperature* is in the standard temperature charging range 1 (*[TR2A]* = 1) and max(*CellVoltage4..1*) is in the CVR3 range.

Table C-126. ST1 Chg Current 3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST1 Chg Current 3	Integer	2	0	20,000	4,000	mA

C.7.4.9 ST2 Chg Voltage

The SN8765 sets *ChargingVoltage* to the ***ST2 Chg Voltage*** value when *Temperature* is in the standard temperature charging range 2 (*[TR3]* = 1).

Table C-127. ST2 Chg Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST2 Chg Voltage	Integer	2	0	20,000	12,600	mA

C.7.4.10 ST2 Chg Current 1

The SN8765 sets *ChargingCurrent* to the ***ST2 Chg Current 1*** value when *Temperature* is in the standard temperature charging range 2 (*[TR3]* = 1) and max(*CellVoltage4..1*) is in the CVR1 range.

Table C-128. ST2 Chg Current 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST2 Chg Current 1	Integer	2	0	20,000	4,000	mA

C.7.4.11 ST2 Chg Current 2

The SN8765 sets *ChargingCurrent* to the ***ST2 Chg Current 2*** value when *Temperature* is in the standard temperature charging range 2 (*[TR3]* = 1) and max(*CellVoltage4..1*) is in the CVR2 range.

Table C-129. ST2 Chg Current 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST2 Chg Current 2	Integer	2	0	20,000	4,000	mA

C.7.4.12 ST2 Chg Current 3

The SN8765 sets *ChargingCurrent* to the ***ST2 Chg Current 3*** value when *Temperature* is in the standard temperature charging range 2 (*[TR3]* = 1) and max(*CellVoltage4..1*) is in the CVR3 range.

Table C-130. ST2 Chg Current 3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST2 Chg Current 3	Integer	2	0	20,000	4,000	mA

C.7.4.13 HT Chg Voltage

The SN8765 sets *ChargingVoltage* to the ***HT Chg Voltage*** value when *Temperature* is in the high temperature charging range (*[TR4]* = 1).

Table C-131. HT Chg Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
HT Chg Voltage	Integer	2	0	20,000	12,570	mV

C.7.4.14 HT Chg Current 1

The SN8765 sets *ChargingCurrent* to the ***HT Chg Current 1*** value when *Temperature* is in the high temperature charging range (*[TR4]* = 1) and max(*CellVoltage4..1*) is in the CVR1 range.

Table C-132. HT Chg Current 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
HT Chg Current 1	Integer	2	0	20,000	3,800	mA

C.7.4.15 HT Chg Current 2

The SN8765 sets *ChargingCurrent* to the ***HT Chg Current 2*** value when *Temperature* is in the high temperature charging range (*[TR4]* = 1) and max(*CellVoltage4..1*) is in the CVR2 range.

Table C-133. HT Chg Current 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
HT Chg Current 2	Integer	2	0	20,000	3,800	mA

C.7.4.16 HT Chg Current 3

The SN8765 sets *ChargingCurrent* to the ***HT Chg Current 3*** value when *Temperature* is in the high temperature charging range (*[TR4]* = 1) and max(*CellVoltage4..1*) is in the CVR3 range.

Table C-134. HT Chg Current 3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
HT Chg Current 3	Integer	2	0	20,000	3,800	mA

C.7.4.17 Cell Voltage Threshold 1

The SN8765 is in cell voltage range 1 (CVR1) when max(*CellVoltage4..1*) < ***Cell Voltage Threshold 1***.

Table C-135. Cell Voltage Threshold 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Voltage Threshold 1	Integer	2	0	5,000	3,900	mV

C.7.4.18 Cell Voltage Threshold 2

The SN8765 enters cell voltage range 2 (CVR2) when ***Cell Voltage Threshold 1*** < max(*CellVoltage4..1*) < ***Cell Voltage Threshold 2***. The SN8765 enters cell voltage range 3 (CVR3) when max(*CellVoltage4..1*) > ***Cell Voltage Threshold 2***.

Table C-136. Cell Voltage Threshold 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Voltage Threshold 2	Integer	2	0	5,000	4,000	mV

C.7.4.19 Cell Voltage Thresh Hys

Cell Voltage Thresh Hys is used to make sure that transitions between cell voltage ranges are not affected by small transients. For example, if the current cell voltage range is CVR2 and cell voltage goes above ***Cell Voltage Threshold 2*** then CVR3 is entered. Cell voltage has to fall below ***Cell Voltage Threshold 2*** – ***Cell Voltage Thresh Hys*** for the SN8765 to go back to CVR2 range.

Table C-137. Cell Voltage Thresh Hys

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Voltage Thresh Hys	Integer	2	0	1,000	10	mV

C.7.5 Termination Cfg.

C.7.5.1 Taper Current

If battery *Current* falls below ***Taper Current*** for 2 consecutive ***Current Taper Window*** time periods during charging and *Voltage* is equal to or higher than ***Charging Voltage–Taper Voltage*** the SN8765 recognizes valid primary charge termination.

Table C-138. Taper Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Taper Current	unsigned integer	2	0	1000	250	mA

C.7.5.2 Taper Voltage

For valid primary charge termination, pack *Voltage* must be equal to or higher than ***Charging Voltage–Taper Voltage***.

Table C-139. Taper Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Taper Voltage	unsigned integer	2	0	1000	300	mV

C.7.5.3 Current Taper Window

For a valid primary charge termination, *Current* must fall below ***Taper Current*** threshold for 2 consecutive ***Current Taper Window*** time periods.

Table C-140. Current Taper Window

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Current Taper Window	unsigned integer	1	0	240	40	s

C.7.5.4 TCA Set %

When set between 0% and 100%, *[TCA]* in *BatteryStatus* is set if *RelativeStateOfCharge* is equal to or above ***TCA Set %***. Set to –1 to disable this function. If set to –1, the *[TCA]* flag is set on primary charge termination and *ChargingCurrent* is set to 0.

Table C-141. TCA Set %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TCA Set %	signed integer	1	–1	100	–1	%

C.7.5.5 TCA Clear %

When set between 0% and 100%, *[TCA]* in *BatteryStatus* is cleared if *RelativeStateOfCharge* is below ***TCA Clear %***. Set to –1 to disable this function.

Table C-142. TCA Clear %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
TCA Clear %	signed integer	1	–1	100	95	%

C.7.5.6 FC Set %

When set between 0% and 100%, *[FC]* in *BatteryStatus* is set if *RelativeStateOfCharge* is equal to or above ***FC Set %***. Set to –1 to disable this function.

Table C-143. FC Set %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FC Set %	signed integer	1	–1	100	–1	%

C.7.5.7 FC Clear %

When set between 0% and 100%, *[FC]* in *BatteryStatus* is cleared if *RelativeStateOfCharge* reaches or falls below ***FC Clear %***. Set to –1 to disable this function. It is recommended, however, not to set ***FC Clear %*** to –1.

Table C-144. FC Clear %

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FC Clear %	signed integer	1	–1	100	98	%

C.7.6 Cell Balancing Cfg

C.7.6.1 Cell Balance Threshold

This value sets the minimum voltage in mV that each cell must achieve to initiate cell balancing.

Table C-145. Cell Balance Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Balance Threshold	integer	2	0	5000	3900	mV

C.7.6.2 Cell Balance Window

This value sets in mV the amount that the cell balance threshold increases during cell balancing.

Table C-146. Cell Balance Window

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Balance Window	integer	2	0	5000	100	mV

C.7.6.3 Cell Balance Min

This value sets in mV the cell differential that must exist to initiate cell balancing.

Table C-147. Cell Balance Min

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Balance Min	unsigned integer	1	0	5000	40	mV

C.7.6.4 Cell Balance Interval

This value sets the cell balancing time interval in seconds.

Table C-148. Cell Balance Interval

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Balance Interval	unsigned integer	1	0	240	20	s

C.7.7 Charging Faults

C.7.7.1 Over Charging Voltage

If the battery pack *Voltage* is equal to or greater than *ChargingVoltage* + ***Over Charging Voltage*** for a time period greater than ***Over Charging Volt Time***, the *[OCHGV]* flag is set and the CHG FET and ZVCHG FET (if used) are turned off if ***[OCHGV]*** is also set in ***Charge Fault Cfg***.

Table C-149. Over Charging Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Charging Voltage	unsigned integer	2	0	3000	500	mV

C.7.7.2 Over Charging Volt Time

If the battery pack *Voltage* is equal to or greater than *ChargingVoltage* + ***Over Charging Voltage*** for a time period greater than ***Over Charging Volt Time*** the *[OCHGV]* flag is set and the CHG FET and ZVCHG FET (if used) are turned off if ***[OCHGV]*** is also set in ***Charge Fault Cfg***. The SN8765 recovers if the battery pack *Voltage* is equal to or below ***Charging Voltage***.

Table C-150. Over Charging Volt Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Charging Volt Time	unsigned integer	1	0	240	2	s

C.7.7.3 Over Charging Current

If the current is equal to or greater than the sum of *ChargingCurrent* and ***Over Charging Current*** for a time period greater than ***Over Charging Curr Time*** the SN8765 goes into an over charging current error, *[OCHGI]* in *ChargingStatus* set and, if ***[OCHGI]*** in ***Charge Fault Cfg*** is set, the CHG FET turns off and the ZVCHG FET (if used) is turned on. If the ZVCHG FET is not used the CHG FET remains on, regardless of the bits set in ***Charge Fault Cfg***, because it acts as the ZVCHG FET.

Table C-151. Over Charging Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Charging Current	unsigned integer	2	0	2000	500	mA

C.7.7.4 Over Charging Curr Time

If the *Current* is equal to or greater than the sum of *ChargingCurrent* and ***Over Charging Current*** for a time period greater than ***Over Charging Curr Time*** the SN8765 goes into over charging current error, *[OCHGI]* in *ChargingStatus* set and, if ***[OCHGI]*** in ***Charge Fault Cfg*** is set, the CHG FET turns off and the ZVCHG FET (if enabled, i.e. ***[ZVCHG1]:[ZVCHG2]*** = 0:0 in ***Operation Cfg A***) is turned on. If the ZVCHG FET is not used the CHG FET remains on, regardless of the bits set in ***Charge Fault Cfg***. The SN8765 recovers if *AverageCurrent* is equal to or lower than the ***Over Charging Curr Recov*** value.

Table C-152. Over Charging Curr Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Charging Curr Time	unsigned integer	1	0	240	2	s

C.7.7.5 Over Charging Curr Recov

The SN8765 recovers from an over charging current fault if *AverageCurrent* is equal to or lower than ***Over Charging Curr Recov***. On recovery, *[OCHGI]* in *ChargingStatus* is reset and the CHG and ZVCHG FETs return to their previous states.

Table C-153. Over Charging Curr Recov

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Charging Curr Recov	unsigned integer	2	0	2000	100	mA

C.7.7.6 Depleted Voltage

The SN8765 goes into a depleted voltage fault and sets *[XCHGLV]* if the charger is present (*PackVoltage* > ***AFE Shutdown Voltage***) and *Voltage* is equal to or lower than ***Depleted Voltage*** for a period equal to or greater than ***Depleted Voltage Time***. The DSG FET is turned off and the CHG and ZVCHG FETs are set according to ***[ZVCHG1,ZVCHG0]*** bits if ***[CS_XCHGLV]*** is set in ***Charge Fault Cfg.***

Table C-154. Depleted Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Depleted Voltage	unsigned integer	2	0	16000	6000	mV

C.7.7.7 Depleted Voltage Time

The SN8765 goes into a depleted voltage fault and sets *[XCHGLV]* if the charger is present and pack *Voltage* is equal to or lower than ***Depleted Voltage*** for a period equal to or greater than ***Depleted Voltage Time***. If ***[CS_XCHGLV]*** is set in ***Charge Fault Cfg*** the DSG FET is turned off and the CHG and ZVCHG FETs are set according to their pre-charge settings.

Table C-155. Depleted Voltage Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Depleted Voltage Time	unsigned integer	1	0	240	2	s

C.7.7.8 Depleted Recovery

The SN8765 recovers from a depleted voltage fault if pack *Voltage* is equal to or higher than the ***Depleted Recovery*** threshold. On recovery, *[OCHGLV]* is reset and the DSG FET, CHG FET, and ZVCHG FET return to their previous states.

Table C-156. Depleted Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Depleted Recovery	unsigned integer	2	0	16000	6500	mV

C.7.7.9 Over Charge Capacity

The SN8765 goes into an overcharge fault and sets the *[OC]* flag in *ChargingStatus* if the internal counted remaining capacity exceeds *FullChargeCapacity* + ***Over Charge Capacity***. The CHG FET and ZVCHG FET (if used) are also turned of if the ***[OC]*** bit is set in ***Charge Fault Cfg***.

Table C-157. Over Charge Capacity

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Charge Capacity	unsigned integer	2	0	4000	300	mAh

C.7.7.10 Over Charge Recovery

The SN8765 recovers from an over charge in non-removable battery mode(***[NR]*** = 1) if it is continuously discharged by an amount of ***Over Charge Recovery*** charge.

Table C-158. Over Charge Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Charge Recovery	unsigned integer	2	0	100	2	mAh

C.7.7.11 FC-MTO

If charge *Current* is equal to or greater than ***Chg Current Threshold*** for ***FC-MTO*** time period the SN8765 generates a FAST CHARGE mode time out fault and sets the *[FCMTO]* flag. The CHG FET and ZVCHG FET (if used) are also turned of if ***[FCMTO]*** is set in ***Charge Fault Cfg***. Set to 0 to disable ***FC-MTO***.

Table C-159. FC-MTO

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FC-MTO	unsigned integer	2	0	65535	10800	s

C.7.7.12 PC-MTO

If charge *Current* is equal to or greater than ***Chg Current Threshold*** for ***PC-MTO*** time period the SN8765 generates a precharge mode-time out error and sets the *[PCMTO]* flag. The CHG FET and ZVCHG FET (if used) are also turned of if ***[PCMTO]*** is set in ***Charge Fault Cfg***. Set to 0 to disable ***PC-MTO***.

Table C-160. PC-MTO

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PC-MTO	unsigned integer	2	0	65535	3600	s

C.7.7.13 Charge Fault Cfg

This register sets the behavior of the charge, discharge, and precharge FETs in fault conditions.

Table C-161. Charge Fault Cfg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Charge Fault Cfg	hex	1	0	0x3f	0x00	

7	6	5	4	3	2	1	0
RSVD	RSVD	PCMTO	FCMTO	OCHGV	OCHGI	OC	CS_XCHGLV
R	R	R/W	R/W	R/W	R/W	R/W	R/W

LEGEND: R/W = Read/Write; R = Read only;–*n* = value after reset; RSVD = Reserved and **must** be programmed to 0.

Figure C-2. Charge Fault Cfg Register

PCMTO — If set, CHG FET and ZVCHG FET (if used as the precharge FET) are turned off when pre-charge time out fault occurs.

FCMTO — If set, CHG FET and ZVCHG FET (if used as the precharge FET) are turned off when fast charge time out fault occurs.

OCHGV — If set, CHG FET and ZVCHG FET (if used as the precharge FET) are turned off when charge voltage fault occurs.

OCHGI — If set, CHG FET is turned off and ZVCHG FET (if used as the precharge FET) is turned on when charge current fault occurs. If ZVCHG FET is not used as the precharge FET, CHG FET remains on, regardless of this bit.

OC — If set, CHG FET and ZVCHG FET (if used as the precharge FET) are turned off when over charge fault occurs.

CS_XCHGLV — If set, DSG FET is turned off when battery depleted fault occurs.

C.8 Configuration

C.8.1 Registers

C.8.1.1 Operation Cfg A

This register enables, disables or configures various features of the SN8765.

Table C-162. Operation Cfg A

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Operation Cfg A	Hex	2	0x0000	0xffff	0x0f29	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	LEDR	LEDRCA	CHGLED	DMODE	LED1	LED0	CC1	CC0
Low Byte	RSVD	RSVD	SLEEP	TEMP1	TEMP0	SLED	ZVCHG1	ZVCHG0

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-3. Operation Cfg A

LEDR — Enables activation of the LED display on device-reset exit.

0 = LED display is not activated on exit from device reset. (default)
1 = LED display is activated (simulates a $\overline{\text{DISP}}$ transition) on exit from device reset.

LEDRCA — Enables flashing of the LED display when the *[RCA]* flag in *BatteryStatus* is set.

0 = The LED display is not activated when *[RCA]* is set. (default)

1 = If the LED display is activated when *[RCA]* is set, the display flashes with ***LED Flash Period***.

CHGLED — Enables the LED display while charging.

0 = Display is not activated by charging; requires push-button event or SMBus command. (default)

1 = Display is active during charging.

DMODE — This bit sets the display to show the *RelativeStateOfCharge* or *AbsoluteStateOfCharge* LED representation.

0 = Display reflects RelativeStateOfCharge (default)

1 = Display reflects AbsoluteStateOfCharge

LED1, LED0 — These bits configure the number of LEDs and threshold levels used in the LED display.

0,0 = User defined threshold

0,1 = 3 LEDs used

1,0 = 4 LEDs used

1,1 = 5 LEDs used (default)

CC1, CC0 — These bits configure the SN8765 for the number of series cells in the battery stack.

0,0 = Reserved

0,1 = 2 cells

1,0 = 3 cells

1,1 = 4 cells (default)

SLEEP — Enables the SN8765 to enter SLEEP mode if the SMBus lines are low.

0 = The SN8765 never enters SLEEP mode.

1 = The SN8765 enters SLEEP mode under normal Sleep entry criteria (default).

TEMP1, TEMP0 — These bits configure the source of the *Temperature* function.

0,0 = Internal Temperature Sensor

0,1 = TS1 Input (default)

1,0 = TS2 Input

1,1 = Average of TS1 and TS2 Inputs

SLED — Enables the SN8765 display to be used in serial or parallel mode. The PF error code display does not work in serial LED mode.

0 = Display is in parallel LED mode (default).

1 = Display is in serial LED mode.

ZVCHG1, ZVCHG0 — These bits enable or disable the use of the ZVCHG or CHG FET in Zero-Volt/Precharge modes.

0,0 = ZVCHG
0,1 = CHG (default)
1,0 = GPOD
1,1 = No Action

C.8.1.2 Operation Cfg B

This register enables, disables, or configures various features of the SN8765.

Table C-163. Operation Cfg B

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Operation Cfg B	Hex	2	0x0000	0xffff	0x6440	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	PDF1	PDF0	RESCAP	NCSMB	NRCHG	CSYNC	CHGTERM	CCT
Low Byte	CHGSUSP	OTFET	CHGFET	CHGIN	NR	CPE	HPE	BCAST

Figure C-4. Operation Cfg B

PDF1, PDF0— Configures the Permanent Failure LED display. This function is disabled if the ***[SLED]*** bit in ***Operation Cfg A*** is set.

0,0 = PF Error Code is not available.
0,1 = PF Error Code is activated after state of charge display if $\overline{\text{DISP}}$ is held low for ***LED Hold Time***. (default)
1,0 = PF Error Code is not available.
1,1 = PF Error Code is automatically activated after state-of charge-display.

RESCAP— This bit configures the compensation model of the Impedance Track algorithm for reserve capacity calculation.

0 = Light Load Compensation
1 = Average Load Compensation defined by ***Load Select*** (default)

NCSMB— Disables extended SMBUS $t_{TIMEOUT}$ feature. Use this bit with caution.

0 = Normal SMBUS $t_{TIMEOUT}$ (default)
1 = Extended SMBUS $t_{TIMEOUT}$

NRCHG— Enables the CHG FET to remain on during sleep when the SN8765 is in non-removable battery mode.

0 = The CHG FET turns off in SLEEP Mode if the ***[NR]*** bit is set (default).
1 = The CHG FET remains on in SLEEP Mode if the ***[NR]*** bit is set.

CSYNC— Enables the SN8765 to write *RemainingCapacity* equal to *FullChargeCapacity* when a valid charge termination is detected.

0 = *RemainingCapacity* is not modified on valid primary charge termination.

1 = *RemainingCapacity* is written to equal *FullChargeCapacity* on valid primary charge termination. (default)

CHGTERM— This bit enables or disables the *[TCA]* and *[FC]* flags in *BatteryStatus* to be cleared after charge termination is confirmed.

0 = *[TCA]* and *[FC]* are not cleared by primary charge termination confirmation, but are cleared by other means. (default)

1 = *[TCA]* and *[FC]* flags are cleared on valid primary charge termination. Note: This does not disable clearing the flags by ***TCA Clear %*** and ***FC Clear %***.

CCT— This bit sets the formula for updating *Cycle Count*.

0 = The SN8765 uses the ***CC Threshold*** value. (default)

1 = The SN8765 uses ***CC %*** of *FullChargeCapacity*.

CHGSUSP— This bit enables the SN8765 to turn off the CHG FET (and ZVCHG FET) when in charge suspend mode.

0 = No FETs change in Charge Suspend mode. (default)

1 = CHG FET and ZVCHG FET (if used) turn off in Charge Suspend mode.

OTFET— This bit enables or disables FET actions from reacting to an overtemperature fault.

0 = There is NO FET action when an overtemperature condition is detected.

1 = When the *[OTC]* flag is set, then the CHG FET is turned off, and when the *[OTD]* flag is set, then the DSG FET is turned off. (default)

CHGFET— This bit enables or disables the CHG FET from reacting to a valid charge termination.

0 = CHG FET stays on at charge termination (*[TCA]* is set). (default)

1 = CHG FET turns off at charge termination.

CHGIN— This bit enables the CHG FET and ZVCHG FET (if used) to turn off when the SN8765 is in charge-inhibit mode.

0 = No FET change in charge-inhibit mode. (default)

1 = CHG and ZVCHG FETs, if used, turn off in charge-inhibit mode.

NR— This bit configures the SN8765 to be in removable or non-removable battery mode and determines the recovery method for current-based primary protection features.

0 = Removable battery mode (default)

1 = Non-removable battery mode.

CPE— This bit enables or disables PEC transmissions to the smart-battery charger for master-mode alarm messages.

0 = No PEC byte on alarm warning to charger (default)

1 = PEC byte on alarm warning to charger

HPE— This bit enables or disables PEC transmissions to the smart-battery host for master-mode alarm messages and prevents receiving communications from all sources in slave mode. If the host uses PEC, this bit should be set.

0 = No PEC byte on alarm warning to host and receiving communications from all sources in slave mode (default)

1 = PEC byte on alarm warning to host and receiving communications from all sources in slave mode. If host uses PEC, this bit should be set.

BCAST— This bit enables or disables SBS broadcasts to the smart-battery charger and host.

0 = Broadcasts to host and charger are disabled (default).

1 = Broadcasts to host and charger are enabled.

C.8.1.3 Operation Cfg C

This register enables, disables, or configures various features of the SN8765.

Table C-164. Operation Cfg C

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Operation Cfg C	hex	2	0x0000	0xffff	0x0040	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	RSVD	CUV_RECOV_CHG	RSVD	RSVD	RSVD	SHUTV	PROD_LTPF_EN	RSOCL

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-5. Operation Cfg C

CUV_RECOV_CHG — This bit configures the cell undervoltage recovery condition.

0 (default) = CUV recovery uses voltage criteria only.

1 = In addition to the voltage criteria, the gas gauge must also be in charge mode for CUV recovery; see Section 1.4.11 for more information on gas gauge operating modes.

SHUTV — This bit configures the voltage threshold used when entering SHUTDOWN mode.

0 = Shutdown occurs when *Voltage* ≤ ***Shutdown Voltage*** AND *Current* ≤ 0 for a period greater than ***Shutdown Time***.

1 (default) = Shutdown occurs when Min (*CellVoltage4..1*) ≤ to ***Cell Shutdown Voltage*** and *Current* ≤ 0 for a period greater than ***Cell Shutdown Time***.

PROD_LTPF_EN — .Production Lifetime Data and PF enable bit; this bit enables or disables Lifetime Data and permanent failures from occurring. This bit can be directly set by the LTPF Enable command (See MAC command 0x0021).

0 (default) = All Lifetime Data logging and PFs (except DFF) are prevented from occurring.

NOTE: If this bit is set to 0, and a Permanent Failure occurs, PFStatus will still report that the failure has occurred. Also, if the FETs have been turned on, they will turn off if a failure occurs. However, data flash write access is still granted and the Permanent Failure is NOT logged in the PF Status section of dataflash. The PFStatus indicator will clear and the FETs will turn on once ManufacturerAccess (0x00) has received the *LTPF Enable* (0x0021) command or the Reset (0x0041) command if the Permanent Failure condition no longer exists.

1 = All Lifetime Data logging and PFs are allowed.

RSOCL — This bit determines the method in which *RelativeStateOfCharge* and *RemainingCapacity* are updated to 100% when charging is complete.

0 (default) = If the ***[RSOCL]*** bit in ***Operation Cfg C*** is cleared then *RelativeStateofCharge* and *RemainingCapacity* are **not** held at 99% until primary charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.

1 = If the ***[RSOCL]*** bit in ***Operation Cfg C*** is set then *RelativeStateofCharge* and *RemainingCapacity* are held at 99% until primary charge termination occurs and only displays 100% upon entering primary charge termination.

NOTE: **PROD_LTPF_EN**—If this bit is set to 0, and a Permanent Failure does occur, *PFStatus* would still report that the failure has occurred. Also, if the FETs have been turned on, they will turn off if a failure occurs. However, dataflash write access is still granted and the Permanent Failure is NOT logged in the PF Status section of dataflash. The *PFStatus* indicator will clear and the FETs will turn back on once *ManufacturerAccess* (0x00) has received the *LTPF Enable* (0x0021) command or the *Reset* (0x0041) command, assuming the Permanent Failure condition no longer exists.

C.8.1.4 Permanent Fail Cfg

The ***Permanent Fail Cfg*** register enables or disables the use of the FUSE pin when the corresponding permanent fail error occurs. If the FUSE pin is driven high ***Fuse Flag*** is set to 0x3672.

Table C-165. Permanent Fail Cfg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Permanent Fail Cfg	hex	2	0x0000	0x5fff	0x0000	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	XPFVSHUT	RSVD	XSOPT	XSOCD	XSOCC	XAFE_P	XAFE_C
Low Byte	XDFF	XDFETF	XCFETF	XCIM	XSOTD	XSOTC	XSOV	XPFIN

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-6. Permanent Fail Cfg

XPFVSHUT — If this bit is set AND any permanent failure happens AND the SN8765 goes into shutdown the FUSE pin is driven high.

XSOPT — If this bit is set AND an open thermistor permanent failure occurs the FUSE pin is driven high.

XSOCD — If this bit is set AND a discharge safety overcurrent permanent failure occurs the FUSE pin is driven high.

XSOCC — If this bit is set AND a charge safety overcurrent failure occurs the FUSE pin is driven high.

XAFE_P — If this bit is set AND a periodic AFE-communications permanent failure occurs the FUSE pin is driven high.

XAFE_C — If this bit is set AND an AFE-communications permanent failure occurs the FUSE pin is driven high.

XDFF — If this bit is set AND a data flash fault permanent failure occurs the FUSE pin is driven high.

XDFETF — If this bit is set AND a DSG FET permanent failure occurs the FUSE pin is driven high.

XCFETF — If this bit is set AND a CHG FET permanent failure occurs the FUSE pin is driven high.

XCIM — If this bit is set AND a cell imbalance permanent failure occurs the FUSE pin is driven high.

XSOTD — If this bit is set AND a discharge overtemperature permanent failure occurs the FUSE pin is driven high.

XSOTC — If this bit is set AND a charge overtemperature permanent failure occurs the FUSE pin is driven high.

XSOV — If this bit is set AND a safety cell overvoltage permanent failure occurs the FUSE pin is driven high.

XPFIN — If this bit is set AND an external input indication permanent failure occurs the FUSE pin is driven high.

C.8.1.5 Non-Removable Cfg

If the SN8765 is in removable battery mode (***[NR]*** = 0) these bits sets the recovery method from 1st level security errors. If the corresponding bit is set it gives an additional recovery option for the particular fault. If ***[NR]*** is set to 1, this register has no effect.

Table C-166. Non Removable Cfg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Non-Removable Cfg	hex	2	0x0000	0x3b17	0x0000	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	RSVD	OCD	OCC	RSVD	RSVD	RSVD	RSVD
Low Byte	RSVD	RSVD	OC	RSVD	RSVD	AOCD	SCC	SCD

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-7. Non-Removable Cfg

OCD — Overcurrent in Discharge

OCC — Overcurrent in Charge

OC — Overcharge

AOCD — AFE Overcurrent in Discharge

SCC — Short Circuit in Charge

SCD — Short Circuit in Discharge

C.8.2 AFE

C.8.2.1 AFE State_Ctl

This register adjusts the AFE hardware overcurrent and short circuit protection thresholds and delay.

Table C-167. AFE State_Ctl

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE State_Ctl	hex	1	0x00	0x30	0x00	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Low Byte	RSVD	RSVD	SDCDX2	RSNS	RSVD	RSVD	RSVD	RSVD

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-8. AFE State_Ctl

SCDDX2 — Set this bit to double the SCD delay periods

0 (default) = Short Circuit current protection delay is as programmed.
1 = Short Circuit current protection delay is twice that programmed.

RSNS — This bit, if set, configures the OCD, SCC, and SCD thresholds into a range suitable for a low sense resistor value by dividing the OCDV, SCCV, and SCDV selected voltage thresholds by 2

0 (default) = Current protection voltage thresholds are as programmed.
1 = Current protection voltage thresholds are divided by 2 as programmed.

C.9 Power

C.9.1 Power

C.9.1.1 Flash Update OK Voltage

This value sets the minimum allowed battery pack voltage for a flash update. If the battery pack *Voltage* is below this threshold no flash update will be made. However, if *PackVoltage* ≥ ***Flash Update OK Voltage*** then the flash can be updated.

Table C-168. Flash Update OK Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Flash Update OK Voltage	unsigned integer	2	6000	20000	7500	mV

C.9.1.2 Shutdown Voltage

The SN8765 goes into shutdown mode if the battery pack *Voltage* is equal to or less than ***Shutdown Voltage*** for ***Shutdown Time*** and has been out of shutdown mode for at least ***Shutdown Time***.

Table C-169. Shutdown Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Shutdown Voltage	unsigned integer	2	5000	20000	5250	mV

C.9.1.3 Shutdown Time

The SN8765 goes into shutdown mode if the battery pack *Voltage* is equal to or less than ***Shutdown Voltage*** for ***Shutdown Time*** and has been out of shutdown mode for at ***Shutdown Time***.

Table C-170. Shutdown Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Shutdown Time	unsigned integer	1	0	240	10	s

C.9.1.4 Cell Shutdown Voltage

The SN8765 goes into shutdown mode if Min (*CellVoltage4..1*) is equal to or less than ***Cell Shutdown Voltage*** for 10s and has been out of shutdown mode for at least ***Cell Shutdown Time***.

Table C-171. Shutdown Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Shutdown Voltage	unsigned integer	2	0	5000	1750	mV

C.9.1.5 Cell Shutdown Time

The SN8765 goes into shutdown mode if Min (*CellVoltage4..1*) is equal to or less than ***Cell Shutdown Voltage*** for 10 s and has been out of shutdown mode for at least ***Cell Shutdown Time***.

Table C-172. Shutdown Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Shutdown Time	unsigned integer	1	0	240	10	s

C.9.1.6 AFE Shutdown Voltage

The SN8765 detects a charger when the *PackVoltage*, measured by the SN8765 at the PACK pin is above the ***AFE Shutdown Voltage*** threshold. If either *Voltage* or *PackVoltage* is greater than the ***Flash Update OK Voltage*** the data flash can be updated. Recommended setting for this value is 4000 mV.

Table C-173. AFE Shutdown Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Shutdown Voltage	unsigned integer	2	0	5000	4000	mV

C.9.1.7 Sleep Current

The SN8765 is allowed to go into SLEEP mode if the charge or discharge current is below ***Sleep Current***. SLEEP mode can be enabled with the ***[SLEEP]*** bit. If the absolute value of *Current* is above ***Sleep Current*** the SN8765 will return to NORMAL mode.

Table C-174. Sleep Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Sleep Current	unsigned integer	2	0	100	10	mA

C.9.1.8 Bus Low Time

The SN8765 is allowed to go into SLEEP mode if it is enabled with the ***[SLEEP]*** bit if the SMBus lines are low for a period greater than ***Bus Low Time***.

Table C-175. Bus low Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Bus Low Time	unsigned integer	1	0	255	5	s

C.9.1.9 Cal Inhibit Temp Low

The SN8765 does not perform auto-calibration on entry to SLEEP mode if *Temperature* is below ***Cal Inhibit Temp Low*** or above ***Cal Inhibit Temp High***.

Table C-176. Cal Inhibit Temp Low

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cal Inhibit Temp Low	signed integer	2	–400	1200	50	0.1°C

C.9.1.10 Cal Inhibit Temp High

The SN8765 does not perform auto-calibration on entry to SLEEP mode if *Temperature* is below ***Cal Inhibit Temp Low*** or above ***Cal Inhibit Temp High***.

Table C-177. Cal Inhibit Temp High

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cal Inhibit Temp High	signed integer	2	–400	1200	450	0.1°C

C.9.1.11 Sleep Voltage Time

During SLEEP mode temperature and voltage measurements will be taken in ***Sleep Voltage Time*** intervals.

Table C-178. Sleep Voltage Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Sleep Voltage Time	unsigned integer	1	1	240	5	s

C.9.1.12 Sleep Current Time

During SLEEP mode current will be measured in ***Sleep Current Time*** intervals.

Table C-179. Sleep Current Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Sleep Current Time	unsigned integer	1	1	255	20	s

C.9.1.13 Wake Current Reg

Wake Current Reg configures the current threshold required to wake the SN8765 from SLEEP mode by detecting voltage across SRP and SRN.

Table C-180. Wake Current Reg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Wake Current Reg	hex	1	0x00	0x07	0x00	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Low Byte	RSVD	RSVD	RSVD	RSVD	RSVD	IWAKE	RSNS1	RSNS0

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-9. Wake Current Reg

IWAKE — This bit sets the current threshold for the Wake function.

0 = 0.5 A (or if RSNS0=RSNS1=0 then this function is disabled)
1 = 1.0 A (or if RSNS0=RSNS1=0 then this function is disabled)

Table C-181. Wake Current Reg

RSNS1	RSNS0	Resistance
0	0	Disabled (default)
0	1	2.5 mΩ
1	0	5 mΩ
1	1	10 mΩ

C.10 LED Support

C.10.1 LED Cfg

C.10.1.1 LED Flash Period

This value sets the LED flashing time period at a 50% duty cycle for alarm conditions.

Table C-182. LED Flash Period

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LED Flash Period	Unsigned integer	2	0	65,535	512	500 µs

C.10.1.2 LED Blink Period

This value sets the LED blinking time period to a 50% duty cycle for the LED indicating the highest actual charge of the battery.

Table C-183. LED Blink Period

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LED Blink Period	Unsigned integer	2	0	65,535	1024	500 µs

C.10.1.3 LED Delay

This value sets the activation delay time from one LED to the next LED after the display is activated.

Table C-184. LED Delay

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LED Delay	Unsigned integer	2	1	65,535	100	500 µs

C.10.1.4 LED Hold Time

This value sets the time the LED stays on after all LEDs required to indicate the state of charge are being activated.

Table C-185. LED Hold Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LED Hold Time	Unsigned integer	1	0	255	4	s

C.10.1.5 CHG Flash Alarm

If the SN8765 is in charge mode ([DSG] = 0) and the battery charge is below this threshold the remaining enabled LEDs start flashing at LED Flash Period. Set to –1 to disable this feature.

Table C-186. CHG Flash Alarm

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CHG Flash Alarm	Integer	1	–1	101	10	%

C.10.1.6 CHG Thresh1

If the SN8765 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 1 is disabled.

Table C-187. CHG Thresh 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CHG Thresh 1	Integer	1	–1	101	0	%

C.10.1.7 CHG Thresh 2

If the SN8765 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 2 is disabled.

Table C-188. CHG Thresh 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CHG Thresh 2	Integer	1	–1	101	20	%

C.10.1.8 CHG Thresh 3

If the SN8765 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 3 is disabled.

Table C-189. CHG Thresh 3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CHG Thresh 3	Integer	1	–1	101	40	%

C.10.1.9 CHG Thresh 4

If the SN8765 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 4 is disabled.

Table C-190. CHG Thresh 4

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CHG Thresh 4	Integer	1	–1	101	60	%

C.10.1.10 CHG Thresh 5

If the SN8765 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 5 is disabled.

Table C-191. CHG Thresh 5

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CHG Thresh 5	Integer	1	–1	101	80	%

C.10.1.11 DSG Flash Alarm

If the SN8765 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, the remaining enabled LEDs start flashing with ***LED Flash Period***. Set to –1 to disable this feature.

Table C-192. DSG Flash Alarm

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
DSG Flash Alarm	Integer	1	–1	101	10	%

C.10.1.12 DSG Thresh 1

If the SN8765 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 1 is disabled.

Table C-193. DSG Thresh 1

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
DSG Thresh 1	Integer	1	–1	101	0	%

C.10.1.13 DSG Thresh 2

If the SN8765 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 2 is disabled.

Table C-194. DSG Thresh 2

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
DSG Thresh 2	Integer	1	–1	101	20	%

C.10.1.14 DSG Thresh 3

If the SN8765 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 3 is disabled.

Table C-195. DSG Thresh 3

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
DSG Thresh 3	Integer	1	–1	101	40	%

C.10.1.15 DSG Thresh 4

If the SN8765 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 4 is disabled.

Table C-196. DSG Thresh 4

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
DSG Thresh 4	Integer	1	–1	101	60	%

C.10.1.16 DSG Thresh 5

If the SN8765 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 5 is disabled.

Table C-197. DSG Thresh 5

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
DSG Thresh 5	Integer	1	–1	101	80	%

C.10.1.17 Sink Current

The sink current setting of the LED inputs to the SN8765 can be programmed with the following settings. All of the LEDs are programmed with the same current level.

Table C-198. Sink Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Sink Current	Unsigned integer	1	0	3	3	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Low Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	ILED1	ILED0

LEGEND: RSVD = This is reserved and must be programmed to 0.

Table C-199. Sink Current Configuration

ILED1	ILED0	Sink Current
0	**0**	**0 mA**
0	**1**	**3 mA**
1	**0**	**4 mA**
1	**1**	**5 mA (default)**

C.11 1st Level Safety Class

C.11.1 Voltage

C.11.1.1 LT COV Threshold

When the SN8765 is operating in the low temperature range (see Section 1.1), it sets the *[COV]* flag in *SafetyStatus* if any *CellVoltage4..1* is equal to or higher than the ***LT COV Threshold*** for a period of 2 s.

Table C-200. LT COV Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LT COV Threshold	Integer	2	3700	5000	4300	mV

C.11.1.2 LT COV Recovery

When the SN8765 is operating in the low temperature range it recovers from a cell overvoltage condition if all cell voltages are lower than the ***LT COV Recovery*** threshold level.

Table C-201. LT COV Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LT COV Recovery	Integer	2	0	4400	3900	mV

C.11.1.3 ST COV Threshold

When the SN8765 is operating in the standard temperature range 1 or 2 (see Section 1.1), it sets the *[COV]* flag in *SafetyStatus* if any *CellVoltage4..1* is equal to or higher than the ***ST COV Threshold*** for a period of 2 s.

Table C-202. ST COV Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST COV Threshold	Integer	2	3700	5000	4500	mV

C.11.1.4 ST COV Recovery

When the SN8765 is operating in the standard temperature range 1 or 2, it recovers from a cell overvoltage condition if all cell voltages are lower than the ***ST COV Recovery*** threshold level.

Table C-203. ST COV Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST COV Recovery	Unsigned integer	2	0	4400	4100	mV

C.11.1.5 HT COV Threshold

When the SN8765 is operating in the high temperature range (see Section 1.1), it sets the *[COV]* flag in *SafetyStatus* if any *CellVoltage4..1* is equal to or higher than the ***HT COV Threshold*** for a period of 2 s.

Table C-204. HT COV Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
HT COV Threshold	Integer	2	3700	5000	4400	mV

C.11.1.6 HT COV Recovery

When the SN8765 is operating in the high temperature range, it recovers from a cell overvoltage condition if all cell voltages are lower than the ***HT COV Recovery*** threshold level.

Table C-205. HT COV Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
HT COV Recovery	Integer	2	0	4400	4000	mV

C.11.1.7 CUV Threshold

The SN8765 sets the *[CUV]* *SafetyAlert* if any *CellVoltage4..1* is equal to or lower than the ***CUV Threshold*** for a period of 2 s.

Table C-206. CUV Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CUV Threshold	unsigned integer	2	0	3500	2200	mV

C.11.1.8 CUV Recovery

The SN8765 recovers from a cell under voltage condition, if all *CellVoltage4..1* are higher than the ***CUV Recovery*** threshold. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriates value per the charging algorithm, the *[TDA]* and *[FD]* flags are reset, the *[CUV]* in *SafetyStatus* is reset, and the *[XDSG]* flag in *OperationStatus* is reset.

Table C-207. CUV Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
CUV Recovery	unsigned integer	2	0	3600	3000	mV

C.11.2 Current

C.11.2.1 OC (1st Tier) Chg

The SN8765 sets the *[OCC]* *SafetyAlert* if charge *Current* is equal to or higher than the ***OC (1st Tier) Chg*** threshold.

Table C-208. OC (1st Tier) Chg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OC (1st Tier) Chg	unsigned integer	2	0	20000	6000	mA

C.11.2.2 OC (1st Tier) Chg Time

If the *[OCC]* in *SafetyAlert* time period exceeds the ***OC (1st Tier) Chg Time*** time the SN8765 goes into an overcurrent charge condition. This function is disabled if ***OC (1st Tier) Chg Time*** is set to 0.

In an overcurrent while charging condition the CHG FET is turned off, the *ChargeCurrent* and *ChargeVoltage* are set to 0, the *[TCA]* flag is set, the *[OCC]* flag in *SafetyAlert* is cleared, and the *[OCC]* flag in *SafetyStatus* is set.

Table C-209. OC (1st Tier) Chg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OC (1st Tier) Chg Time	unsigned integer	1	0	240	2	s

C.11.2.3 OC Chg Recovery

The SN8765 recovers from an overcurrent charge condition in non-removable battery mode if the *AverageCurrent* is equal to or lower than the ***OC Chg Recovery*** threshold for a length of ***Current Recovery Time***. The SN8765 recovers in removable battery mode by removing and reinserting the battery pack. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to appropriate their values per the charging algorithm, *[TCA]* is reset, and the *[OCC]* flag in *SafetyStatus* is reset.

Table C-210. OC Chg Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OC Chg Recovery	signed integer	2	–1000	1000	200	mA

C.11.2.4 OC (1st Tier) Dsg

The SN8765 sets the *[OCD]* *SafetyAlert* if the discharge *Current* is equal to or higher than the ***OC (1st Tier) Dsg*** threshold.

Table C-211. OC (1st Tier) Dsg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OC (1st Tier) Dsg	unsigned integer	2	0	20000	6000	mA

C.11.2.5 OC (1st Tier) Dsg Time

If the *[OCD]* in *SafetyAlert* time period exceeds the ***OC (1st Tier) Dsg Time*** SN8765 goes into an overcurrent discharge condition. This function is disabled if ***OC (1st Tier) Dsg Time*** is set to 0.

In an overcurrent discharge condition the DSG FET is turned off, the *ChargeCurrent* is set to ***Pre-chg Current***, the *[TDA]* flag is set, the *[OCD]* flag in *SafetyAlert* is reset, the *[OCD]* flag in *SafetyStatus* is set, and the *[XDSG]* flag is set.

Table C-212. OC (1st Tier) Dsg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OC (1st Tier) Dsg Time	unsigned integer	1	0	240	2	s

C.11.2.6 OC Dsg Recovery

The SN8765 recovers from an overcurrent discharge condition in non-removable battery mode if the *AverageCurrent* is equal to or lower than the ***OC Dsg Recovery*** current level for a length of ***Current Recovery Time***. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, *[TDA]* is reset, the *[OCD]* *SafetyStatus* flag is reset, and the *[XDSG]* flag is reset.

Table C-213. OC Dsg Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OC Dsg Recovery	signed integer	2	0	1000	200	mA

C.11.2.7 Current Recovery Time

The ***Current Recovery Time*** sets the minimum time period where the *AverageCurrent* need to be below the overcurrent charge/discharge recovery threshold to recover from an overcurrent charge/discharge condition.

Table C-214. Current Recovery Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Current Recovery Time	unsigned integer	1	0	240	8	s

C.11.2.8 AFE OC Dsg

The ***AFE OC Dsg*** threshold sets the OCDV register of the integrated AFE device. Changes to this data flash value requires a software full reset or a power reset of the SN8765 to take effect.

Table C-215. AFE OC Dsg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE OC Dsg	hex	1	0x00	0x0f	0x07	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
AFE OCDV Register	RSVD	RSVD	RSVD	RSVD	OCDV3	OCDV2	OCDV1	OCDV0

LEGEND: RSVD = This is reserved and must be programmed to 0.

Figure C-10. OCDV Register

OCDV3, OCDV2, OCDV1, OCDV0 — Sets the overload voltage threshold

[RSNS] = 0, 0x00–0x0f = sets the voltage threshold between 50 mV and 200 mV in 10-mV steps.

[RSNS] = 1, 0x00–0x0f = sets the voltage threshold between 20 mV and 100 mV in 5-mV steps.

Table C-216. OCDV (b3-b0) Configuration Bits with Corresponding Voltage Threshold When STATE_CTL[RSNS] = 0

OCDV (b3–b0) configuration bits with corresponding voltage threshold			
0x00	0.050 V	0x08	0.130 V
0x01	0.060 V	0x09	0.140 V
0x02	0.070 V	0x0a	0.150 V
0x03	0.080 V	0x0b	0.160 V
0x04	0.090 V	0x0c	0.170 V
0x05	0.100 V	0x0d	0.180 V
0x06	0.110 V	0x0e	0.190 V
0x07	0.120 V	0x0f	0.200 V

Table C-217. OCDV (b3-b0) Configuration Bits with Corresponding Voltage Threshold When STATE_CTL[RSNS] = 1

OCDV (b3–b0) configuration bits with corresponding voltage threshold(1)			
0x00	0.025 V	0x08	0.065 V
0x01	0.030 V	0x09	0.070 V
0x02	0.035 V	0x0a	0.075 V
0x03	0.040 V	0x0b	0.080 V
0x04	0.045 V	0x0c	0.085 V
0x05	0.050 V	0x0d	0.090 V
0x06	0.055 V	0x0e	0.095 V
0x07	0.060 V	0x0f	0.100 V

C.11.2.9 AFE OC Dsg Time

The ***AFE OC Discharge Time*** is programmed into the OCDD register of the integrated AFE device. If an overcurrent discharge condition is detected, *ChargingCurrent* is set to 0, *[TDA]* in ***BatteryStatus*** is set, and *[AOCD]* in *SafetyStatus* is set. Changes to this data flash value requires a software full reset or a power reset of the SN8765 to take effect.

Table C-218. AFE OC Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE OC Dsg Time	hex	1	0x00	0x0f	0x0f	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
AFE OCDD Register	RSVD	RSVD	RSVD	RSVD	OCDD3	OCDD2	OCDD1	OCDD0

LEGEND: RSVD = Reserved and **must** be programmed to 0.

Figure C-11. OCDD Register

OCDD3, OCDD2, OCDD1, OCDD0 — Sets the overload voltage delay

0x00–0x0f = Sets the overvoltage trip delay between 1 ms–31 ms in 2-ms steps

Table C-219. OCDD (b3-b0) Configuration Bits with Corresponding OC Dsg Delay Time

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	1 ms	0x04	9 ms	0x08	17 ms	0x0c	25 ms
0x01	3 ms	0x05	11 ms	0x09	19 ms	0x0d	27 ms
0x02	5 ms	0x06	13 ms	0x0a	21 ms	0x0e	29 ms
0x03	7 ms	0x07	15 ms	0x0b	23 ms	0x0f	31 ms

C.11.2.10 AFE OC Dsg Recovery

The SN8765 recovers from an overcurrent discharge condition in non-removable battery mode if the *AverageCurrent* is equal to or lower than the ***(–)AFE OC Dsg Recovery*** current level for the length of ***Current Recovery Time***. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, *[TDA]* is reset, the *[AOCD]* flag in *SafetyStatus* is reset, and *[XDSG]* is reset.

Table C-220. AFE OC Dsg Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE OC Dsg Recovery	signed integer	2	10	1000	5	mA

C.11.2.11 AFE SC Chg Cfg

The ***AFE SC Charge Cfg*** is programmed into the SCC register of the integrated AFE device. ***AFE SC Charge Cfg*** sets the short circuit in charging voltage threshold and the short circuit in charging delay of the integrated AFE. Changes to this data flash value requires a software full reset or a power reset of the SN8765 to take effect.

If the SN8765 identifies a charge in short circuit situation, *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* in *BatteryStatus* is set, and *[SCC]* in *SafetyStatus* is set.

Table C-221. AFE SC Chg Cfg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE SC Chg Cfg	hex	1	0x00	0xf7	0x73	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
AFE SCC Register	SCCD3	SCCD2	SCCD1	SCCD0	—	SCCV2	SCCV1	SCCV0

Figure C-12. SCC Register

SCCD3, SCCD2, SCCD1, SCCD0 — Sets the short circuit delay in charging

0x0–0xf = Sets the short circuit delay in charging between 0 μs–915 μs in 61-μs steps. Exceeding the short circuit in charge voltage threshold for longer than this period turns off the CHG and DSG outputs. 0000 is the AFE power on reset default.

SCCV2, SCCV1, SCCV0 — Sets the short circuit voltage threshold in charging

[RSNS] = 0, 0x0–0x4 = Sets the short circuit voltage threshold between 100 mV and 300 mV in 50-mV steps. Note: Settings for 0x05 to 0x07 are not supported.

[RSNS] = 1, 0x0–0x7 = Sets the short circuit voltage threshold between 50 mV and 225 mV in 25-mV steps

SCC (b3) — Not used.

Table C-222. SCCV (b2-b0) Configuration Bits with Corresponding Voltage Threshold When STATE_CTL[RSNS] = 0

Setting	Threshold	Setting	Threshold
0x00	–0.100 V	0x04	–0.300 V
0x01	–0.150 V	0x05	N/A
0x02	–0.200 V	0x06	N/A
0x03	–0.250 V	0x07	N/A

Table C-223. SCCV (b2-b0) Configuration Bits with Corresponding Voltage Threshold When STATE_CTL[RSNS] = 1

Setting	Threshold	Setting	Threshold
0x00	–0.050 V	0x04	–0.150 V
0x01	–0.075 V	0x05	–0.175 V
0x02	–0.100 V	0x06	–0.200 V
0x03	–0.125 V	0x07	–0.225 V

Table C-224. SCCD (b7-b4) Configuration Bits with Corresponding SC Chg Delay Time

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 μs	0x04	244 μs	0x08	488 μs	0x0c	732 μs
0x01	61 μs	0x05	305 μs	0x09	549 μs	0x0d	793 μs
0x02	122 μs	0x06	366 μs	0x0a	610 μs	0x0e	854 μs
0x03	183 μs	0x07	427 μs	0x0b	671 μs	0x0f	915 μs

C.11.2.12 AFE SC Dsg Cfg

The ***AFE SC Dsg Cfg*** is programmed into the SCD register of the integrated AFE device. The ***AFE SC Dsg Cfg*** sets the short circuit in discharging voltage threshold and the short circuit in discharging delay of the integrated AFE. Changes to this data flash value requires a software full reset or a power reset of the SN8765 to take effect.

If the SN8765 identifies a discharge in short circuit situation from the integrated AFE *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TDA]* in *BatteryStatus* is set, *[SCD]* in *SafetyStatus* is set, and *[XDSG]* in *OperationStatus* is set.

Table C-225. AFE SC Dsg Cfg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE SC Dsg Cfg	hex	1	0x00	0xff	0x77	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
AFE SCD Register	SCDD3	SCDD2	SCDD1	SCDD0	—	SCDV2	SCDV1	SCDV0

Figure C-13. SCD Register

SCDD3, SCDD2, SCDD1, SCDD0 — Sets the short circuit delay in discharging of the integrated AFE

0x0–0xf = Sets the short circuit in discharging delay between 0 µs–915 µs in 61-µs steps. Exceeding the short circuit in discharge voltage threshold for longer than this period turns off the CHG and DSG outputs. 0000 is the AFE power on reset default. If STATE_CTL[SCDDx2] is set, the delay time is double of that programmed in this register.

SCDV2, SCDV1, SCDV0 — Sets the short circuit voltage threshold in discharging of the integrated AFE

[RSNS] = 0, 0x0–0x7 = Sets the short circuit voltage threshold between 100 mV and 450 mV in 50-mV steps

[RSNS] = 1, 0x0–0x7 = Sets the short circuit voltage threshold between 50 mV and 475 mV in 25-mV steps

SCD (b3) — Not used.

Table C-226. SCDV (b2-b0) Configuration Bits with Corresponding Voltage Threshold When STATE_CTL[RSNS] = 0

Setting	Threshold	Setting	Threshold
0x00	0.100 V	0x04	0.300 V
0x01	0.150 V	0x05	0.350 V
0x02	0.200 V	0x06	0.400 V
0x03	0.250 V	0x07	0.450 V

Table C-227. SCDV (b2-b0) Configuration Bits with Corresponding Voltage Threshold When STATE_CTL[RSNS] = 1

Setting	Threshold	Setting	Threshold
0x00	0.050 V	0x04	0.150 V
0x01	0.075 V	0x05	0.175 V
0x02	0.100 V	0x06	0.200 V
0x03	0.125 V	0x07	0.225 V

Table C-228. SCDD (b7-b4) Configuration Bits with Corresponding SC Dsg Delay Time

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	244 µs	0x08	488 µs	0x0c	732 µs
0x01	61 µs	0x05	305 µs	0x09	549 µs	0x0d	793 µs
0x02	122 µs	0x06	366 µs	0x0a	610 µs	0x0e	854 µs
0x03	183 µs	0x07	427 µs	0x0b	671 µs	0x0f	915 µs

C.11.2.13 AFE SC Recovery

The SN8765 recovers from a short circuit in charging or discharging condition in non-removable battery mode if the absolute value of *AverageCurrent* is equal to or lower than the ***AFE SC Recovery*** current level for the length of ***Current Recovery Time***. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, *[TDA]* and *[TCA]* in *BatteryStatus* are reset, *[SCC]* and *[SCD]* in *SafetyStatus* are reset, and *[XDSG]* is reset.

Table C-229. AFE SC Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE SC Recovery	unsigned integer	2	0	200	1	mA

C.11.3 Temperature

C.11.3.1 Over Temp Chg

The SN8765 sets the *[OTC]* flag in *SafetyAlert* if the pack *Temperature* is equal to or higher than the ***Over Temp Chg*** threshold.

Table C-230. Over Temp Chg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Temp Chg	unsigned integer	2	0	1200	550	0.1°C

C.11.3.2 OT Chg Time

If the *[OTC]* in *SafetyAlert* time period exceeds the ***OT Chg Time*** period the SN8765 goes into an over temperature charge condition. This function is disabled if ***OT Chg Time*** is set to 0.

In and over temperature charge condition the *ChargingVoltage* and *ChargingCurrent* are set to 0, the *[OTA]* flag in *BatteryStatus* is set, *[TCA]* is set, the *[OTC]* flag in *SafetyAlert* is reset, and the *[OTC]* flag in *SafetyStatus* is set. If the *[OTFET]* bit is enabled the CHG FET also turns off.

Table C-231. OT Chg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OT Chg Time	unsigned integer	1	0	240	2	s

C.11.3.3 OT Chg Recovery

The SN8765 recovers from an over temperature charge condition if the *Temperature* is equal to or lower than the ***OT Chg Recovery*** level. On recovery, the CHG FET returns to its normal operating state, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, the *[OTA]* flag is reset, and the *[OTC]* flag in *SafetyStatus* is reset.

Table C-232. OT Chg Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OT Chg Recovery	unsigned integer	2	0	1200	500	0.1°C

C.11.3.4 Over Temp Dsg

The SN8765 sets the *[OTD]* in *SafetyAlert* if the pack *Temperature* is equal to or higher than the ***Over Temp Dsg*** threshold.

Table C-233. Over Temp Dsg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Over Temp Dsg	unsigned integer	2	0	1200	600	0.1°C

C.11.3.5 OT Dsg Time

If the *[OTD]* in *SafetyAlert* time period exceeds the ***OT Dsg Time*** the SN8765 goes into an over temperature discharge condition. This function is disabled if ***OT Dsg Time*** is set to 0.

In an over temperature discharge condition the *ChargingCurrent* is set to 0, *[OTA]* is set, the *[OTD]* flag in *SafetyAlert* is reset, and the *[OTD]* *SafetyStatus* flag is set. If the *[OTFET]* bit is enabled, the DSG FET also turns off and *[XDSG]* in *OperationStatus* is set.

Table C-234. OT Dsg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OT Dsg Time	unsigned integer	1	0	240	2	s

C.11.3.6 OT Dsg Recovery

The SN8765 recovers from an over temperature discharge condition if the *Temperature* is equal to or lower than the ***OT Dsg Recovery*** level. On recovery, the DSG FET returns to its normal operating state, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, the *[OTA]* flag is reset, the *[OTD]* *SafetyStatus* flag is reset, and the *[XDSG]* flag in *OperationStatus* is reset.

Table C-235. OT Dsg Recovery

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
OT Dsg Recovery	unsigned integer	2	0	1200	550	0.1°C

C.12 2nd-Level Safety

C.12.1 Voltage

C.12.1.1 LT SOV Threshold

When the SN8765 is operating in the low temperature charging range (*[TR2]* = 1), it sets the *[SOV]* flag in *PFStatus* if any *CellVoltage4..1* is equal to or higher than the ***LT SOV Threshold*** for a period of ***SOV Time***.

Table C-236. LT SOV Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
LT SOV Threshold	Integer	2	0	20000	4400	mV

C.12.1.2 ST SOV Threshold

When the SN8765 is operating in the standard temperature charging range 1 or 2(*[TR2A] = 1*, or *[TR3]* = 1), it sets the *[SOV]* flag in *PFStatus* if any *CellVoltage4..1* is equal to or higher than the ***ST SOV Threshold*** for a period of ***SOV Time***.

Table C-237. ST SOV Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
ST SOV Threshold	Integer	2	0	20000	4600	mV

C.12.1.3 HT SOV Threshold

When the SN8765 is operating in the high temperature charging range (*[TR4]* = 1), it sets the *[SOV]* flag in *PFStatus* if any *CellVoltage4..1* is equal to or higher than the ***HT SOV Threshold*** for a period of ***SOV Time***.

Table C-238. HT SOV Threshold

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
HT SOV Threshold	Integer	2	0	20000	4500	mV

C.12.1.4 SOV Time

The SN8765 sets the *[SOV]* flag in *PFStatus* and goes into a safety overvoltage condition if any *CellVoltage4..1* is equal to or higher than the appropriate SOV threshold (depending on temperature range) for a period of ***SOV Time***. If the ***[XSOV]*** bit in ***Permanent Fail Cfg 1*** is set, the SAFE pin is driven high. This function is disabled if ***SOV Time*** is set to 0.

Table C-239. SOV Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOV Time	Unsigned integer	1	0	240	0	s

C.12.1.5 PF SOV Fuse Blow Delay

In case of a safety overvoltage permanent failure condition, the assertion of the FUSE output (to blow a fuse) can be delayed to allow the battery to discharge to a safe level before blowing the fuse. A PF timer is started once an SOV PF event occurs (i.e. ***when SOV Time*** has passed and the *[SOV]* flag has been set). The FUSE output will be driven high (thus, blowing the fuse) once this timer reaches ***PF SOV Fuse Blow Delay***, or as soon as all cell voltages go below the ***COV Recovery threshold*** for the current temperature range, whichever comes first.

Table C-240. PF SOV Fuse Blow Delay

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PF SOV Fuse Blow Delay	Unsigned integer	2	0	65,535	0	s

C.12.1.6 Cell Imbalance Current

The battery pack *Current* must be below the ***Cell Imbalance Current*** limit for ***Cell Imbalance Time*** before the SN8765 starts detecting cell imbalance.

Table C-241. Cell Imbalance Current

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Imbalance Current	unsigned integer	1	0	200	5	mA

C.12.1.7 Cell Imbalance Fail Voltage

If the *Current* goes below ***Cell Imbalance Current*** for ***Battery Rest Time*** the SN8765 starts cell imbalance measurements. The SN8765 sets the *[CIM]* flag in *PFAlert* if the SN8765 measures a difference between any *CellVoltage4..1* equal to or higher than the ***Cell Imbalance Fail Voltage*** threshold.

Table C-242. Cell Imbalance Fail Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Imbalance Fail Voltage	unsigned integer	2	0	5000	1000	mV

C.12.1.8 Cell Imbalance Time

If the *[CIM]* *PFAlert* time period exceeds the ***Cell Imbalance Time*** limit the SN8765 goes into a cell imbalance condition, *[CIM]* in *PFAlert* is cleared, *[CIM]* in *PFStatus* is set and, if ***[XCIM]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is also driven high. This function is disabled if ***Cell Imbalance Time*** is set to 0.

Table C-243. Cell Imbalance Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Cell Imbalance Time	unsigned integer	1	0	240	0	s

C.12.1.9 Battery Rest Time

The battery *Current* must be below ***Cell Imbalance Current*** limit for at least ***Battery Rest Time*** period before the SN8765 starts detecting a cell imbalance. Cell imbalance detection is disabled if ***Battery Rest Time*** is set to 0.

Table C-244. Battery Rest Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Battery Rest Time	unsigned integer	2	0	65535	1800	s

C.12.1.10 Min CIM-Check Voltage

The battery *Current()* must be below *Cell Imbalance Current* limit for at least *Battery Rest Time* AND all *CellVoltage4...1()* must be greater than Min CIM-check voltage before the SN8765 initiates cell imbalance detection.

Table C-245. Min CIM-Check Voltage

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Min CIM-check voltage	unsigned integer	2	0	65535	3000	mV

C.12.1.11 PFIN Detect Time

If the FUSE pin is driven logic high externally then *[PFIN]* in *PFAlert* is set. If the *[PFIN]* PF alert time period exceeds ***PFIN Detect Time*** *[PFIN]* in *PFAlert* is reset, *[PFIN]* in *PFStatus* is set, and both DSG- and CHG-FET are turned OFF. If ***[XPFIN]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is also driven high by the SN8765. This function is disabled if ***PFIN Detect Time*** is set to 0.

Regardless of PFIN being disabled or not, however, when the FUSE pin is driven high externally, both DSG- and CHG-FET are turned OFF by the AFE hardware.

Table C-246. PFIN Detect Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
PFIN Detect Time	unsigned integer	1	0	240	0	s

C.12.2 Current

C.12.2.1 SOC Chg

The SN8765 sets the *[SOCC]* in *PFAlert* if *Current* is equal to or higher than the ***SOC Chg*** threshold.

Table C-247. SOC Chg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOC Chg	unsigned integer	2	0	30000	10000	mA

C.12.2.2 SOC Chg Time

If the *[SOCC]* in *PFAlert* time period exceeds the ***SOC Chg Time*** the SN8765 goes into a SOCC condition *[SOCC]* in *PFAlert* is cleared, *[SOCC]* in *PFStatus* is set and, if ***[XSOCC]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***SOC Chg Time*** is set to 0.

Table C-248. SOC Chg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOC Chg Time	unsigned integer	1	0	240	0	s

C.12.2.3 SOC Dsg

The SN8765 sets the *[SOCD]PFAlert* if discharge *Current* is equal to or higher than the ***(–)SOC Dsg*** threshold.

Table C-249. SOC Dsg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOC Dsg	unsigned integer	2	0	30000	10000	mA

C.12.2.4 SOC Dsg Time

If the *[SOCD]* *PFAlert* time period exceeds the safety overcurrent charge time the SN8765 goes into a SOCD condition, *[SOCD]* in *PFAlert* is cleared, *[SOCD]* in *PFStatus* is set and, if the ***[XSOCD]*** bit in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***SOCD Dsg Time*** is set to 0.

Table C-250. SOC Dsg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOC Dsg Time	unsigned integer	1	0	240	0	s

C.12.3 Temperature

C.12.3.1 SOT Chg

The SN8765 sets the *[SOTC]* *PFAlert* if *Temperature* is equal to or higher than the ***SOT Chg*** threshold during charging (*[DSG]* = 0).

Table C-251. SOT Chg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOT Chg	unsigned integer	2	0	1200	650	0.1°C

C.12.3.2 SOT Chg Time

If the *[SOT]* flag in *PFAlert* time period exceeds ***SOT Chg Time*** the SN8765 goes into a SOTC condition, *[SOTC]* in *PFAlert* is cleared, *[SOTC]* in *PFStatus* is set and, if ***[XSOTC]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***SOT Chg Time*** is set to 0.

Table C-252. SOT Chg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOT Chg Time	unsigned integer	1	0	240	0	s

C.12.3.3 SOT Dsg

The SN8765 sets the *[SOTD]* *PFAlert* if *Temperature* is equal to or higher than the *SOT Dsg* threshold during discharging (*[DSG]* = 1).

Table C-253. SOT Dsg

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOT Dsg	unsigned integer	2	0	1200	750	0.1°C

C.12.3.4 SOT Dsg Time

If the *[SOTD]* in *PFAlert* time period exceeds ***SOT Dsg Time*** the SN8765 goes into a *SOTD* condition, *[SOTD]* in *PFAlert* is reset, *[SOTD]* in *PFStatus* is set and, if ***[XSOTD]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***SOT Dsg Time*** is set to 0.

Table C-254. SOT Dsg Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
SOT Dsg Time	unsigned integer	1	0	240	0	s

C.12.3.5 Open Thermistor

The SN8765 sets the *[SOPT]* flag in *PFAlert* if the thermistor *Temperature* is equal to or lower than the ***Open Thermistor*** threshold.

Table C-255. Open Thermistor

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Open Thermistor	signed integer	2	–1000	1200	–333	0.1°C

C.12.3.6 Open Time

If the *[SOPT]* *PFAlert* time period exceeds ***Open Time*** period the SN8765 goes into a safety open thermistor condition, *[SOPT]* in *PFAlert* is reset, *[SOPT]* in *PFStatus* is set and, if ***[XSOPT]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***Open Time*** is set to 0.

Table C-256. Open Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Open Time	unsigned integer	1	0	240	0	s

C.12.4 FET Verification

C.12.4.1 FET Fail Limit

The SN8765 sets the *[CFETF]* *PFAlert* if the SN8765 detects charge *Current* equal to or higher than the ***FET Fail Limit*** threshold when the CHG FET is supposed to be off.

The SN8765 sets the *[DFETF]* *PFAlert* if the SN8765 detects discharge *Current* equal to or lower than the ***(–)FET Fail Limit*** threshold when the DSG FET is supposed to be off.

Table C-257. FET Fail Limit

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FET Fail Limit	unsigned integer	2	0	500	20	mA

C.12.4.2 FET Fail Time

If the *[CFETF]* alert time period exceeds ***FET Fail Time*** the SN8765 goes into a CHG FET failure condition, *[CFETF]* in *PFAlert* is reset, *[CFETF]* in *PFStatus* is set and, if ***[XCFETF]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***FET Fail Time*** is set to 0.

If the *[DFETF]* alert time period exceeds ***FET Fail Time*** the SN8765 goes into a DSG FET failure condition, *[DFETF]* in *PFAlert* is reset, *[DFETF]* in *PFStatus* is set and, if ***[XDFETF]*** in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***FET Fail Time*** is set to 0.

Table C-258. FET Fail Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
FET Fail Time	unsigned integer	1	0	240	0	s

C.12.5 AFE Verification

C.12.5.1 AFE Check Time

The SN8765 compares periodically, with a period of ***AFE Check Time***, certain RAM content and expected control bit states of the integrated AFE with the values stored in data flash. If an error is detected, the internal AFE fail counter is incremented. Set to 0 to disable *[AFE_P]* faults.

Table C-259. AFE Check Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Check Time	unsigned integer	1	0	255	0	s

C.12.5.2 AFE Fail Limit

If the internal AFE fail counter reaches the ***AFE Fail Limit*** the SN8765 reports a *[AFE_C]* permanent failure and, if *[XAFE_C]* in ***Permanent Fail Cfg*** is set, the FUSE pin is driven high. This function is disabled if ***AFE Fail Limit*** is set to zero.

Table C-260. AFE Fail Limit

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Fail Limit	unsigned integer	1	0	255	10	

C.12.5.3 AFE Fail Recovery Time

The SN8765 decrements the internal AFE fail counter by one each ***AFE Fail Recovery Time*** period to a minimum of zero.

Table C-261. AFE Fail Recovery Time

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Fail Recovery Time	unsigned integer	1	0	255	20	s

C.12.5.4 AFE Init Retry Limit

After a full reset the AFE offset and gain values are read twice and then compared. ***AFE Init Retry Limit*** is the maximum number of times that the initial AFE offset and gain values will be read—if they are not considered the same—until the *[AFE_C]* permanent failure occurs.

Table C-262. AFE Init Retry Limit

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Init Retry Limit	unsigned integer	1	0	255	6	

C.12.5.5 AFE Init Limit

AFE Init Limit is the difference in A/D counts that two successive readings of AFE offset and gain can be and still considered the be same value, after a full reset.

Table C-263. AFE Init Limit

Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
AFE Init Limit	unsigned integer	1	0	255	20	

C.13 Data Flash Values

Table C-264. DATA FLASH VALUES

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Calibration	Voltage	Cell Scale 0	I2	0	32767	20500	-
Calibration	Voltage	Cell Scale 1	I2	0	32767	20500	-
Calibration	Voltage	Cell Scale 2	I2	0	32767	20500	-
Calibration	Voltage	Cell Scale 3	I2	0	32767	20500	-
Calibration	Voltage	Pack Gain	U2	0	65535	44100	-
Calibration	Voltage	BAT Gain	U2	0	65535	44100	-
Calibration	Current	CC Gain	F4	1.00E-01	4.00E+00	0.9419	-
Calibration	Current	Capacity Gain	F4	2.98E+04	1.19E+06	280932.625	-
Calibration	Current Offset	CC Offset	I2	–32767	32767	–7744	-
Calibration	Current Offset	Coulomb Counter Offset Samples	U2	0	65535	64	-
Calibration	Current Offset	Board Offset	I2	–32768	32767	0	-
Calibration	Temperature	Internal Temp Offset	I1	–128	127	0	0.1degC
Calibration	Temperature	Ext1 Temp Offset	I1	–128	127	0	0.1degC
Calibration	Temperature	Ext2 Temp Offset	I1	–128	127	0	0.1degC
Calibration	Temperature	Ext3 Temp Offset	I1	–128	127	0	0.1 degC
Calibration	Temperature	Ext4 Temp Offset	I1	–128	127	0	0.1 degC
Calibration	Internal Temp Model	Int Coeff 1	I2	–32768	32767	0	-
Calibration	Internal Temp Model	Int Coeff 2	I2	–32768	32767	0	-
Calibration	Internal Temp Model	Int Coeff 3	I2	–32768	32767	–11136	-
Calibration	Internal Temp Model	Int Coeff 4	I2	–32768	32767	5754	-
Calibration	Internal Temp Model	Int Min AD	I2	–32768	32767	0	-
Calibration	Internal Temp Model	Int Max Temp	I2	–32768	32767	5754	0.1degK
Calibration	External Temp Model	Ext Coef a1	I2	–32768	32767	–14520	-

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Calibration	External Temp Model	Ext Coef a2	I2	–32768	32767	23696	-
Calibration	External Temp Model	Ext Coef a3	I2	–32768	32767	–20298	-
Calibration	External Temp Model	Ext Coef a4	I2	–32768	32767	28073	-
Calibration	External Temp Model	Ext Coef a5	I2	–32768	32767	865	-
Calibration	External Temp Model	Ext Coef b1	I2	–32768	32767	–694	-
Calibration	External Temp Model	Ext Coef b2	I2	–32768	32767	1326	-
Calibration	External Temp Model	Ext Coef b3	I2	–32768	32767	–3880	-
Calibration	External Temp Model	Ext Coef b4	I2	–32768	32767	5127	-
Calibration	External Temp Model	Ext rc0	I2	–32768	32767	11703	-
Calibration	External Temp Model	Ext adc0	I2	–32768	32767	11703	-
Calibration	External Temp Model	Rpad	I2	–32768	32767	0	-
Calibration	External Temp Model	Rint	I2	–32768	32767	0	-
Calibration	Current Deadband	Deadband	U1	0	255	3	mA
Calibration	Current Deadband	CC Deadband	U1	0	255	34	294 nV
Calibration	Current Deadband	Filter	U1	0	255	239	-
System Data	Manufacturer Data	Pack Lot Code	H2	0x0	0xffff	0x0	
System Data	Manufacturer Data	PCB Lot Code	H2	0x0	0xffff	0x0	
System Data	Manufacturer Data	Firmware Version	H2	0x0	0xffff	0x0	
System Data	Manufacturer Data	Hardware Revision	H2	0x0	0xffff	0x0	
System Data	Manufacturer Data	Cell Revision	H2	0x0	0xffff	0x0	
SBS Configuration	Data	Rem Cap Alarm	I2	0	700	300	mAh
SBS Configuration	Data	Rem Energy Alarm	I2	0	1000	432	10mW
SBS Configuration	Data	Rem Time Alarm	U2	0	30	10	min
SBS Configuration	Data	Init Battery Mode	H2	0x0	0xffff	0x81	hex
SBS Configuration	Data	Design Voltage	I2	7000	18000	10800	mV
SBS Configuration	Data	Spec Info	H2	0x0	0xffff	0x31	hex
SBS Configuration	Data	Manuf Date	U2	0	65535	0	Day + Mo*32 + (Yr –1980)*256

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
SBS Configuration	Data	Ser. Num.	H2	0x0000	0xffff	0x1	hex
SBS Configuration	Data	Cycle Count	U2	0	65535	0	Count
SBS Configuration	Data	CC Threshold	I2	100	32767	4400	mAh
SBS Configuration	Data	CC %	U1	0	100	90	%
SBS Configuration	Data	CF MaxError Limit	U1	0	100	100	%
SBS Configuration	Data	Design Capacity	I2	0	65535	4400	mAh
SBS Configuration	Data	Design Energy	I2	0	65535	4752	10 mW
SBS Configuration	Data	Full Charge Capacity	I2	0	65535	4400	mAh
SBS Configuration	Data	DOD at EDV2	I2	0	16384	15232	
SBS Configuration	Data	Manuf Name	S21	x	x	Texas Instruments	
SBS Configuration	Data	Device Name	S21	x	x	SN8765	
SBS Configuration	Data	Device Chemistry	S5	x	x	LION	
SBS Configuration	Configuration	TDA Set %	I1	–1	100	6	%
SBS Configuration	Configuration	TDA Clear %	I1	–1	100	8	%
SBS Configuration	Configuration	FD Set %	I1	–1	100	2	%
SBS Configuration	Configuration	FD Clear %	I1	–1	100	5	%
SBS Configuration	Configuration	TDA Set Volt Threshold	I2	0	16800	3750	mV
SBS Configuration	Configuration	TDA Set Volt Time	U1	0	240	5	s
SBS Configuration	Configuration	TDA Clear Volt	I2	0	16800	4125	mV
SBS Configuration	Configuration	FD Set Volt Threshold	I2	0	16800	3750	mV
SBS Configuration	Configuration	FD Volt Time	U1	0	240	5	s
SBS Configuration	Configuration	FD Clear Volt	I2	0	16800	4125	mV
System Data	Manufacturer Info	Manuf. Info	S32	x	x	0123456789ABCDEF0123456789ABCDE	
PF Status	Device Status Data	PF Flags 1	H2	0x0	0xffff	0x0	
PF Status	Device Status Data	Fuse Flag	H2	0x0	0xffff	0x0	
PF Status	Device Status Data	PF Voltage	I2	0	32767	0	mV
PF Status	Device Status Data	PF C4 Voltage	I2	0	9999	0	mV

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
PF Status	Device Status Data	PF C3 Voltage	I2	0	9999	0	mV
PF Status	Device Status Data	PF C2 Voltage	I2	0	9999	0	mV
PF Status	Device Status Data	PF C1 Voltage	I2	0	9999	0	mV
PF Status	Device Status Data	PF Current	I2	–32768	32767	0	mA
PF Status	Device Status Data	PF Temperature	I2	–9999	9999	0	0.1 degK
PF Status	Device Status Data	PF Batt Stat	H2	0x0	0xffff	0x0	
PF Status	Device Status Data	PF RC-mAh	I2	0	32767	0	mAh
PF Status	Device Status Data	PF FCC	I2	0	65535	0	mAh
PF Status	Device Status Data	PF Chg Status	H2	0x0	0xffff	0x0	
PF Status	Device Status Data	PF Safety Status	H2	0x0	0xffff	0x0	
PF Status	Device Status Data	PF DOD	I2	0	32767	0	
PF Status	Device Status Data	PF Flags 2	H2	0x0	0xffff	0x0	
PF Status	AFE Regs	AFE Status	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE State Control	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE Control	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE Output Status	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE Function Control	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE Cell Select	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE OLV	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE OLT	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE SCC	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE SCD	H1	0x0	0xff	0x0	
PF Status	AFE Regs	AFE SCD2	H1	0x0	0xff	0x0	
Gas Gauging	State	Qmax Cell 0	I2	0	32767	4400	mAh
Gas Gauging	State	Qmax Cell 1	I2	0	32767	4400	mAh
Gas Gauging	State	Qmax Cell 2	I2	0	32767	4400	mAh
Gas Gauging	State	Qmax Cell 3	I2	0	32767	4400	mAh
Gas Gauging	State	Qmax Pack	I2	0	32767	4400	mAh
Gas Gauging	CEDV Cfg	CEDV Config	H1	0x0	0xff	0x0	
Gas Gauging	CEDV Cfg	EMF	U2	0	65535	3743	mV
Gas Gauging	CEDV Cfg	C0	U2	0	65535	149	
Gas Gauging	CEDV Cfg	R0	U2	0	65535	867	
Gas Gauging	CEDV Cfg	T0	U2	0	65535	4030	
Gas Gauging	CEDV Cfg	R1	U2	0	65535	316	
Gas Gauging	CEDV Cfg	TC	U1	0	255	9	
Gas Gauging	CEDV Cfg	C1	U1	0	255	0	

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Gas Gauging	CEDV Cfg	Age Factor	U1	0	255	0	
Gas Gauging	CEDV Cfg	Fixed EDV 0	U2	0	65535	3031	mV
Gas Gauging	CEDV Cfg	Fixed EDV 1	U2	0	65535	3385	mV
Gas Gauging	CEDV Cfg	Fixed EDV 2	U2	0	65535	3501	mV
Gas Gauging	CEDV Cfg	Low Temp	U1	0	255	119	0.1 degC
Gas Gauging	CEDV Cfg	Overload Current	U2	0	65535	5000	mA
Gas Gauging	CEDV Cfg	Self Discharge Rate	U1	0	255	20	0.01%/day
Gas Gauging	CEDV Cfg	Electronics Load	U1	0	255	0	3 µA
Gas Gauging	CEDV Cfg	Battery Low %	U2	0	65535	4608	%/2.56
Gas Gauging	CEDV Cfg	Near Full	U2	0	65535	200	mAH
Charge Control	Charge Temperature Cfg	JT1	I2	–400	1200	0	0.1 degC
Charge Control	Charge Temperature Cfg	JT2	I2	–400	1200	120	0.1 degC
Charge Control	Charge Temperature Cfg	JT2a	I2	–400	1200	300	0.1 degC
Charge Control	Charge Temperature Cfg	JT3	I2	–400	1200	450	0.1 degC
Charge Control	Charge Temperature Cfg	JT4	I2	–400	1200	550	0.1 degC
Charge Control	Charge Temperature Cfg	Temp Hys	I2	0	100	10	0.1 degC
Charge Control	Pre-Charge Cfg	Pre-chg Current	I2	0	2000	250	mA
Charge Control	Pre-Charge Cfg	Pre-chg Voltage	I2	0	20000	3000	mV
Charge Control	Pre-Charge Cfg	Recovery Voltage	I2	0	20000	3100	mV
Charge Control	Charge Cfg	LT Chg Voltage	I2	0	20000	9000	mV
Charge Control	Charge Cfg	LT Chg Current1	I2	0	20000	250	mA
Charge Control	Charge Cfg	LT Chg Current2	I2	0	20000	250	mA
Charge Control	Charge Cfg	LT Chg Current3	I2	0	20000	250	mA
Charge Control	Charge Cfg	ST1 Chg Voltage	I2	0	20000	12600	mV
Charge Control	Charge Cfg	ST1 Chg Current1	I2	0	20000	4000	mA
Charge Control	Charge Cfg	ST1 Chg Current2	I2	0	20000	4000	mA
Charge Control	Charge Cfg	ST1 Chg Current3	I2	0	20000	4000	mA
Charge Control	Charge Cfg	ST2 Chg Voltage	I2	0	20000	12600	mV

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Charge Control	Charge Cfg	ST2 Chg Current1	I2	0	20000	4000	mA
Charge Control	Charge Cfg	ST2 Chg Current2	I2	0	20000	4000	mA
Charge Control	Charge Cfg	ST2 Chg Current3	I2	0	20000	4000	mA
Charge Control	Charge Cfg	HT Chg Voltage	I2	0	20000	12570	mV
Charge Control	Charge Cfg	HT Chg Current1	I2	0	20000	3800	mA
Charge Control	Charge Cfg	HT Chg Current2	I2	0	20000	3800	mA
Charge Control	Charge Cfg	HT Chg Current3	I2	0	20000	3800	mA
Charge Control	Charge Cfg	Cell Voltage Threshold1	I2	0	5000	3900	mV
Charge Control	Charge Cfg	Cell Voltage Threshold2	I2	0	5000	4000	mV
Charge Control	Charge Cfg	Cell Voltage Thresh Hys	I2	0	1000	10	mV
Charge Control	Termination Cfg	Taper Current	I2	0	1000	250	mA
Charge Control	Termination Cfg	Taper Voltage	I2	0	1000	300	mV
Charge Control	Termination Cfg	Current Taper Window	U1	0	240	40	s
Charge Control	Termination Cfg	TCA Set %	I1	–1	100	–1	%
Charge Control	Termination Cfg	TCA Clear %	I1	–1	100	95	%
Charge Control	Termination Cfg	FC Set %	I1	–1	100	–1	%
Charge Control	Termination Cfg	FC Clear %	I1	–1	100	98	%
Charge Control	Cell Balancing Cfg	Cell Balance Threshold	I2	0	5000	3900	mV
Charge Control	Cell Balancing Cfg	Cell Balance Window	I2	0	5000	100	mV
Charge Control	Cell Balancing Cfg	Cell Balance Min	U1	0	5000	40	mV
Charge Control	Cell Balancing Cfg	Cell Balance Interval	U1	0	240	20	sec
Charge Control	Charging Faults	Over Charging Voltage	I2	0	3000	500	mV
Charge Control	Charging Faults	Over Charging Volt Time	U1	0	240	2	s
Charge Control	Charging Faults	Over Charging Current	I2	0	2000	500	mA
Charge Control	Charging Faults	Over Charging Curr Time	U1	0	240	2	s
Charge Control	Charging Faults	Over Charging Curr Recov	I2	0	2000	100	mA
Charge Control	Charging Faults	Depleted Voltage	I2	0	16000	6000	mV
Charge Control	Charging Faults	Depleted Voltage Time	U1	0	240	2	s

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Charge Control	Charging Faults	Depleted Recovery	I2	0	16000	6500	mV
Charge Control	Charging Faults	Over Charge Capacity	I2	0	4000	300	mAh
Charge Control	Charging Faults	Over Charge Recovery	I2	0	100	2	mAh
Charge Control	Charging Faults	FC-MTO	U2	0	65535	10800	s
Charge Control	Charging Faults	PC-MTO	U2	0	65535	3600	s
Charge Control	Charging Faults	Charge Fault Cfg	H1	0x0	0xffff	0x0	
Configuration	Registers	Operation Cfg A	H2	0x0	0xffff	0x228	
Configuration	Registers	Operation Cfg B	H2	0x0	0xffff	0x440	
Configuration	Registers	Operation Cfg C	H2	0x0	0xffff	0x40	
Configuration	Registers	Permanent Fail Cfg	H2	0x0	0xffff	0x0	
Configuration	Registers	Non-Removable Cfg	H2	0x0	0xffff	0x0	
Configuration	Registers	Manufacturing Status	H2	0x0	0xffff	0x8000	
Configuration	AFE	AFE State_CTL	H1	0x0	0xff	0x0	
Power	Power	Flash Update OK Voltage	I2	6000	20000	7500	mV
Power	Power	Shutdown Voltage	I2	5000	20000	5250	mV
Power	Power	Shutdown Time	U1	0	240	10	s
Power	Power	Cell Shutdown Voltage	I2	0	5000	1750	mV
Power	Power	Cell Shutdown Time	U1	0	240	10	s
Power	Power	AFE Shutdown Voltage	I2	0	5500	3000	mV
Power	Power	Sleep Current	I2	0	100	10	mA
Power	Power	Bus Low Time	U1	0	255	5	s
Power	Power	Cal Inhibit Temp Low	I2	–400	1200	50	0.1 degC
Power	Power	Cal Inhibit Temp High	I2	–400	1200	450	0.1 degC
Power	Power	Sleep Voltage Time	U1	1	240	5	s
Power	Power	Sleep Current Time	U1	1	255	20	s
Power	Power	Wake Current Reg	H1	0x0	0xff	0x0	
Gas Gauging	Current Thresholds	Dsg Current Threshold	I2	0	2000	100	mA
Gas Gauging	Current Thresholds	Chg Current Threshold	I2	0	2000	50	mA

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Quit Current	I2	0	1000	10	mA
Gas Gauging	Current Thresholds	Dsg Relax Time	U1	0	240	1	s
Gas Gauging	Current Thresholds	Chg Relax Time	U1	0	240	60	s
LED Support	LED Cfg	LED Flash Period	U2	0	65535	512	500 µs
LED Support	LED Cfg	LED Blink Period	U2	0	65535	1024	500 µs
LED Support	LED Cfg	LED Delay	U2	1	65535	100	500 µs
LED Support	LED Cfg	LED Hold Time	U1	0	255	4	sec
LED Support	LED Cfg	CHG Flash Alarm	I1	–1	101	10	%
LED Support	LED Cfg	CHG Thresh 1	I1	–1	101	0	%
LED Support	LED Cfg	CHG Thresh 2	I1	–1	101	20	%
LED Support	LED Cfg	CHG Thresh 3	I1	–1	101	40	%
LED Support	LED Cfg	CHG Thresh 4	I1	–1	101	60	%
LED Support	LED Cfg	CHG Thresh 5	I1	–1	101	80	%
LED Support	LED Cfg	DSG Flash Alarm	I1	–1	101	10	%
LED Support	LED Cfg	DSG Thresh 1	I1	–1	101	0	%
LED Support	LED Cfg	DSG Thresh 2	I1	–1	101	20	%
LED Support	LED Cfg	DSG Thresh 3	I1	–1	101	40	%
LED Support	LED Cfg	DSG Thresh 4	I1	–1	101	60	%
LED Support	LED Cfg	DSG Thresh 5	I1	–1	101	80	%
LED Support	LED Cfg	Sink Current	U1	0	3	1	
1st Level Safety	Voltage	LT COV Threshold	I2	3700	5000	4300	mV
1st Level Safety	Voltage	LT COV Recovery	I2	0	4400	4100	mV
1st Level Safety	Voltage	ST COV Threshold	I2	3700	5000	4500	mV
1st Level Safety	Voltage	ST COV Recovery	I2	0	4400	4300	mV
1st Level Safety	Voltage	HT COV Threshold	I2	3700	5000	4200	mV
1st Level Safety	Voltage	HT COV Recovery	I2	0	4400	4000	mV
1st Level Safety	Voltage	CUV Threshold	I2	0	3500	2200	mV
1st Level Safety	Voltage	CUV Recovery	I2	0	3600	3000	mV
1st Level Safety	Current	OC (1st Tier) Chg	I2	0	20000	6000	mA
1st Level Safety	Current	OC (1st Tier) Chg Time	U1	0	240	2	mA
1st Level Safety	Current	OC Chg Recovery	I2	–1000	1000	200	mA
1st Level Safety	Current	OC (1st Tier) Dsg	I2	0	20000	6000	mA
1st Level Safety	Current	OC (1st Tier) Dsg Time	U1	0	240	2	mA

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
1st Level Safety	Current	OC Dsg Recovery	I2	0	1000	200	mA
1st Level Safety	Current	Current Recovery Time	U1	0	240	8	s
1st Level Safety	Current	AFE OC Dsg	H1	0x0	0xf	0x7	
1st Level Safety	Current	AFE OC Dsg Time	H1	0x0	0xf	0x7	
1st Level Safety	Current	AFE OC Dsg Recovery	I2	5	1000	5	mA
1st Level Safety	Current	AFE SC Chg Cfg	H1	0x0	0xf7	0x73	
1st Level Safety	Current	AFE SC Dsg Cfg	H1	0x0	0xf7	0x73	
1st Level Safety	Current	AFE SC Dsg Cfg 2	H1	0x0	0xf7	0xe3	
1st Level Safety	Current	AFE SC Recovery	I2	0	200	1	mA
1st Level Safety	Temperature	Over Temp Chg	I2	0	1200	550	0.1 degC
1st Level Safety	Temperature	OT Chg Time	U1	0	240	2	s
1st Level Safety	Temperature	OT Chg Recovery	I2	0	1200	500	0.1 degC
1st Level Safety	Temperature	Over Temp Dsg	I2	0	1200	600	0.1 degC
1st Level Safety	Temperature	OT Dsg Time	U1	0	240	2	s
1st Level Safety	Temperature	OT Dsg Recovery	I2	0	1200	550	0.1 degC
2nd Level Safety	Voltage	LT SOV Threshold	I2	0	20000	4400	mV
2nd Level Safety	Voltage	ST SOV Threshold	I2	0	20000	4600	mV
2nd Level Safety	Voltage	HT SOV Threshold	I2	0	20000	4500	mV
2nd Level Safety	Voltage	SOV Time	U1	0	240	0	Sec
2nd Level Safety	Voltage	PF SOV Fuse Blow Delay	U2	0	240	0	Sec
2nd Level Safety	Voltage	Cell Imbalance Current	I1	0	127	5	mA
2nd Level Safety	Voltage	Cell Imbalance Fail Voltage	I2	0	5000	1000	mV
2nd Level Safety	Voltage	Cell Imbalance Time	U1	0	240	0	s
2nd Level Safety	Voltage	Battery Rest Time	U2	0	65535	1800	s
2nd Level Safety	Voltage	Min CIM-check voltage	U2	0	65535	3000	mV
2nd Level Safety	Voltage	PFIN Detect Time	U1	0	240	0	s
2nd Level Safety	Current	SOC Chg	I2	0	30000	10000	mA

Table C-264. DATA FLASH VALUES (continued)

Class	SubClass	Name	Data Type	Min	Max	Default	Unit
2nd Level Safety	Current	SOC Chg Time	U1	0	240	0	s
2nd Level Safety	Current	SOC Dsg	I2	0	30000	10000	mA
2nd Level Safety	Current	SOC Dsg Time	U1	0	240	0	s
2nd Level Safety	Temperature	SOT Chg	I2	0	1200	650	0.1 degC
2nd Level Safety	Temperature	SOT Chg Time	U1	0	240	0	s
2nd Level Safety	Temperature	SOT Dsg	I2	0	1200	750	0.1 degC
2nd Level Safety	Temperature	SOT Dsg Time	U1	0	240	0	s
2nd Level Safety	Temperature	Open Thermistor	I2	–1000	1200	–333	0.1 degC
2nd Level Safety	Temperature	Open Time	I1	0	240	0	s
2nd Level Safety	FET Verification	FET Fail Limit	I2	0	500	20	mA
2nd Level Safety	FET Verification	FET Fail Time	U1	0	240	0	s
2nd Level Safety	AFE Verification	AFE Check Time	U1	0	255	0	s
2nd Level Safety	AFE Verification	AFE Fail Limit	U1	0	255	10	
2nd Level Safety	AFE Verification	AFE Fail Recovery Time	U1	0	255	20	s
2nd Level Safety	AFE Verification	AFE Init Retry Limit	U1	0	255	6	
2nd Level Safety	AFE Verification	AFE Init Limit	U1	0	255	20	
System Data	Lifetime Data	Lifetime Max Temp	I2	0	1400	300	0.1 degC
System Data	Lifetime Data	Lifetime Min Temp	I2	–600	1400	200	0.1 degC
System Data	Lifetime Data	Lifetime Max Cell Voltage	I2	0	32767	3500	mV
System Data	Lifetime Data	Lifetime Min Cell Voltage	I2	0	32767	3200	mV

Glossary

ADC	Analog to Digital Converter
AFE	Analog Front End
alert	A warning set by the SN8765
bit	A single bit in an SBS command or data flash value, which can be changed by the user.
CC	Coulomb Counter
CHG FET	Charge FET, connected to the CHG pin of the integrated AFE; used by the integrated AFE to enable or disable charging.
COV	Cell Over Voltage
CPU	Central Processing Unit
CUV	Cell Under Voltage
DF	Data Flash
DSG	Flag set by the SN8765 to indicate charge (DSG= 0) or discharge (DSG=1)
DSG FET	Discharge FET, connected to the DSG pin of the integrated AFE; used by the integrated AFE to enable or disable discharging.
FAS	Full Access Security
FC	Fully Charged
FCHG	Fast Charge
FCMTO	Fast Charge Timeout
FD	Fully Discharged
flag	A single bit in an SBS command or data flash value, which is set by the SN8765 or the integrated AFE and indicates a status change.
IC	Integrated Circuit
Li-Ion	Lithium-Ion
NR	Non-Removable
OC	Overcurrent
OCA	Over Charge Alarm
OCV	Open Circuit Voltage
OTC	Over Temperature Charging
OTD	Over Temperature Discharging
PCHG	Pre-Charge
PCMTO	Pre-Charge Timeout
PEC	Packet Error Checking
PF	Permanent Fail
PRES	System Present Flag
Qmax	Maximum Chemical Capacity
RCA	Remaining Capacity Alarm
RSOC	Relative State of Charge
SBS	Smart Battery System
SCC	Short Circuit Charge

SCD	Short Circuit Discharge
SMBus	System Management Bus
SOC	Safety overcurrent
SOT	Safety Over Temperature
SS	SEALED mode flag
SYS_PRES	System present terminal
TCA	Terminate Charge Alarm
TDA	Terminate Discharge Alarm
Zero-volt charge	The action of charging a totally depleted battery, i.e. the battery cell's voltage is 0 V.
ZVCHG FET	Precharge FET, connected to the ZVCHG pin; it is used for pre-charging only in SN8765.
XDSG	Discharge Fault flag

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