BQ4050

Technical Reference Manual

Literature Number: SLUUAQ3A
APRIL 2016 – REVISED OCTOBER 2022

Table of Contents

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About This Manual

This manual discusses the modules and peripherals of the BQ4050 device, and how each is used to build a complete battery pack gas gauge and protection solution. See the *BQ4050 CEDV Gas Gauge and Protection Solution for 1-Series to 4-Series Cell Li-Ion Battery Packs Data Sheet* for electrical specifications.

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, for example, *RemainingCapacity()*.
- Data Flash: *italics*, **bold**, and breaking spaces; for example, ***Design Capacity***.
- Register Bits and Flags: *italics* and brackets; for example, *[TDA]* Data
- Flash Bits: *italics* and **bold**; for example, ***[LED1]***
- Modes and states: ALL CAPITALS; for example, 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)

Trademarks

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Chapter 1

Introduction

1.1

The BQ4050 device provides a feature-rich gas gauging solution for 1-series cell to 4-series cell battery-pack applications. The device has extended capabilities, including:

- Fully Integrated 1-Series, 2-Series, 3-Series, and 4-Series Li-Ion or Li-Polymer Cell Battery Pack Manager and Protection
- Compensated End-of-Discharge Voltage (CEDV) Technology Accurately Measures Available Charge in Li-Ion and Li-Polymer Batteries
- High Side N-CH Protection FET Drive
- Integrated Cell Balancing While Charging or At Rest
- Low Power Modes
  - LOW POWER
  - SLEEP
- Full Array of Programmable Protection Features
  - Voltage
  - Current
  - Temperature
  - Charge Timeout
  - CHG/DSG FETs
  - Cell Imbalance
- Sophisticated Charge Algorithms
  - JEITA
  - Advanced Charging Algorithm
- Diagnostic Lifetime Data Monitor
- Black Box Event Recorder
- Supports Two-Wire SMBus v1.1 Interface
- SHA-1 Authentication
- Ultra-Compact Package: 32-Lead QFN

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2.1 Introduction

The BQ4050 device provides recoverable protection. When the protection is triggered, charging and/or discharging is disabled. This is indicated by the *OperationStatus()[XCHG]* = 1 when charging is disabled, and/or the *OperationStatus()[XDSG]* = 1 when discharging is disabled. Once the protection is recovered, charging and discharging resume. All protection items can be enabled or disabled under ***Settings:Enabled Protections A***, ***Settings:Enabled Protections B***, ***Settings:Enabled Protections C***, and ***Settings:Enabled Protections D***.

When the protections and permanent fails are triggered, the *BatteryStatus()[TCA][TDA][FD][OCA][OTA]* is set according to the type of safety protections. A summary of the set conditions of the various alarms flags is available in Section 4.8.

2.2 Cell Undervoltage Protection

The device can detect cell undervoltage in batteries and protect cells from damage by preventing further discharge.

Status	Condition	Action
Normal	Min cell voltage1..4 > ***CUV:Threshold***	*SafetyAlert()[CUV]* = 0 *BatteryStatus()[TDA]* = 0
Alert	Min cell voltage1..4 ≤ ***CUV:Threshold***	*SafetyAlert()[CUV]* = 1 *BatteryStatus()[TDA]* = 1
Trip	Min cell voltage1..4 ≤ ***CUV:Threshold*** for ***CUV:Delay*** duration	*SafetyAlert()[CUV]* = 0 *SafetyStatus()[CUV]* = 1 *BatteryStatus()[FD]* = 1,*[TDA]* = 0 *OperationStatus()[XDSG]* = 1
Recovery	Condition 1: *SafetyStatus()[CUV]* = 1 AND Min cell voltage1..4 ≥ ***CUV:Recovery*** AND ***Protection Configuration[CUV_RECOV_CHG]*** = 0	*SafetyStatus()[CUV]* = 0 *BatteryStatus()[FD]* = 0, *[TDA]* = 0 *OperationStatus()[XDSG]* = 0
	OR Condition 2: *SafetyStatus()[CUV]* = 1 AND Min cell voltage1..4 ≥ ***CUV:Recovery*** AND ***Protection Configuration[CUV_RECOV_CHG]*** = 1 AND Charging detected (that is, *BatteryStatus()[DSG]* = 0)	

2.3 Cell Overvoltage Protection

The device can detect cell overvoltage in batteries and protect cells from damage by preventing further charging.

Note

The protection detection threshold may be influenced by the temperature settings of the advanced charging algorithm and the measured temperature.

Status	Condition	Action
Normal, *ChargingStatus()[UT] or [LT]* = 1	Max cell voltage1..4 < ***COV:Threshold Low Temp***	*SafetyAlert()[COV]* = 0
Normal, *ChargingStatus()[STL] or [STH]* = 1	Max cell voltage1..4 < ***COV:Threshold Standard Temp***	
Normal, *ChargingStatus()[RT]* = 1	Max cell voltage1..4 < ***COV:Threshold Rec Temp***	
Normal, *ChargingStatus()[HT] or [OT]* = 1	Max cell voltage1..4 < ***COV:Threshold High Temp***	
Alert, *ChargingStatus()[UT] or [LT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Low Temp***	*SafetyAlert()[COV]* = 1 *BatteryStatus()[TCA]* = 1
Alert, *ChargingStatus()[STL] or [STH]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Standard Temp***	
Alert, *ChargingStatus()[RT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Rec Temp***	
Alert, *ChargingStatus()[HT] or [OT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold High Temp***	
Trip, *ChargingStatus()[UT] or [LT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Low Temp*** for ***COV:Delay*** duration	*SafetyAlert()[COV]* = 0 *SafetyStatus()[COV]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1
Trip, *ChargingStatus()[STL] or [STH]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Standard Temp*** for ***COV:Delay*** duration	*SafetyAlert()[COV]*= 0 *SafetyStatus()[COV]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1
Trip, *ChargingStatus()[RT]* = 1	Max cell voltage1..4≥ ***COV:Threshold Rec Temp*** for ***COV:Delay*** duration	
Trip, *ChargingStatus()[HT] or [OT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold High Temp*** for ***COV:Delay*** duration	
Recovery, *ChargingStatus()[UT] or [LT]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery Low Temp***	*SafetyStatus()[COV]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0
Recovery, *ChargingStatus()[STL] or [STH]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery Standard Temp***	
Recovery, *ChargingStatus()[RT]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery Rec Temp***	
Recovery, *ChargingStatus()[HT] or [OT]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery High Temp***	

2.4 Overcurrent in Charge Protection

The device has two independent overcurrent in charge protections that can be set to different current and delay thresholds to accommodate different charging behaviors.

Status	Condition	Action
Normal	*Current()* < ***OCC1:Threshold***	*SafetyAlert()[OCC1]* = 0
Normal	*Current()* < ***OCC2:Threshold***	*SafetyAlert()[OCC2]* = 0
Alert	*Current()* ≥ ***OCC1:Threshold***	*SafetyAlert()[OCC1]* = 1 *BatteryStatus()[TCA]* = 1
Alert	*Current()* ≥ ***OCC2:Threshold***	*SafetyAlert()[OCC2]* = 1 *BatteryStatus()[TCA]* = 1
Trip	*Current()* continuous ≥ ***OCC1:Threshold*** for ***OCC1:Delay*** duration	*SafetyAlert()[OCC1]* = 0 *SafetyStatus()[OCC1]* = 1 *BatteryStatus()[TCA]* = 0 Charging is not allowed. *OperationStatus()[XCHG]* = 1
Trip	*Current()* continuous ≥ ***OCC2:Threshold*** for ***OCC2:Delay*** duration	*SafetyAlert()[OCC2]* = 0 *SafetyStatus()[OCC2]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1
Recovery	*SafetyStatus()[OCC1]* = 1 AND *Current()* continuous ≤ ***OCC:Recovery Threshold*** for ***OCC:Recovery Delay*** time	*SafetyStatus()[OCC1]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0
Recovery	*SafetyStatus()[OCC2]* = 1 AND *Current()* continuous ≤ ***OCC:Recovery Threshold*** for ***OCC:Recovery Delay*** time	*SafetyStatus()[OCC2]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

2.5 Overcurrent in Discharge Protection

The device has two independent overcurrent in discharge protections that can be set to different current and delay thresholds to accommodate different load behaviors.

Status	Condition	Action
Normal	*Current()* > ***OCD1:Threshold***	*SafetyAlert()[OCD1]* = 0
Normal	*Current()* > ***OCD2:Threshold***	*SafetyAlert()[OCD2]* = 0
Alert	*Current()* ≤ ***OCD1:Threshold***	*SafetyAlert()[OCD1]* = 1 *BatteryStatus()[TDA]* = 1
Alert	*Current()* ≤ ***OCD2:Threshold***	*SafetyAlert()[OCD2]* = 1 *BatteryStatus()[TDA]* = 1
Trip	*Current()* continuous ≤ ***OCD1:Threshold*** for ***OCD1:Delay*** duration	*SafetyAlert()[OCD1]* = 0 *SafetyStatus()[OCD1]* = 1 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 1
Trip	*Current()* continuous ≤ ***OCD2:Threshold*** for ***OCD2:Delay*** duration	*SafetyAlert()[OCD2]* = 0 *SafetyStatus()[OCD2]* = 1 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 1
Recovery	*SafetyStatus()[OCD1]* = 1 AND *Current()* continuous ≥ ***OCD:Recovery Threshold*** for ***OCD:Recovery Delay*** time	*SafetyStatus()[OCD1]* = 0 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 0
Recovery	*SafetyStatus()[OCD2]* = 1 AND *Current()* continuous ≥ ***OCD:Recovery Threshold*** for ***OCD:Recovery Delay*** time	*SafetyStatus()[OCD2]* = 0 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 0

2.6 Hardware-Based Protection

The BQ4050 device has three main hardware-based protections—AOLD, ASCC, and ASCD1,2—with adjustable current and delay time. Setting ***AFE Protection Configuration[RSNS]*** divides the threshold value in half. The ***Threshold*** settings are in mV; therefore, the actual current that triggers the protection is based on the R_{SENSE} used in the schematic design.

In addition, setting the ***AFE Protection Configuration[SCDDx2]*** bit provides an option to double all of the SCD1,2 delay times for maximum flexibility towards the application's needs.

For details on how to configure the AFE hardware protection, refer to the tables in *Chapter 15*.

All of the hardware-based protections provide a Trip/Latch Alert/Recovery protection. The latch feature stops the FETs from toggling on and off continuously on a persistent faulty condition.

In general, when a fault is detected after the ***Delay*** time, both CHG and DSG FETs will be disabled (Trip stage), and an internal fault counter will be incremented (Alert stage). Since both FETs are off, the current will drop to 0 mA. After ***Recovery*** time, the CHG and DSG FETs will be turned on again (Recovery stage).

If the alert is caused by a current spike, the fault count will be decremented after ***Counter Dec Delay*** time. If this is a persistent faulty condition, the device will enter the Trip stage after ***Delay*** time, and repeat the Trip/Latch Alert/Recovery cycle. The internal fault counter is incremented every time the device goes through the Trip/Latch Alert/Recovery cycle. Once the internal fault counter hits the ***Latch Limit***, the protection enters a Latch stage and the fault will only be cleared through the Latch Reset condition.

The Trip/Latch Alert/Recovery/Latch stages are documented in each of the following hardware-based protection sections.

The recovery condition for removable pack (***[NR]*** = 0) is based on the transition on the $\overline{PRES}$ pin, while the recovery condition for embedded pack (***[NR]*** = 1) is based on the ***Reset*** time.

2.6.1 Overload in Discharge Protection

The device has a hardware-based overload in discharge protection with adjustable current and delay.

Status	Condition	Action
Normal	*Current()* > (***OLD Threshold[3:0]***/R_{SENSE})	*SafetyAlert()[AOLDL]* = 0, if OLDL counter = 0

Status	Condition	Action
Trip	*Current()* continuous ≤ (***OLD Threshold[3:0]***/R_{SENSE}) for ***OLD Threshold[7:4]*** duration	*SafetyStatus()[AOLD]* = 1 *OperationStatus()[XDSG]* = 1 Increment AOLDL counter
Recovery	*SafetyStatus()[AOLD]* = 1 for ***OLD:Recovery*** time	*SafetyStatus()[AOLD]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[AOLDL]* = 0.
Latch Alert	AOLDL counter > 0	*SafetyAlert()[AOLDL]* = 1 Decrement AOLDL counter by one after each ***OLD:Counter Dec Delay*** period
Latch Trip	AOLDL counter ≥ ***OLD:Latch Limit***	*SafetyAlert()[AOLDL]* = 0 *SafetyStatus()[AOLDL]* = 1 *OperationStatus()[XDSG]* = 1
Latch Reset (***[NR]*** = 0)	*SafetyStatus()[AOLDL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{PRES}$ pin	*SafetyStatus()[AOLDL]* = 0 Reset AOLDL counter *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[AOLD]* = 0.
Latch Reset (***[NR]*** = 1)	*SafetyStatus()[AOLDL]* = 1 AND ***DA Configuration[NR]*** = 1 for ***OLD:Reset*** time	*SafetyStatus()[AOLDL]* = 0 Reset AOLDL counter *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[AOLD]* = 0.

2.6.2 Short Circuit in Charge Protection

The device has a hardware based short circuit in charge protection with adjustable current and delay.

Status	Condition	Action
Normal	*Current()* < (***SCC Threshold[2:0]***/R_{SENSE})	*SafetyAlert()[ASCCL]* = 0, if ASCCL counter = 0
Trip	*Current()* continuous ≥ (***SCC Threshold[2:0]***/R_{SENSE}) for ***SCC Threshold[7:4]*** duration	*SafetyStatus()[ASCC]* = 1 *BatteryStatus()[TCA]* = 1 *OperationStatus()[XCHG]* = 1 increment ASCCL counter
Recovery	*SafetyStatus()[ASCC]* = 1 for ***SCC:Recovery*** time	*SafetyStatus()[ASCC]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[ASCCL]* = 0.
Latch Alert	ASCCL counter > 0	*SafetyAlert()[ASCCL]* = 1 Decrement ASCCL counter by one after each ***SCC:Counter Dec Delay*** period
Latch Trip	ASCCL counter ≥ ***SCC:Latch Limit***	*SafetyAlert()[ASCCL]* = 0 *SafetyStatus()[ASCCL]* = 1 *OperationStatus()[XCHG]* = 1
Latch Reset (***[NR]*** = 0)	*SafetyStatus()[ASCCL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{PRES}$ pin	*SafetyStatus()[ASCCL]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[ASCC]* = 0.
Latch Reset (***[NR]*** = 1)	*SafetyStatus()[ASCCL]* = 1 AND ***DA Configuration[NR]*** = 1 for ***SCC:Reset*** time	*SafetyStatus()[ASCCL]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[ASCC]* = 0.

2.6.3 Short Circuit in Discharge Protection

The device has a hardware based short circuit in discharge protection with adjustable current and delay.

Status	Condition	Action
Normal	*Current()* > (***SCD1 Threshold[2:0]***/R_{SENSE}) AND *Current()* > (***SCD2 Threshold[2:0]***/R_{SENSE})	*SafetyAlert()[ASCDL]* = 0 if ASCDL counter = 0
Trip	*Current()* continuous ≤ (***SCD1 Threshold[2:0]***/R_{SENSE}) for ***SCD1 Threshold[7:4]*** duration OR *Current()* continuous ≤ (***SCD2 Threshold[2:0]***/R_{SENSE}) for ***SCD2 Threshold[7:4]*** duration	*SafetyStatus()[ASCD]* = 1 *OperationStatus()[XDSG]* = 0 Increment ASCDL counter
Recovery	*SafetyStatus()[ASCD]* = 1 for ***SCD:Recovery*** time	*SafetyStatus()[ASCD]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[ASCDL]* = 0.
Latch Alert	ASCDL counter > 0	*SafetyAlert()[ASCDL]* = 1 Decrement ASCDL counter by one after each ***SCD:Counter Dec Delay*** period
Latch Trip	SCD counter ≥ ***SCD:Latch Limit***	*SafetyStatus()[ASCD]* = 0 *SafetyStatus()[ASCDL]* = 1 *OperationStatus()[XDSG]* = 1

Status	Condition	Action
Latch Reset (***[NR]*** = 0)	*SafetyStatus()[ASCDL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	*SafetyStatus()[ASCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[ASCD]* = 0.
Latch Reset (***[NR]*** = 1)	*SafetyStatus()[ASCCL]* = 1 AND ***DA Configuration[NR]*** = 1 for ***SCD:Reset*** time	*SafetyStatus()[ASCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[ASCD]* = 0.

2.7 Temperature Protections

The device provides overtemperature and undertemperature protections based on Cell Temperature measurement and FET temperature measurements. The Cell Temperature based protections are further divided into a protection-in-charging direction and discharging directions. This section describes in detail each of the protection functions.

For temperature reporting, the device supports a maximum of four external thermistors and one internal temperature sensor. Unused temperature sensors must be disabled by clearing the corresponding flag in ***Settings:Temperature Enable[TS4][TS3][TS2][TS1][TSInt]***.

Each of the external thermistors and the internal temperature sensor can be set up individually as a source for Cell Temperature or FET Temperature reporting. Setting the corresponding flag to 1 in ***Settings:Temperature Mode[TS4 Mode][TS3 Mode][TS2 Mode][TS1 Mode][TSInt Mode]*** configures that temperature sensor to report for FET Temperature. Clearing the corresponding flag sets that temperature sensor to report for Cell Temperature. The ***Settings:DA Configuration[FTEMP][CTEMP]*** allows users to use the maximal (setting the corresponding flag to 0) or the average (setting the corresponding flag to 1) of the source temperature sensors for Cell Temperature and FET Temperature reporting.

The *Temperature()* command returns the Cell Temperature measurement. The MAC and extended command *DAStatus2()* also returns the temperature measurement from the internal temperature sensor, the external thermistors TS1, TS2, TS3, and TS4, and the Cell and FET Temperatures.

The Cell Temperature based overtemperature and undertemperature safety provide protections in charge and discharge conditions. The battery pack is considered in CHARGE mode when *BatteryStatus()[DSG]* = 0, where *Current()* > ***Chg Current Threshold***. The overtemperature and undertemperature in charging protections are active in this mode. The *BatteryStatus()[DSG]* is set to 1 in a NON-CHARGE mode condition, which includes RELAX and DISCHARGE modes. The overtemperature and undertemperature in discharge protections are active in these two modes. See Section 6.2 for detailed descriptions of the gas gauge modes.

2.8 Overtemperature in Charge Protection

The device has an overtemperature protection for cells under charge.

Status	Condition	Action
Normal	*Temperature()* < ***OTC:Threshold*** OR not charging	*SafetyAlert()[OTC]* = 0
Alert	*Temperature()* ≥ ***OTC:Threshold*** AND charging	*SafetyAlert()[OTC]* = 1 *BatteryStatus()[TCA]* = 1
Trip	*Temperature()* ≥ ***OTC:Threshold*** AND Charging for ***OTC:Delay*** duration	*SafetyAlert()[OTC]* = 0 *SafetyStatus()[OTC]* = 1 *BatteryStatus()[OTA]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1 if ***FET Options[OTFET]*** = 1.
Recovery	*SafetyStatus()[OTC]* AND *Temperature()* ≤ ***OTC:Recovery***	*SafetyStatus()[OTC]* = 0 *BatteryStatus()[OTA]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

2.9 Overtemperature in Discharge Protection

The device has an overtemperature protection for cells in DISCHARGE or RELAX state (that is, non-charging state with *BatteryStatus[DSG]* = 1).

Status	Condition	Action
Normal	*Temperature()* < ***OTD:Threshold*** OR charging	*SafetyAlert()[OTD]* = 0

Status	Condition	Action
Alert	*Temperature()* ≥ ***OTD:Threshold*** AND Not charging (that is, *BatteryStatus[DSG]* = 1)	*SafetyAlert()[OTD]* = 1 *BatteryStatus()[TDA]* = 1
Trip	*Temperature()* ≥ ***OTD:Threshold*** AND Not charging (that is, *BatteryStatus[DSG]* = 1) for ***OTD:Delay*** duration	*SafetyAlert()[OTD]* = 0 *SafetyStatus()[OTD]* = 1 *BatteryStatus()[OTA]* = 1 *OperationStatus()[XDSG]* = 1 if ***FET Options[OTFET]*** = 1. *BatteryStatus()[TDA]* = 0
Recovery	*SafetyStatus()[OTD]* AND *Temperature()* ≤ ***OTD:Recovery***	*SafetyStatus()[OTD]* = 0 *BatteryStatus()[OTA]* = 0 *OperationStatus()[XDSG]* = 0 *BatteryStatus()[TDA]* = 0

2.10 Overtemperature FET Protection

The device has an overtemperature protection to limit the FET temperature.

Status	Condition	Action
Normal	FET Temperature in *DAStatus2()* < ***OTF:Threshold***	*SafetyAlert()[OTF]* = 0
Alert	FET Temperature in *DAStatus2()* ≥ ***OTF:Threshold***	*SafetyAlert()[OTF]* = 1 *BatteryStatus()[TDA]* = 1, *[TCA]* = 1
Trip	FET Temperature in *DAStatus()* ≥ ***OTF:Threshold*** for ***OTF:Delay*** duration	*SafetyAlert()[OTF]* = 0 *SafetyStatus()[OTF]* = 1 *BatteryStatus()[OTA]* = 1 *BatteryStatus()[TDA]* = 0, *[TCA]* = 0 *OperationStatus()[XCHG][XDSG]* = 1,1 if ***FET Options[OTFET]*** = 1
Recovery	*SafetyStatus()[OTF]* AND FET Temperature in *DAStatus2()* ≤ ***OTF:Recovery***	*SafetyStatus()[OTF* = 0 *BatteryStatus()[OTA]* = 0 *BatteryStatus()[TDA]* = 0, *[TCA]* = 0 *OperationStatus()[XCHG][XDSG]* = 0,0

2.11 Undertemperature in Charge Protection

The device has an undertemperature protection for cells in charge direction.

Status	Condition	Action
Normal	*Temperature()* > ***UTC:Threshold*** OR not charging	*SafetyAlert()[UTC]* = 0
Alert	*Temperature()* ≤ ***UTC:Threshold*** AND charging	*SafetyAlert()[UTC]* = 1
Trip	*Temperature()* ≤ ***UTC:Threshold*** AND Charging for ***UTC:Delay*** duration	*SafetyAlert()[UTC]* = 0 *SafetyStatus()[UTC]* = 1 *OperationStatus()[XCHG]* = 1
Recovery	*SafetyStatus()[UTC]* AND *Temperature()* ≥ ***UTC:Recovery***	*SafetyStatus()[UTC]* = 0 *OperationStatus()[XCHG]* = 0

2.12 Undertemperature in Discharge Protection

The device has an undertemperature protection for cells in DISCHARGE or RELAX state (that is, non-charging state with *BatteryStatus[DSG]* = 1).

Status	Condition	Action
Normal	*Temperature()* > ***UTD:Threshold*** OR charging	*SafetyAlert()[UTD]* = 0
Alert	*Temperature()* ≤ ***UTD:Threshold*** AND Not charging (that is, *BatteryStatus[DSG]* = 1)	*SafetyAlert()[UTD]* = 1
Trip	*Temperature()* ≤ ***UTD:Threshold*** AND Not charging (that is, *BatteryStatus[DSG]* = 1) for ***UTD:Delay*** duration	*SafetyAlert()[UTD]* = 0 *SafetyStatus()[UTD]* = 1 *OperationStatus()[XDSG]* = 1
Recovery	*SafetyStatus()[UTD]* AND *Temperature()* ≥ ***UTD:Recovery***	*SafetyStatus()[UTD]* = 0 *OperationStatus()[XDSG]* = 0

2.13 SBS Host Watchdog Protection

The device can check periodic communication over SBS and prevent usage of the battery pack if no valid communication is detected.

Status	Condition	Action
Trip	No valid SBS transaction for ***HWD:Delay*** duration	*SafetyStatus()[HWD]* = 1 *OperationStatus()[XCHG]* = 1
Recovery	Valid SBS transaction detected	*SafetyStatus()[HWD]* = 0 *OperationStatus()[XCHG]* = 0

2.14 Precharge Timeout Protection

The device can measure the precharge time and stop charging if it exceeds the adjustable period.

Status	Condition	Action
Enable	*Current()* > ***PTO:Charge Threshold*** AND *ChargingStatus()[PV]* = 1	Start PTO timer *SafetyAlert()[PTOS]* = 0
Suspend or Recovery	*Current()* < ***PTO:Suspend Threshold***	Stop PTO timer *SafetyAlert()[PTOS]* = 1
Trip	PTO timer > ***PTO:Delay***	Stop PTO timer *SafetyStatus()[PTO]* = 1 *BatteryStatus()[TCA]* = 1 *OperationStatus()[XCHG]* = 1
Reset	*SafetyStatus()[PTO]* = 1 AND ***DA Configuration[NR]*** = 0 AND (Discharge by an amount of ***PTO:Reset*** OR low-high-low transition on $\overline{\text{PRES}}$)	Stop and reset PTO timer *SafetyAlert()[PTOS]* = 0 *SafetyStatus()[PTO]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0
Reset	*SafetyStatus()[PTO]* = 1 AND ***DA Configuration[NR]*** = 1 AND (Discharge by an amount of ***PTO:Reset***)	Stop and reset PTO timer *SafetyAlert()[PTOS]* = 0 *SafetyStatus()[PTO]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

2.15 Fast Charge Timeout Protection

The device can measure the charge time and stop charging if it exceeds the adjustable period.

Status	Condition	Action
Enable	*Current()* > ***CTO:Charge Threshold*** AND (*ChargingStatus()[LV]* = 1 OR *ChargingStatus()[MV]* = 1 OR *ChargingStatus()[HV]* = 1)	Start CTO timer *SafetyAlert()[CTOS]* = 0
Suspend or Recovery	*Current()* < ***CTO:Suspend Threshold***	Stop CTO timer *SafetyAlert()[CTOS]* = 1
Trip	CTO time > ***CTO:Delay***	Stop CTO timer *SafetyStatus()[CTO]* = 1 *OperationStatus()[XCHG]* = 1
Reset	*SafetyStatus()[CTO]* = 1 AND ***DA Configuration[NR]*** = 0 AND (Discharge by an amount of ***CTO:Reset*** OR low-high-low transition on $\overline{\text{PRES}}$)	Stop and reset CTO timer *SafetyAlert()[CTOS]* = 0 *SafetyStatus()[CTO]* = 0 *OperationStatus()[XCHG]* = 0
Reset	*SafetyStatus()[CTO]* = 1 AND ***DA Configuration[NR]*** = 1 AND (Discharge by an amount of ***CTO:Reset***)	Stop and reset CTO timer *SafetyAlert()[CTOS]* = 0 *SafetyStatus()[CTO]* = 0 *OperationStatus()[XCHG]* = 0

2.16 Overcharge Protection

The device can prevent continuing charging if the pack is charged in excess over *FullChargeCapacity()*.

Status	Condition	Action
Normal	*RemainingCapacity()* < *FullChargeCapacity()*	*SafetyAlert()[OC]* = 0
Alert	*RemainingCapacity()* ≥ *FullChargeCapacity()* AND Internal charge counter > 0	*SafetyAlert()[OC]* = 1 *BatteryStatus()[TCA]* = 1
Trip	*RemainingCapacity()* ≥ *FullChargeCapacity()* AND Internal charge counter ≥ ***OC:Threshold***	*SafetyAlert()[OC]* = 0 *SafetyStatus()[OC]* = 1 *BatteryStatus()[TCA]* = 0, *[OCA]* = 1 if the device is in charge state (that is, *BatteryStatus[DSG]* = 0). *OperationStatus()[XCHG]* = 1

Status	Condition	Action
Recovery, ***[NR]*** = 0	*SafetyStatus()[OC]* = 1 AND ***DA Configuration[NR]*** = 0 AND (Low-high-low transition on $\overline{\text{PRES}}$ pin)	*SafetyStatus()[OC]* = 0 *BatteryStatus()[TCA]* = 0, *[OCA]* = 0 *OperationStatus()[XCHG]* = 0
Recovery ***[NR]*** = 1	Condition 1: *SafetyStatus()[OC]* = 1 AND ***DA Configuration[NR]*** = 1 AND continuous discharge of ***Recovery*** OR Condition 2: *SafetyStatus()[OC]* = 1 AND ***DA Configuration[NR]*** = 1 AND *RelativeStateOfCharge()* < ***OC:RSOC Recovery***	*SafetyStatus()[OC]* = 0 *BatteryStatus()[TCA]* = 0, *[OCA]* = 0 *OperationStatus()[XCHG]* = 0

2.17 OverChargingVoltage() Protection

The device can stop charging if it measures a difference between the requested *ChargingVoltage()* and the delivered voltage from the charger. This feature only operates when the device is in CHARGE mode.

Note

ChargingVoltage() will be set to 0 mV when the protection is tripped. The *ChargingVoltage()* for the recovery is the intended or targeted Charging Voltage, not the 0 mV that was set due to the trip of protection.

Status	Condition	Action
Normal	Pack pin voltage in *DAStatus1()* < *ChargingVoltage()* + ***CHGV:Threshold*** × Number of series cells	*SafetyAlert()[CHGV]* = 0
Alert	Pack pin voltage in *DAStatus1()* ≥ *ChargingVoltage()* + ***CHGV:Threshold*** × Number of series cells	*SafetyAlert()[CHGV]* = 1 *BatteryStatus()[TCA]* = 1
Trip	Pack pin voltage in *DAStatus1()* continuous ≥ *ChargingVoltage()* + ***CHGV:Threshold*** × Number of series cells for ***CHGV:Delay*** period	*SafetyAlert()[CHGV]* = 0 *SafetyStatus()[CHGV]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1
Recovery	*SafetyStatus()[CHGV]* = 1 AND Pack pin voltage in *DAStatus1()* ≤ intended *ChargingVoltage()* + ***CHGV Recovery*** × Number of series cells	*SafetyStatus()[CHGV]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

2.18 OverChargingCurrent() Protection

The device can stop charging if it measures a difference between the requested *ChargingCurrent()* and the delivered current from the charger. This protection is designed to recover by a discharge event; therefore, ***CHGC:Recovery*** should be set to a negative value in data flash.

Status	Condition	Action
Normal	*Current()* < *ChargingCurrent()* + ***CHGC:Threshold***	*SafetyAlert()[CHGC]* = 0
Alert	*Current()* ≥ *ChargingCurrent()* + ***CHGC:Threshold***	*SafetyAlert()[CHGC]* = 1 *BatteryStatus()[TCA]* = 1
Trip	*Current()* continuous ≥ *ChargingCurrent()* + ***CHGC:Threshold***for ***CHGC:Delay*** period	*SafetyAlert()[CHGC]* = 0 *SafetyStatus()[CHGC]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1
Recovery	*SafetyStatus()[CHGC]* = 1 AND *Current()* ≤ ***CHGC:Recovery Threshold*** for ***CHGC:Recovery Delay*** time	*SafetyStatus()[CHGC]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

2.19 OverPreChargingCurrent() Protection

The device can stop charging if it measures a difference between the requested *ChargingCurrent()* and the delivered current from the charger during precharge. This protection is designed to recover by a discharge event; therefore, ***PCHGC:Recovery*** should be set to a negative value in data flash.

Status	Condition	Action
Normal	*Current()* < *ChargingCurrent()* + ***PCHGC:Threshold*** AND *ChargingStatus()[PV]* = 1	*SafetyAlert()[PCHGC]* = 0
Alert	*Current()* ≥ *ChargingCurrent()* + ***PCHGC:Threshold*** AND *ChargingStatus()[PV]* = 1	*SafetyAlert()[PCHGC]* = 1 *BatteryStatus()[TCA]* = 1
Trip	*Current()* continuous ≥ *ChargingCurrent()* + ***PCHGC:Threshold***for ***PCHGC:Delay*** period AND *ChargingStatus()[PV]* = 1	*SafetyAlert()[PCHGC]* = 0 *SafetyStatus()[PCHGC]* = 1 If charging, *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1
Recovery	*SafetyStatus()[PCHGC]* = 1 AND *Current()* ≤ ***PCHGC:Recovery Threshold*** for ***PCHGC:Recovery Delay*** time	*SafetyStatus()[PCHGC]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

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Chapter 3

Permanent Fail

3.1 Introduction

The device can permanently disable the use of the battery pack in case of a severe failure. The permanent failure checks, except for IFC and DFW, can be individually enabled or disabled by setting the appropriate bit in ***Settings:Enabled PF A***, ***Settings:Enabled PF B***, ***Settings:Enabled PF C***, and ***Settings:Enabled PF D***. All permanent failure checks, except for IFC and DFW, are disabled until *ManufacturingStatus()[PF]* is set. When any *PFStatus()* bit is set, the device enters PERMANENT FAIL mode and the following actions are taken in sequence:

1. Precharge, charge, and discharge FETs are turned off.
2. *OperationStatus()[PF]* = 1, *[XCHG]* = 1, *[XDSG]* = 1
3. The following SBS data is changed: *BatteryStatus()[TCA]* = 1, *BatteryStatus()[TDA]* = 1, *ChargingCurrent()* = 0, and *ChargingVoltage()* = 0.
4. A backup of the internal AFE hardware registers are written to data flash: ***AFE Interrupt Status***, ***AFE FET Status***, ***AFE RXIN***, ***AFE Latch Status***, ***AFE Interrupt Enable***, ***AFE FET Control***, ***AFE RXIEN***, ***AFE RLOUT***, ***AFE RHOUT***, ***AFE RHINT***, ***AFE Cell Balance***, ***AFE AD/CC Control***, ***AFE ADC Mux***, ***AFE LED Output***, ***AFE State Control***, ***AFE LED/Wake Control***, ***AFE Protection Control***, ***AFE OCD***, ***AFE SCC***, ***AFE SCD1***, and ***AFE SCD2***.
5. The black box data of the last three *SafetyStatus()* changes leading up to PF with the time difference is written into the black box data flash along with the 1st *PFStatus()* value.
6. The following SBS values are preserved in data flash for failure analysis:
   - *SafetyAlert()*
   - *SafetyStatus()*
   - *PFAlert()*
   - *PFStatus()*
   - *OperationStatus()*
   - *ChargingStatus()*
   - *GaugingStatus()*
   - Voltages in *DAStatus1()*
   - *Current()*
   - TSINT, TS1, TS2, TS3, and TS4 from *DAStatus2()*
   - Cell DOD0 and passed charge
7. Data flash writing is disabled (except to store subsequent *PFStatus()* flags).
8. The FUSE pin is driven high if configured for specific failures and *Voltage()* is above ***Min Blow Fuse Voltage*** or there is a CHG FET (CFETF) or DSG FET (DFETF) failure. The FUSE pin will remain asserted until the ***Fuse Blow Timeout*** expired.

Note

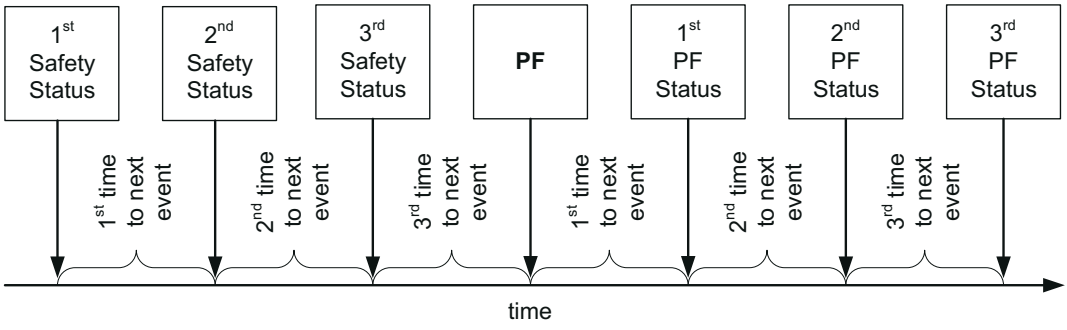
If ***[PACK_FUSE]*** = 0, *Voltage()* is used to check for ***Min Blow Fuse Voltage***, indicating the fuse is connected to the BAT side.

If ***[PACK_FUSE]*** = 1 (that is, Fuse is connected to the PACK side and is required to have a charger connected in order to blow the fuse), then the pack voltage is used to check for ***Min Blow Fuse Voltage*** threshold.

While the device is in PERMANENT FAIL mode, any new *SafetyAlert()*, *SafetyStatus()*, *PFAlert()*, and *PFStatus()* flags that are set are added to the permanent fail log. Any new *PFStatus()* flags that occur during PERMANENT FAIL mode can trigger the FUSE pin. In addition, new *PFStatus()* flags are recorded in the Black Box Recorder 2nd and 3rd PF Status entries.

3.1.1 Black Box Recorder

The Black Box Recorder maintains the last three updates of *SafetyStatus()* in memory. When entering PERMANENT FAIL mode, this information is written to data flash together with the first three updates of *PFStatus()* after the PF event.



Note

This information is useful in failure analysis, and can provide a full recording of the events and conditions leading up to the permanent failure.

If there were less than three safety events before PF, then some information will be left blank.

3.2 Safety Cell Undervoltage Permanent Fail

The device can permanently disable the battery in the case of severe undervoltage in any of the cells.

Status	Condition	Action
Normal	Min cell voltage1..4 > ***SUV:Threshold***	*PFAlert()[SUV]* = 0 *BatteryStatus()[TDA]* = 0
Alert	Min cell voltage1..4 ≤ ***SUV:Threshold***	*PFAlert()[SUV]* = 1 *BatteryStatus()[TDA]* = 1
Trip	Min cell voltage1..4 continuous ≤ ***SUV:Threshold*** for ***SUV:Delay*** duration	*PFAlert()[SUV]* = 0 *PFStatus()[SUV]* = 1 *BatteryStatus()[FD]* = 1

3.2.1 SUV Check Option

When ***Protection Configuration[SUV_MODE]*** is set, the SUV PF check only applies when the gauge wakes up from shutdown. The CHG and DSG FETs are disabled for the duration of the test (***SUV:Delay***) to prevent an applied charge voltage from masking a copper deposition condition.

3.3 Safety Cell Overvoltage Permanent Fail

The device can permanently disable the battery in the case of severe overvoltage in any of the cells.

Status	Condition	Action
Normal	Max cell voltage1..4 < ***SOV:Threshold***	*PFAlert()[SOV]* = 0
Alert	Max cell voltage1..4 ≥ ***SOV:Threshold***	*PFAlert()[SOV]* = 1 *BatteryStatus()[TCA]* = 1
Trip	Max cell voltage1..4 continuous ≥ ***SOV:Threshold*** for ***SOV:Delay*** duration	*PFAlert()[SOV]* = 0 *PFStatus()[SOV]* = 1

3.4 Safety Overcurrent in Charge Permanent Fail

The device can permanently disable the battery in the case of severe overcurrent in charge state.

Status	Condition	Action
Normal	*Current()* < ***SOCC:Threshold***	*PFAlert()[SOCC]* = 0
Alert	*Current()* ≥ ***SOCC:Threshold***	*PFAlert()[SOCC]* = 1 *BatteryStatus()[TCA]* = 1 *BatteryStatus()[OCA]* = 1
Trip	*Current()* ≥ ***SOCC:Threshold*** for ***SOCC:Delay*** duration	*PFAlert()[SOCC]* = 1 *PFStatus()[SOCC]* = 1

3.5 Safety Overcurrent in Discharge Permanent Fail

The device can permanently disable the battery in the case of severe overcurrent in discharge or RELAX state.

Status	Condition	Action
Normal	*Current()* > ***SOCD:Threshold***	*PFAlert()[SOCD]* = 0
Alert	*Current()* ≤ ***SOCD:Threshold***	*PFAlert()[SOCC]* = 1 *BatteryStatus()[TDA]* = 1
Trip	*Current()* ≤ ***SOCD:Threshold*** for ***SOCD:Delay*** duration	*PFAlert()[SOCC]* = 1 *PFStatus()[SOCC]* = 1

3.6 Safety Overtemperature Cell Permanent Fail

The device can permanently disable the battery pack in case of severe overtemperature of the cells detected using the external TS1...4 temperature sensor(s), which are configured to report as cell temperature, *Temperature()*. The *Temperature()* measurement configuration is done by setting the corresponding flag in ***Temperature Mode*** and ***DA Configuration[CTEMP]***.

Status	Condition	Action
Normal	*Temperature()* < ***SOT:Threshold***	*PFAlert()[SOT]* = 0
Alert	*Temperature()* ≥ ***SOT:Threshold***	*PFAlert()[SOT]* = 1 *BatteryStatus()[OTA]* = 1
Trip	*Temperature()* continuous ≥ ***SOT:Threshold*** for ***SOT:Delay*** duration	*PFAlert()[SOT]* = 0 *PFStatus()[SOT]* = 1 *BatteryStatus()[OTA]* = 1

3.7 Safety Overtemperature FET Permanent Fail

The device can permanently disable the battery pack in case of severe overtemperature on the power FET. The temperature sensor(s) can be configured to report as FET Temperature in *DAStatus2()* by setting the corresponding flag in ***Temperature Mode*** and ***DA Configuration[FTEMP]***.

Status	Condition	Action
Normal	FET Temperature in *DAStatus2()* < ***SOTF:Threshold***	*PFAlert()[SOTF]* = 0
Alert	FET Temperature in *DAStatus2()* ≥ ***SOTF:Threshold***	*PFAlert()[SOTF]* = 1 *BatteryStatus()[OTA]* = 1
Trip	FET Temperature in *DAStatus2()* continuous ≥ ***SOTF:Threshold*** for ***SOTF:Delay*** duration	*PFAlert()[SOTF]* = 0 *PFStatus()[SOTF]* = 1 *BatteryStatus()[OTA]* = 1

3.8 Voltage Imbalance At Rest Permanent Fail

The device can permanently disable the battery pack in case of a voltage difference between the cells in a stack while at rest.

Status	Condition	Action
Normal	Max cell voltage1..4 < ***VIMR:Check Voltage*** OR |*Current()*| > ***VIMR:Check Current*** OR Max cell voltage1..4 – Min cell voltage1..4 < ***VIMR:Delta Threshold***	*PFAlert()[VIMR]* = 0
Alert	(Max cell voltage1..4 ≥ ***VIMR:Check Voltage*** AND |*Current()*| < ***VIMR:Check Current)*** for ***VIMR:Duration*** AND Max cell voltage1..4 – Min cell voltage1..4 ≥ ***VIMR:Delta Threshold***	*PFAlert()[VIMR]* = 1
Trip	(Max cell voltage1..4 ≥ ***VIMR:Check Voltage*** AND |*Current()*| < ***VIMR:Check Current***) for ***VIMR:Duration*** AND Max cell voltage1..4 – Min cell voltage1..4 ≥ ***VIMR:Delta Threshold*** for ***VIMR:Delta Delay***	*PFAlert()[VIMR]* = 0 *PFStatus()[VIMR]* = 1

3.9 Voltage Imbalance Active Permanent Fail

The device can permanently disable the battery pack in case of a voltage difference between the cells in a stack while active.

Status	Condition	Action
Normal	Max cell voltage1..4 < ***VIMA:Check Voltage*** OR *Current()* < ***VIMA:Check Current*** OR Max cell voltage1..4 – Min cell voltage1..4 < ***VIMA:Delta Threshold***	*PFAlert()[VIMA]* = 0
Alert	Max Cell voltage ≥ ***VIMA:Check Voltage*** AND *Current()* > ***VIMA:Check Current*** AND Max cell voltage1..4 – Min cell voltage1..4 ≥ ***VIMA:Delta Threshold***	*PFAlert()[VIMA]* = 1
Trip	(Max cell voltage1..4 ≥ ***VIMA:Check Voltage*** AND *Current()* > ***VIMA:Check Current*** AND Max cell voltage1..4 – Min cell voltage1..4 ≥ ***VIMA:Delta Threshold)*** for ***VIMA:Delay***	*PFAlert()[VIMA]* = 0 *PFStatus()[VIMA]* = 1

3.10 Charge FET Permanent Fail

The device can permanently disable the battery pack in case the charge FET is not working properly.

Status	Condition	Action
Normal	CHG FET off AND *Current()* < ***CFET:OFF Threshold***	*PFAlert()[CFETF]* = 0
Alert	CHG FET off AND *Current()* ≥ ***CFET:OFF Threshold***	*PFAlert()[CFETF]* = 1
Trip	CHG FET off AND *Current()* continuously ≥ ***CFET:OFF Threshold*** for ***CFET:OFF Delay***duration	*PFAlert()[CFETF]* = 0 *PFStatus()[CFETF]* = 1

3.11 Discharge FET Permanent Fail

The device can permanently disable the battery pack in case the discharge FET is not working properly.

Status	Condition	Action
Normal	DSG FET off AND *Current()* > ***DFET:OFF Threshold***	*PFAlert()[DFETF]* = 0
Alert	DSG FET off AND *Current()* ≤ ***DFET:OFF Threshold***	*PFAlert()[DFETF]* = 1
Trip	DSG FET off AND *Current()* continuously ≤ ***DFET:OFF Threshold*** for ***DFET:OFF Delay*** duration	*PFAlert()[DFETF]* = 0 *PFStatus()[DFETF]* = 1

3.12 Chemical Fuse Permanent Fail

The device can detect a non-working fuse. It cannot disable the battery pack permanently, but can record this event for analysis.

Status	Condition	Action
Normal	FUSE pin = high AND |*Current()*| < ***FUSE:Threshold***	*PFAlert()[FUSE]* = 0
Alert	FUSE pin = high AND |*Current()*| ≥ ***FUSE:Threshold***	*PFAlert()[FUSE]* = 1
Trip	FUSE pin = high AND |*Current()*| continuous ≥ ***FUSE:Threshold*** for ***FUSE:Delay*** duration	*PFAlert()[FUSE]* = 0 *PFStatus()[FUSE]* = 1

3.13 AFE Register Permanent Fail

The device compares the AFE hardware register periodically with a RAM backup and corrects any errors. If any errors are found during the check, the device increments the AFE register fail counter. If the comparison fails too many times, the device disables the pack permanently.

Status	Condition	Action
Normal	AFE register fail counter = 0	*PFAlert()[AFER]* = 0 Compare AFE register and RAM backup every ***AFER:Compare Period***
Alert	AFE register fail counter > 0	*PFAlert()[AFER]* = 1 Decrement AFE register fail counter by one after each ***AFER:Delay Period*** Compare AFE register and RAM backup every ***AFER:Compare Period***
Trip	AFE register fail counter ≥ ***AFER:Threshold***	*PFAlert()[AFER]* = 0 *PFStatus()[AFER]* = 1

3.14 AFE Communication Permanent Fail

The device monitors the internal communication to the AFE hardware and increments the AFE read/write fail counter on any communication error. If the read or write fails exceed a limit within a configurable timeframe, the device disables the pack permanently.

Status	Condition	Action
Normal	AFE read/write fail counter = 0	*PFAlert()[AFEC]* = 0
Alert	AFE read/write fail counter > 0	*PFAlert()[AFEC]* = 1 Decrement AFE read/write fail counter by one after each ***AFEC:Delay Period***
Trip	Read and Write Fail counter ≥ ***AFEC:Threshold***	*PFAlert()[AFEC]* = 0 *PFStatus()[AFEC]* = 1

3.15 PTC Permanent Fail

The device can detect overtemperature using a positive temperature coefficient (PTC) resistor connected to the PTC pin. This protection also works in SHUTDOWN mode.

If the device detects a PTC pin high state, the CHG and DSG FETs are turned off, and the pack is disabled permanently. For manufacturer testing, the fault state can be reset by a full power cycle of the device.

This is a hardware controlled feature. To enable this feature, the PTCEN pin should be tied to BAT. To disable this feature, connect the PTCEN pin to ground.

Status	Condition	Action
Normal	Reset AFE and PTC pin = low	*PFStatus()[PTC]* = 0
Trip	PTC pin = high	*PFStatus()[PTC]* = 1 FUSE = high *BatteryStatus()[TCA]* = 1 *BatteryStatus()[TDA]* = 1

3.16 Second Level Protection Permanent Fail

The device can detect an external trigger of the chemical fuse by an external protection circuit such as a 2nd-level protector by monitoring the FUSE pin state.

If the device detects a FUSE pin high state, the CHG and DSG FETs are turned off.

Setting ***Enabled PF C[2LVL]*** = 0 will not prevent the second level protector from triggering and blowing the fuse, setting ***[2LVL]*** = 0 will only prevent the gauge from detecting the fuse state.

Status	Condition	Action
Normal	Reset AFE and FUSE pin = low AND No FUSE trigger by firmware	*PFAlert()[2LVL]* = 0
Alert	FUSE pin = high AND No FUSE trigger by firmware	*PFAlert()[2LVL]* = 1 Reset AFE FUSE bit
Trip	FUSE pin continuously high for ***2LVL:Delay*** period AND No FUSE trigger by firmware	*PFAlert()[2LVL]* = 0 *PFStatus()[2LVL]* = 1

3.17 Instruction Flash (IF) Checksum Permanent Fail

The device can permanently disable the battery if it detects a difference between the stored IF checksum and the calculated IF checksum only following a device reset.

Status	Condition	Action
Normal	Stored and calculated IF checksum match	—
Trip	Stored and calculated IF checksum after reset does not match	*PFStatus()[IFC]* = 1

3.18 Open Cell Voltage Connection Permanent Fail

The device can permanently disable the battery if it detects a difference between the BAT pin voltage and the sum of the individual cell voltages. *Recommendation*: Perform BAT pin calibration in production if this protection is enabled.

Status	Condition	Action
Normal	|*Voltage()* – BAT voltage in *DAStatus1()*|	*PFAlert()[OPNCELL]* = 0
Alert	|*Voltage()* – BAT voltage in *DAStatus1()*| ≥ ***OPNC:Threshold***	*PFAlert()[OPNCELL]* = 1
Trip	|*Voltage()* – BAT voltage in *DAStatus1()*| continuous ≥ ***OPNC:Threshold*** for ***OPNC:Delay*** Period	*PFAlert()[OPNCELL]* = 0 *PFStatus()[OPNCELL]* = 1

3.19 Data Flash (DF) Permanent Fail

The device can permanently disable the battery in case a data flash write fails.

Note

A DF write failure causes the gauge to disable further DF writes.

Status	Condition	Action
Normal	Data flash write OK	—
Trip	Data flash write not successful	*PFStatus()[DFW]* = 1

3.20 Open Thermistor Permanent Fail (TS1, TS2, TS3, TS4)

The device can permanently disable the battery if it detects an open thermistor on TS1, TS2, TS3, or TS4. The state of TS1..4 and the internal temperature sensor is available in *DAStatus2()*.

Status	Condition	Action
Normal, TS1	TS1 Temperature > ***Open Thermistor:Threshold*** OR Internal Temperature ≤ TS1 Temperature + ***Cell Delta*** if ***Temperature Mode[TS1 Mode] = 0*** OR Internal Temperature ≤ TS1 Temperature + ***FET Delta*** if ***Temperature Mode[TS1 Mode] = 1***	*PFAlert()[TS1]* = 0
Normal, TS2	TS2 Temperature > ***Open Thermistor:Threshold*** OR Internal Temperature ≤ TS2 Temperature + ***Cell Delta*** if ***Temperature Mode[TS2 Mode] = 0*** OR Internal Temperature ≤ TS2 Temperature + ***FET Delta*** if ***Temperature Mode[TS2 Mode] = 1***	*PFAlert()[TS2]* = 0
Normal, TS3	TS3 Temperature > ***Open Thermistor:Threshold*** OR Internal Temperature ≤ TS3 Temperature + ***Cell Delta*** if ***Temperature Mode[TS3 Mode] = 0*** OR Internal Temperature ≤ TS3 Temperature + ***FET Delta*** if ***Temperature Mode[TS3 Mode] = 1***	*PFAlert()[TS3]* = 0
Normal, TS4	TS4 Temperature > ***Open Thermistor:Threshold*** OR Internal Temperature ≤ TS4 Temperature + ***Cell Delta*** if ***Temperature Mode[TS4 Mode] = 0*** OR Internal Temperature ≤ TS4 Temperature + ***FET Delta*** if ***Temperature Mode[TS4 Mode] = 1***	*PFAlert()[TS4]* = 0
Alert, TS1	Condition 1: TS1 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS1 Temperature + ***Cell Delta*** if ***Temperature Mode[TS1 Mode] = 0*** OR Condition 2: TS1 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS1 Temperature + ***FET Delta*** if ***Temperature Mode[TS1 Mode] = 1***	*PFAlert()[TS1]* = 1
Alert, TS2	Condition 1: TS2 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS2 Temperature + ***Cell Delta*** if ***Temperature Mode[TS2 Mode] = 0*** OR Condition 2: TS2 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS2 Temperature + ***FET Delta*** if ***Temperature Mode[TS2 Mode] = 1***	*PFAlert()[TS1]* = 1
Alert, TS3	Condition 1: TS3 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS3 Temperature + ***Cell Delta*** if ***Temperature Mode[TS3 Mode] = 0*** OR Condition 2: TS3 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS3 Temperature + ***FET Delta*** if ***Temperature Mode[TS3 Mode] = 1***	*PFAlert()[TS1]* = 1
Alert, TS4	Condition 1: TS4 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS4 Temperature + ***Cell Delta*** if ***Temperature Mode[TS4 Mode] = 0*** OR Condition 2: TS4 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS4 Temperature + ***FET Delta*** if ***Temperature Mode[TS4 Mode] = 1***	*PFAlert()[TS1]* = 1

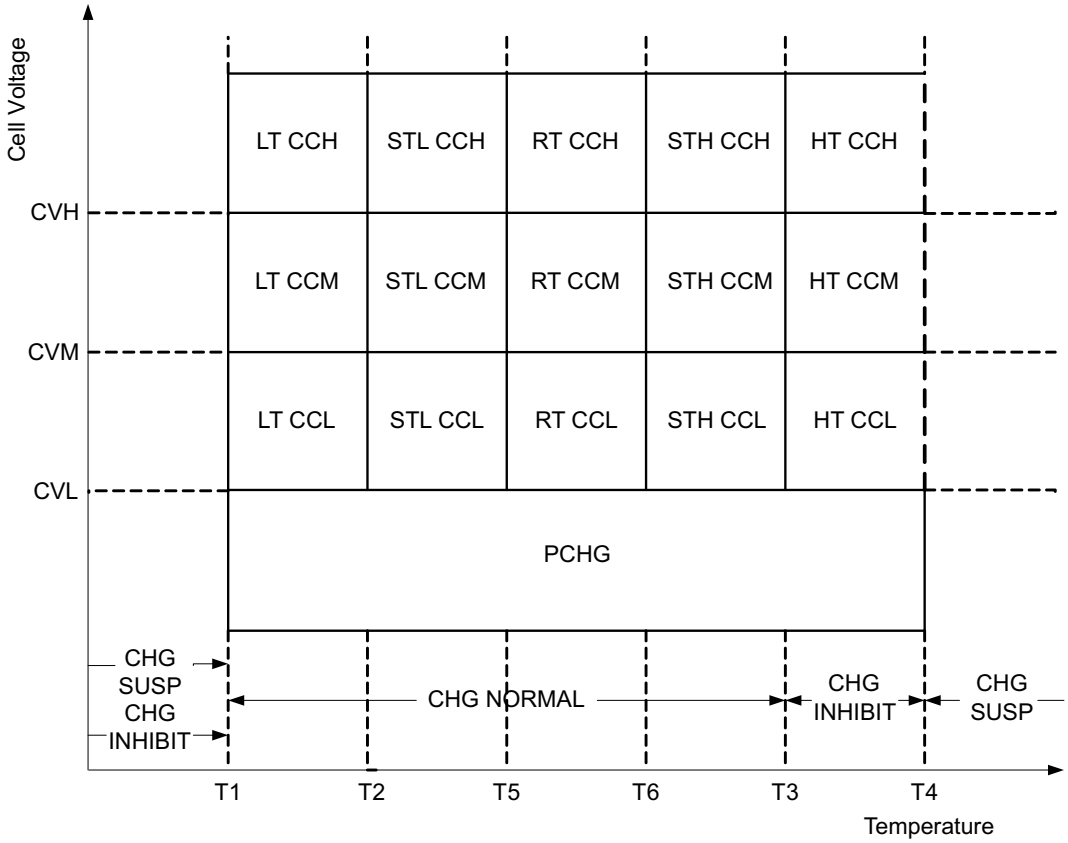
Status	Condition	Action
Trip, TS1	Condition 1: TS1 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS1 Temperature + ***Cell Delta*** for ***Open Thermistor:Delay*** duration if ***Temperature Mode[TS1 Mode] = 0***	*PFAlert()[TS1]* = 0 *PFStatus()[TS1]* = 1
	OR Condition 2: TS1 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS1 Temperature + ***FET Delta*** for ***OpenThermistor:Delay*** duration if ***Temperature Mode[TS1 Mode] = 1***	
Trip, TS2	Condition 1: TS2 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS2 Temperature + ***Cell Delta*** for ***Open Thermistor:Delay*** duration if ***Temperature Mode[TS2 Mode] = 0***	*PFAlert()[TS2]* = 0 *PFStatus()[TS2]* = 1
	OR Condition 2: TS2 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS2 Temperature + ***FET Delta*** for ***OpenThermistor:Delay*** duration if ***Temperature Mode[TS2 Mode] = 1***	
Trip, TS3	Condition 1: TS3 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS3 Temperature + ***Cell Delta*** for ***Open Thermistor:Delay*** duration if ***Temperature Mode[TS3 Mode] = 0***	*PFAlert()[TS3]* = 0 *PFStatus()[TS3]* = 1
	OR Condition 2: TS3 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS3 Temperature + ***FET Delta*** for ***OpenThermistor:Delay*** duration if ***Temperature Mode[TS3 Mode] = 1***	
Trip, TS4	Condition 1: TS4 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS4 Temperature + ***Cell Delta*** for ***Open Thermistor:Delay*** duration if ***Temperature Mode[TS4 Mode] = 0***	*PFAlert()[TS4]* = 0 *PFStatus()[TS4]* = 1
	OR Condition 2: TS4 Temperature ≤ ***Open Thermistor:Threshold*** AND Internal Temperature > TS4 Temperature + ***FET Delta*** for ***OpenThermistor:Delay*** duration if ***Temperature Mode[TS4 Mode] = 1***	

Chapter 4

Advanced Charge Algorithm

4.1 Introduction

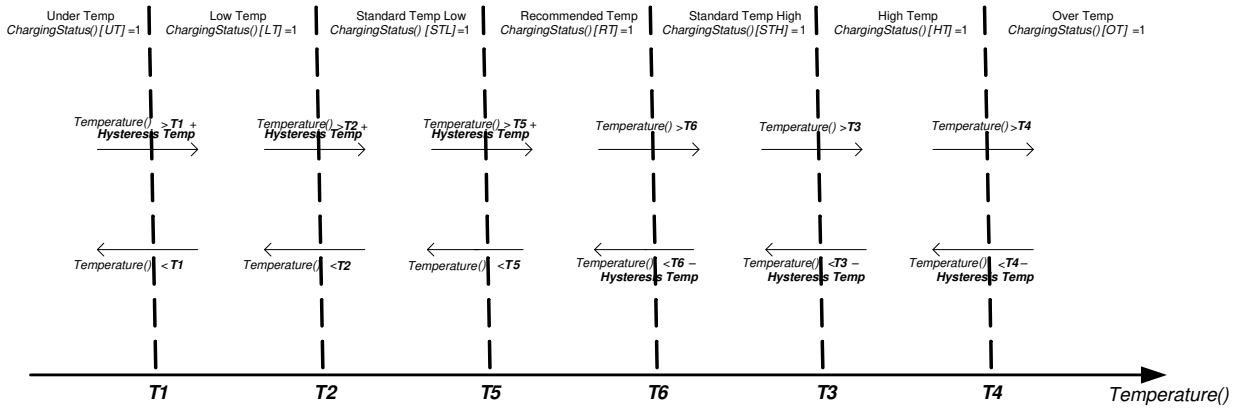
The device can change the values of *ChargingVoltage()* and *ChargingCurrent()* based on *Temperature()* and cell voltage1..4 or *RelativeStateofCharge()*. Its flexible charging algorithm is JEITA compatible and can also meet other specific cell manufacturer charge requirements. The *ChargingStatus()* register shows the state of the charging algorithm.



4.2 Charge Temperature Ranges

The measured temperature is segmented into several temperature ranges. The charging algorithm adjusts *ChargingCurrent()* and *ChargingVoltage()* according to the temperature range. The temperature ranges set in data flash should adhere to the following format:

T1 ≤ ***T2*** ≤ ***T5*** ≤ ***T6*** ≤ ***T3*** ≤ ***T4***.

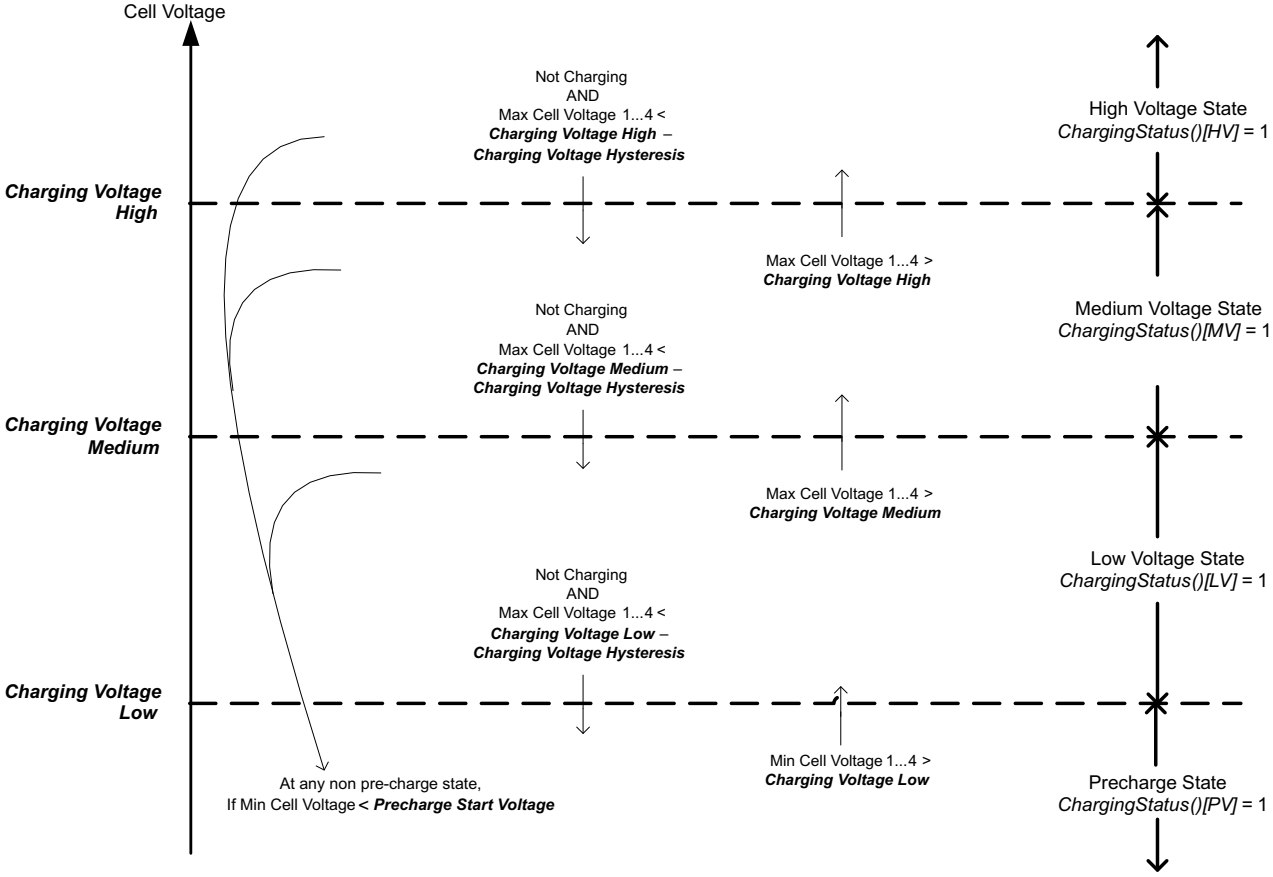


4.3 Voltage Range

The measured cell voltage is segmented into several voltage ranges. The charging algorithm adjusts *ChargingCurrent()* according to the temperature range and voltage range. The voltage ranges set in data flash need to adhere to the following format:

Charging Voltage Low ≤ Charging Voltage Med ≤ Charging Voltage High ≤ × Temp Charging:Voltage

where × is Standard or Rec. Depending on the specific charging profile, the ***Low Temp Charging:Voltage*** and ***High Temp Charging:Voltage*** settings do not necessarily have the highest setting values.



4.3.1 RelativeStateofCharge() Range

If ***[SOC_CHARGE]*** in ***Charging Configuration*** is set, then the voltages threshold control, as described in Section 4.3, is replaced with *RelativeStateOfCharge()* control.

With this method, the following changes in control transitions occur:

1. [LV] state and *RelativeStateOfCharge()* > ***Charging SoC Mid***; move to [MV].
2. [MV] state and *RelativeStateOfCharge()* > ***Charging SoC High***; move to [HV].
3. [MV] state [DSG]=1, and *RelativeStateOfCharge()* < ***Charging SoC Mid*** – ***SoC Hysteresis***; move to [LV].
4. [HV] state [DSG]=1, and *RelativeStateOfCharge()* < ***Charging SoC High*** – ***Charging SoC Hysteresis***; move to [MV].

Table 4-1. *RelativeStateofCharge()* Range

Class	Subclass	Name	Type	Min Value	Max Value	Default Value	Unit
Advanced Charge Algorithm	SOC Range	Charging SoC Mid	U1	0	100	50	%
Advanced Charge Algorithm	SOC Range	Charging SoC High	U1	0	100	75	%
Advanced Charge Algorithm	SOC Range	Charging SoC Hysteresis	U1	0	100	1	%

4.4 Charging Current

The *ChargingCurrent()* value changes depending on the detected temperature and voltage per the charging algorithm.

The ***Charging Configuration[CRATE]*** flag provides an option to adjust the *ChargingCurrent()* based on *FullChargeCapacity()/DesignCapacity()*.

For example, with ***[CRATE]*** = 1, if *FullChargeCapacity()*/*DesignCapacity()* = 90% and ***Rec Temp Charging: Current Med*** is active per the charging algorithm, the *ChargeCurrent()* = ***Rec Temp Charging: Current Med*** × 90%.

Note

Table priority is top to bottom.

Temp Range	Voltage Range	Condition	Action
Any	Any	*OperationStatus()[XCHG]* = 1	*ChargingCurrent()* = 0
UT or OT	Any	—	*ChargingCurrent()* = 0
Any	PV	—	*ChargingCurrent()* = ***Pre-Charging:Current***
Any	LV, MV, or HV	*ChargingStatus()[MCHG]* = 1	*ChargingCurrent()* = ***Maintenance Charging:Current***
LT	LV	—	*ChargingCurrent()* = ***Low Temp Charging:Current Low***
	MV	—	*ChargingCurrent()* = ***Low Temp Charging:Current Med***
	HV	—	*ChargingCurrent()* = ***Low Temp Charging:Current High***
STL or STH	LV	—	*ChargingCurrent()* = ***Standard Temp Charging:Current Low***
	MV	—	*ChargingCurrent()* = ***Standard Temp Charging:Current Med***
	HV	—	*ChargingCurrent()* = ***Standard Temp Charging:Current High***
RT	LV	—	*ChargingCurrent()* = ***Rec Temp Charging:Current Low***
	MV	—	*ChargingCurrent()* = ***Rec Temp Charging:Current Med***
	HV	—	*ChargingCurrent()* = ***Rec Temp Charging:Current High***

Temp Range	Voltage Range	Condition	Action
HT	LV	—	*ChargingCurrent()* = ***High Temp Charging:Current Low***
	MV	—	*ChargingCurrent()* = ***High Temp Charging:Current Med***
	HV	—	*ChargingCurrent()* = ***High Temp Charging:Current High***

4.5 Charging Voltage

The *ChargingVoltage()* changes depending on the detected temperature per the charge algorithm.

Note

Table priority is top to bottom.

Temp Range	Condition	Action
Any	*OperationStatus()[XCHG]* = 1	*ChargingVoltage()* = 0
UT or OT	—	*ChargingVoltage()* = 0
LT	—	*ChargingVoltage()* = ***Low Temp Charging:Voltage*** × (***DA Configuration[CC1:CC0]*** + 1)
STL or STH	—	*ChargingVoltage()* = ***Standard Temp Charging:Voltage*** × (***DA Configuration[CC1:CC0]*** + 1)
RT	—	*ChargingVoltage()* = ***Rec Temp Charging:Voltage*** × (***DA Configuration[CC1:CC0]*** + 1)
HT	—	*ChargingVoltage()* = ***High Temp Charging:Voltage*** × (***DA Configuration[CC1:CC0]*** + 1)

4.6 Valid Charge Termination

The charge termination condition must be met to enable valid charge termination. The device has the following actions at charge termination, based on the flags settings:

- If ***SBS Gauging Configuration[CSYNC]*** = 1, *RemainingCapacity()* = *FullChargeCapacity()*.
- If ***SBS Gauging Configuration[RSOCL]*** = 1, *RelativeStateOfCharge()* and *RemainingCapacity()* are held at 99% until charge termination occurs. Only on entering charge termination is 100% displayed.
- If ***SBS Gauging Configuration[RSOCL]*** = 0, *RelativeStateOfCharge()* and *RemainingCapacity()* are not held at 99% until charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.

Status	Condition	Action
Charging	*GaugingStatus()[DSG]* = 0	Charge Algorithm active
Valid Charge Termination	All of the following conditions must occur for two consecutive 40-s periods: Charging (that is, *BatteryStatus[DSG]* = 0) AND *AverageCurrent()* < ***Charge Term Taper Current*** AND Max cell voltage1..4 + ***Charge Term Voltage*** ≥ *ChargingVoltage()* / number of cells in series AND The accumulated change in capacity > 0.25 mAh.	*ChargingStatus()[VCT]* = 1 *ChargingStatus()[MCHG]* = 1 *ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm *BatteryStatus()[FC]* = 1 and *GaugingStatus()[FC]* = 1 if ***SOCFlagConfig A[FCSETVCT]*** = 1 *BatteryStatus()[TCA]* = 1 and *GaugingStatus()[TCA]* = 1 if ***SOCFlagConfig B[TCASETVCT]*** = 1

4.7 Charge and Discharge Termination Flags

The *[TC]* and *[FC]* bits in *GaugingStatus()* can be set at charge termination as well as based on RSOC or cell voltages. If multiple set and clear conditions are selected, then the corresponding flag will be set whenever a

valid set or clear condition is met. If both set and clear conditions are true at the same time, the flag will clear. The same functionality is applied to the *[TD]* and *[FD]* bits in *GaugingStatus()*.

Note

GaugingStatus()[TC][TD][FC][FD] are the status flags based on the gauging conditions only. These flags are set and cleared based on ***SOC Flag Config A*** and ***SOC Flag Config B***.

The *BatteryStatus()[TAC][FC][TDA][FD]* flags will be set and cleared according to the *BatteryStatus() [TC][FC][TD][FD]* flags as well as the safety and permanent failure protections status. For more information, see Section 4.8.

When *GaugingStatus() [FC]* is set AND ***FET Option[CHGFET] = 1***, the CHG FET turns off.

The *[FC]* flag is identical between gauging status and battery status, but not *[TD]*. The table below summarizes the various options to set and clear the *[TC]* and *[FC]* flags in *GaugingStatus()*.

Flag	Set Criteria	Set Condition	Enable
[TC]	cell voltage	Max cell voltage1..4 ≥ ***TC: Set Voltage Threshold***	***SOC Flag Config A[TCSetV]*** = 1
	RSOC	*RelativeStateOfCharge()* ≥ ***T C: Set % RSOC Threshold***	***SOC Flag Config A[TCSetRSOC]*** = 1
	Valid Charge Termination (enable by default)	When *ChargingStatus[VCT]* = 1	***SOC Flag Config A[TCSetVCT]*** = 1
[FC]	cell voltage	Max cell voltage1..4 ≥ ***FC: Set Voltage Threshold***	***SOC Flag Config B[FCSetV]*** = 1
	RSOC	*RelativeStateOfCharge()* ≥ ***C: Set % RSOC Threshold***	***SOC Flag Config B[FCSetRSOC]*** = 1
	Valid Charge Termination (enable by default)	When *ChargingStatus[VCT]* = 1	***SOC Flag Config A[FCSetVCT]*** = 1

Flag	Clear Criteria	Clear Condition	Enable
[TC]	cell voltage	Max cell voltage1..4 ≤ ***TC: Clear Voltage Threshold***	***SOC Flag Config A[TCClearV]*** = 1
	RSOC (enable by default)	*RelativeStateOfCharge()* ≤ ***TC: Clear % RSOC Threshold***	***SOC Flag Config A[TCClearRSOC]*** = 1
[FC]	cell voltage	Max cell voltage1..4 ≤ ***FC: Clear Voltage Threshold***	***SOC Flag Config B[FCClearV]*** = 1
	RSOC (enable by default)	*RelativeStateOfCharge()* ≤ ***FC: Clear % RSOC Threshold***	***SOC Flag Config B[FCClearRSOC]*** = 1

[TD] and *[FD]* both have extra conditions. If gauging status *[FD]* is set then battery status is always set, but clearing depends also on some safety conditions (CUV/SUV).

The table below summarizes the various options to set and clear the *[TD]*, and *[FD]* flags in *GaugingStatus()*.

Flag	Set Criteria	Set Condition	Enable
[TD]	cell voltage	Min cell voltage1..4 ≤ ***TD: Set Voltage Threshold***	***SOC Flag Config A[TDSetV]*** = 1
	RSOC (enable by default)	*RelativeStateOfCharge()* < = ***TD: Set % RSOC Threshold***	***SOC Flag Config A[TDSetRSOC]*** = 1
[FD]	cell voltage	Min cell voltage1..4 ≤ ***FD: Set Voltage Threshold***	***SOC Flag Config B[FDSetV]*** = 1
	RSOC (enable by default)	*RelativeStateOfCharge()* < = ***FD: Set % RSOC Threshold***	***SOC Flag Config B[FDSetRSOC]*** = 1

Flag	Clear Criteria	Clear Condition	Enable
[TD]	cell voltage	Min cell voltage1..4 ≥ ***TD: Clear Voltage Threshold***	***SOC Flag Config A[TDClearV]*** = 1
	RSOC (enable by default)	*RelativeStateOfCharge()* ≥ ***TD: Clear % RSOC Threshold***	***SOC Flag Config A[TDClearRSOC]*** = 1
[FD]	cell voltage	Min cell voltage1..4 ≥ ***FD: Clear Voltage Threshold***	***SOC Flag Config B[FDClearV***] = 1
	RSOC (enable by default)	*RelativeStateOfCharge()* ≥ ***FD: Clear % RSOC Threshold***	***SOC Flag Config B[FDClearRSOC]*** = 1

4.8 Terminate Charge and Discharge Alarms

When the protections and permanent fails are triggered, the *BatteryStatus()[TCA][TDA][FD][OCA][OTA][FC]* will be set according to the type of safety protections. Here is a summary of the set conditions of the various alarms flags.

[TCA] = 1 if

- *SafetyAlert()[OCC1]*, *[OCC2]*, *[COV]*, *[OTC]*, *[OTF]*, *[OC]*, *[CHGC]*, *[CHGV]*, or *[PCHGC]* = 1, OR
- *PFAlert()[SOV] or [SOCC]* = 1, OR
- *Any PFStatus()* = 1, OR
- *OperationStatus()[PRES]* = 0, OR
- *GaugingStatus()[TC]* = 1 AND in CHARGE mode

[FC] = 1

- if GaugingStatus()[FC] = 1

[OCA] = 1 if

- *SafetyStatus()[OC]* = 1 AND in CHARGE mode

[TDA] = 1 if

- *SafetyAlert()[OCD1]*, *[OCD2]*, *[CUV]*, *[CUVC]*, *[OTD]*, or *[OTF]* = 1, OR
- *PFAlert()[SUV]* or *[SOCD]* = 1, OR
- Any *PFStatus()* = 1, OR
- *OperationStatus()[PRES]* = 0
- *GaugingStatus()[TD]* = 1 AND in DISCHARGE mode

[FD] = 1 if

- *SafetyStatus()[CUV]* = 1, OR
- *PFStatus()[SUV]* = 1, OR
- *GaugingStatus()[FD]*

[OTA] = 1 if

- *SafetyStatus()[OTC]*, *[OTD]*, or *[OTF]* = 1, OR
- *PFStatus()[SOT]* or *[SOTF]* = 1

4.9 Precharge

The gauge enters PRECHARGE mode if,

1. Min cell voltage1..4 < ***Precharge Start Voltage***, OR
2. Max cell voltage1..4 < ***Charging Voltage Low – Charging Voltage Hysteresis*** and not in CHARGE mode

Depending on the ***FET Options[PCHG_COMM]*** settings, the external precharge FET or CHG FET can be used in PRECHARGE mode. Setting the ***Precharge Start Voltage and Charging Voltage Low*** = 0 mV disables the precharge function.

[PCHG_COMM] = 0	*[PCHG_COMM]* = 1
FET USED: external precharge FET	FET USED: CHG FET

The device also supports 0-V charging using either an external precharge FET or CHG FET. If ***[PCHG_COMM]*** = 1, the gauge enables the hardware 0-V charging circuit automatically when the battery stack voltage is below the minimum operation voltage of the device (see the *BQ4050 1-Series to 4-Series Li-Ion Battery Pack Manager* data sheet [SLUSC67] for BQ4050 electrical specifications).

4.10 Maintenance Charge

Maintenance charge can be configured to provide charge current after charge termination is reached.

If the Overcharge Protection is enabled, ***Enabled Protections C[OC]*** = 1, extra margin may be needed for ***OC:Threshold*** to prevent triggering the OC protection by the maintenance charging.

Status	Condition	Action
Set	*ChargingStatus()[IN]* = 0 AND *ChargingStatus()[SU]* = 0 AND *ChargingStatus()[PV]* = 0 AND *GaugingStatus()[TCA]* = 1	*ChargingStatus()[MCHG]* = 1 *ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm
Clear	*ChargingStatus()[IN]* = 1 OR *ChargingStatus()[SU]* = 1 OR *ChargingStatus()[PV]* = 1 OR *GaugingStatus()[TCA]* = 0	*ChargingStatus()[MCHG]* = 0 *ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm

4.11 Charge Control SMBus Broadcasts

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. The ***[BCAST]*** bit enables all broadcasts to a host or a smart charger. When the ***[BCAST]*** bit is enabled, the following broadcasts are sent:

- *ChargingVoltage()* and *ChargingCurrent()* broadcasts are sent to the smart-charger device address (0x12) every 10 to 60 s.
- 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 s. Broadcasts stop when all flags above have been cleared.
- If any of the *[OCA]*, *[TCA]*, *[OTA]*, *[TDA]* flags are set, the *AlarmWarning()* broadcast is sent to a smart-charger device address every 10 s. Broadcasts stop when all flags above have been cleared.

4.12 Charge Disable and Discharge Disable

The device can disable charging if certain safety conditions are detected, setting the *OperationStatus()[XCHG]* = 0.

Status	Condition	Action
Normal	*ALL PFStatus()* = 0 AND *SafetyStatus()[COV]* = 0 AND *SafetyStatus()[OCC1][OCC2]* = 0,0 AND *SafetyStatus()[ASCC]* = 0 AND *SafetyStatus()[ASCCL]* = 0 AND *SafetyStatus()[CTO]* = 0 AND *SafetyStatus()[PTO]* = 0 AND *OperationStatus()[PRES]* = 1 AND *GaugingStatus()[TCA]* = 0 if ***Charging Configuration[CHGFET]*** = 1	*ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm *OperationStatus()[XCHG]* = 0

Status	Condition	Action
Trip	*ManufacturingStatus()[FET_EN]* = 0 OR *ANY PFStatus()[]* = 1 OR *SafetyStatus()[COV]* = 1 OR *SafetyStatus()[OCC1]* = 1 OR *SafetyStatus()[OCC2]* = 1 OR *SafetyStatus()[ASCC]* = 1 OR *SafetyStatus()[ASCCL]* = 1 OR *SafetyStatus()[CTO]* = 1 OR *SafetyStatus()[PTO]* = 1 OR *SafetyStatus()[HWDF]* = 1 OR *SafetyStatus()[OC]* = 1 OR *SafetyStatus()[CHGC]* = 1 OR *SafetyStatus()[CHGV]* = 1 OR *SafetyStatus()[PCHGC]* = 1 OR *SafetyStatus()[UTC]* = 1 OR *SafetyStatus()[OTC]* = 1 if ***[OTFET]*** = 1 OR *ChargingStatus()[IN]* = 1 if ***[CHGIN]*** = 1 OR *ChargingStatus()[SU]* = 1 if ***[CHGSU]*** = 1 OR *OperationStatus()[SLEEP]* = 1 if ***[NR]*** = 1 AND ***[SLEEPCHG]*** = 0 OR *OperationStatus()[EMSHUT]* = 1 OR *OperationStatus()[PRES]* = 0 OR *GaugingStatus()[TCA]* = 1 if ***Charging Configuration[CHGFET]*** = 1	*ChargingVoltage()* = 0 *ChargingCurrent()* = 0 *OperationStatus()[XCHG]* = 1

Similarly, the device can disable discharge if any of the following conditions are detected, setting the *OperationStatus()[XDSG]* = 1.

- *ManufacturingStatus()[FET_EN]* = 0, OR
- Any *PFStatus()* set, OR
- *SafetyStatus()[OCD1]* or *[OCD2]* or *[CUV]* or *[CUVC]* or *[AOLD]* or *[AOLDL]* or *[ASCD]* or *[ASCDL]* or *[UTD]* = 1, OR
- *SafetyStatus()[OTD]* or *[OTF]* = 1 if ***[OTFET]*** = 1, OR
- *OperationStatus()[PRES]* = 0, OR
- *OperationStatus()[EMSHUT]* = 1 ,OR
- *OperationStatus()[SDM]* = 1 AND delay time > ***FET Off Time***, OR
- *OperationStatus()[SDV]* = 1 AND low voltage time ≥ ***Shutdown Time***

4.13 Charge Inhibit

The device can inhibit the start of charging at high and low temperatures to prevent damage of the cells. This feature prevents the start of charging when the temperature is at the inhibit range; therefore, if the device is already in the charging state when the temperature reaches the inhibit range, a FET action will not take place even if ***FET Options[CHGIN]*** = 1.

Status	Condition	Action
Normal	*ChargingStatus()[LT]* = 1 OR *ChargingStatus()[STL]* = 1 OR *ChargingStatus()[RT]* = 1 OR *ChargingStatus()[STH]* = 1	*ChargingStatus()[IN]* = 0 *ChargingVoltage()* = charging algorithm *ChargingCurrent()* = charging algorithm
Trip	Not charging AND *(ChargingStatus()[HT]* = 1 OR *ChargingStatus()[OT]* = 1 OR *ChargingStatus()[UT]* = 1	*ChargingStatus()[IN]* = 1 *ChargingStatus()[SU]* = 0 *ChargingVoltage()* = 0 *ChargingCurrent()* = 0 *OperationStatus()[XCHG]* = 1 if ***FET Options[CHGIN]*** = 1.

4.14 Charge Suspend

The device can stop charging at high and low temperatures to prevent damage of the cells.

The *ChargingStatus()[SU]* condition is only active in the CHARGING mode. Once CHARGE SUSPEND is triggered, the gauge will exit CHARGING mode after ***Chg Relax Time*** and the CHARGE SUSPEND will change to CHARGE INHIBIT.

Status	Condition	Action
Normal	*ChargingStatus()[LT]* = 1 OR *ChargingStatus()[STL]* = 1 OR *ChargingStatus()[RT]* = 1 OR *ChargingStatus[STH]* = 1 OR *ChargingStatus()[HT]* = 1	*ChargingStatus()[SU]* = 0 *ChargingVoltage()* = charging algorithm *ChargingCurrent()* = charging algorithm
Trip	*ChargingStatus()[UT]* = 1 OR *ChargingStatus()[OT]* = 1	*ChargingStatus()[SU]* = 1 *ChargingVoltage()* = 0 *ChargingCurrent()* = 0 *OperationStatus()[XCHG]* = 1 if ***FET Options[CHGSU]*** = 1.

4.15 ChargingVoltage() Rate of Change

The device can slope the value changes from one range to another to avoid jumping between different voltage ranges. Setting the ***Voltage Rate*** to 1 disables this feature because the *ChargingVoltage()* changes in one step. The gauge will not apply any voltage stepping if ***Voltage Rate*** is set to 1.

Note

The host needs to read *ChargingVoltage()* at least once a second during charging to adjust the charger accordingly.

Status	Condition	Action
Trip	*ChargingVoltage()* Change	*ChargingStatus()[CVR]* = 1 *ChargingVoltage()* = Old + n × (New – Old)/***Voltage Rat***e, where Old = present *ChargingVoltage()* New = the target *ChargingVoltage()* that the device is going to change to n = 1..***Voltage Rate***, increment in steps of one per second.

4.16 ChargingCurrent() Rate of Change

The device can slope the value changes from one range to another to avoid jumping between different current ranges. Setting the ***Current Rate*** to 1 disables this feature because the *ChargingCurrent()* changes in one step. The gauge will not do any current stepping if ***Current Rate*** is set to 1.

Note

The host needs to read *ChargingCurrent()* at least once a second during charging to adjust the charger accordingly.

Status	Condition	Action
Trip	*ChargingCurrent()* Change	*ChargingStatus()[CCR]* = 1 *ChargingCurrent()* = Old + n × (New – Old)/***Current Rate***, where Old = present *ChargingCurrent()* New = the target *ChargingCurrent()* that the device will change to n = 1..***Current Rate***, increment in steps of 1 per second.

4.17 Charging Loss Compensation

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

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

Note

The host must read *ChargingVoltage()* and/or *ChargingCurrent()* at least once a second during charging to adjust the charger accordingly.

Status	Condition	Action
Normal	*Current()* > ***CCC Current Threshold*** AND *Voltage()* = Charging algorithm voltage	*ChargingStatus()[CCC]* = 0 *ChargingVoltage()* = Charging Algorithm
Active	*Current()* > ***CCC Current Threshold*** AND *Voltage()* < Charging algorithm voltage	*ChargingStatus()[CCC]* = 1 *ChargingVoltage()* = Charging Algorithm + (*PackVoltage()* – *Voltage()*)
Limit	(Pack pin voltage in *DAStatus1()* – *Voltage()*) > ***CCC Voltage Threshold***	*ChargingVoltage()* = Charging Algorithm + ***CCC Voltage Threshold***

Chapter 5

Power Modes

5.1 Introduction

To enhance battery life, the BQ4050 supports several power modes to minimize power consumption during operation.

5.2 NORMAL Mode

In NORMAL mode, the device takes voltage, current, and temperature readings every 250 ms, performs protection and gauging calculations, updates SBS data, and makes status decisions at 1-s intervals. Between these periods of activity, the device is in a reduced power state.

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

5.2.1 BATTERY PACK REMOVED Mode/System Present Detection

5.2.1.1 System Present

$\overline{\text{PRES}}$ is sampled four times per second, and if $\overline{\text{PRES}}$ is high for 4 samples (one second), the *OperationStatus[PRES]* flag is cleared. If $\overline{\text{PRES}}$ is low for 4 samples (one second), 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 is ignored and can be left floating.

5.2.1.2 Battery Pack Removed

The BQ4050 detects the BATTERY PACK REMOVED mode if the ***[NR]*** bit is set to 0 AND the $\overline{\text{PRES}}$ input is high (*[PRES]* = 0).

On entry to the BATTERY PACK REMOVED mode, the *[TCA]* and *[TDA]* flags are set, *ChargingCurrent()* and *ChargingVoltage()* are set to 0, the CHG and DSG FETs are turned off, and the Precharge FET is turned off (if used).

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

The BQ4050 exits the BATTERY PACK REMOVED state if the ***[NR]*** flag is set to 0 AND the $\overline{\text{PRES}}$ input is low (*[PRES]* = 1). When this occurs, the *[TCA]* and *[TDA]* flags are reset.

5.3 SLEEP Mode

5.3.1 Device Sleep

When the sleep conditions are met, the device goes into SLEEP mode with periodic wake-ups for voltage, temperature, and current measurements to reduce power consumption.

OperationStatus()[SLPAD] is set when the gauge wakes to measure voltage and temperature. Similarly, the *[SLPCC]* is set when the gauge wakes for current measurement. In general, it is not possible to read these flags because an SMBus communication will wake up the gauge.

The device returns to NORMAL mode if any exit sleep condition is met.

Status	Condition	Action
Activate	SMBus low for ***Bus Timeout*** (1) if ***[IN_SYSTEM_SLEEP]*** = 0, or no communication for ***Bus Timeout*** if ***[IN_SYSTEM_SLEEP]*** = 1 AND ***DA Config[SLEEP]*** = 1(1) AND |*Current()*| ≤ ***Sleep Current*** AND ***Voltage Time*** > 0 AND (*OperationStatus()[PRES]* = 0 OR ***DA Config[NR]*** = 1) AND *OperationStatus()[SDM]* = 0 AND No *PFAlert()* bits set AND(5) No *PFStatus()* bits set AND No *SafetyAlert()* bits set AND(5) No [AOLD], [AOLDL], [ASCC], [ASCCL], [ASCD], [ASCDL] set in *SafetyStatus()*	Turn off CHG FET and PCHG FET if ***DA Configuration[SLEEPCHG]*** = 0.(3) Device goes to sleep. Device wakes up every ***Sleep:Voltage Time*** period to measure voltage and temperature. Device wakes up every ***Sleep:Current Time*** period to measure current.
Exit	SMBus connected (1)OR SMBus command received (2) OR ***DA Config[SLEEP]*** = 1(1) OR |*Current()*| > ***Sleep Current*** OR Wake comparator activates(4) OR ***Voltage Time*** = 0 OR (*OperationStatus()[PRES]* = 1 AND ***DA Config[NR]*** = 0) OR *OperationStatus()[SDM]* = 1 OR *PFAlert()* bits set OR *PFStatus()* bits set OR *SafetyAlert()* bits set OR *[AOLD], [AOLDL], [ASCC], [ASCCL], [ASCD], [ASCDL]* set in *SafetyStatus()*	Return to NORMAL mode

(1) ***DA Config[SLEEP]*** and SMBus low are not checked if the *ManufacturerAccess()* SLEEP mode command is used to enter SLEEP mode.
(2) Wake on SMBus command is only possible when the gas gauge is put to sleep using the *ManufacturerAccess()* SLEEP mode command or ***[IN_SYSTEM_SLEEP]*** is enabled with ***Bus Timeout*** = 0. Otherwise, the gas gauge wakes on an SMBus connection (clock or data high).
(3) For ***[NR]*** = 0, the CHG FET and PCHG FET remains on in SLEEP mode if ***[SLEEPCHG]*** = 1, but if the battery pack is removed from the system, the CHG FET is off because the system present takes higher priority than ***[SLEEPCHG]***.
(4) The wake comparator threshold is set through ***Power.WakeComparator[WK1,WK0]*** (see Section 5.3.4).
(5) *SafetyAlert()[PTO]*, *[PTOS]*, *[CTO]*, *[CTOS]* or *PFAlert() [OC]* will not prevent the gauge to enter SLEEP mode.

5.3.2 IN SYSTEM SLEEP Mode

The device provides an option for removable packs (that is, ***DA Config[NR]*** = 0) to enter SLEEP mode in-system. When the ***DA Config[IN_SYSTEM_SLEEP]*** = 1, the device will enter SLEEP mode even if the *OperationStatus()[PRES] = 1*. This option ignores the $\overline{\text{PRES}}$ pin status only. All the other sleep conditions must be met for the device to enter SLEEP mode.

In the IN SYSTEM SLEEP mode, it is possible to read the *[SLPAC]* and *[SLPCC]* flags if ***[IN_SYSTEM_SLEEP]*** = 1 and ***Bus Timeout*** = 0. This setting allows the gauge to enter SLEEP mode with active communication in progress.

Note

Setting the ***Bus Timeout*** = 0 with ***[IN_SYTEM_SLEEP]*** can be used for testing purposes, but it is not recommended to set the ***Bus Timeout*** = 0 in the field. If ***Bus Timeout*** = 0, the device's sleep and wake conditions are strictly controlled by current detection. If the host system performs a low load operation periodically (for example, wireless detection in a tablet application), this small load current may be missed, introducing an error into remaining capacity tracking. Having a non-zero ***Bus Timeout*** setting enables the gauge to wake up by a communication and capture the current measurement.

5.3.3 ManufacturerAccess() MAC Sleep

The SLEEP MAC command can override the requirement for bus low to enter sleep. In this case, the BQ4050 clock and data high condition is ignored for sleep to exit, though sleep will also exit if there is any further SMBus communication. The device can be sent to sleep with *ManufacturerAccess()* if specific sleep entry conditions are met.

5.3.4 Wake Function

The device can exit SLEEP mode if enabled by the presence of a voltage across SRP and SRN. The voltage threshold needed for the device to wake from SLEEP mode is programmed in ***Power:Wake Comparator***. This allows the gauge to wake up quickly in response to a higher current detection. Otherwise, the gauge only wakes up every ***Sleep Current Time*** to detect if |*Current()*| is > Sleep Current.

Reserved (Bits 7–4, 1–0): Reserved. Do not use.

WK1,0 (Bits 3–2): Wake Comparator Threshold

WK1	WK0	Voltage
0	0	±0.625 mV
0	1	±1.25 mV
1	0	±2.5 mV
1	1	±5 mV

5.4 SHUTDOWN Mode

5.4.1 Voltage Based Shutdown

To minimize power consumption and to avoid draining the battery, the device can be configured to shut down at a programmable stack voltage threshold. This function also works in PERMANENT FAILURE mode. When the device is in PERMANENT FAILURE mode, the parameters ***PF Shutdown Voltage*** and ***PF Shutdown Time*** configure the shutdown threshold.

Status	Condition	Action
Enable	Min cell voltage < ***Shutdown Voltage***	*OperationStatus()[SDV]* = 1
Trip	Min cell voltage continuous < ***Shutdown Voltage*** for ***Shutdown Time***	Turn DSG FET off
Shutdown	Voltage at PACK pin < ***Charger Present Threshold***	Send device into SHUTDOWN mode
Exit	Voltage at PACK pin > $V_{STARTUP}$	*OperationStatus()[SDV]* = 0 Return to NORMAL mode

Table 5-1. PF Shutdown Voltage

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Power	Shutdown	PF Shutdown Voltage	Int	2	0	32767	1750	mV

Table 5-2. PF Shutdown Time

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Power	Shutdown	PF Shutdown Time	Unsigned Int	1	0	255	10	s

Note

The device goes through a full reset when exiting from SHUTDOWN mode, which means the device will re-initialize. On power up, the gauge will check some special memory locations. If the memory checksum is incorrect, or if the gauge or the AFE watchdog has been triggered, the gauge will do a full reset.

The memory checksum is good; for example, in a case of a short power glitch, the gauge will do a partial reset. The initialization is faster in a partial reset, and certain memory data will not be re-initialized (for example, all SBS registers, last known FET state, last ADC and CC readings, and so on), and so a partial reset is usually transparent to the host.

5.4.2 ManufacturerAccess() MAC Shutdown

In SHUTDOWN mode, the device turns off the FETs after ***FET Off Time***, and then shuts down to minimize power consumption after ***Delay*** time. Both ***FET Off Time*** and ***Delay*** time are referenced to the time the gauge receives the command. Thus, the ***Delay*** time must be set longer than the ***FET Off Time***. The device returns to NORMAL mode when voltage at PACK pin > $V_{STARTUP}$. The device can be sent to this mode with the *ManufacturerAccess() Shutdown* command. Charger voltage must not be present for the device to enter SHIP SHUTDOWN mode.

Note

If the gauge is unsealed and the MAC *Shutdown()* command is sent twice in a row, the gauge will execute the shutdown sequence immediately and skip the normal delay sequence.

5.4.3 Time Based Shutdown

The device can be configured to shut down after staying in SLEEP mode without communication for a preset time interval specified in the ***Auto Ship Time***. Setting the ***PowerConfig[AUTO_SHIP_EN]*** = 1 enables this feature. Any communication to the device will restart the timer. When the timer reaches the Auto Ship Time, the time based shutdown effectively triggers the MAC shutdown command to start the shutdown sequence. The device returns to NORMAL mode when voltage at PACK pin > $V_{STARTUP}$.

5.4.4 Emergency Shutdown (EMSHUT)

The EMERGENCY SHUTDOWN function provides an option to disable the battery power to the system by opening up both CHG and DSG FETs before removing an embedded battery pack. There are two ways to enter the EMERGENCY SHUTDOWN state:

1. Use an external signal (for example, a push-button switch) to detect a low-level threshold signal on the $\overline{\text{SHUTDN}}$ pin.
2. Send a Manual FET Control (MFC) sequence to *ManufacturerAccess()*.

When the gauge is in the EMERGENCY SHUTDOWN state, the *OperationStatus()[EMSHUT]* = 1.

5.4.4.1 Enter Emergency Shutdown Through $\overline{\text{SHUTDN}}$

When a high-to-low transition on the $\overline{\text{SHUTDN}}$ pin is detected with a debounce delay of about 1 s for the low level threshold, the gauge will turn off both CHG and DSG FETs immediately. This entry method only applies if ***[NR]*** = 1 and ***DA Configuration[EMSHUT]*** = 1. If ***[NR]*** = 0, the $\overline{\text{SHUTDN}}$ pin will restore to the regular system present detection.

5.4.4.2 Enter Emergency Shutdown Through MFC

Alternately, sending a Manual FET Control (MFC) sequence using the steps below also puts the gauge to the EMERGENCY SHUTDOWN state. This entry method applies to ***NR]*** = 0 and ***[NR]*** = 1.

1. Send word 0x207C to *ManufacturerAccess()* (0x00) to enable the MFC.
2. Within 4 s, send word 0x043D to *ManufacturerAccess()* (0x00) to turn off CHG and DSG FETs.
3. The CHG and DSG FETs will be off after ***MFC Delay***.

5.4.4.3 Exit Emergency Shutdown

Regardless of which EMSHUT entry method is used, the gauge can exit the EMSHUT mode by turning on the CHG and DSG FETs with the following conditions:

- A high-to-low transition on the $\overline{\text{SHUTDN}}$ pin is detected with a debounce delay of 1 s for the low level threshold. For example, a push button is pressed again.
- Send word 0x23A7 to *ManufacturerAccess()* (0x00).

In addition to these exit conditions, if the gauge enters EMSHUT (via a push-button, for example), it can exit the EMSHUT mode after a shutdown restore timeout defined by the ***Timeout*** parameter.

For the case of ***[NR]*** = 0, a battery insertion will also exit the EMERGENCY SHUTDOWN mode.

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6.1 Gas Gauge Operation

6.1.1 General

The operational overview in Figure 6-1 illustrates the gas operation of the BQ4050.

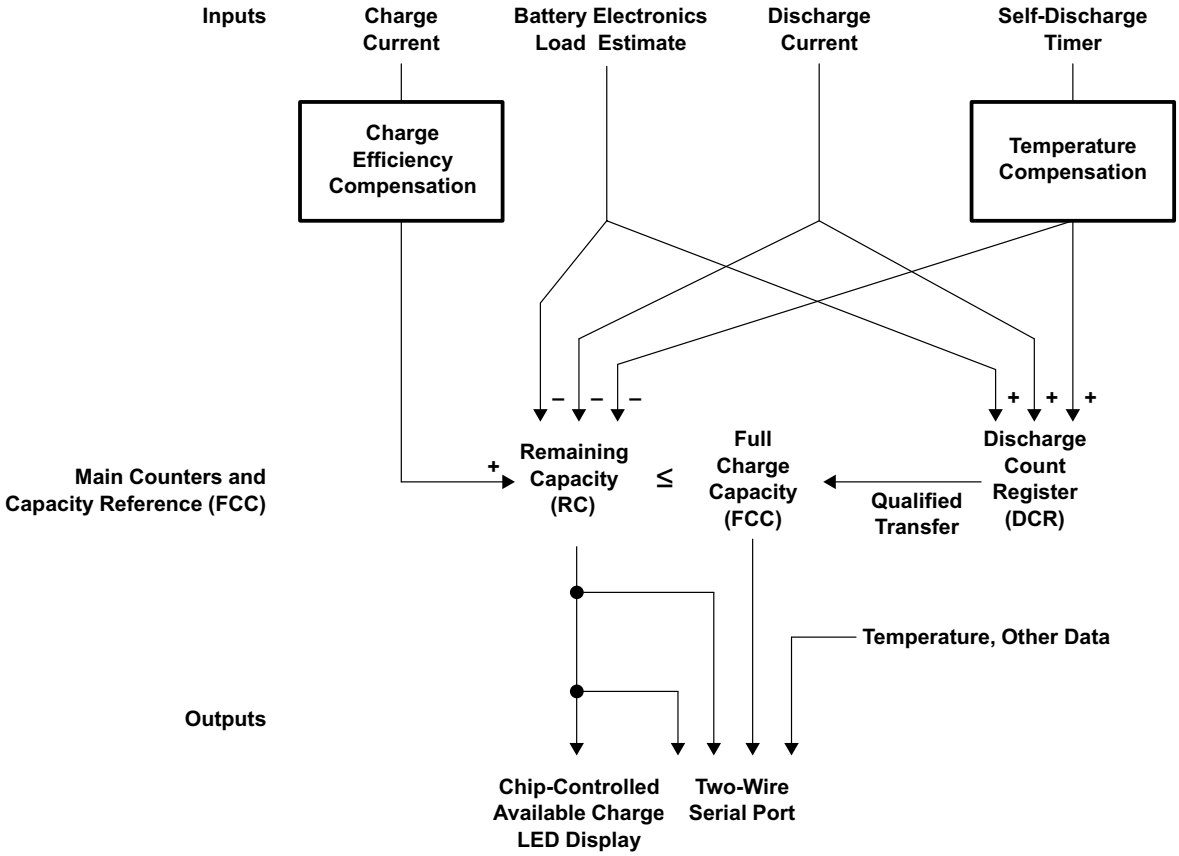

Figure 6-1. BQ4050 Operational Overview

The BQ4050 accumulates the measured quantities of charge and discharge and estimates self-discharge of the battery. The BQ4050 compensates the charge current measurement for temperature and state-of-charge of the battery. The BQ4050 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 BQ4050 adjusts RM for charge, self-discharge, and other compensation factors. The information in the RM register is accessible through the SMBus interface and is also represented through the LED display.

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 BQ4050 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 BQ4050 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 BQ4050 learns the true discharge capacity of the battery under system use conditions.

6.1.2 Main Gas-Gauge Registers

RemainingCapacity() (RM)

RM represents the remaining capacity in the battery. The BQ4050 computes RM in units of either mAh or 10 mWh depending on the selected mode. See *BatteryMode()* for units 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 BQ4050 calibrates RM at three low-battery-voltage thresholds, EDV2, EDV1, and EDV0 and three programmable midrange thresholds VOC25, VOC50, and VOC75. This provides a voltage-based calibration to the RM counter.

DesignCapacity() (DC)

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)

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 mode. On initialization, the BQ4050 sets FCC to the value stored in *Last Measured Discharge (FCC)*. During subsequent discharges, the BQ4050 updates FCC 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 BQ4050 writes the new FCC value to data flash in mAh to *Last Measured Discharge*. FCC 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 BQ4050initializes 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 *Gauge Configuration*) and is not reduced if SC = 0. DCR stops counting when the battery voltage reaches the EDV2 threshold on discharge.

6.2 Fuel Gauge Operating Modes

During a gauging operation, different features and functions occur based on whether the battery is discharging, charging, or in a rest state.

Entry and exit of each mode is controlled by data flash parameters in the subclass *Fuel Gauging: Current Thresholds* section.

- In RELAX mode or DISCHARGE mode, the *[DSG]* flag in *CEDVStatus()* is set.
- CHARGE mode is entered when *Current* goes above ***Chg Current Threshold***.
- CHARGE mode is exited and RELAX 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 RELAX mode is entered when *Current* goes above ***(–)Quit Current*** threshold for a period of ***Dsg Relax Time***.

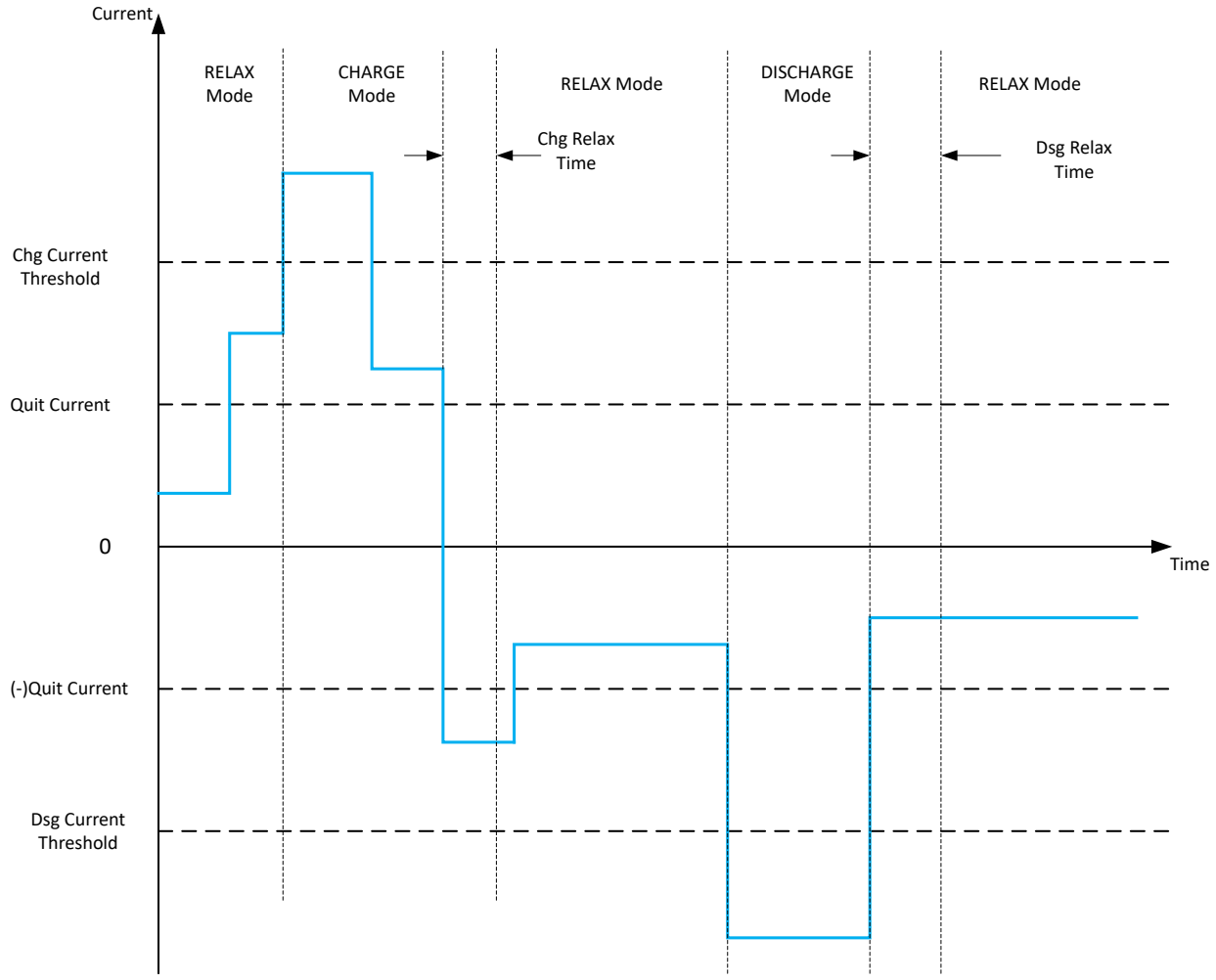

Figure 6-2. Fuel Gauge Operating Mode Example

6.2.1

Class	Subclass	Name	Format	Size in Bytes	Min	Max	Default	Unit
Fuel Gauging	Current Thresholds	Dsg Current Threshold	Unsigned Integer	2	0	2000	100	mA
Fuel Gauging	Current Thresholds	Dsg Relax Time	Unsigned Integer	1	0	255	1	s
Fuel Gauging	Current Thresholds	Chg Current Threshold	Unsigned Integer	2	0	2000	50	mA
Fuel Gauging	Current Thresholds	Chg Relax Time	Unsigned Integer	1	0	255	60	s
Fuel Gauging	Current Thresholds	Quit Current	Unsigned Integer	2	0	1000	10	mA

6.3 Capacity Learning (FCC Update) and Qualified Discharge

The BQ4050 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 + (FCCx *Battery Low%*)

Battery Low % = (DF value) ÷ 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 *Learning 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 BQ4050 detected EDV2.
- No midrange voltage correction occurs during the discharge period.
- Current remains ≥3C/32 when EDV2 or *Battery Low %* level is reached.
- No overload condition exists when EDV2 threshold is reached or if RM() has dropped to *Battery Low%* × FCC.

The BQ4050 sets VDQ = 1 in pack status when a qualified discharge begins. The BQ4050 sets VDQ = 0 if any disqualifying condition occurs. FCC cannot be reduced by more than 256 mAh or increased by more than 512 mAh during any single update cycle. The BQ4050 saves the new FCC value to the data flash within 4 seconds of being updated.

6.4 End-of-Discharge Thresholds and Capacity Correction

The BQ4050 monitors the battery for three low-voltage thresholds, EDV0, EDV1, and EDV2. The EDV thresholds can be programmed for determination based on the overall pack voltage or an individual cell level. The EDVV bit in *Pack Configuration* configures the BQ4050 for overall voltage or single-cell EDV thresholds. If programmed for single cell EDV determination, the BQ4050 determines EDV on the basis of the lowest single-cell voltage.

Fixed EDV thresholds may be programmed in *EMF/EDV0*, *EDV C0 Factor/EDV1*, and *EDV R0 Factor/EDV2* in mV. If the CEDV bit in *Gauge Configuration* is set, automatic EDV compensation is enabled and the BQ4050 computes the EDV0, EDV1, and EDV2 thresholds based on the values and the battery's current discharge rate and temperature.

The BQ4050 disables EDV detection if *Current()* exceeds the *Overload Current* threshold programmed in (<DF value>). The BQ4050 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.

Table 6-1. State of Charge Based on Low Battery Voltage

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

The BQ4050 uses the EDV thresholds to apply voltage-based corrections to the RM register according to Table 6-1. The performs EDV-based RM adjustments with *Current()* ≥ C/32. No EDVs are set if *Current()* ≥ C/32. The BQ4050 adjusts RM as it detects each threshold. If the voltage threshold is reached before the corresponding capacity on discharge, the BQ4050 reduces RM to the appropriate amount as shown in Table 6-1.

This reduction occurs only if *Current()* ≥ C/32 when the EDV threshold is detected. If RM reaches the capacity level before the voltage threshold is reached on discharge, the BQ4050 prevents RM from decreasing further until the battery voltage reaches the corresponding threshold only on a full learning cycle discharge. RM is not held at the associated EDV percentage on a non-learning discharge cycle (VDQ = 0) or if current < C/32. If *Battery Low* % is set to zero, EDV1 and EDV0 corrections are disabled.

6.4.1 EDV Discharge Rate and Temperature Compensation

If EDV compensation is enabled, the 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 as follows:

EDV0,1,2 = n (EMF • FBL – | ILOAD | • R0 • FTZ)

EMF is a no-load cell voltage higher than the highest cell EDV threshold computed. EMF is programmed in mV in EMF/EDV1.

ILOAD is the current discharge load magnitude.

n = the number of series cells

FBL is the factor that adjusts the EDV voltage for battery capacity and temperature to match the no-load characteristics of the battery.

FBL = f (C0, C + C1, T)

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/EDV1. 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.

FTZ = f (R1, T0, T, C + C1, TC)

R0 is the first order rate dependency factor stored in EDV R0 Factor/EDV2.

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.

Typical values for the EDV compensation factors, based on overall pack voltages for a Li-Ion 3s2p 18650 pack, are as follows:

EMF = 11550/3(1)

T0 = 4475

C0 = 235

C1 = 0

R0 = 5350/3(1)

R1 = 250

TC = 3

(1) = Divided by 3 (number of cells) if cell based compensated EDVs are used.

The graphs in Figure 6-3 show the calculated EDV0, EDV1, and EDV2 thresholds versus capacity using the typical compensation values for different temperatures and loads for a Li-Ion 3s2p 18650 pack. The compensation values vary widely for different cell types and manufacturers and must be matched exactly to the unique characteristics for optimal performance.

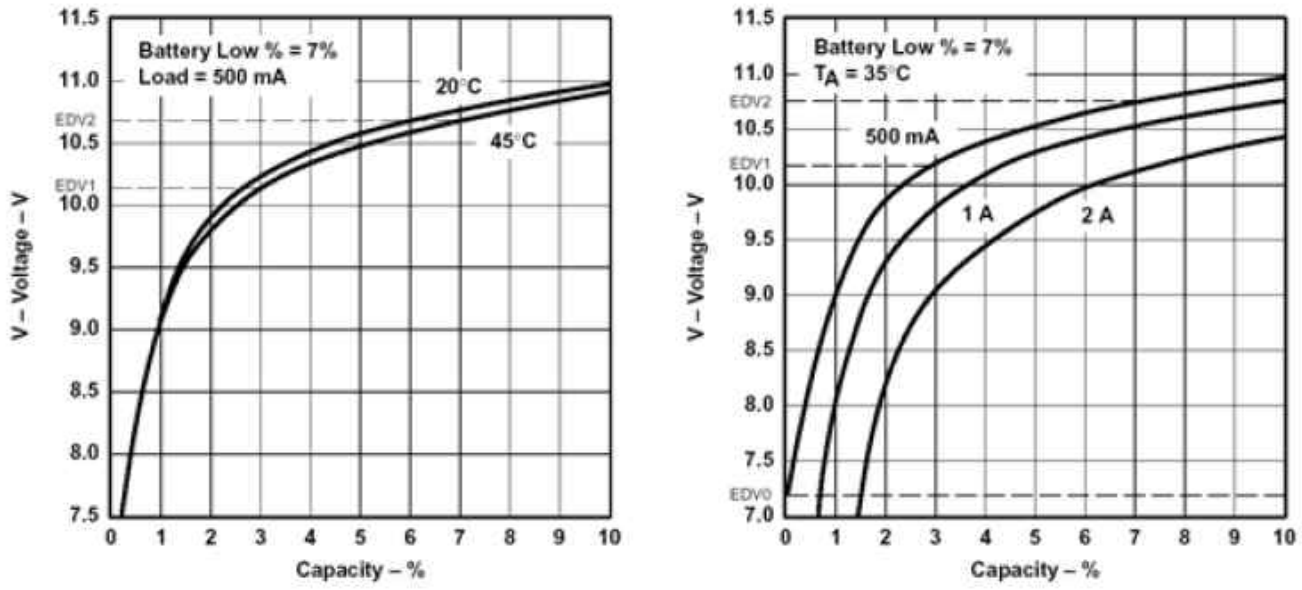

Figure 6-3. (a) EDV Calculations vs. Capacity for Various Temperatures, (b) EDV Calculations vs. Capacity for Various Loads

6.5 CEDV Smoothing

The BQ4050 device has the ability to smooth the *RemainingCapacity()* during discharge in order to avoid a drop in *RelativeStateOfCharge()* when the EDV thresholds are reached. This feature is enabled by setting the ***Smoothing Config [SMEN]*** = 1 and configuring the ***Smoothing Start Voltage*** and ***Smoothing Delta Voltage***.

The smoothing will activate only when all of the following conditions are true:

- *Current()* < 0
- *Voltage()* < ***Smoothing Start Voltage***
- EDV2 has been reached (*[EDV2]* = 1) OR (*Voltage()* – present EDV2 threshold) < ***Smoothing Delta Voltage***.
- Maximum *Voltage()* during the previous one minute is less than the maximum *Voltage()* during the current minute (that is, "drop rate" is greater than 0).
- *RemainingCapacity()* is greater than the capacity at the next EDV point.

While smoothing is active, the "drop rate" is used to estimate the time to the EDV point under the assumption that the rate is constant (linear). This information is then used to estimate how much current would need to be applied in order to have *RemainingCapacity()* reach the expected capacity at the EDV point. The actual *Current()* is then scaled by the "smoothing current." This will either speed up or slow down the *RemainingCapacity()* accumulation to reach the EDV threshold at the correct time.

Whenever the *RemainingCapacity()* accumulation is actively scaled, the *OperationStatus()[SMTH]* bit will be set.

Smoothing deactivates whenever an EDV threshold is reached until the rate to the next EDV threshold can be calculated. However, smoothing past the EDV2 point only occurs if the ***Smoothing Config [SMEXT]*** is set to 1.

To improve smoothing at the end of discharge, the SME0 configuration bit provides additional flexibility. This is particularly useful when ***FIXED_EDV0*** is set and the calculated EDV2/EDV1 is lower than EDV0. In this scenario, the SOC smooths to EDV2, then to EDV1, and then to EDV0, leading to SOC jumps. If the SME0 bit is set, then the SOC smooths directly to EDV0, leading to a smooth transition to empty.

Table 6-2 shows the available smoothing configurations.

Table 6-2. Smoothing Configurations

SMEN	SMEXT	SME0	Description
0	0	0	No Smoothing
0	0	1	No Smoothing
0	1	0	No Smoothing
0	1	1	No Smoothing
1	0	0	Smoothing to EDV2
1	0	1	Smoothing to EDV0 if calculated EDV2/EDV1 is less than EDV0.
1	1	0	Smoothing to EDV2 ≥ EDV1 ≥ EDV0
1	1	1	Smoothing to EDV0 if calculated EDV2/EDV1 is less than EDV0.

The BQ4050 device can also add smoothing during charging. In situations when the FCC is not updated during a discharge cycle or on a subsequent charge cycle, if the valid charge termination is reached, RSOC is synced to 100% regardless of the true RSOC. To help in scenarios like these, the device enables the SMOOTHEOCEN bit (default is enabled).

When enabled, the RSOC value is gradually increased to 100% instead of a sudden jump if the following is true:

1. Battery is charging.
2. Cell Voltage > Taper Voltage
3. Charge Current is decreasing AND is below the ***EOC Smooth Current*** threshold for ***EOC Smooth Current Time.***

6.6 State-of-Health (SoH)

The BQ4050 implements a new state-of-health (SoH) function. Previously, the SoH of a battery was typically represented by the actual runtime ***FullChargeCapacity/Design Capacity*** (or FCC/DC). Using the runtime FCC, however, was not a very good representation for the state-of-health because the runtime FCC reflects the usable capacity under load. A high current load reduces the runtime FCC. If using just the FCC/DC calculation for SoH, the SoH under high load will be worse than the SoH under typical load. However, a smaller usable capacity at high load does not mean the SoH of a battery is degraded. This is the same when FCC is reduced at a lower temperature.

6.7 Battery Trip Point (BTP)

Required for WIN8 OS, the Battery Trip Point (BTP) feature indicates when the RSOC of a battery pack has depleted to a certain value set in a DF register.

The BTP feature allows a host to program two capacity-based thresholds that govern the triggering of a BTP interrupt on the BTP_INT pin and the setting or clearing of the *OperationStatus()[BTP_INT]* on the basis of *RemainingCapacity()*. The interrupt is enabled or disabled via ***Settings.Configuration.IO Config[BTP_EN]***. Similarly, the polarity of the interrupt is configurable based on the value set in ***Settings.Configuration.IO Config[BTP_POL]***.

- *OperationStatus()[BTP_INT]* is set when:
  - Current > 0 and RemCap > “clear” threshold (“charge set threshold”). This threshold is initialized at reset from ***Settings.BTP.Init Charge Set***.
  - Current ≤ 0 and RemCap < “set” threshold (“discharge set threshold”). This threshold is initialized at reset from ***Settings.BTP.Init Discharge Set***.
- When *OperationStatus()[BTP_INT]* is set, if ***Settings.Configuration.IO Config[BTP_EN]*** is set, then the BTP_INT pin output is asserted.
  - If ***Settings.Configuration.IO Config[BTP_POL]*** is set, it will assert high; otherwise, it will assert low.
- When either *BTPDischargeSet()* or *BTPChargeSet()* commands are received, *OperationStatus()[BTP_INT]* will clear and the pin will be de-asserted. The new threshold is written to either *BTPDischargeSet()* or *BTPChargeSet()*.
- At reset, the pin is set to the de-asserted state.

– If ***[BTP_POL]*** is changed, one of the BTP commands must be reset or sent to “clear" the state.

Chapter 7

Cell Balancing

7.1 Introduction

Cell balancing in the BQ4050 device is accomplished by connecting an external parallel bypass load to each cell of the associated AFE, and enabling the bypass load depending on each 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~VC15 pins of the associated AFE are required to be 1 kΩ.

Using this circuit, the BQ4050 balances the cells during charge by enabling the bypass around 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 BQ4050 measures the cell voltages at an interval set in ***Cell Balance Interval***.

The cell(s) to be balanced are prioritized by highest cell voltage but the BQ4050 will not try to balance adjacent cells. If adjacent cells need to be balanced, the BQ4050 will alternate between the highest and next-highest adjacent cells until they are balanced.

On the basis of the cell voltages, the BQ4050 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.

More in-depth details and data on this cell balancing algorithm can be found in: http://www.ti.com/lit/slva155.

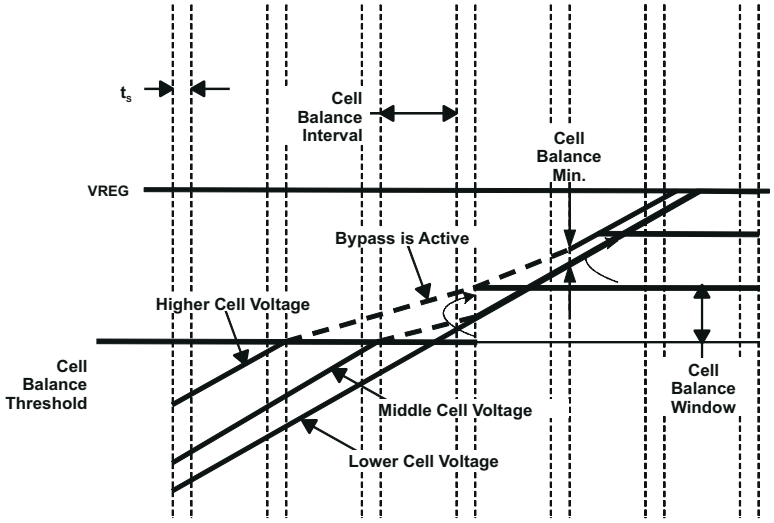

Figure 7-1. Cell Balancing

Cell balancing only occurs when charging current is detected, and on non-adjacent cells at the same time. 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.

The configuration data flash is stored in ***Advanced Charging Algorithms: Cell Balancing Config.***

7.1.1 Cell Balancing Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Charge Algorithm	Cell Balancing Config	Cell Balance Threshold	I2	0	5000	3900	mV
Charge Algorithm	Cell Balancing Config	Cell Balance Window	I2	0	5000	100	mV
Charge Algorithm	Cell Balancing Config	Cell Balance Min	U1	0	255	40	mV
Charge Algorithm	Cell Balancing Config	Cell Balance Interval	U1	0	255	20	s

7.1.2

For more details, see Section 14.4.12.

Class	Subclass	Name	Format	Size in Bytes	Min	Max	Default	Unit
Settings	Configuration	Balancing Configuration	Hex	1	0x00	0xFF	0x01	—

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	CB

RSVD (Bits 7–1): Reserved

CB (Bit 0): Cell balancing

1 = Enabled (default)

0 = Disabled

Chapter 8
LED Display

8.1 Introduction

The BQ4050 device has an LED display that shows various status information when a high-to-low transition of the $\overline{\text{DISP}}$ pin is detected. The LED display is disabled if *SafetyStatus[CUV]* or *[CUVC]* = 1 or if the device is in SHUTDOWN mode.

8.1.1 LED Display of State-of-Charge

When the $\overline{\text{DISP}}$ pin is pressed and a high-to-low transition of the pin is detected, the LED display shows the state-of-charge for ***LED Hold Time***. The state-of-charge can display the *RelativeStateOfCharge()* or *AbsoluteStateOfCharge()* based on the ***[LEDMODE]*** setting.

The state-of-charge threshold can be set according to the number of LEDs available. The following table shows an example for data flash setting with 5-LED display.

If ***[LEDCHG]*** = 1, the LED display will show the state-of-charge during charging when *Current()* > ***Charge Current Threshold***.

	State-of-Charge	
	Current() > 0	*Current()* ≤ 0
LED1	***CHG Thresh 1*** – 100%	***DSG Thresh 1*** – 100%
LED2	***CHG Thresh 2*** – 100%	***DSG Thresh 2*** – 100%
LED3	***CHG Thresh 3*** – 100%	***DSG Thresh 3*** – 100%
LED4	***CHG Thresh 4*** – 100%	***DSG Thresh 4*** – 100%
LED5	***CHG Thresh 5*** – 100%	***DSG Thresh 5*** – 100%

If ***[LEDRCA]*** = 1 and the BatteryStatus[RCA] change from 0 to 1, the LED display will also flash with ***LED Flash Rate*** according to the ***CHG Flash Alarm*** or ***DSG Flash Alarm*** setting as shown below.

	State-of-Charge	
	Current() > 0	*Current()* ≤ 0
Flash Alert	0 % – ***CHG Flash Alarm***	0 % – ***DSG Flash Alarm***

8.1.2 LED Display of PF Error Code

If ***[LEDPF1, LEDPF0]*** = 0,1, then the LED display shows each PF code for 2× the ***LED Hold Time*** after showing the state-of-charge information.

The following table shows each PF error code. Each code is shown with the lowest to highest priority order.

PF Flag	Priority	LED3	LED2	LED1
No PF	0	***LED Blink Rate***	off	off
SUV	0	***LED Blink Rate***	on	off
SOV	1	***LED Blink Rate***	***LED Flash Rate***	off
SOCC	2	***LED Blink Rate***	off	on
SOCD	3	***LED Blink Rate***	on	on
SOT	4	***LED Blink Rate***	***LED Flash Rate***	on
Reserved	5	***LED Blink Rate***	off	***LED Flash Rate***

PF Flag	Priority	LED3	LED2	LED1
SOTF	6	***LED Blink Rate***	on	***LED Flash Rate***
Reserved	7	***LED Blink Rate***	***LED Flash Rate***	***LED Flash Rate***
Reserved	8	***LED Blink Rate***	off	***LED Blink Rate***
Reserved	9	LED Blink Rate	on	LED Blink Rate
CD	10	LED Flash Rate	LED Blink Rate	off
VIMR	11	off	***LED Blink Rate***	off
VIMA	12	on	***LED Blink Rate***	off
Reserved	13	***LED Flash Rate***	***LED Blink Rate***	on
Reserved	14	off	***LED Blink Rate***	on
Reserved	15	on	***LED Blink Rate***	on
CFETF	16	***LED Flash Rate***	***LED Blink Rate***	***LED Flash Rate***
DFETF	17	off	***LED Blink Rate***	***LED Flash Rate***
Reserved	18	on	***LED Blink Rate***	***LED Flash Rate***
FUSE	19	***LED Flash Rate***	***LED Blink Rate***	***LED Blink Rate***
AFER	20	off	***LED Blink Rate***	***LED Blink Rate***
AFEC	21	on	off	***LED Blink Rate***
2LVL	22	***LED Flash Rate***	off	***LED Blink Rate***
PTC	23	off	off	***LED Blink Rate***
IFC	24	on	on	***LED Blink Rate***
OPNCELL	25	***LED Flash Rate***	on	***LED Blink Rate***
DF	26	off	on	***LED Blink Rate***
Reserved	27	on	***LED Flash Rate***	***LED Blink Rate***
Open Therm TS1	28	***LED Flash Rate***	***LED Flash Rate***	***LED Blink Rate***
Open Therm TS2	29	off	***LED Flash Rate***	***LED Blink Rate***
Open Therm TS3	30	on	***LED Blink Rate***	***LED Blink Rate***
Open Therm TS4	31	***LED Flash Rate***	***LED Blink Rate***	***LED Blink Rate***

8.1.3 LED Display on Exit of a Reset

If the ***[LEDR]*** = 1 and a reset occurs at the exit of the rest, the LED display shows the state-of-charge for ***LED Hold Time***. If ***[LEDPF1, LEDPF0]*** = 0,1, the LED display also shows each of the PF error code for 2 × of the ***LED Hold Time*** afterward.

8.1.4 LED Display Control Through ManufacturerAccess()

The gauge provides *ManufacturerAccess()* command (MAC) for testing purpose. The MAC *LED Toggle()* command can toggle the LED display on and off. The MAC *LED Display Press()* command can trigger the LED display and simulate 100% RSOC to demonstrate with all LEDs in actions.

Chapter 9

Lifetime Data Collection

9.1 Description

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

- Every 10 hours if RAM content is different from flash.
- In permanent fail, before data flash updates are disabled.
- A reset counter increments. The lifetime RAM data is reset; therefore, only the reset counters are updated to data flash.
- Before scheduled shutdown
- Before low voltage shutdown and the voltage is above the ***Valid Update Voltage***.

The Lifetime Data stops collecting under following conditions:

- After permanent fail
- Lifetime Data Collection is disabled by setting *ManufacturingStatus()[LF_EN]* = 0.

9.2

Total firmware Runtime starts when Lifetime Data is enabled.

- Voltage
  - Max/Min Cell Voltage Each Cell
  - Max Delta Cell Voltage at any given time (that is, the max cell imbalance voltage)
- Current
  - Max Charge/Discharge Current
  - Max Average Discharge Current
  - Max Average Discharge Power
- Safety Events that trigger the *SafetyStatus()* (The 12 most common are tracked.)
  - Number of Safety Events
  - Cycle Count at Last Safety Event(s)
- Charging Events
  - Number of Valid Charge Terminations (That is, the number of times *[VCT]* is set.)
  - Cycle Count at Last Charge Termination
- Power Events
  - Number of Resets, Partial Resets, and Watchdog Resets
  - Number of shutdowns
- Cell Balancing (This data is stored with a resolution of 2 hours up to a limit of 510 hours.)
  - Cell Balancing Time each Cell
- Temperature
  - Max/Min Cell Temp
  - Delta Cell Temp (max delta cell temperature across the thermistors that are used to report cell temperature)
  - Max/Min Int Temp Sensor
  - Max FET Temp
- Time (This data is stored with a resolution of 2 hours.)

- Total runtime
- Time spent different temperature ranges

Chapter 10

Device Security

10.1 Introduction

There are three levels of secured operation within the device. To switch between the levels, different operations are needed with different keys. The three levels are SEALED, UNSEALED, and FULL ACCESS. The device also supports SHA-1 HMAC authentication with the host system.

10.2 SHA-1 Description

As of March 2012, the latest revision is FIPS 180–4. SHA-1, or secure hash algorithm, is used to compute a condensed representation of a message or data also known as hash. For messages < 2^{64}, the SHA-1 algorithm produces a 160-bit output called a digest.

In a SHA-1 one-way hash function, there is no known mathematical method of computing the input given, only the output. The specification of SHA-1, as defined by FIPS 180–4, states that the input consists of 512-bit blocks with a total input length less than 264 bits. Inputs that do not conform to integer multiples of 512-bit blocks are padded before any block is input to the hash function. The SHA-1 algorithm outputs the 160-bit digest.

The device generates a SHA-1 input block of 288 bits (total input = 160-bit message + 128-bit key). To complete the 512-bit block size requirement of the SHA-1 function, the device pads the key and message with a 1, followed by 159 0s, followed by the 64 bit value for 288 (000...00100100000), which conforms to the pad requirements specified by FIPS 180–4.

Detailed information about the SHA-1 algorithm can be found here:

1. http://www.nist.gov/itl/
2. http://csrc.nist.gov/publications/fips
3. www.faqs.org/rfcs/rfc3174.html

10.3 HMAC Description

The SHA-1 engine calculates a modified HMAC value. Using a public message and a secret key, the HMAC output is considered to be a secure fingerprint that authenticates the device used to generate the HMAC.

To compute the HMAC: Let H designate the SHA-1 hash function, M designate the message transmitted to the device, and KD designate the unique 128-bit Unseal/Full Access/Authentication key of the device. HMAC(M) is defined as:

H[KD || H(KD || M)], where || symbolizes an append operation.

The message, M, is appended to the unseal/full access/authentication key, KD, and padded to become the input to the SHA-1 hash. The output of this first calculation is then appended to the unseal/full access/authentication key, KD, padded again, and cycled through the SHA-1 hash a second time. The output is the HMAC digest value.

10.4 Authentication

1. Generate 160-bit message M using a random number generator that meets approved random number generators described in FIPS PUB 140–2.
2. Generate SHA-1 input block B1 of 512 bytes (total input = 128-bit authentication key KD + 160-bit message M + 1 + 159 0s + 100100000).
3. Generate SHA-1 hash HMAC1 using B1.

4. Generate SHA-1 input block B2 of 512 bytes (total input = 128-bit authentication key KD + 160-bit hash HMAC1 + 1 + 159 0s + 100100000).
5. Generate SHA-1 hash HMAC2 using B2.
6. With no active *Authentication()* data waiting, write 160-bit message M to *Authentication()* in the format: 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTT, where AA is LSB.
7. Wait 250 ms, then read *Authentication()* for HMAC3.
8. Compare host HMAC2 with device HMAC3. If it matches, both host and device have the same key KD and the device is authenticated.

10.5 Security Modes

10.5.1 FULL ACCESS or UNSEALED to SEALED

The MAC *Seal Device()* command instructs the device to limit access to the SBS functions and data flash space, and sets the *[SEC1][SEC0]* flags. In SEALED mode, standard SBS functions have access (per the Smart Battery Data Specification). Most of the extended SBS functions and data flash are not accessible. Refer to Chapter 13 where each command has documented the accessibility information. Once in SEALED mode, the gauge can never permanently return to UNSEALED or FULL ACCESS modes.

10.5.2 SEALED to UNSEALED

SEALED to UNSEALED instructs the device to extend access to the SBS and data flash space and clears the *[SEC1][SEC0]* flags. In UNSEALED mode, all data, SBS, and DF have read/write access. Note that although writing to most of the SBS commands are accepted by the gauge, the written data will be immediately overwritten by the gauge and the write action is ignored. Unsealing is a two-step command performed by writing the first word of the unseal key to *ManufacturerAccess() (MAC)*, followed by the second word of the unseal key to *ManufacturerAccess()*. The two words must be sent within 4 s. The unseal key can be read and changed via the *MAC SecurityKey()* command when in the FULL ACCESS mode. To return to the SEALED mode, either a hardware reset is needed or the *MAC Seal Device()* command is needed to transit from FULL ACCESS or UNSEALED to SEALED.

10.5.3 UNSEALED to FULL ACCESS

UNSEALED to FULL ACCESS instructs the device to allow full access to all SBS commands and data flash. The device is shipped from TI in this mode. The keys for UNSEALED to FULL ACCESS can be read and changed via the MAC command *SecurityKey()* when in FULL ACCESS mode. Changing from UNSEALED to FULL ACCESS is performed by using the *ManufacturerAccess()* command, by writing the first word of the Full Access Key to *ManufacturerAccess()*, followed by the second word of the Full Access Key to *ManufacturerAccess()*. The two words must be sent within 4 s. In FULL ACCESS mode, the command to go to boot ROM can be sent.

11.1 Manufacture Testing

To improve the manufacture testing flow, the gas gauge device allows certain features to be toggled on or off through *ManufacturerAccess()* commands; for example, the *PCHG FET()*, *CHG FET()*, *DSG FET()*, *Lifetime Data Collection()*, *Calibration()*, and so on. Enabling only the feature under test can simplify the test flow in production by avoiding any feature interference. The *ManufacturerAccess()* commands that toggle the *ManufacturingStatus()[CAL_EN]*, *[LT_TEST]*, *[DSG_TEST]*, *[CHG_TEST]*, and *[PCHG_TEST]* will only set the RAM data, meaning the conditions set by these commands will be cleared if a reset or seal is issued to the gauge. The *ManufacturerAccess()* commands that toggle the *ManufacturingStatus()[LED_EN]*, *[FUSE_EN]*, *[BBR_EN]*, *[PF_EN]*, and *[LT_EN], [FET_EN], [GAUGE_EN]* will be updated to data flash and synchronized between *ManufacturingStatus()* and ***Mfg Status Init***. The *ManufacturingStatus()* keeps track of the status (enabled or disabled) of each feature.

The ***Mfg Status Init*** provides the option to enable or disable individual features for normal operation. Upon a reset or a seal command, *ManufacturingStatus()* will be re-loaded from data flash ***Mfg Status Init***. This means if an update is made to ***Mfg Status Init*** to enable or disable a feature, the gauge will only take the new setting if a reset or seal command is sent.

11.2 Calibration

Refer to the *BQ40zxx Manufacture, Production, and Calibration Application Note* (SLUA734) for the detailed calibration procedure.

The device has integrated routines that support calibration of current, voltage, and temperature readings, accessible after writing 0xF081 or 0xF082 to *ManufacturerAccess()* when the *ManufacturingStatus()[CAL]* bit is ON. While the calibration is active, the raw ADC data is available on *ManufacturerData()*. The device stops reporting calibration data on *ManufacturerData()* if any other MAC commands are sent or the device is reset or sealed.

Note

The *ManufacturingStatus()[CAL]* bit must be turned OFF after calibration is completed. The *ManufacturingStatus()[CAL]* bit is set by default when the ***Manufacturing Status Init*** is set to zero. This bit is cleared at reset or after sealing.

ManufacturerAccess()	Description
0x002D	Enables/Disables *ManufacturingStatus()[CAL]*
0xF080	Disables raw ADC data output on *ManufacturerData()*
0xF081	Outputs raw ADC data of voltage, current, and temperature on *ManufacturerData()*
0xF082	Outputs raw ADC data of voltage, current, and temperature on *ManufacturerData()*. This mode enables an internal short on the coulomb counter inputs (SRP, SRN).

The *ManufacturerData()* output format is: ZZYYaaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKK,

where:

Value	Format	Description
ZZ	byte	8-bit counter, increments when raw ADC values are refreshed (every 250 ms)

Value	Format	Description
YY	byte	Output status *ManufacturerAccess()* = 0xF081: 1 *ManufacturerAccess()* = 0xF082: 2
AAaa	2's comp	Current (coulomb counter)
BBbb	2's comp	Cell Voltage 1
CCcc	2's comp	Cell Voltage 2
DDdd	2's comp	Cell Voltage 3
EEee	2's comp	Cell Voltage 4
FFff	2's comp	PACK Voltage
GGgg	2's comp	BAT Voltage
HHhh	2's comp	Cell Current 1
IIii	2's comp	Cell Current 2
JJjj	2's comp	Cell Current 3
KKkk	2's comp	Cell Current 4

11.2.1 Calibration Data Flash

11.2.1.1 Voltage

Class	Subclass	Name	Start	Type	Min	Max	Default	Unit	Description
Calibration	Voltage	Cell Gain	0x4000	I2	–32767	32767	12101(1)	—	VC[n]–VC[n–1] gain
Calibration	Voltage	PACK Gain	0x4002	U2	0	65535	49669(1)	—	PACK–VSS gain
Calibration	Voltage	BAT Gain	0x4004	U2	0	65535	48936(1)	—	BAT–VSS gain

(1) Setting this value to 0 causes the gauge to use the internal factory calibration default.

11.2.1.2 Current

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Current	CC Gain	F4	1.00E–001	4.00E+000	3.58422	Coulomb Counter Gain
Calibration	Current	Capacity Gain	F4	2.98E+004	1.19E+006	1069035.256	Capacity Gain

11.2.1.3 Current Offset

11.2.1.3.1 CC Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Current Offset	CC Offset	I2	–32767	32767	0	—

Description: Coulomb Counter Offset. This offset is used for *Current()* and *AverageCurrent()* measurement.

11.2.1.3.2 Coulomb Counter Offset Samples

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Current Offset	Coulomb Counter Offset Samples	U2	0	65535	64	—

Description: Coulomb Counter Offset Samples is used for averaging.

11.2.1.3.3 CC Auto Config

Class	Subclass	Name	Type	Min	Max	Default	Units
Calibration	Current Offset	CC Auto Config	H1	0x00	0x07	0x00	hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	OFFSET_ TAKEN	AUTO_ NESTON	AUTO_ CAL_EN

RSVD (Bits 7–3): Reserved. Do not use.

OFFSET_TAKEN (Bit 2): CC Auto offset is taken.

1 = ***CC Auto Offset*** is updated.

0 = ***CC Auto Offset*** has not updated.

AUTO_NESTON (Bit 1): NEST Circuit ON

1 = FW automatically manages nested chopping hardware for highest-accuracy current and cell current measurements.

0 = Nested chopping hardware is turned off. Cell current measurement is not optimized for best accuracy.

AUTO_CAL_EN (Bit 0): Auto CC offset calibration enable

1 = FW performs auto CC calibration on entry into SLEEP mode. A min auto CC calibration interval is set to 10 hr to prevent flash wear out. The result is saved to ***CC Auto Offset***.

0 = ***CC Auto Offset*** calibration is disabled.

11.2.1.3.4 CC Auto Offset

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Current Offset	CC Auto Offset	I2	–10000	10000	0	***CC offset*** collected via ***CC Auto Calibration***. This offset is used for cell current measurement and is different than ***CC Offset***.

11.2.1.3.5 Board Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Current Offset	Board Offset	I2	–32768	32767	0	—

Description: PCB board offset

11.2.1.4 Temperature

11.2.1.4.1 Internal Temp Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Temperature	Internal Temp Offset	I1	–128	127	0	0.1 °C

Description: Internal temperature sensor reading offset

11.2.1.4.2 External 1 Temp Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Temperature	External 1 Temp Offset	I1	–128	127	0	0.1 °C

Description: TS1 temperature sensor reading offset

11.2.1.4.3 External 2 Temp Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Temperature	External 2 Temp Offset	I1	–128	127	0	0.1 °C

Description: TS2 temperature sensor reading offset

11.2.1.4.4 External 3 Temp Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Temperature	External 3 Temp Offset	I1	–128	127	0	0.1 °C

Description: TS3 temperature sensor reading offset

11.2.1.4.5 External 4 Temp Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Temperature	External 4 Temp Offset	I1	–128	127	0	0.1 °C

Description: TS4 temperature sensor reading offset

11.2.1.5 Internal Temp Model

11.2.1.5.1 Int Gain

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Internal Temp Model	Int Gain	I2	–32768	32767	–12143	—

Description: Internal temperature gain

11.2.1.5.2 Int Base Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Internal Temp Model	Int Base Offset	I2	–32768	32767	6232	—

Description: Internal temperature base offset

11.2.1.5.3 Int Minimum AD

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Internal Temp Model	Int Minimum AD	I2	–32768	32767	0	—

Description: Minimum AD count used for calculation

11.2.1.5.4 Int Maximum Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Internal Temp Model	Int Maximum Temp	I2	–32768	32767	6232	0.1 °K

Description: Maximum Temperature boundary

11.2.1.6 Cell Temp Model

11.2.1.6.1 Coefficient a1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient a1	I2	–32768	32767	–11130	—

Description: Cell Temperature calculation polynomial a1

11.2.1.6.2 Coefficient a2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient a2	I2	–32768	32767	19142	—

Description: Cell Temperature calculation polynomial a2

11.2.1.6.3 Coefficient a3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient a3	I2	–32768	32767	–19262	—

Description: Cell Temperature calculation polynomial a3

11.2.1.6.4 Coefficient a4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient a4	I2	–32768	32767	28203	—

Description: Cell Temperature calculation polynomial a4

11.2.1.6.5 Coefficient a5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient a5	I2	–32768	32767	892	—

Description: Cell Temperature calculation polynomial a5

11.2.1.6.6 Coefficient b1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient b1	I2	–32768	32767	328	—

Description: Cell Temperature calculation polynomial b1

11.2.1.6.7 Coefficient b2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient b2	I2	–32768	32767	–605	—

Description: Cell Temperature calculation polynomial b2

11.2.1.6.8 Coefficient b3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient b3	I2	–32768	32767	–2443	—

Description: Cell Temperature calculation polynomial b3

11.2.1.6.9 Coefficient b4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Coefficient b4	I2	–32768	32767	4969	—

Description: Cell Temperature calculation polynomial b4

11.2.1.6.10 Rc0

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Rc0	I2	–32768	32767	11703	Ω

Description: Resistance at 25°C

11.2.1.6.11 Adc0

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Adc0	I2	–32768	32767	11703	—

Description: ADC reading at 25°C

11.2.1.6.12 Rpad

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Rpad	I2	–32768	32767	0(1)	Ω

(1) Setting this value to 0 causes the gauge to use the internal factory calibration default.

Description: Pad Resistance (0 to use factory calibration)

11.2.1.6.13 Rint

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Cell Temp Model	Rint	I2	–32768	32767	0(1)	Ω

(1) Setting this value to 0 causes the gauge to use the internal factory calibration default.

Description: Pull up resistor resistance (0 to use factory calibration)

11.2.1.7 FET Temp Model

11.2.1.7.1 Coefficient a1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient a1	I2	–32768	32767	–11130	—

Description: FET Temperature calculation polynomial a1

11.2.1.7.2 Coefficient a2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient a2	I2	–32768	32767	19142	—

Description: FET Temperature calculation polynomial a2

11.2.1.7.3 Coefficient a3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient a3	I2	–32768	32767	–19262	—

Description: FET Temperature calculation polynomial a3

11.2.1.7.4 Coefficient a4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient a4	I2	–32768	32767	28203	—

Description: FET Temperature calculation polynomial a4

11.2.1.7.5 Coefficient a5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient a5	I2	–32768	32767	892	—

Description: FET Temperature calculation polynomial a5

11.2.1.7.6 Coefficient b1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient b1	I2	–32768	32767	328	—

Description: FET Temperature calculation polynomial b1

11.2.1.7.7 Coefficient b2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient b2	I2	–32768	32767	–605	—

Description: FET Temperature calculation polynomial b2

11.2.1.7.8 Coefficient b3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient b3	I2	–32768	32767	–2443	—

Description: FET Temperature calculation polynomial b3

11.2.1.7.9 Coefficient b4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Coefficient b4	I2	–32768	32767	4969	—

Description: FET Temperature calculation polynomial b4

11.2.1.7.10 Rc0

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Rc0	I2	–32768	32767	11703	Ω

Description: Resistance at 25°C

11.2.1.7.11 Adc0

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Adc0	I2	–32768	32767	11703	—

Description: ADC reading at 25°C

11.2.1.7.12 Rpad

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Rpad	I2	–32768	32767	0(1)	Ω

(1) Setting this value to 0 causes the gauge to use the internal factory calibration default.

Description: Pad Resistance (0 to use factory calibration)

11.2.1.7.13 Rint

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	FET Temp Model	Rint	I2	–32768	32767	0(1)	Ω

(1) Setting this value to 0 causes the gauge to use the internal factory calibration default.

Description: Pull up resistor resistance (0 to use factory calibration)

11.2.1.8 Current Deadband

11.2.1.8.1 Deadband

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Current Deadband	Deadband	U1	0	255	3	mA

Description: Pack-based Deadband to report 0 mA

11.2.1.8.2 Coulomb Counter Deadband

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Current Deadband	Coulomb Counter Deadband	U1	0	255	9	116 nV

Description: Coulomb counter deadband to report 0 charge (This setting should not be modified.)

Chapter 12

Device SMBus Address

12.1

The BQ4050 SMBus address (default 0x16) can be changed. The target address should be programmed in ***Address*** and the 2's complement of that value should be programmed in ***Address Check***.

The BQ4050 will check these values upon exit from POR, and if the two data flash values are not valid or the programmed address is 0x00 or 0xFF, then the device defaults to 0x16.

Table 12-1. Address

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Settings	SMBus	Address	Hex	1	0x00	0xFF	0x16	—

Table 12-2. Address Check

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Settings	SMBus	Address Check	Hex	1	0x00	0xFF	0xEA	—

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13.1 0x00 ManufacturerAccess() and 0x44 ManufacturerBlockAccess()

ManufacturerBlockAccess() provides a method of reading and writing data in the Manufacturer Access System (MAC). This block MAC access method is a new standard for the BQ40zxy family. The MAC command is sent via *ManufacturerBlockAccess()* by the SMBus block protocol. The result is returned on *ManufacturerBlockAccess()* via an SMBus block read.

Example: Send a MAC *Gauging()* to enable/disable firmware control of the CHG/DSG/PCHG FETs via *ManufacturerBlockAccess()*.

1. With firmware control of the CHG/DSG/PCHG FETs enabled, send *Gauging()* (0x0022) to *ManufacturerBlockAccess().*
   a. MBus block write. Command = 0x44. Data = 22 00 (Data must be sent in Little Endian.)
2. FET Control is disabled, *ManufacturingStatus()[FET_EN]* = 0.

Example: Read *HardwareVersion()* (0x0003) via *ManufacturerBlockAccess()*

1. Send *HardwareVersion()* to *ManufacturerBlockAccess().*
   a. SMBus block write. Command = 0x44. Data sent = 03 00 (Data must be sent in Little Endian.)
2. Read the result from *ManufacturerBlockAccess()*.
   a. SMBus block read. Command = 0x44. Data read = 03 00 00 01 (Each data entity is returned in Little Endian.)
   b. The first 2 bytes, “03 00”, is the MAC command.
   c. The second 2 bytes, “00 01”, is the hardware version returning in Little Endian. That is 0x0100, *HardwareVersion()* 100.

For backwards compatibility with the BQ30zxy families, sending MAC commands via *ManufacturerAccess()* (0x00) as well as the returning data on *ManufacturerData()* are supported in BQ4050. Note that MAC commands are sent through *ManufacturerAccess()* (0x00) by an SMBus write word protocol. The result reading from *ManufacturerData()* does not include the MAC command.

Example: Send a MAC *Gauging()* to enable/disable firmware control of the CHG/DSG/PCHG FETs via *ManufacturerBlockAccess()*.

1. With firmware control of the CHG/DSG/PCHG FETs enabled, send *Gauging()* (0x0022) to *ManufacturerBlockAccess()*.
   a. SMBus word write. Command = 0x00. Data = 00 22
2. FET Control is disabled, *ManufacturingStatus()[FET_EN]* = 0.

Example: Read *HardwareVersion()* (0x0003) via *ManufacturerBlockAccess()*

1. Send *HardwareVersion()* to *ManufacturerBlockAccess()*.
   a. SMBus block write. Command = 0x00. Data sent = 00 03
2. Read the result from *ManufacturerData().*
   a. SMBus block read. Command = 0x06. Data read = 00 01
   b. That is 0x0100, *HardwareVersion()* 100.

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

Table 13-1. ManufacturerAccess() Command List

Command	Function	Access	Format	Data Read on 0x44 or 0x23	Data Read on 0x2F	Available in SEALED Mode	Type	Unit
0x0001	DeviceType	R	Block	Yes	—	Yes	Hex	—
0x0002	FirmwareVersion	R	Block	Yes	—	Yes	Hex	—
0x0003	HardwareVersion	R	Block	Yes	—	Yes	Hex	—
0x0004	IFChecksum	R	Block	Yes	—	Yes	Hex	—
0x0005	StaticDFSignature	R	Block	Yes	—	Yes	Hex	—
0x0009	AllDFSignature	R	Block	Yes	—	Yes	Hex	—
0x0010	ShutdownMode	W	—	—	—	Yes	Hex	—
0x0011	SleepMode	W	—	—	—	—	Hex	—
0x001D	FuseToggle	W	—	—	—	—	Hex	—
0x001E	PrechargeFET	W	—	—	—	—	Hex	—
0x001F	ChargeFET	W	—	—	—	—	Hex	—
0x0020	DischargeFET	W	—	—	—	—	Hex	—
0x0022	FETControl	W	—	—	—	—	Hex	—
0x0023	LifetimeDataCollection	W	—	—	—	—	Hex	—
0x0024	PermanentFailure	W	—	—	—	—	Hex	—
0x0025	BlackBoxRecorder	W	—	—	—	—	Hex	—
0x0026	Fuse	W	—	—	—	—	Hex	—
0x0028	LifetimeDataReset	W	—	—	—	—	Hex	—
0x0029	PermanentFailureData Reset	W	—	—	—	—	Hex	—
0x002E	LifetimeDataFlush	W	—	—	—	—	Hex	—
0x002F	LifetimeDataSpeedUp Mode	W	—	—	—	—	Hex	—
0x002A	BlackBoxRecorderReset	W	—	—	—	—	Hex	—
0x002D	CalibrationMode	W	—	—	—	—	Hex	—
0x0030	SealDevice	W	—	—	—	—	Hex	—
0x0035	SecurityKeys	R/W	Block	Yes	—	—	Hex	—
0x0037	AuthenticationKey	R/W	Block	—	Yes	—	Hex	—
0x0041	DeviceReset	W	—	—	—	—	Hex	—
0x0050	SafetyAlert	R	Block	Yes	—	Yes	Hex	—
0x0051	SafetyStatus	R	Block	Yes	—	Yes	Hex	—
0x0052	PFAlert	R	Block	Yes	—	Yes	Hex	—
0x0053	PFStatus	R	Block	Yes	—	Yes	Hex	—
0x0054	OperationStatus	R	Block	Yes	—	Yes	Hex	—
0x0055	ChargingStatus	R	Block	Yes	—	Yes	Hex	—
0x0056	GaugingStatus	R	Block	Yes	—	Yes	Hex	—
0x0057	ManufacturingStatus	R	Block	Yes	—	Yes	Hex	—
0x0058	AFERegister	R	Block	Yes	—	Yes	Hex	—
0x0060	LifetimeDataBlock1	R	Block	Yes	—	Yes	Mixed	Mixed
0x0061	LifetimeDataBlock2	R	Block	Yes	—	Yes	Mixed	Mixed
0x0062	LifetimeDataBlock3	R	Block	Yes	—	Yes	Mixed	Mixed
0x0070	ManufacturerInfo	R	Block	Yes	—	Yes	Hex	—
0x0071	DAStatus1	R	Block	Yes	—	Yes	Mixed	Mixed
0x0072	DAStatus2	R	Block	Yes	—	Yes	Mixed	Mixed
0x007A	ManufacturerInfo2	R	Block	Yes	—	Yes	Hex	—
0x0F00	ROMMode	W	—	—	—	—	Hex	—
0xF080	ExitCalibrationOutput	R/W	Block	Yes	—	—	Hex	—
0xF081	OutputCCandADCfor Calibration	R/W	Block	Yes	—	—	Hex	—

Table 13-1. ManufacturerAccess() Command List (continued)

Command	Function	Access	Format	Data Read on 0x44 or 0x23	Data Read on 0x2F	Available in SEALED Mode	Type	Unit
0xF082	OutputShortedCCand ADCforCalibration	R/W	Block	Yes	—	—	Hex	—

13.1.1 ManufacturerAccess() 0x0000

A read word on this command returns the lowest 16 bits of the *OperationStatus()* data.

13.1.2 ManufacturerAccess() 0x0001 Device Type

The device can be checked for the IC part number. The IC part number returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aaAA, where:

Value	Description
AAaa	Device Type

13.1.3 ManufacturerAccess() 0x0002 Firmware Version

The device can be checked for the firmware version of the IC. The firmware revision returns on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: ddDDvvVVbbBBTTzzZZRREE, where:

Value	Description
DDdd	Device Number
VVvv	Version
BBbb	Build Number
TT	Firmware Type
ZZzz	Version
RR	Reserved
EE	Reserved

13.1.4 ManufacturerAccess() 0x0003 Hardware Version

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

13.1.5 ManufacturerAccess() 0x0004 Instruction Flash Signature

The device can return the instruction flash signature. The IF signature returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

13.1.6 ManufacturerAccess() 0x0005 Static DF Signature

The device can return the data flash checksum. The signature of all static DF returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*. MSB is set to 1 if the calculated signature does not match the signature stored in DF.

13.1.7 ManufacturerAccess() 0x0009 All DF Signature

The device can return the data flash checksum. The signature of all DF parameters returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*. MSB is set to 1 if the calculated signature does not match the signature stored in DF. It is normally expected that this signature will change due to updates of lifetime, gauging, and other information.

13.1.8 ManufacturerAccess() 0x0010 SHUTDOWN Mode

To reduce power consumption, the device can be sent to SHUTDOWN mode before shipping. After sending this command, the *OperationStatus()[SDM]* = 1, an internal counter will start, the CHG and DSG FETs will be turned off when the counter reaches ***Ship FET Off Time***. When the counter reaches `Ship Delay` time, the device will enter SHUTDOWN mode if no charger present is detected.

If the device is SEALED, this feature requires the command to be sent twice in a row within 4 seconds (for safety purposes). If the device is in UNSEALED or FULL ACCESS mode, sending the command the second time will cancel the delay and enter shutdown immediately.

To wake up the device, a voltage > ***Charger Present Threshold*** must apply to the PACK pin. The device will power up and a full reset is applied.

13.1.9 ManufacturerAccess() 0x0011 SLEEP Mode

If the sleep conditions are met, the device can be sent to sleep with *ManufacturerAccess()*.

Status	Condition	Action
Enable	0x0011 to *ManufacturerAccess()*	*OperationStatus()[SLEEPM]* = 1
Activate	***DA Configuration[NR]*** = 0 AND *OperationStatus()[PRES]* = 0 AND |*Current()*| < ***Power:Sleep Current***	Turn off CHG FET, DSG FET, PCHG FET Device goes to sleep. Device wakes up every Power***:Sleep Voltage Time*** period to measure voltage and temperature. Device wakes up every Power***:Sleep Current Time*** period to measure current.
Activate	***DA Configuration[NR]*** = 1 AND |*Current()*| < ***Power:Sleep Current***	Turn off DSG FET, PCHG FET Turn off CHG FET if ***DA Configuration[SLEEPCHG]*** = 0 Device goes to sleep. Device wakes up every Power***:Sleep Voltage Time*** period to measure voltage and temperature. Device wakes up every Power***:Sleep Current Time*** period to measure current.
Exit	***DA Configuration[NR]*** = 0 AND *OperationStatus()[PRES]* = 1	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode
Exit	|*Current()*| > Configuration:Sleep Current	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode
Exit	Wake Comparator trips	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode
Exit	*SafetyAlert()* flag or *PFAlert()* flag set	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode

13.1.10 ManufacturerAccess() 0x001D Fuse Toggle

This command manually activates/deactivates the FUSE output to ease testing during manufacturing. If the *OperationStatus()[FUSE]* = 0 indicates the FUSE output is low. Sending this command toggles the FUSE output to be high and the *OperationStatus()[FUSE]* = 1.

13.1.11 ManufacturerAccess() 0x001E PCHG FET Toggle

This command turns on/off the PCHG FET drive function to ease testing during manufacturing. If the *ManufacturingStatus()[PCHG_TEST]* = 0, sending this command will turn on the PCHG FET and the *ManufacturingStatus()[PCHG_TEST]* = 1 and vice versa. This toggling command is only enabled if *ManufacturingStatus()[FET_EN]* = 0, indicating an FW FET control is not active and manual control is allowed. A reset clears the [PCHG_TEST] flag and turns off the PCHG FET.

13.1.12 ManufacturerAccess() 0x001F CHG FET Toggle

This command turns on/off the CHG FET drive function to ease testing during manufacturing. If the *ManufacturingStatus()[CHG_TEST]* = 0, sending this command turns on the CHG FET and the *ManufacturingStatus()[CHG_TEST]* = 1 and vice versa. This toggling command is only enabled if *ManufacturingStatus()[FET_EN]* = 0, indicating an FW FET control is not active and manual control is allowed. A reset clears the [CHG_TEST] flag and turns off the CHG FET.

13.1.13 ManufacturerAccess() 0x0020 DSG FET Toggle

This command turns on/off DSG FET drive function to ease testing during manufacturing. If the *ManufacturingStatus()[DSG_TEST]* = 0, sending this command turns on the DSG FET and the *ManufacturingStatus()[DSG_TEST]* = 1 and vice versa. This toggling command is only enabled if *ManufacturingStatus()[FET_EN]* = 0, indicating an FW FET control is not active and manual control is allowed. A reset clears the [DSG_TEST] flag and turns off the DSG FET.

13.1.14 ManufacturerAccess() 0x0022 FET Control

This command disables/enables control of the CHG, DSG, and PCHG FET by the firmware. The initial setting is loaded from ***Mfg Status Init[FET_EN]***. If the *ManufacturingStatus()[FET_EN]* = 0, sending this command allows the FW to control the PCHG, CHG, and DSG FETs and the *ManufacturingStatus()[FET_EN]* = 1 and vice versa.

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

13.1.15 ManufacturerAccess() 0x0023 Lifetime Data Collection

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

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

13.1.16 ManufacturerAccess() 0x0024 Permanent Failure

This command disables/enables Permanent Failure to help streamline production testing.

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

In UNSEALED mode, *ManufacturingStatus()[PF_EN]* status is copied to ***Mfg Status Init[PF_EN]*** when the command is received by the gauge. The device remains on its PF enable/disable setting prior to a reset.

13.1.17 ManufacturerAccess() 0x0025 Black Box Recorder

This command enables/disables Black Box Recorder function to help streamline production testing. The initial setting is loaded from ***Mfg Status Init[BBR_EN]***. If the *ManufacturingStatus()[BBR_EN]* = 0, sending this command enables the Black Box Recorder and the *ManufacturingStatus()[BBR_EN]* = 1 and vice versa.

In UNSEALED mode, the *ManufacturingStatus()[BBR_EN]* status is copied to ***Mfg Status Init[BBR_EN]*** when the command is received by the gauge. The device remains on its latest Black Box Recorder enable/disable setting prior to a reset.

13.1.18 ManufacturerAccess() 0x0026 Fuse

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

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

13.1.19 ManufacturerAccess() 0x0027 LED DISPLAY Enable

This command enables or disables the LED display function to ease testing during manufacturing. The initial setting is loaded from ***Mfg Status Init[LED_EN]***. If the *ManufacturingStatus()[LED_EN]* = 0, sending this command will enable the LED display and the *ManufacturingStatus()[LED_EN]* = 1 and vice versa. In UNSEALED mode, the *ManufacturingStatus()[LED_EN]* status is copied to ***Mfg Status Init[LED_EN]*** when the command is received by the gauge. The device remains on its latest setting prior to a reset.

13.1.20 ManufacturerAccess() 0x0028 Lifetime Data Reset

Sending this command resets Lifetime Data in data flash to help streamline production testing.

13.1.21 ManufacturerAccess() 0x0029 Permanent Fail Data Reset

Sending this command resets PF data in data flash to help streamline production testing.

13.1.22 ManufacturerAccess() 0x002A Black Box Recorder Reset

Sending this command resets the Black Box Recorder data in data flash to help streamline production testing.

13.1.23 ManufacturerAccess() 0x002B LED TOGGLE

This command toggles the LED display on or off to help streamline testing during manufacturing. When the LED display is off, the *OperationStatus()[LED]* = 0. Sending this command turns on all LED displays with *OperationStatus()[LED]* set to 1, and vice versa.

13.1.24 ManufacturerAccess() 0x002C LED DISPLAY PRESS

This command simulates a low-high-low detection of the $\overline{\text{DISP}}$ pin, activating the LED display according to the LED Support data flash setting. This command forces RSOC to 100% in order to demonstrate all LEDs in use, the full speed, and the brightness.

13.1.25 ManufacturerAccess() 0x002D CALIBRATION Mode

This command disables/enables entry into CALIBRATION mode. Status is indicated by the *ManufacturingStatus()[CAL_EN]* flag. CALIBRATION mode is disabled upon a reset.

Status	Condition	Action
Disable	*ManufacturingStatus()[CAL_EN]* = 1 AND 0x002D to *ManufacturerAccess()*	*ManufacturingStatus()[CAL_EN]* = 0 Disable output of ADC and CC raw data on *ManufacturingData()*
Enable	*ManufacturingStatus()[CAL_EN]* = 0 AND 0x002D to *ManufacturerAccess()*	*ManufacturingStatus()[CAL_EN]* = 1 Enable output of ADC and CC raw data on *ManufacturingData()*, controllable with 0xF081 and 0xF082 on *ManufacturerAccess()*

13.1.26 ManufacturerAccess() 0x002E Lifetime Data Flush

This command flushes the RAM Lifetime Data to data flash to help streamline evaluation testing.

13.1.27 ManufacturerAccess() 0x002F Lifetime Data SPEED UP Mode

For ease of evaluation testing, this command enables a lifetime SPEED UP mode where every 1 s in real time counts as 2 hours in FW time. When the lifetime SPEED UP mode is enabled, the *ManufacturingStatus()[LT_TEST]* = 1.

The SPEED UP mode will be disabled if this command is sent again when *[LT_TEST]* = 1, the MAC *LifetimeDataReset()* command is sent, the MAC *SealDevice()* command is sent, or the device is reset.

13.1.28 ManufacturerAccess() 0x0030 Seal Device

This command seals the device for the field, disabling certain SBS commands and access to data flash. See Table 13-1 and Chapter 13 for details.

When the device is sealed, the *OperationStatus()[SEC1, SEC0]* = 1,1. All the test features in *ManufacturingStatus()* will also be disabled.

13.1.29 ManufacturerAccess() 0x0035 Security Keys

This is a read/write command for 2-word UNSEAL and FULL ACCESS keys.

When reading the keys, data can be read from *ManufacturerData()* or *ManufacturerBlockAccess()*. The keys are returned in the following format: aaAAbbBBccCCddDD, where:

Value	Description
AAaa	First word of the UNSEAL key
BBbb	Second word of the UNSEAL key
CCcc	First word of the FULL ACCESS key
DDdd	Second word of the FULL ACCESS key

The default UNSEAL key is 0x0414 and 0x3672. The default FULL ACCESS key is 0xFFFF and 0xFFFF.

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

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

Example: Change UNSEAL key to 0x1234, 0x5678, and leave the FULL ACCESS as default.

Send an SMBus block write with Command = 0x44.

Data = MAC command + New UNSEAL key + New FULL ACCESS KEY

= 35 00 34 12 78 56 FF FF FF FF

Note

The first word of the keys cannot be the same. That means an UNSEAL key with 0xABCD 0x1234 and FULL ACCESS key with 0xABCD 0x5678 are not valid because the first word is the same.

This is because the first word is used as a “detection” for the right command. This also means the first word cannot be the same as any existing MAC command.

13.1.30 ManufacturerAccess() 0x0037 Authentication Key

This command enables the update of the authentication key into the device. The device must be in FULL ACCESS mode for the authentication key to update.

To update a new authentication key:

- Send the *AuthenticationKey()* + the new 128-bit authentication key to *ManufacturerBlockAccess()*, OR
- Send the *AuthenticationKey()* to *ManufacturerAccess()*, then send the 128-bit authentication key to *Authentication()*.

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

To verify the new authentication key:

- Read the response from *ManufacturerBlockAccess()* after updating the new authentication key, OR
- Read the response from *Authentication()* after updating the new authentication key.

13.1.31 ManufacturerAccess() 0x0041 Device Reset

This command resets the device.

Note

Command 0x0012 also resets the device (for backwards compatibility with the BQ30zxy device).

13.1.32 ManufacturerAccess() 0x0050 SafetyAlert

This command returns the *SafetyAlert()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
RSVD	RSVD	RSVD	RSVD	UTD	UTC	PCHGC	CHGV	CHGC	OC	CTOS	CTO	PTOS	PTO	RSVD	OTF
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	CUVC	OTD	OTC	ASCDL	RSVD	ASCCL	RSVD	AOLDL	RSVD	OCD2	OCD1	OCC2	OCC1	COV	CUV

RSVD (Bits 31–28): Reserved. Do not use.

UTD (Bit 27): Undertemperature During Discharge

1 = Detected

0 = Not Detected

UTC (Bit 26): Undertemperature During Charge

1 = Detected

0 = Not Detected

PCHGC (Bit 25): Over-Precharge Current

1 = Detected

0 = Not Detected

CHGV (Bit 24): Overcharging Voltage

1 = Detected

0 = Not Detected

CHGC (Bit 23): Overcharging Current

1 = Detected

0 = Not Detected

OC (Bit 22): Overcharge

1 = Detected

0 = Not Detected

CTOS (Bit 21): Charge Timeout Suspend

1 = Detected

0 = Not Detected

CTO (Bit 20): Charge Timeout

1 = Detected

0 = Not Detected

PTOS (Bit 19): Precharge Timeout Suspend

1 = Detected

0 = Not Detected

PTO (Bit 18): Precharge Timeout

1 = Detected

0 = Not Detected

RSVD (Bit 17): Reserved. Do not use.

OTF (Bit 16): Overtemperature FET

1 = Detected

0 = Not Detected

RSVD (Bit 15): Reserved. Do not use.

CUVC (Bit 14): Cell Undervoltage Compensated

1 = Detected

0 = Not Detected

OTD (Bit 13): Overtemperature During Discharge

1 = Detected

0 = Not Detected

OTC (Bit 12): Overtemperature During Charge

1 = Detected

0 = Not Detected

ASCDL (Bit 11): Short-Circuit During Discharge Latch

1 = Detected

0 = Not Detected

RSVD (Bit 10): Reserved. Do not use.

ASCCL (Bit 9): Short-Circuit During Charge Latch

1 = Detected

0 = Not Detected

RSVD (Bit 8): Reserved. Do not use.

AOLDL (Bit 7): Overload During Discharge Latch

1 = Detected

0 = Not Detected

RSVD (Bit 6): Reserved. Do not use.

OCD2 (Bit 5): Overcurrent During Discharge 2

1 = Detected

0 = Not Detected

OCD1 (Bit 4): Overcurrent During Discharge 1

1 = Detected

0 = Not Detected

OCC2 (Bit 3): Overcurrent During Charge 2

1 = Detected

0 = Not Detected

OCC1 (Bit 2): Overcurrent During Charge 1

1 = Detected

0 = Not Detected

COV (Bit 1): Cell Overvoltage

1 = Detected

0 = Not Detected

CUV (Bit 0): Cell Undervoltage

1 = Detected

0 = Not Detected

13.1.33 ManufacturerAccess() 0x0051 SafetyStatus

This command returns the *SafetyStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
RSVD	RSVD	RSVD	RSVD	UTD	UTC	PCHGC	CHGV	CHGC	OC	RSVD	CTO	RSVD	PTO	RSVD	OTF
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	CUVC	OTD	OTC	ASCDL	ASCD	ASCCL	ASCC	AOLDL	AOLD	OCD2	OCD1	OCC2	OCC1	COV	CUV

RSVD (Bits 31–28): Reserved. Do not use.

UTD (Bit 27): Undertemperature During Discharge

1 = Detected

0 = Not Detected

UTC (Bit 26): Undertemperature During Charge

1 = Detected

0 = Not Detected

PCHGC (Bit 25): Over-Precharge Current

1 = Detected

0 = Not Detected

CHGV (Bit 24): Overcharging Voltage

1 = Detected

0 = Not Detected

CHGC (Bit 23): Overcharging Current

1 = Detected

0 = Not Detected

OC (Bit 22): Overcharge

1 = Detected

0 = Not Detected

RSVD (Bit 21): Reserved. Do not use.

CTO (Bit 20): Charge Timeout

1 = Detected

0 = Not Detected

RSVD (Bit 19): Reserved. Do not use.

PTO (Bit 18): Precharge Timeout

1 = Detected

0 = Not Detected

RSVD (Bit 17): Reserved. Do not use.

OTF (Bit 16): Overtemperature FET

1 = Detected

0 = Not Detected

RSVD (Bit 15): Reserved. Do not use.

CUVC (Bit 14): Cell Undervoltage Compensated

1 = Detected

0 = Not Detected

OTD (Bit 13): Overtemperature During Discharge

1 = Detected

0 = Not Detected

OTC (Bit 12): Overtemperature During Charge

1 = Detected

0 = Not Detected

ASCDL (Bit 11): Short-circuit During Discharge Latch

1 = Detected

0 = Not Detected

ASCD (Bit 10): Short-circuit During Discharge

1 = Detected

0 = Not Detected

ASCCL (Bit 9): Short-circuit During Charge Latch

1 = Detected

0 = Not Detected

ASCC (Bit 8): Short-circuit During Charge

1 = Detected

0 = Not Detected

AOLDL (Bit 7): Overload During Discharge Latch

1 = Detected

0 = Not Detected

AOLD (Bit 6): Overload During Discharge

1 = Detected

0 = Not Detected

OCD2 (Bit 5): Overcurrent During Discharge 2

1 = Detected

0 = Not Detected

OCD1 (Bit 4): Overcurrent During Discharge 1

1 = Detected

0 = Not Detected

OCC2 (Bit 3): Overcurrent During Charge 2

1 = Detected

0 = Not Detected

OCC1 (Bit 2): Overcurrent During Charge 1

1 = Detected

0 = Not Detected

COV (Bit 1): Cell Overvoltage

1 = Detected

0 = Not Detected

CUV (Bit 0): Cell Undervoltage

1 = Detected

0 = Not Detected

13.1.34 ManufacturerAccess() 0x0052 PFAlert

This command returns the *PFAlert()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
TS4	TS3	TS2	TS1	RSVD	RSVD	OPNC	RSVD	RSVD	2LVL	AFEC	AFER	FUSE	RSVD	DFE TF	CFE TF
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	VIMA	VIMR	RSVD	RSVD	RSVD	RSVD	SOTF	RSVD	SOT	SOCD	SOCC	SOV	SUV

TS4 (Bit 31): Open Thermistor–TS4 Failure

1 = Detected

0 = Not Detected

TS3 (Bit 30): Open Thermistor–TS3 Failure

1 = Detected

0 = Not Detected

TS2 (Bit 29): Open Thermistor–TS2 Failure

1 = Detected

0 = Not Detected

TS1 (Bit 28): Open Thermistor–TS1 Failure

1 = Detected

0 = Not Detected

RSVD (Bits 27–26): Reserved. Do not use.

OPNC (Bit 25): Open Cell Tab Connection Failure

1 = Detected

0 = Not Detected

RSVD (Bits 24–23): Reserved. Do not use.

2LVL (Bit 22): Second Level Protector Failure

1 = Detected

0 = Not Detected

AFEC (Bit 21): AFE Communication Failure

1 = Detected

0 = Not Detected

AFER (Bit 20): AFE Register Failure

1 = Detected

0 = Not Detected

FUSE (Bit 19): Chemical Fuse Failure

1 = Detected

0 = Not Detected

DFETF (Bit 17): Discharge FET Failure

1 = Detected

0 = Not Detected

CFETF (Bit 16): Charge FET Failure

1 = Detected

0 = Not Detected

RSVD (Bits 15–13): Reserved. Do not use.

VIMA (Bit 12): Voltage Imbalance While Pack Is Active Failure

1 = Detected

0 = Not Detected

VIMR (Bit 11): Voltage Imbalance While Pack Is At Rest Failure

1 = Detected

0 = Not Detected

RSVD (Bits 10–7): Reserved. Do not use.

SOTF (Bit 6): Safety Overtemperature FET Failure

1 = Detected

0 = Not Detected

RSVD (Bit 5): Reserved. Do not use.

SOT (Bit 4): Safety Overtemperature Cell Failure

1 = Detected

0 = Not Detected

SOCD (Bit 3): Safety Overcurrent in Discharge

1 = Detected

0 = Not Detected

SOCC (Bit 2): Safety Overcurrent in Charge

1 = Detected

0 = Not Detected

SOV (Bit 1): Safety Cell Overvoltage Failure

1 = Detected

0 = Not Detected

SUV (Bit 0): Safety Cell Undervoltage Failure

1 = Detected

0 = Not Detected

13.1.35 ManufacturerAccess() 0x0053 PFStatus

This command returns the *PFStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
TS4	TS3	TS2	TS1	RSVD	DFW	OPN CELL	IFC	PTC	2LVL	AFEC	AFER	FUSE	RSVD	DFE TF	CFE TF
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	VIMA	VIMR	RSVD	RSVD	RSVD	RSVD	SOTF	RSVD	SOT	SOCD	SOCC	SOV	SUV

TS4 (Bit 31): Open Thermistor–TS4 Failure

1 = Detected

0 = Not Detected

TS3 (Bit 30): Open Thermistor–TS3 Failure

1 = Detected

0 = Not Detected

TS2 (Bit 29): Open Thermistor–TS2 Failure

1 = Detected

0 = Not Detected

TS1 (Bit 28): Open Thermistor–TS1 Failure

1 = Detected

0 = Not Detected

RSVD (Bit 27): Reserved. Do not use.

DFW (Bit 26): Data Flash Wearout Failure

1 = Detected

0 = Not Detected

OPNCELL (Bit 25): Open Cell Tab Connection Failure

1 = Detected

0 = Not Detected

IFC (Bit 24): Instruction Flash Checksum Failure

1 = Detected

0 = Not Detected

PTC (Bit 23): PTC Failure

1 = Detected

0 = Not Detected

2LVL (Bit 22): Second Level Protector Failure

1 = Detected

0 = Not Detected

AFEC (Bit 21): AFE Communication Failure

1 = Detected

0 = Not Detected

AFER (Bit 20): AFE Register Failure

1 = Detected

0 = Not Detected

FUSE (Bit 19): Chemical Fuse Failure

1 = Detected

0 = Not Detected

RSVD (Bit 18): Reserved. Do not use.

DFETF (Bit 17): Discharge FET Failure

1 = Detected

0 = Not Detected

CFETF (Bit 16): Charge FET Failure

1 = Detected

0 = Not Detected

RSVD (Bits 15–13): Reserved. Do not use.

VIMA (Bit 12): Voltage Imbalance While Pack Is Active Failure

1 = Detected

0 = Not Detected

VIMR (Bit 11): Voltage Imbalance While Pack At Rest Failure

1 = Detected

0 = Not Detected

RSVD (Bits 10–7): Reserved. Do not use.

SOTF (Bit 6): Safety Overtemperature FET Failure

1 = Detected

0 = Not Detected

RSVD (Bit 5): Reserved. Do not use.

SOT (Bit 4): Safety Overtemperature Cell Failure

1 = Detected

0 = Not Detected

SOCD (Bits 3): Safety Overcurrent in Discharge

1 = Detected

0 = Not Detected

SOCC (Bits 2): Safety Overcurrent in Charge

1 Detected

0 Not Detected

SOV (Bit 1): Safety Cell Overvoltage Failure

1 = Detected

0 = Not Detected

SUV (Bit 0): Safety Cell Undervoltage Failure

1 = Detected

0 = Not Detected

13.1.36 ManufacturerAccess() 0x0054 OperationStatus

This command returns the *OperationStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
RSVD	RSVD	EM SHUT	CB	SLP CC	SLP AD	SMBL CAL	INIT	SLEEP M	XL	CAL_ OFF SET	CAL	AUTO CALM	AUTH	LED	SDM
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SLEEP	XCHG	XDSG	PF	SS	SDV	SEC1	SEC0	BTP_ INT	SMOOTH	FUSE	RSVD	PCHG	CHG	DSG	PRES

RSVD (Bits 31–30): Reserved. Do not use.

EMSHUT (Bit 29): Emergency Shutdown

1 = Active

0 = Inactive

CB (Bit 28): Cell balancing status

1 = Active

0 = Inactive

SLPCC (Bit 27): CC Measurement in SLEEP mode

1 = Active

0 = Inactive

SLPAD (Bit 26): ADC Measurement in SLEEP mode

1 = Active

0 = Inactive

SMBLCAL (Bit 25): Auto CC calibration when the bus is low. This bit may not be read by the host because the FW will clear it when a communication is detected.

1 = Auto CC calibration starts

0 = When the bus is high or communication is detected for the case of ***[IN_SYSTEM_SLEEP]*** = 1.

INIT (Bit 24): Initialization after full reset

1 = Active

0 = Inactive

SLEEPM (Bit 23): SLEEP mode triggered via command

1 = Active

0 = Inactive

XL (Bit 22): 400-kHz SMBus mode

1 = Active

0 = Inactive

CAL_OFFSET (Bit 21): Calibration Output (raw CC offset data).

1 = Active when MAC *OutputShortedCCADCCal()* is sent and the raw shorted CC data for calibration is available.

0 = When the raw shorted CC data for calibration is not available.

CAL (Bit 20): Calibration Output (raw ADC and CC data)

1 = Active when either the MAC *OutputCCADCCal()* or *OutputShortedCCADCCal()* is sent and the raw CC and ADC data for calibration is available.

0 = When the raw CC and ADC data for calibration is not available.

AUTOCALM (Bit 19): Auto CC Offset Calibration by MAC *AutoCCOffset()*

1 = The gauge receives the MAC *AutoCCOffset()* and starts the auto CC offset calibration.

0 = Clear when the calibration is completed.

AUTH (Bit 18): Authentication in progress

1 = Active

0 = Inactive

LED (Bit 17): LED Display

1 = LED display is on.

0 = LED display is off.

SDM (Bit 16): Shutdown triggered via command

1 = Active

0 = Inactive

SLEEP (Bit 15): SLEEP mode conditions met

1 = Active

0 = Inactive

XCHG (Bit 14): Charging disabled

1 = Active

0 = Inactive

XDSG (Bit 13): Discharging disabled

1 = Active

0 = Inactive

PF (Bit 12): PERMANENT FAILURE mode status

1 = Active

0 = Inactive

SS (Bit 11): SAFETY mode status

1 = Active

0 = Inactive

SDV (Bit 10): Shutdown triggered via low pack voltage

1 = Active

0 = Inactive

SEC1, SEC0 (Bits 9–8): SECURITY mode

0, 0 = Reserved

0, 1 = Full Access

1, 0 = Unsealed

1, 1 = Sealed

BTP_INT (Bit 7): Battery Trip Point Interrupt. Setting and clearing this bit depends on various conditions.

See Section 6.7 for details.

SMOOTH (Bit 6): Smoothing active status

1 = Smoothing is active.

0 = Smoothing is inactive.

FUSE (Bit 5): Fuse status

1 = Active

0 = Inactive

RSVD (Bit 4): Reserved. Do not use.

PCHG (Bit 3): Precharge FET status

1 = Active

0 = Inactive

CHG (Bit 2): CHG FET status

1 = Active

0 = Inactive

DSG (Bit 1): DSG FET status

1 = Active

0 = Inactive

PRES (Bit 0): System present low

1 = Active

0 = Inactive

13.1.37 ManufacturerAccess() 0x0055 ChargingStatus

This command returns the *ChargingStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
								RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TAPER	RSVD	RSVD	RSVD	RSVD	CCC	CVR	CCR	VCT	MCHG	SU	IN	HV	MV	LV	PV

RSVD (Bits 23–16): Reserved. Do not use.

TAPER (Bit 15): This is set when the Taper voltage condition is satisfied while charging.

1 = Taper voltage condition is satisfied during charge.

0 = Taper voltage condition is not satisfied during charge.

RSVD (Bits 14–11): Reserved. Do not use.

CCC (Bit 10): Charging Loss Compensation

1 = Active

0 = Inactive

CVR (Bit 9): Charging Voltage Rate of Change

1 = Active

0 = Inactive

CCR (Bit 8): Charging Current Rate of Change

1 = Active

0 = Inactive

VCT (Bit 7): Charge Termination

1 = Active

0 = Inactive

MCHG (Bit 6): Maintenance Charge

1 = Active

0 = Inactive

SU (Bit 5): Charge Suspend

1 = Charge suspend active

0 = Charge suspend inactive

IN (Bit 4): Charge Inhibit

1 = Active

0 = Inactive

HV (Bit 3): High Voltage Region

1 = Active

0 = Inactive

MV (Bit 2): Mid Voltage Region

1 = Active

0 = Inactive

LV (Bit 1): Low Voltage Region

1 = Active

0 = Inactive

PV (Bit 0): Precharge Voltage Region

1 = Active

0 = Inactive

13.1.38 ManufacturerAccess() 0x0056 GaugingStatus

This command returns the *GaugingStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

15	14	13	12	11	10	9	8
VDQ	EDV2	EDV1	RSVD	RSVD	FCCX	RSVD	RSVD

7	6	5	4	3	2	1	0
CF	DSG	EDV0	BAL_EN	TC	TD	FC	FD

VDQ (Bit 15): Discharge Qualified for Learning (based on RU flag)

1 = Detected

0 = Not Detected

EDV2 (Bit 14): End-of-Discharge Voltage 2 has been reached.

1 = EDV2 point has been reached during discharge.

0 = EDV2 point has not been reached during discharge.

EDV1 (Bit 13): End-of-Discharge Voltage 1 has been reached.

1 = EDV1 point has been reached during discharge.

0 = EDV1 point has not been reached during discharge.

RSVD (Bits 12–11): Reserved. Do not use.

FCCX (Bit 10): When the FCC value is updated on reaching EDV2, then this flag is set (stays on till the end of discharge).

1 = FCC value has been updated.

0 = FCC value has not been updated.

RSVD (Bits 9–8): Reserved. Do not use.

CF (Bit 7): Condition Flag

1 = *MaxError()* > Max Error Limit (Condition Cycle Needed)

0 = *MaxError()* < Max Error Limit (Condition Cycle Not Needed)

DSG (Bit 6): Discharge/Relax

1 = Charging Not Detected

0 = Charging Detected

EDV0 (Bit 5): End-of-Discharge Voltage 0 has been reached.

1 = EDV0 point is reached during discharge.

0 = EDV0 point is not reached (or not in DISCHARGE mode).

BAL_EN (Bit 4): Cell Balancing

1 = Cell balancing is possible if enabled.

0 = Cell balancing is not allowed.

TC (Bit 3): Terminate Charge

1 = Detected

0 = Not Detected

TD (Bit 2): Terminate Discharge

1 = Detected

0 = Not Detected

FC (Bits 1): Fully Charged

1 = Detected

0 = Not Detected

FD (Bit 0): Fully Discharged

1 = Detected

0 = Not Detected

13.1.39 ManufacturerAccess() 0x0057 ManufacturingStatus

This command returns the *ManufacturingStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*.

15	14	13	12	11	10	9	8
CAL_EN	LT_TEST	RSVD	RSVD	RSVD	RSVD	LED_EN	FUSE_EN

7	6	5	4	3	2	1	0
BBR_EN	PF_EN	LF_EN	FET_EN	RSVD	DSG_TEST	CHG_TEST	PCHG_TEST

CAL_EN (Bit 15): CALIBRATION mode

1 = Enabled

0 = Disabled

LT_TEST (Bit 14): LIFETIME SPEED UP mode

1 = Enabled

0 = Disabled

RSVD (Bits 13–10): Reserved. Do not use.

LED_EN (Bit 9): LED Display

1 = LED display is on.

0 = LED display is off.

FUSE_EN (Bit 8): Fuse Action

1 = Enabled

0 = Disabled

BBR_EN (Bit 8): Black Box Recorder

1 = Enabled

0 = Disabled

PF_EN (Bit 6): Permanent Failure

1 = Enabled

0 = Disabled

LF_EN (Bit 5): Lifetime Data Collection

1 = Enabled

0 = Disabled

FET_EN (Bit 4): All FET Action

1 = Enabled

0 = Disabled

RSVD (Bit 3): Reserved. Do not use.

DSG_TEST (Bit 2): Discharge FET Test

1 = Discharge FET test activated

0 = Disabled

CHG_TEST (Bit 1): Charge FET Test

1 = Charge FET test activated

0 = Disabled

PCHG_TEST (Bit 0): Precharge FET Test

1 = Precharge FET test activated

0 = Disabled

13.1.40 ManufacturerAccess() 0x0058 AFE Register

This command returns the *AFERegister()* values on *ManufacturerBlockAccess()* or *ManufacturerData()*. These are the AFE hardware registers and are intended for internal debug use only.

Status	Condition
Activate	0x0058 to *ManufacturerAccess()*

Action: Output AFE Register values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUU where:

Value	Description
AA	AFE Interrupt Status. AFE Hardware interrupt status (for example, wake time, push-button, and so on)
BB	AFE FET Status. AFE FET status (for example, CHG FET, DSG FET, PCHG FET, FUSE input, and so on)
CC	AFE RXIN. AFE I/O port input status
DD	AFE Latch Status. AFE protection latch status
EE	AFE Interrupt Enable. AFE interrupt control settings
FF	AFE Control. AFE FET control enable setting
GG	AFE RXIEN. AFE I/O input enable settings
HH	AFE RLOUT. AFE I/O pins output status
II	AFE RHOUT. AFE I/O pins output status
JJ	AFE RHINT. AFE I/O pins interrupt status
KK	AFE Cell Balance. AFE cell balancing enable settings and status
LL	AFE ADC/CC Control. AFE ADC/CC Control settings
MM	AFE ADC Mux Control. AFE ADC channel selections
NN	AFE LED Control
OO	AFE Control. AFE control on various HW based features
PP	AFE Timer Control. AFE comparator and timer control
QQ	AFE Protection. AFE protection delay time control
RR	AFE OCD. AFE OCD settings
SS	AFE SCC. AFE SCC settings
TT	AFE SCD1. AFE SCD1 settings
UU	AFE SCD2. AFE SCD2 settings

13.1.41 ManufacturerAccess() 0x0060 Lifetime Data Block 1

This command returns the Lifetime Data with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMNNOOPPQQRRSS.

Value	Description
AAaa	Cell 1 Max Voltage
BBbb	Cell 2 Max Voltage
CCcc	Cell 3 Max Voltage
DDdd	Cell 4 Max Voltage
EEee	Cell 1 Min Voltage
FFff	Cell 2 Min Voltage
GGgg	Cell 3 Min Voltage
HHhh	Cell 4 Min Voltage
IIii	Max Delta Cell Voltage
JJjj	Max Charge Current
KKkk	Max Discharge Current
LLll	Max Avg Dsg Current
MMmm	Max Avg Dsg Power
NN	Max Temp Cell
OO	Min Temp Cell
PP	Max Delta Cell temp
QQ	Max Temp Int Sensor
RR	Min Temp Int Sensor
SS	Max Temp Fet

13.1.42 ManufacturerAccess() 0x0061 Lifetime Data Block 2

This command returns the Lifetime Data with the following format:

AABBCCDDEEFFGGHH.

Value	Description
AA	No. of Shutdowns
BB	No. of Partial Resets
CC	No. of Full Resets
DD	No. of WDT resets
EE	CB Time Cell 1
FF	CB Time Cell 2
GG	CB Time Cell 3
HH	CB Time Cell 4

13.1.43 ManufacturerAccess() 0x0062 Lifetime Data Block 3

This command returns the Lifetime Data with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHH.

Value	Description
AAaa	Total FW Runtime
BBbb	Time Spent in UT
CCcc	Time Spent in LT
DDdd	Time Spent in STL
EEee	Time Spent in RT
FFff	Time Spent in STH
GGgg	Time Spent in HT
HHhh	Time Spent in OT

13.1.44 ManufacturerAccess() 0x0063 Lifetime Data Block 4

This command returns the Lifetime Data with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHIlLLmmMMnnNNooOOppPP.

Value	Description
AAaa	No. of COV Events
BBbb	Last COV Event
CCcc	No. of CUV Events
DDdd	Last CUV Event
EEee	No. of OCD1 Events
FFff	Last OCD1 Event
GGgg	No. of OCD2 Events
HHhh	Last OCD2 Event
Iii	No. of OCC1 Events
JJjj	Last OCC1 Event
KKkk	No. of OCC2 Events
LLll	Last OCC2 Event
MMmm	No. of AOLD Events
NNnn	Last AOLD Event
OOoo	No. of ASCD Events
PPpp	Last ASCD Event

13.1.45 ManufacturerAccess() 0x0064 Lifetime Data Block 5

This command returns the Lifetime data with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIjjJJ.

Value	Description
AAaa	No. of ASCC Events
BBbb	Last ASCC Event
CCcc	No. of OTC Events
DDdd	Last OTC Event
EEee	No. of OTD Events
FFff	Last OTD Event
GGgg	No. of OTF Events
HHhh	Last OTF Event
IIii	No. Valid Charge Term
JJjj	Last Valid Charge Term

13.1.46 ManufacturerAccess() 0x0070 ManufacturerInfo

This command returns ManufacturerInfo on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition	Action
Activate	0x0070 to *ManufacturerAccess()*	Output 32 bytes of ManufacturerInfo on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: AABBCCDDEEFFGGHHIIJJKKLLMMNN OOPPQQRRSSTTUUVVWWXXVVZZ112233 445566

13.1.47 ManufacturerAccess() 0x0071 DAStatus1

This command returns the Cell Voltages, Pack Voltage, Bat Voltage, Cell Currents, Cell Powers, Power, and Average Power on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition
Activate	0x0071 to *ManufacturerBlockAccess()* or *ManufacturerAccess()*

Action: Output 32 bytes of data on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP where:

Value	Description	Unit
AAaa	Cell Voltage 1	mV
BBbb	Cell Voltage 2	mV
CCcc	Cell Voltage 3	mV
DDdd	Cell Voltage 4	mV
EEee	BAT Voltage. Voltage at the BAT pin. This is different than *Voltage()*, which is the sum of all the cell voltages.	mV
FFff	PACK Voltage	mV
GGgg	Cell Current 1. Simultaneous current measured during Cell Voltage1 measurement	mA
HHhh	Cell Current 2. Simultaneous current measured during Cell Voltage2 measurement	mA
IIii	Cell Current 3. Simultaneous current measured during Cell Voltage3 measurement	mA
JJjj	Cell Current 4. Simultaneous current measured during Cell Voltage 4 measurement	mA
KKkk	Cell Power 1. Calculated using Cell Voltage1 and Cell Current 1 data	mA
LLll	Cell Power 2. Calculated using Cell Voltage2 and Cell Current 2 data	cW
MMmm	Cell Power 3. Calculated using Cell Voltage3 and Cell Current 3 data	cW
NNnn	Cell Power 4. Calculated using Cell Voltage4 and Cell Current 4 data	cW
OOoo	Power calculated by *Voltage()* × *Current()*	cW
PPpp	Average Power	cW

13.1.48 ManufacturerAccess() 0x0072 DAStatus2

This command returns the internal temp sensor, TS1, TS2, TS3, TS4, Cell Temp, and FETTemp on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition
Activate	0x0072 to *ManufacturerBlockAccess()* or *ManufacturerAccess()*

Action: Output 14 bytes of temperature data values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aaAAbbBBccCCddDDeeEEffFFggGG where:

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

13.1.49 ManufacturerAccess() 0x007A ManufacturerInfo2

This command returns ***ManufacturerInfo2*** on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition	Action
Activate	0x007A to *ManufacturerAccess()*	Output 32 bytes of ManufacturerInfo2 on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: AABBCCDDEEFFGGHHIIJJKKLLMMNN OOPPQQRRSSTTUUVVWWXXVVZZ112233 445566

13.1.50 ManufacturerAccess() 0x0F00 ROM Mode

This command sends the device into ROM mode in preparation for firmware re-programming. To enter ROM mode, the device must be in FULL ACCESS mode. To return from ROM mode to FW mode, issue the SMBus command 0x08.

Note

Command 0x0033 also puts the device in ROM mode (for backwards compatibility with the BQ30zxy device).

13.1.51 0x4000–0x5FFF Data Flash Access()

Accessing data flash (DF) is only supported by the *ManufacturerBlockAccess()* by addressing the physical address.

To write to the DF, send the starting address, followed by the DF data block. The DF data block is the intended revised DF data to be updated to DF. The size of the DF data block ranges from 1 byte to 32 bytes. All individual data must be sent in Little Endian.

Write to DF example:

Assuming: data1 locates at address 0x4000 and data2 locates at address 0x4002.
Both data1 and data2 are U2 type.

To update data1 and data2, send an SMBus block write with command = 0x44

block = starting address + DF data block

= 0x00 + 0x40 + data1_LowByte + data1_HighByte + data2_LowByte + data2_HighByte

To read the DF, send an SMBus block write to the *ManufacturerBlockAccess(),* followed by the starting address, then send an SMBus block read to the *ManufacturerBlockAccess()*. The return data contains the starting address followed by 32 bytes of DF data in Little Endian.

Read from DF example:

Taking the same assuming from the read DF example, to read DF,

a. Send SMBus write block with command 0x44, block = 0x00 + 0x40

b. Send SMBus read block with command 0x44

The returned block = a starting address + 32 bytes of DF data

= 0x00 + 0x40 + data1_LowByte + data1_HighByte + data2_LowByte + data2_HighByte.... data32_LowByte + data32_HighByte

The gauge supports an auto-increment on the address during a DF read. This greatly reduces the time required to read out the entire DF. Continue with the read from the DF example. If another SMBus read block is sent with command 0x44, the gauge returns another 32 bytes of DF data, starting with address 0x4020.

13.1.52 ManufacturerAccess() 0xF080 Exit Calibration Output Mode

This command stops the output of calibration data to the *ManufacturerBlockAccess()* or *ManufacturerData()* command. Any other MAC command sent to the gauge will also stop the output of the calibration data.

Status	Condition	Action
Activate	*ManufacturerBlockAccess()* OR *ManufacturerData()* = 1 AND 0xF080 to *ManufacturerAccess()*	Stop output of ADC or CC data on *ManufacturerBlockAccess()* or *ManufacturerData()*

13.1.53 ManufacturerAccess() 0xF081 Output CCADC Cal

This command instructs the device to output the raw values for calibration purposes on *ManufacturerBlockAccess()* or *ManufacturerData()*. All values are updated every 250 ms and the format of each value is 2's complement, MSB first.

Status	Condition
Disable	*ManufacturingStatus()[CAL]* = 1 AND 0xF080 to *ManufacturerAccess()*

Action: *OperationStatus()[CAL]* = 0, *[CAL_OFFSET]* = 0
Stop output of ADC and CC data on *ManufacturerBlockAccess()* or *ManufacturerData()*

Status	Condition
Enable	0xF081 to *ManufacturerAccess()*

Action: *OperationStatus()[CAL]* = 1, *[CAL_OFFSET]* = 0
Outputs the raw CC and AD values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the format of ZZYYaaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKK:

Value	Description
ZZ	Rolling 8-bit counter, increments when values are refreshed.
YY	Status, 1 when *ManufacturerAccess()* = 0xF081, 2 when *ManufacturerAccess()* = 0xF082
AAaa	Current (coulomb counter)
BBbb	Cell Voltage 1
CCcc	Cell Voltage 2
DDdd	Cell Voltage 3
EEee	Cell Voltage 4
FFff	PACK Voltage
GGgg	BAT Voltage
HHhh	Cell Current 1
IIii	Cell Current 2
JJjj	Cell Current 3
KKkk	Cell Current 4

13.1.54 ManufacturerAccess() 0xF082 Output Shorted CCADC Cal

This command instructs the device to output the raw values for calibration purposes on *ManufacturerBlockAccess()* or *ManufacturerData()*. All values are updated every 250 ms and the format of each value is 2's complement, MSB first. This mode includes an internal short on the coulomb counter inputs for measuring offset.

Status	Condition
Disable	*ManufacturingStatus()[CAL]* = 1 AND 0xF080 to *ManufacturerAccess()*

Action: *OperationStatus()[CAL]* = 0, *[CAL_OFFSET]* = 0
Stop output of ADC and CC data on *ManufacturerBlockAccess()* or *ManufacturerData()*

Status	Condition
Enable	0xF081 to *ManufacturerAccess()*

Action: *OperationStatus()[CAL]* = 1, *[CAL_OFFSET]* = 1
Outputs the raw CC and AD values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the format of ZZYYaaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKK:

Value	Description
ZZ	Rolling 8-bit counter, increments when values are refreshed.
YY	Status, 1 when *ManufacturerAccess()* = 0xF081, 2 when *ManufacturerAccess()* = 0xF082
AAaa	Current (coulomb counter)
BBbb	Cell Voltage 1
CCcc	Cell Voltage 2
DDdd	Cell Voltage 3
EEee	Cell Voltage 4
FFff	PACK Voltage
GGgg	BAT Voltage
HHhh	Cell Current 1
IIii	Cell Current 2
JJjj	Cell Current 3
KKkk	Cell Current 4

13.2 0x01 RemainingCapacityAlarm()

This read/write word function sets a low capacity alarm threshold for the cell stack.

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Default	Unit
		SE	US	FA						
0x01	*RemainingCapacityAlarm()*	R/W			Word	U2	0	700	300	mAh 10 mWh

Note

If *BatteryMode()[CAPM]* = 0, then the data reports in mAh.

If *BatteryMode()[CAPM]* = 1, then the data reports in 10 mWh.

13.3 0x02 RemainingTimeAlarm()

This read/write word function sets a low remaining time-to-fully discharge alarm threshold for the cell stack.

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Default	Unit
		SE	US	FA						
0x02	*RemainingTimeAlarm()*	R/W			Word	U2	0	30	10	min

13.4 0x03 BatteryMode()

This read/write word function sets various battery operating mode options.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x03	*BatteryMode()*	R/W			Word	H2	0x0000	0xFFFF	—

15	14	13	12	11	10	9	8
CAPM	CHGM	AM	RSVD	RSVD	RSVD	PB	CC

7	6	5	4	3	2	1	0
CF	RSVD	RSVD	RSVD	RSVD	RSVD	PBS	ICC

CAPM (Bit 15): CAPACITY Mode (R/W)

0 = Report in mA or mAh (default)

1 = Report in 10 mW or 10 mWh

CHGM (Bit 14): CHARGER Mode (R/W)

0 = Enable *ChargingVoltage()* and *ChargingCurrent()* broadcasts to host and smart battery charger

1 = Disable *ChargingVoltage()* and *ChargingCurrent()* broadcasts to host and smart battery charger (default)

AM (Bit 13): ALARM Mode (R/W)

0 = Enable AlarmWarning broadcasts to host and smart battery charger (default)

1 = Disable Alarm Warning broadcasts to host and smart battery charger

RSVD (Bits 12–10): Reserved. Do not use.

PB (Bit 9): Primary Battery

0 = Battery operating in its secondary role (default)

1 = Battery operating in its primary role

CC (Bit 8): Charge Controller Enabled (R/W)

0 = Internal charge controller disabled (default)

1 = Internal charge controller enabled

CF (Bit 7): Condition Flag (R)

0 = Battery OK

1 = Conditioning cycle requested

RSVD (Bits 6–2): Reserved. Do not use.

PBS (Bit 1): Primary Battery Support (R)

0 = Function not supported (default)

1 = Primary or Secondary Battery Support

ICC (Bit 0): Internal Charge Controller (R)

0 = Function not supported (default)

1 = Function supported

13.5 0x04 AtRate()

This read/write word function sets the value used in calculating *AtRateTimeToFull()* and *AtRateTimeToEmpty()*.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x04	*AtRate()*	R/W			Word	I2	–32768	32767	0	mA 10 mW

Note

If *BatteryMode()[CAPM]* = 0, then the data reports in mA.

If *BatteryMode()[CAPM]* = 1, then the data reports in 10 mW.

13.6 0x05 AtRateTimeToFull()

This word read function returns the remaining time-to-fully charge the battery stack.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x05	*AtRateTimeToFull()*	R			Word	U2	0	65535	min

Note

65535 indicates not being charged.

13.7 0x06 AtRateTimeToEmpty()

This word read function returns the remaining time-to-fully discharge the battery stack.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x06	*AtRateTimeToEmpty()*	R			Word	U2	0	65535	min

Note

65535 indicates not being charged.

13.8 0x07 AtRateOK()

This read-word function returns a Boolean value that indicates whether the battery can deliver *AtRate()* for at least 10 s.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x07	*AtRateOK()*	R			Word	U2	0	65535	—

Note

0 = False. The gauge *cannot* deliver energy for 10 s, based on the discharge rate indicated in *AtRate()*.

> than 0 = True. The gauge *can* deliver energy for 10 s, based on the discharge rate indicated in *AtRate()*.

13.9 0x08 Temperature()

This read-word function returns the temperature in units 0.1°K.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x08	*Temperature()*	R			Word	U2	0	65535	0.1°K

13.10 0x09 Voltage()

This read-word function returns the sum of the measured cell voltages.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x09	*Voltage()*	R			Word	U2	0	65535	mV

13.11 0x0A Current()

This read-word function returns the measured current from the coulomb counter. If the input to the device exceeds the maximum value, the value is clamped at the maximum and does not roll over.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x0A	*Current()*	R			Word	I2	–32767	32768	mA

13.12 0x0B AverageCurrent()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x0B	*AverageCurrent()*	R			Word	I2	–32767	32768	mA

13.13 0x0C MaxError()

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

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x0C	*MaxError()*	R			Word	U1	0	100	%

Condition	Action
Full device reset	*MaxError()* = 100%

13.14 0x0D RelativeStateOfCharge()

This read-word function returns the predicted remaining battery capacity as a percentage of *FullChargeCapacity()*.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x0D	*RelativeStateOfCharge()*	R			Word	U1	0	100	%

13.15 0x0E AbsoluteStateOfCharge()

This read-word function returns the predicted remaining battery capacity as a percentage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x0E	*AbsoluteStateOfCharge()*	R			Word	U1	0	100	%

13.16 0x0F RemainingCapacity()

This read-word function returns the predicted remaining battery capacity.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x0F	*RemainingCapacity()*	R	R	R	Word	U2	0	65535	mAh 10 mWh

Note

If *BatteryMode()[CAPM]* = 0, then the data reports in mAh.

If *BatteryMode()[CAPM]* = 1, then the data reports in 10 mWh.

13.17 0x10 FullChargeCapacity()

This read-word function returns the predicted battery capacity when fully charged. The value returned will not be updated during charging.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x10	*FullChargeCapacity()*	R	R	R	Word	U2	0	65535	mAh 10 mWh

Note

If *BatteryMode()[CAPM]* = 0, then the data reports in mAh.

If *BatteryMode()[CAPM]* = 1, then the data reports in 10 mWh.

13.18 0x11 RunTimeToEmpty()

This read-word function returns the predicted remaining battery capacity based on the present rate of discharge.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x11	*RunTimeToEmpty()*	R	R	R	Word	U2	0	65535	min

Note

65535 = Battery is not being discharged.

13.19 0x12 AverageTimeToEmpty()

This read-word function returns the predicted remaining battery capacity based on *AverageCurrent()*.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x12	*AverageTimeToEmpty()*	R	R	R	Word	U2	0	65535	min

Note

65535 = Battery is not being discharged.

13.20 0x13 AverageTimeToFull()

This read-word function returns the predicted time-to-full charge based on *AverageCurrent()*.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x13	*AverageTimeToFull()*	R	R	R	Word	U2	0	65535	min

Note

65535 = Battery is not being discharged.

13.21 0x14 ChargingCurrent()

This read-word function returns the desired charging current.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x14	*ChargingCurrent()*	R	R	R	Word	U2	0	65535	mA

Note

65535 = Request maximum current

13.22 0x15 ChargingVoltage()

This read-word function returns the desired charging voltage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x15	*ChargingVoltage()*	R	R	R	Word	U2	0	65535	mV

Note

65535 = Request maximum voltage

13.23 0x16 BatteryStatus()

This read-word function returns various battery status information.

SBS Cmd	Name	Access			Protocol	Type	Min	Max
		SE	US	FA				
0x16	*BatteryStatus()*	R	R	R	Word	H2	—	—

15	14	13	12	11	10	9	8
OCA	TCA	RSVD	OTA	TDA	RSVD	RCA	RTA

7	6	5	4	3	2	1	0
INIT	DSG	FC	FD	EC3	EC2	EC1	EC0

OCA (Bit 15): Overcharged Alarm

1 = Detected

0 = Not Detected

TCA (Bit 14): Terminate Charge Alarm

1 = Detected

0 = Not Detected

RSVD (Bit 13): Undefined

OTA (Bit 12): Overtemperature Alarm

1 = Detected

0 = Not Detected

TDA (Bit 11): Terminate Discharge Alarm

1 = Detected

0 = Not Detected

RSVD (Bit 10): Undefined

RCA (Bit 9): Remaining Capacity Alarm

1 = *RemainingCapacity()* < *RemainingCapacityAlarm()* when in DISCHARGE or RELAX mode

0 = *RemainingCapacity()* ≥ *RemainingCapacityAlarm()*

RTA (Bit 8): Remaining Time Alarm

1 = *AverageTimeToEmpty()* < *RemainingTimeAlarm() or*

0 = *AverageTimeToEmpty()* ≥ *RemainingTimeAlarm()*

INIT (Bit 7): Initialization

1 = Gauge initialization is complete.

0 = Initialization is in progress.

DSG (Bit 6): Discharging or Relax

1 = Battery is in DISCHARGE or RELAX mode.

0 = Battery is in CHARGE mode.

FC (Bit 5): Fully Charged

1 = Battery fully charged when *GaugingStatus()[FC]* = 1

0 = Battery not fully charged

FD (Bit 4): Fully Discharged

1 = Battery fully depleted

0 = Battery not depleted

EC3,EC2,EC1,EC0 (Bits 3–0): Error Code

0x0 = OK

0x1 = Busy

0x2 = Reserved Command

0x3 = Unsupported Command

0x4 = AccessDenied

0x5 = Overflow/Underflow

0x6 = BadSize

0x7 = UnknownError

13.24 0x17 CycleCount()

This read-word function returns the number of discharge cycles the battery has experienced. The default value is stored in the data flash value ***Cycle Count***, which is updated in runtime.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x17	*CycleCount()*	R	R/W	R/W	Word	U2	0	65535	cycles

13.25 0x18 DesignCapacity()

This read-word function returns the theoretical pack capacity. The default value is stored in the data flash value ***Design Capacity mAh*** or ***Design Capacity cWh.***

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x18	*DesignCapacity()*	R	R/W	R/W	Word	U2	0	65535	4400	mAh
									6336	10 mWh

Note

If *BatteryMode()[CAPM]* = 0, then the data reports in mAh.

If *BatteryMode()[CAPM]* = 1, then the data reports in 10 mWh.

13.26 0x19 DesignVoltage()

This read-word function returns the theoretical pack voltage. The default value is stored in data flash value ***Design Voltage***.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x19	*DesignVoltage()*	R	R/W	R/W	Word	U2	7000	18000	14400	mV

13.27 0x1A SpecificationInfo()

SBS Cmd	Name	Access			Protocol	Type	Min	Max
		SE	US	FA				
0x1A	*SpecificationInfo()*	R	R/W	R/W	Word	H2	0x0000	0xFFFF

15	14	13	12	11	10	9	8
IPScale	IPScale	IPScale	IPScale	VScale	VScale	VScale	VScale

7	6	5	4	3	2	1	0
Version	Version	Version	Version	Revision	Revision	Revision	Revision

IPScale (Bits 15–12): IP Scale Factor

Not supported by the gas gauge

MUST be set to 0, 0, 0, 0.

VScale (Bits 11–8): Voltage Scale Factor

Not supported by the gas gauge

MUST be set to 0, 0, 0, 0.

Version (Bits 7–4): Version

0,0,0,1 = Version 1.0

0,0,1,1 = Version 1.1

0,0,1,1 = Version 1.1 with optional PEC support

Revision (Bits 3–0): Revision

0,0,0,1 = Version 1.0 and 1.1 (default)

13.28 0x1B ManufacturerDate()

This read-word function returns the pack's manufacturer date.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default
		SE	US	FA					
0x1B	*ManufacturerDate()*	R	R/W	R/W	Word	U2		65535	0

Note

ManufacturerDate() value in the following format: Day + Month*32 + (Year–1980)*256

13.29 0x1C SerialNumber()

This read-word function returns the assigned pack serial number.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x1C	*SerialNumber()*	R	R/W	R/W	Word	H2	0x0000	0xFFFF	0x0001	

13.30 0x20 ManufacturerName()

This read-block function returns the pack manufacturer's name.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x20	*ManufacturerName()*	R	R	R	Block	S20+1	—	—	Texas Inst.	ASCII

13.31 0x21 DeviceName()

This read-block function returns the assigned pack name.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x21	*DeviceName()*	R	R	R	Block	S20+1	—	—	BQ4050	ASCII

13.32 0x22 DeviceChemistry()

This read-block function returns the battery chemistry used in the pack.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x22	*DeviceChemistry()*	R	R	R	Block	S4+1	—	—	LION	ASCII

13.33 0x23 ManufacturerData()

This read-block function returns ***ManufacturerInfo*** by default. The command also returns a response to MAC command in order to maintain compatibility of the MAC system in BQ30zxy family.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x23	*ManufacturerData()*	R	R	R	Block	Mixed	—	—	—

13.34 0x2F Authenticate()

This read/write block function provides SHA-1 authentication to send the challenge and read the response in the default mode. It is also used to input a new authentication key when the MAC *AuthenticationKey()* is used.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x2F	*Authenticate()*	R/W	R/W	R/W	Block	H20+1	—	—	—

13.35 0x3C CellVoltage4()

This read-word function returns the Cell 4 voltage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x3C	*CellVoltage4()*	R	R	R	Word	U2	—	65535	0	mV

13.36 0x3D CellVoltage3()

This read-word function returns the Cell 3 voltage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x3D	*CellVoltage3()*	R	R	R	Word	U2	—	65535	0	mV

13.37 0x3E CellVoltage2()

This read-word function returns the Cell 2 voltage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x3E	*CellVoltage2()*	R	R	R	Word	U2	—	65535	0	mV

13.38 0x3F CellVoltage1()

This read-word function returns the Cell 1 voltage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x3F	*CellVoltage1()*	R	R	R	Word	U2	—	65535	0	mV

13.39 0x4A BTPDischargeSet()

This read/write word command updates the BTP set threshold for discharge mode for the next BTP interrupt, de-asserts the present BTP interrupt, and clears the *OperationStatus()[BTP_INT]* bit.

SBS Cmd	Name	Access			Format	Size in Bytes	Min	Max	Default	Unit
		SE	US	FA						
0x4A	*BTPDischargeSet()*	R/W	R/W	R/W	Signed Int	2	—	65535	150	mAh

13.40 0x4B BTPChargeSet()

The read/write word command updates the BTP set threshold for charge mode for the next BTP interrupt, de-asserts the present BTP interrupt, and clears the *OperationStatus()[BTP_INT]* bit.

SBS Cmd	Name	Access			Format	Size in Bytes	Min	Max	Default	Unit
		SE	US	FA						
0x4B	*BTPChargeSet()*	R/W	R/W	R/W	Signed Int	2	—	65535	175	mAh

13.41 0x4F StateOfHealth()

This read-word command returns the state-of-health (SoH) information of the battery in percentage of design capacity and design energy.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x4F	*StateOfHealth()*	—	R	R	Word	U2	0	100	—	%

13.42 0x50 SafetyAlert()

This command returns the *SafetyAlert()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x50	*SafetyAlert()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.43 0x51 SafetyStatus

This command returns the *SafetyStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x51	*SafetyStatus()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.44 0x52 PFAlert

This command returns the *PFAlert()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x52	*PFAlert()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.45 0x53 PFStatus

This command returns the *PFStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x53	*PFStatus()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.46 0x54 OperationStatus

This command returns the *OperationStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x54	*OperationStatus()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.47 0x55 ChargingStatus

This command returns the *ChargingStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x55	*ChargingStatus()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.48 0x56 GaugingStatus

This command returns the *GaugingStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x56	*GaugingStatus()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.49 0x57 ManufacturingStatus

This command returns the *ManufacturingStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x57	*ManufacturingStatus()*	—	R	R	Block	H4	0x00000000	0xFFFFFFFF	—	—

13.50 0x58 AFE Register

This command returns a snapshot of the AFE register settings. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x58	*AFERegister()*	—	R	R	Block	—	—	—	—	—

13.51 0x60 Lifetime Data Block 1

This command returns the first block of Lifetime Data. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x60	*LifeTimeDataBlock1()*	—	R	R	Block	—	—	—	—	—

13.52 0x61 Lifetime Data Block 2

This command returns the second block of Lifetime Data. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x61	*LifeTimeDataBlock2()*	—	R	R	Block	—	—	—	—	—

13.53 0x62 Lifetime Data Block 3

This command returns the third block of Lifetime Data. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x62	*LifeTimeDataBlock3()*	—	R	R	Block	—	—	—	—	—

13.54 0x63 Lifetime Data Block 4

This command returns the third block of Lifetime Data. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x63	*LifeTimeDataBlock4()*	—	R	R	Block	—	—	—	—	—

13.55 0x64 Lifetime Data Block 5

This command returns the third block of Lifetime Data. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x64	*LifeTimeDataBlock5()*	—	R	R	Block	—	—	—	—	—

13.56 0x70 ManufacturerInfo

This command returns manufacturer information. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x70	*ManufacturerInfo()*	R	R/W	R/W	Block	—	—	—	—	—

13.57 0x71 DAStatus1

This command returns the Cell Voltages, Pack Voltage, Bat Voltage, Cell Currents, Cell Powers, Power, and Average Power. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x71	*DAStatus1()*	—	R	R	Block	—	—	—	—	—

13.58 0x72 DAStatus2

This command returns the internal temp sensor, TS1, TS2, TS3, TS4, Cell Temp, and FETTemp. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 13.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x72	*DAStatus2()*	—	R	R	Block	—	—	—	—	—

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14.1 Data Formats

14.1.1 Unsigned Integer

Unsigned integers are stored without changes as 1-byte, 2-byte, or 4-byte values in Little Endian byte order.

0
U1 MSB

0	1
U2 LSB	U2 MSB

0	1	2	3
U4 L LSB	U4 L MSB	U4 H LSB	U4 H MSB

14.1.2 Integer

Integer values are stored in 2's-complement format in 1-byte, 2-byte, or 4-byte values in Little Endian byte order.

0
I1 MSB

0	1
I2 LSB	I2 MSB

0	1	2	3
I4 L LSB	I4 L MSB	I4 H LSB	I4 H MSB

14.1.3 Floating Point

Floating point values are stored using the IEEE754 Single Precision 4-byte format in Little Endian byte order.

0	1	2	3
Fract [0–7]	Fract [8–15]	Exp[0] + Fract[16–22]	Sign + Exp[1–7]

Where:

Exp: 8-bit exponent stored with an offset bias of 127. The values 00 and FF have unique meanings.

Fract: 23-bit fraction. If the exponent is > 0, then the mantissa is 1.fract. If the exponent is zero, then the mantissa is 0.fract.

The floating point value depends on the unique cases of the exponent:

- If the exponent is FF and the fraction is zero, this represents +/– infinity.
- If the exponent is FF and the fraction is non-zero this represents "not a number" (NaN).
- If the exponent is 00 then the value is a subnormal number represented by $(-1)^{sign} \times 2^{-126} \times 0.fraction$.
- Otherwise, the value is a normalized number represented by $(-1)^{sign} \times 2^{(exponent - 127)} \times 1.fraction$.

14.1.4 Hex

Bit register definitions are stored in unsigned integer format.

14.1.5 String

String values are stored with length byte first, followed by a number of data bytes defined with the length byte.

0	1	. . .	N
Length	Data0	. . .	DataN

14.2 Settings

14.2.1 Configuration

14.2.1.1 FET Options

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	FET Options	H1	0x00	0xFF	0x20	Hex

7	6	5	4	3	2	1	0
PACK_FUSE	SLEEPCHG	CHGFET	CHGIN	CHGSU	OTFET	RSVD	PCHG_COMM

PACK_FUSE (Bit 7): Source of voltage to check for ***Min Blow Fuse Voltage***

1 = Pack+ voltage

0 = Battery stack voltage

SLEEPCHG (Bit 6): CHG FET enabled during sleep

1 = CHG FET remains on during sleep

0 = CHG FET off during sleep (default)

CHGFET (Bit 5): FET action on setting of *GaugeStatus()[TC]*

1 = Charging and Precharging disabled, FET off

0 = FET active (default)

CHGIN (Bit 4): FET action in CHARGE INHIBIT mode

1 = Charging and Precharging disabled, FETs off

0 = FET active (default)

CHGSU (Bit 3): FET action in CHARGE SUSPEND mode

1 = Charging and Precharging disabled, FETs off

0 = FET active (default)

OTFET (Bit 2): FET action in OVERTEMPERATURE mode

1 = CHG and DSG FETs will be turned off for overtemperature conditions

0 = No FET action for overtemperature condition (default)

RSVD (Bit 1): Reserved. Do not use.

PCHG_COMM (Bit 0): Precharge FET selection

1 = CHG FET

0 = PCHG FET (default)

14.2.1.2 SBS Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SBS Gauging Configuration	H1	0x00	0xFF	0x04	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	LOCK0	RSVD	RSOCL

RSVD (Bits 7–3): Reserved. Do not use.

LOCK0 (Bit 2): Keep *RemainingCapacity()* and *RelativeStateOfCharge()* jumping back during relaxation after 0 was reached during discharge.

1 = Enabled (default)

0 = Disabled

RSVD (Bit 1): Reserved. Do not use.

RSOCL (Bit 0): *RelativeStateOfCharge()* and *RemainingCapacity()* behavior at end of charge

1 = Held at 99% until valid charge termination. On entering valid charge termination, updates to 100%

0 = Actual value shown (default)

14.2.1.3 SBS Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SBS Configuration	H1	0x7F	0xFF	0x20	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	BLT1	BLT0	XL	HPE	CPE	BCAST

RSVD (Bit 7): Reserved. Do not use.

RSVD (Bit 6): Reserved. Do not use.

BLT1 (Bit 5): Bus low timeout

0,0 = No SBS bus low timeout

0,1 = 1-s SBS bus low timeout

1,0 = 2-s SBS bus low timeout (default)

1,1 = 3-s SBS bus low timeout

BLT0 (Bit 4): Bus low timeout

0,0 = No SBS bus low timeout

0,1 = 1-s SBS bus low timeout

1,0 = 2-s SBS bus low timeout (default)

1,1 = 3-s SBS bus low timeout

XL (Bit 3): Enable 400-kHz COM mode

1 = 400-kHz bus speed

0 = Normal SBS bus speed (default)

HPE (Bit 2): PEC on host communication

1 = Enabled

0 = Disabled (default)

CPE (Bit 1): PEC on charger broadcast

1 = Enabled

0 = Disabled (default)

BCAST (Bit 0): Enable alert and charging broadcast from device to host

1 = Enabled

0 = Disabled (default)

14.2.1.4 Power Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Power Config	H1	0x00	0x01	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	AUTO_SHIP_EN

RSVD (Bits 7–1): Reserved. Do not use.

AUTO_SHIP_EN (Bit 0): *Automatically Shut Down for Shipment*

1 = Enable auto shutdown after the device is in SLEEP mode without communication for a set period of time.

0 = Disable auto shutdown feature

14.2.1.5 IO Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	IO Config	H1	0x0	0x03	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	BTP_POL	BTP_EN

RSVD (Bits 7–2): Reserved. Do not use.

BTP_POL (Bit 1): *Control polarity of BTP pin*

1 = BTP pin is asserted high when BTP is triggered.

0 = BTP pin is asserted low when BTP is triggered (default).

BTP_EN (Bit 0): *Enable assertion of BTP pin*

1 = Enable assertion of BTP pin when BTP is triggered.

0 = Disable assertion of BTP pin when BTP is triggered (default).

14.2.1.6 LED Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	LED Configuration	H1	0x0	0xFF	0x0D0	Hex

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	LED PFON

7	6	5	4	3	2	1	0
LEDC1	LEDC0	LEDPF1	LEDPF0	LEDMODE	LEDCHG	LEDRCA	LEDR

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

RSVD (Bits 15–9): Reserved. Do not use.

LEDPFON (Bit 8): LED in PF Mode Enable

1 = Display available in PF Mode

0 = Display not available in PF mode (default)

LEDC1, LEDC0 (Bit 7, Bit 6): LED Current sink

0,0 = 0.94 mA average LED current (default)

0, 1 = 1.87 mA average LED current

1, 0 = 2.81 mA average LED current

1, 1 = 3.75 mA average LED current

LEDPF1, LEDPF0 (Bit 5, Bit 4): LED Display PF Error Code

0,0 = PF Error Code not available

0, 1 = PF Error Code shown after SOC if DISP is held low for LED Hold Time (default)

1, 0 = PF Error Code not available

1, 1 = PF Error Code shown after SOC

LEDMODE (Bit 3): LED Display Capacity Selector

1 = Display ASOC/DC

0 = Display RSOC (default)

LEDCHG (Bit 2): LED Display During Charging

1 = Enabled

0 = Disabled

LEDRCA (Bit 1): Flashing of LED Display when [RCA] is set

1 = Enabled

0 = Disabled

LEDR (Bit 0): LED Display activation at Exit of Device Reset

1 = Enabled

0 = Disabled

14.2.1.7 SOC Flag Config A

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SOC Flag Config A	H2	0x0	0xFFF	0xC8C	Hex

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	RSVD	TCSETVCT	FCSETVCT	RSVD	RSVD

7	6	5	4	3	2	1	0

TCCLEAR RSOC	TCSETRSOC	TCCLEARV	TCSETV	TDCLEAR RSOC	TDSETRSOC	TDCLEARV	TDSETV

RSVD (Bit 15–12): Reserved. Do not use.

TCSETVCT (Bit 11): Enable TC flag set by primary charge termination

1 = Enabled (default)

0 = Disabled

FCSETVCT (Bit 10): Enable FC flag set by primary charge termination

1 = Enabled (default)

0 = Disabled

RSVD (Bit 9–8): Reserved. Do not use.

TCCLEARRSOC (Bit 7): Enable TC flag clear by RSOC threshold

1 = Enabled (default)

0 = Disabled

TCSETRSOC (Bit 6): Enable TC flag set by RSOC threshold

1 = Enabled

0 = Disabled (default)

TCCLEARV (Bit 5): Enable TC flag clear by cell voltage threshold

1 = Enabled

0 = Disabled (default)

TCSETV (Bit 4): Enable TC flag set by cell voltage threshold

1 = Enabled

0 = Disabled (default)

TDCLEARRSOC (Bit 3): Enable TD flag clear by RSOC threshold

1 = Enabled (default)

0 = Disabled

TDSETRSOC (Bit 2): Enable TD flag set by RSOC threshold

1 = Enabled (default)

0 = Disabled

TDCLEARV (Bit 1): Enable TD flag clear by cell voltage threshold

1 = Enabled

0 = Disabled (default)

TDSETV (Bit 0): Enable TD flag set by cell voltage threshold

1 = Enabled

0 = Disabled (default)

14.2.1.8 SOC Flag Config B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SOC Flag Config B	H1	0x00	0xFF	0x8C	Hex

7	6	5	4	3	2	1	0
FCCLEAR RSOC	FCSETRSOC	FCCLEARV	FCSETV	FDCLEAR RSOC	FDSETRSOC	FDCLEARV	FDSETV

FCCLEARRSOC (Bit 7): Enable FC flag clear by RSOC threshold

1 = Enabled (default)

0 = Disabled

FCSETRSOC (Bit 6): Enable FC flag set by RSOC threshold

1 = Enabled

0 = Disabled (default)

FCCLEARV (Bit 5): Enable FC flag clear by cell voltage threshold

1 = Enabled

0 = Disabled (default)

FCSETV (Bit 4): Enable FC flag set by cell voltage threshold

1 = Enabled

0 = Disabled (default)

FDCLEARRSOC (Bit 3): Enable FD flag clear by RSOC threshold

1 = Enabled (default)

0 = Disabled

FDSETRSOC Bit 2: Enable FD flag set by RSOC threshold

1 = Enabled (default)

0 = Disabled

FDCLEARV (Bit 1): Enable FD flag clear by cell voltage threshold

1 = Enabled

0 = Disabled (default)

FDSETV (Bit 0): Enable FD flag set by cell voltage threshold

1 = Enabled

0 = Disabled (default)

14.2.1.9 CEDV Smoothing Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	CEDV Smoothing Config	TBD	0x00	0xFF	0x08	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	SMOOTH EOC_EN	SMEXT	VAVG	SMEN

RSVD (Bits 7–4): Reserved. Do not use.

SMOOTHEOC_EN (Bit 3): Allows smoothing of Remcap once Current starts decreasing during the end of charge (EOC)

1 = Enables smoothing of Remcap during EOC

0 = Disables smoothing of Remcap during EOC

SMEXT (Bit 2): Allows smoothing to continue to EDV1 and EDV0 points.

1 = Enables smoothing down to EDV1 and EDV0

0 = Smoothing stops at EDV2.

VAVG (Bit 1): Enables smoothing to use average voltage

1 = Smoothing uses average voltage.

0 = Smoothing uses measured voltage. Default is 0.

SMEN (Bit 0): Smoothing result is reported on *RemainingCapacity()*.

1 = Smoothed version of *RemainingCapacity* is reported

0 = The normal CEDV remaining capacity is reported. Default is 0.

14.2.1.10 CEDV Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Gauging Configuration	H1	0x000	0x1FFF	0x200	Hex

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	SME0	IGNORE_SD	FC_FOR_VDQ	CHG_DEFICIT_EN	FCC_LIMIT
7	6	5	4	3	2	1	0
VFLT_EN	RSVD	FIXED_EDV0	SC	EDV_CMP	EDV_PACK	CSYNC	CCT

RSVD (Bits 15–13): Reserved. Do not use.

SME0 (Bit 12): Enables smoothing until the EDV0 point

1 = Enable smoothing to EDV0

0 = Disable smoothing to EDV0

IGNORE_SD (Bit 11): Enables ignoring of self-discharge

1 = Enable ignore self-discharge

0 = Disable ignore self-disharge

FC_FOR_VDQ (Bit 10):

1 = FC is required to get VDQ.

0 = FC is not required to get VDQ.

CHG_DEFICIT_EN (Bit 9): Charge Deficit after Valid Charge Termination

1 = Apply charge deficit at charge termination (that is, *FullChargeCapacity()* – *RemainingCapacity()*) to subsequent starting capacity at next discharge

0 = Do not apply charge deficit (that is, start discharge from *RemainingCapacity()* = *FullChargeCapacity()*)

FCC_LIMIT (Bit 8): Full Charge Capacity Limiting

1 = Cap Full Charge Capacity to Design Capacity

0 = Do not cap Full Charge Capacity to Design Capacity

VFLT_EN (Bit 7): Voltage Filter for EDV Detection

1 = Apply filtering to voltage check for EDV detection. This is useful for pulse loading scenarios.

0 = Do not apply filtering to voltage check for EDV detection

RSVD (Bit 6): Prevent OCV Measurement in Flat Region

1 = Enable

0 = Disable

FIXED_EDV0 (Bit 5): Use fixed voltage for EDV0

1 = Enable

0 = Disable

SC (Bit 4): FCC Learning Optimized for Smart Charger

1 = Enable

0 = Disable

EDV_CMP (Bit 3): Dynamically calculate voltages for EDV2, 1, and 0

1 = Enable

0 = Disable

EDV_PACK (Bit 2): EDV Detection Method

1 = Pack-based

0 = Cell-based

CSYNC (Bit 1): Sync *RemainingCapacity()* to *FullChargeCapacity()* on Valid Charge Termination

1 = Enable

0 = Disable

CCT (Bit 0): Cycle Count Increment Threshold

1 = Uses Full Charge Capacity

0 = Uses Design Capacity

14.2.1.11 Charging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Charging Configuration	H1	0x0	0x3F	0x0	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	SOC_CHARGE	CCC	CRATE

RSVD (Bits 7–3): Reserved. Do not use.

SOC_CHARGE (Bit 2)

1 = Enable SOC threshold to replace voltage thresholds (CLV, CMV, and CHV) in Advanced Charging Algorithm

0 = Use voltage thresholds (CLV, CMV, and CHV) in Advanced Charging Algorithm

CCC (Bit 1)

1 = Enable Charging Loss Compensation feature

0 = Disabled Charging Loss Compensation (default)

CRATE (Bit 0): ChargeCurrent rate

1 = *ChargingCurrent()* adjusted based on *FullChargeCapacity()* / *DesignCapacity()*

0 = No adjustment to *ChargingCurrent()* (default)

14.2.1.12 Temperature Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Temperature Enable	H1	0x0	0x1F	0x6	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	TS4	TS3	TS2	TS1	Internal TS

RSVD (Bit 7–5): Reserved. Do not use.

TS4 (Bit 4): Enable TS4

1 = Enable TS4 (default)

0 = Disable TS4

TS3 (Bit 3): Enable TS3

1 = Enable TS3 (default)

0 = Disable TS3

TS2 (Bit 2): Enable TS2

1 = Enable TS2 (default)

0 = Disable TS2

TS1 (Bit 1): Enable TS1

1 = Enable TS1 (default)

0 = Disable TS1

Internal TS (Bit 0): Enable internal TS

1 = Enable internal TS

0 = Disable internal TS (default)

14.2.1.13 Temperature Mode

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Temperature Mode	H1	0x0	0x1F	0x4	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	TS4 Mode	TS3 Mode	TS2 Mode	TS1 Mode	TSInt Mode

RSVD (Bit 7–5): Reserved. Do not use.

TS4 Mode (Bit 4): Cell temp or FET temp

1 = FET temp

0 = Cell temp (default)

TS3 Mode (Bit 3): Cell temp or FET temp

1 = FET temp

0 = Cell temp (default)

TS2 Mode (Bit 2): Cell temp or FET temp

1 = FET temp (default)

0 = Cell temp

TS1 Mode (Bit 1): Cell temp or FET temp

1 = FET temp

0 = Cell temp (default)

TSInt Mode (Bit 0): Cell temp or FET temp

1 = FET temp

0 = Cell temp (default)

14.2.1.14 DA Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	DA Configuration	H1	0x0	0xFF	0x12	Hex

7	6	5	4	3	2	1	0
FTEMP	CTEMP	EMSHUT_EN	SLEEP	IN_SYSTEM_SLEEP	NR	CC1	CC0

FTEMP (Bit 7): FET Temperature protection source

1 = Average

0 = MAX (default)

CTEMP (Bit 6): Cell Temperature protection source

1 = Average

0 = MAX (default)

EMSHUT_EN (Bit 5): Emergency Shutdown Enable

1 = Enable

0 = Disable

SLEEP (Bit 4): SLEEP mode

1 = Enable SLEEP mode (default)

0 = Disable SLEEP mode

IN_SYSTEM_SLEEP (Bit 3): In-system SLEEP mode

1 = Enable

0 = Disable (default)

NR (Bit 2): Use $\overline{\text{PRES}}$ in system detection

1 = NON-REMOVABLE mode

0 = Use $\overline{\text{PRES}}$, REMOVABLE mode (default)

CC1, CC0 (Bit 1,0): Cell Count

1,1 = 4 cell

1,0 = 3 cell (default)

0,1 = 2 cell

0,0 = 1 cell

14.2.1.15 Balancing Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Balancing Configuration	H1	0x0	0xFF	0x1	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	CB

RSVD (Bits 7–1): Reserved. Do not use.

CB (Bit 0): Cell balancing

1 = Cell balancing enabled (default)

0 = Cell balancing disabled

14.2.2 Fuse

14.2.2.1 Permanent Fail Fuse A

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse A	H1	0x0	0xFF	0x0	—

7	6	5	4	3	2	1	0
RSVD	SOTF	RSVD	SOT	SOCD	SOCC	SOV	SUV

Fuse blow action for *PFStatus()* bits:

RSVD (Bit 7): Reserved. Do not use.

SOTF (Bit 6): Safety Overtemperature FET

1 = Enabled

0 = Disabled (default)

RSVD (Bit 5): Reserved. Do not use.

SOT (Bit 4): Safety Overtemperature

1 = Enabled

0 = Disabled (default)

SOCD (Bit 3): Safety Overcurrent in Discharge

1= Enabled

0 = Disabled (default)

SOCC (Bit 2): Safety Overcurrent in Charge

1= Enabled

0 = Disabled (default)

SOV (Bit 1): Safety Cell Overvoltage

1 = Enabled

0 = Disabled (default)

SUV (Bit 0): Safety Cell Undervoltage

1 = Enabled

0 = Disabled (default)

14.2.2.2 Permanent Fail Fuse B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse B	H1	0x0	0xFF	0	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	VIMA	VIMR	RSVD	RSVD	RSVD

Fuse blow action for *PFStatus()* bits:

RSVD (Bits 7–5): Reserved. Do not use.

VIMA (Bit 4): Voltage imbalance when active

1 = Enabled

0 = Disabled (default)

VIMR (Bit 3): Voltage imbalance at rest

1 = Enabled

0 = Disabled (default)

RSVD (Bits 2–0): Reserved. Do not use.

14.2.2.3 Permanent Fail Fuse C

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse C	H1	0x0	0xFF	0	Hex

7	6	5	4	3	2	1	0
PTC	2LVL	AFEC	AFER	FUSE	RSVD	DFETF	CFETF

Fuse blow action for *PFStatus()* bits:

PTC (Bit 7): Permanent Fail flag Display

1 = Allow ***PFStatus[PTC]*** = 1 when PTC fault is triggered. Function should be enabled/disabled by the PTCEN pin connection.

0 = Disable the ***PFStatus[PTC]*** = 1 when PTC fault is triggered. Function should be enabled/disabled by the PTCEN pin connection.

2LVL (Bit 6): FUSE input indicating fuse trigger by external 2nd level protection

1 = Enabled

0 = Disabled (default)

AFEC (Bit 5): AFE Communication

1 = Enabled

0 = Disabled (default)

AFER (Bit 4): AFE Register

1 = Enabled

0 = Disabled (default)

FUSE (Bit 3): Fuse

1 = Enabled

0 = Disabled (default)

RSVD (Bit 2): Reserved. Do not use.

DFETF (Bit 1): Discharge FET

1 = Enabled

0 = Disabled (default)

CFETF (Bit 0): Charge FET

1 = Enabled

0 = Disabled (default)

14.2.2.4 Permanent Fail Fuse D

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse D	H1	0x0	0xFF	0x0	Hex

15	14	13	12	11	10	9	8
TS4	TS3	TS2	TS1	RSVD	DFW	OPNCELL	IFC

Fuse blow action for *PFStatus()* bits:

TS4 (Bit 15)

1 = Enabled

0 = Disabled (default)

TS3 (Bit 14)

1 = Enabled

0 = Disabled (default)

TS2 (Bit 13)

1 = Enabled

0 = Disabled (default)

TS1 (Bit 12)

1 = Enabled

0 = Disabled (default)

RSVD (Bit 11): Reserved. Do not use.

DFW (Bit 10): DF wearout

1 = Enabled

0 = Disabled (default)

OPNCELL (Bit 9): Open Cell tab (tab to PCB)

1 = Enabled

0 = Disabled (default)

IFC (Bit 8)

1 = Enabled

0 = Disabled (default)

14.2.2.5 Min Blow Fuse Voltage

Class	Subclass	Name	Type	Min	Max	Default
Settings	Fuse	Min Blow Fuse Voltage	I2	0	65535	3500

Description: Minimum voltage required to attempt fuse blow, pack based, FET failures bypass this requirement to blow the fuse.

14.2.2.6 Fuse Blow Timeout

Class	Subclass	Name	Type	Min	Max	Default
Settings	Fuse	Min Blow Fuse Voltage	U1	0	255	30

Description: Minimum time to keep the fuse blow voltage high

14.2.3 BTP

14.2.3.1 Init Discharge Set

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	BTP	Init Discharge Set	I2	0	32767	150	mAH

Description: Initial value for *BTPDischargeSet()*

14.2.3.2 Init Charge Set

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	BTP	Init Discharge Set	I2	0	32767	175	mAH

Description: Initial value for *BTPChargeSet()*

14.2.4 Protection

14.2.4.1 Protection Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Protection Configuration	H1	0x00	0x03	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	CUV_RECOV_CHG	SUV_MODE

RSVD (Bits 7–2): Reserved. Do not use.

CUV_RECOV_CHG (Bit 1): Require charge to recover *SafetyStatus()[CUV]*

1 = Enabled (default)

0 = Disabled

SUV_MODE (Bit 0): Copper Deposition check for *PFStatus()[CUV]*

1 = Enabled (default)

0 = Disabled

14.2.4.2 Enabled Protections A

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Enabled Protections A	H1	0x00	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
AOLDL	RSVD_ONE	OCD2	OCD1	OCC2	OCC1	COV	CUV

AOLDL (Bit 7): Overload in Discharge latch

1 = Enabled (default)

0 = Disabled

RSVD_ONE (Bit 6): Reserved and programmed to 1. Do not use.

OCD2 (Bit 5): Overcurrent in Discharge 2nd Tier

1 = Enabled (default)

0 = Disabled

OCD1 (Bit 4): Overcurrent in Discharge 1st Tier

1 = Enabled (default)

0 = Disabled

OCC2 (Bit 3): Overcurrent in Charge 2nd Tier

1 = Enabled (default)

0 = Disabled

OCC1 (Bit 2): Overcurrent in Charge 1st Tier

1 = Enabled (default)

0 = Disabled

COV (Bit 1): Cell Overvoltage

1 = Enabled (default)

0 = Disabled

CUV (Bit 0): Cell Undervoltage

1 = Enabled (default)

0 = Disabled

14.2.4.3 Enabled Protections B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Enabled Protections B	H1	0x00	0xFF	0xFF	—

7	6	5	4	3	2	1	0
RSVD	RSVD	OTD	OTC	ASCDL	RSVD_ONE	ASCCL	ASCC

RSVD (Bits 7–6): Reserved. Do not use.

OTD (Bit 5): Overtemperature in discharge

1 = Enabled (default)

0 = Disabled

OTC (Bit 4): Overtemperature in charge

1 = Enabled (default)

0 = Disabled

ASCDL (Bit 3): Short circuit in discharge latch

1 = Enabled (default)

0 = Disabled

RSVD_ONE (Bit 2): Reserved and programmed to 1. Do not use.

ASCCL (Bit 1): Short circuit in charge latch

1 = Enabled (default)

0 = Disabled

ASCC (Bit 0): Short circuit in charge

1 = Enabled (default)

0 = Disables the *SafetyAlert()* and *SafetyStatus()* flag only and does NOT disable the FET actions.

14.2.4.4 Enabled Protections C

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Enabled Protections C	H1	0x00	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
CHGC	OC	RSVD	CTO	RSVD	PTO	HWDF	OTF

CHGC (Bit 7): *ChargingCurrent()* higher than requested

1 = Enabled (default)

0 = Disabled

OC (Bit 6): Overcharge

1 = Enabled (default)

0 = Disabled

RSVD (Bit 5): Reserved. Do not use.

CTO (Bit 4): Charging timeout

1 = Enabled (default)

0 = Disabled

RSVD (Bit 3): Reserved. Do not use.

PTO (Bit 2): Pre-charging timeout

1 = Enabled (default)

0 = Disabled

HWDF (Bit 1): SBS Host watchdog timeout

1 = Enabled (default)

0 = Disabled

OTF (Bit 0): FET overtemperature

1 = Enabled (default)

0 = Disabled

14.2.4.5 Enabled Protections D

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Enabled Protections D	H1	0x00	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	UTD	UTC	PCHGV	CHGV

RSVD (Bits 7–4): Reserved. Do not use.

UTD (Bit 3): Under temperature while not charging

1 = Enabled (default)

0 = Disabled

UTC (Bit 2): Under temperature while charging

1 = Enabled (default)

0 = Disabled

PCHGV (Bit 1): *ChargingVoltage()* higher than requested in precharge

1 = Enabled (default)

0 = Disabled

CHGV (Bit 0): *ChargingVoltage()* higher than requested

1 = Enabled (default)

0 = Disabled

14.2.5 Permanent Failure

14.2.5.1 Enabled PF A

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Permanent Failure	Enabled PF A	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	SOTF	RSVD	SOT	SOCD	SOCC	SOV	SUV

RSVD (Bit 7): Reserved. Do not use.

OTF (Bit 6): Overtemperature FET

1 = Enabled (default)

0 = Disabled

RSVD (Bit 5): Reserved. Do not use.

PF_OTCE (Bit 4): Overtemperature

1 = Enabled (default)

0 = Disabled

RSVD (Bits 3–2): Reserved. Do not use.

SOT (Bit 4): Safety Overtemperature

1 = Enabled

0 = Disabled (default)

SOCD (Bit 3): Safety Overcurrent in Discharge

1= Enabled

0 = Disabled (default)

SOCC (Bit 2): Safety Overcurrent in Charge

1= Enabled

0 = Disabled (default)

SOV (Bit 1): Safety Cell Overvoltage

1 = Enabled

0 = Disabled (default)

SUV (Bit 0): Safety Cell Undervoltage

1 = Enabled

0 = Disabled (default)

14.2.5.2 Enabled PF B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Permanent Failure	Enabled PF B	H1	0x00	0xFF	0x00	—

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	VIMA	VIMR	RSVD	RSVD	RSVD

RSVD (Bits 7–5): Reserved. Do not use.

VIMA (Bit 4): Voltage Imbalance When Active

1 = Enabled (default)

0 = Disabled

VIMR (Bit 3): Voltage Imbalance At Rest

1 = Enabled (default)

0 = Disabled

RSVD (Bits 2–0): Reserved. Do not use.

14.2.5.3 Enabled PF C

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Permanent Failure	Enabled PF C	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0
PTC	2LVL	AFEC	AFER	FUSE	RSVD	DFET	CFETF

PTC (Bit 7): Permanent Fail Flag Display

1 = Allow ***PFStatus[PTC]*** = 1 when PTC fault is triggered. Function should be enabled/disabled by the PTCEN pin connection.

0 = Disable the ***PFStatus[PTC]*** = 1 when PTC fault is triggered. Function should be enabled/disabled by the PTCEN pin connection.

2LVL (Bit 6): FUSE input indicating fuse trigger by external 2nd level protection

1 = Enabled (default)

0 = Disabled

AFEC (Bit 5): AFE Communication

1 = Enabled (default)

0 = Disabled

AFER (Bit 4): AFE Register

1 = Enabled (default)

0 = n/a

FUSE (Bit 3): Fuse

1 = Enabled (default)

0 = Disabled

RSVD (Bit 2): Reserved. Do not use.

DFET (Bit 1): Discharge FET

1 = Enabled (default)

0 = Disabled

CFETF (Bit 0): Charge FET

1 = Enabled (default)

0 = Disabled

14.2.5.4 Enabled PF D

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Permanent Failure	Enabled PF D	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0
TS4	TS3	TS2	TS1	RSVD	RSVD	OPNCELL	RSVD

TS4 (Bit 7)

1 = Enabled (default)

0 = Disabled

TS3 (Bit 6)

1 = Enabled (default)

0 = Disabled

TS2 (Bit 5)

1 = Enabled (default)

0 = Disabled

TS1 (Bit 4)

1 = Enabled (default)

0 = Disabled

RSVD (Bits 3–2): Reserved. Do not use.

OPNCELL (Bit 1): Open Cell tab (tab to PCB)

1 = Enabled (default)

0 = Disabled

RSVD (Bit 0): Reserved. Do not use.

14.2.6 AFE

14.2.6.1 AFE Protection Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
Configuration	AFE	AFE Protection Control	H1	0x00	0xFF	0x70	Hex

7	6	5	4	3	2	1	0
RSTRIM	RSTRIM	RSTRIM	RSTRIM	RSVD	RSVD	SCDDx2	RSNS

RSTRIM (Bits 7–4): *Unsupport* function. Should leave the default setting 0x7. Changing this setting may cause an error to the AFE current protection accuracy.

RSVD (Bits 3–2): Reserved. Do not use.

SCDDx2 (Bit 1): Double SCD Delay Times

1 = 2 × SCD delay times

0 = Normal SCD delay times (default)

RSNS (Bit 0): AOLD, ASCC, ASCD1, ASCD2 Thresholds

1 = Normal AFE Protection Thresholds

0 = 0.5 × AFE Protection Thresholds (default)

14.2.7 ZVCHG Exit Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Configuration	AFE	ZVCHG Exit Threshold	I2	0x0	0xFFFF	0x0000	mV

Description: *Voltage()* threshold where the gauge will exit ZVCHG mode when CFET is used for precharging.

14.3 Manufacturing

14.3.1 Manufacturing Status Init

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Manufacturing	Manufacturing Status Init	H2	0x0	0xFFFF	0x0000	Hex

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	LED_EN	FUSE_EN

7	6	5	4	3	2	1	0
BBR_EN	PF_EN	LF_EN	FET_EN	GAUGE_EN	RSVD	RSVD	RSVD

RSVD (Bits 15–10): Reserved. Do not use.

LED_EN (Bit 9): LED Display

1 = Enabled

0 = Disabled

FUSE_EN (Bit 8): FUSE action

1 = Enabled

0 = Disabled (default)

BBR_EN (Bit 7): Black Box Recorder

1 = Enabled

0 = Disabled (default)

PF_EN (Bit 6): Permanent Fail

1 = Enabled

0 = Disabled (default)

LF_EN (Bit 5): Lifetime Data Collection

1 = Enabled

0 = Disabled

FET_EN (Bit 4): FET action

1 = Enabled

0 = Disabled (default)

GAUGE_EN (Bit 3): Gauging

1 = Enabled

0 = Disabled (default)

RSVD (Bits 2–0): Reserved. Do not use.

14.4 Advanced Charging Algorithm

14.4.1 Temperature Ranges

14.4.1.1 T1 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Temperature Ranges	T1 Temp	I1	–128	127	0	°C

Description: T1 low temperature range lower limit

14.4.1.2 T2 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Temperature Ranges	T2 Temp	I1	–128	127	12	°C

Description: T2 low temperature range to standard temperature range

14.4.1.3 T5 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Temperature Ranges	T5 Temp	I1	–128	127	20	°C

Description: T5 recommended temperature range lower limit

14.4.1.4 T6 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Temperature Ranges	T6 Temp	I1	–128	127	25	°C

Description: T6 recommended temperature range upper limit

14.4.1.5 T3 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Temperature Ranges	T3 Temp	I1	–128	127	30	°C

Description: T3 standard temperature range to high temperature range

14.4.1.6 T4 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Temperature Ranges	T4 Temp	I1	–128	127	55	°C

Description: T4 high temperature range upper limit

14.4.1.7 Hysteresis

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Temperature Ranges	Hysteresis Temp	I1	–128	127	1	°C

Description: Temperature Hysteresis, applied when temperature is decreasing.

14.4.2 Low Temp Charging

14.4.2.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Low Temp Charging	Voltage	I2	0	32767	4000	mV

Description: Low temperature range *ChargingVoltage()*

14.4.2.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Low Temp Charging	Current Low	I2	0	32767	132	mA

Description: Low temperature range low voltage range *ChargingCurrent()*

14.4.2.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Low Temp Charging	Current Med	I2	0	32767	352	mA

Description: Low temperature range medium voltage range *ChargingCurrent()*

14.4.2.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Low Temp Charging	Current High	I2	0	32767	264	mA

Description: Low temperature range high voltage range *ChargingCurrent()*

14.4.3 Standard Temp Charging

14.4.3.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Standard Temp Charging	Voltage	I2	0	32767	4200	mV

Description: Standard temperature range *ChargingVoltage()*

14.4.3.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Standard Temp Charging	Current Low	I2	0	32767	1980	mA

Description: Standard temperature range low voltage range *ChargingCurrent()*

14.4.3.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Standard Temp Charging	Current Med	I2	0	32767	4004	mA

Description: Standard temperature range medium voltage range *ChargingCurrent()*

14.4.3.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Standard Temp Charging	Current High	I2	0	32767	2992	mA

Description: Standard temperature range high voltage range *ChargingCurrent()*

14.4.4 High Temp Charging

14.4.4.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	High Temp Charging	Voltage	I2	0	32767	4000	mV

Description: High temperature range *ChargingVoltage()*

14.4.4.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	High Temp Charging	Current Low	I2	0	32767	1012	mA

Description: High temperature range low voltage range *ChargingCurrent()*

14.4.4.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	High Temp Charging	Current Med	I2	0	32767	1980	mA

Description: High temperature range medium voltage range *ChargingCurrent()*

14.4.4.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	High Temp Charging	Current High	I2	0	32767	1496	mA

Description: High temperature range high voltage range *ChargingCurrent()*

14.4.5 Rec Temp Charging

14.4.5.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Rec Temp Charging	Voltage	I2	0	32767	4100	mV

Description: Recommended temperature range *ChargingVoltage()*

14.4.5.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Rec Temp Charging	Current Low	I2	0	32767	2508	mA

Description: Recommended temperature range low voltage range *ChargingCurrent()*

14.4.5.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Rec Temp Charging	Current Med	I2	0	32767	4488	mA

Description: Recommended temperature range medium voltage range *ChargingCurrent()*

14.4.5.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Rec Temp Charging	Current High	I2	0	32767	3520	mA

Description: Recommended temperature range high voltage range *ChargingCurrent()*

14.4.6 Pre-Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	PCHG	Current	I2	0	32767	88	mA

Description: Precharge *ChargingCurrent()*

14.4.7 Maintenance Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	MCHG	Current	I2	0	32767	44	mA

Description: Maintenance *ChargingCurrent()*

14.4.8 Voltage Range

14.4.8.1 Precharge Start Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Voltage Range	Precharge Start Voltage	I2	0	32767	2500	mV

Description: Min cell voltage to enter PRECHARGE mode

14.4.8.2 Charging Voltage Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Voltage Range	Charging Voltage Low	I2	0	32767	2900	mV

Description: Precharge Voltage range to Charging Voltage Low range

14.4.8.3 Charging Voltage Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Voltage Range	Charging Voltage Med	I2	0	32767	3600	mV

Description: Charging Voltage Low range to Charging Voltage Med range

14.4.8.4 Charging Voltage High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Voltage Range	Charging Voltage High	I2	0	32767	4000	mV

Description: Charging Voltage Med to Charging Voltage High range

14.4.8.5 Charging Voltage Hysteresis

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Voltage Range	Charging Voltage Hysteresis	U1	0	255	0	mV

Description: Charging Voltage Hysteresis applied when voltage is decreasing

14.4.9 Termination Config

14.4.9.1 Charge Term Taper Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Termination Config	Charge Term Taper Current	I2	0	32767	250	mA

Description: Valid Charge Termination taper current qualifier threshold

14.4.9.2 Charge Term Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Termination Config	Charge Term Voltage	I2	0	32767	75	mV

Description: Valid Charge Termination delta voltage qualifier, max cell-based

14.4.10 Charging Rate of Change

14.4.10.1 Current Rate

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Charging Rate of Change	Current Rate	U1	1	255	1	steps/s

Description: Number of steps to add between any two *ChargingCurrent()* settings

14.4.10.2 Voltage Rate

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Charging Rate of Change	Voltage Rate	U1	1	255	1	steps/s

Description: Number of steps to add between any two *ChargingVoltage()* settings

14.4.11 Charge Loss Compensation

14.4.11.1 CCC Current Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Charge Loss Compensation	CCC Current Threshold	I2	0	32767	3520	mA

Description: CONSTANT CURRENT CHARGE mode *ChargingCurrent()* threshold to activate Charge Loss Compensation

14.4.11.2 CCC Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithms	Charge Loss Compensation	CCC Voltage Threshold	I2	0	32767	4200	mV

Description: CONSTANT CURRENT CHARGE mode max *ChargingVoltage()* increase limit

14.4.12 Cell Balancing Config

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charging Algorithms	Cell Balancing Config	Cell Balance Threshold	I2	0	5000	3900	mV	Threshold to allow cell balancing
Advanced Charging Algorithms	Cell Balancing Config	Cell Balance Window	I2	0	5000	100	mV	Adjustment applied to Cell Balance Threshold if all cells exceed it or max cell is greater than ***Cell Balance Threshold*** + ***Cell Balance Min***
Advanced Charging Algorithms	Cell Balancing Config	Cell Balance Min	U1	0	255	40	mV	Minimum imbalance to enable cell balance circuit
Advanced Charging Algorithms	Cell Balancing Config	Cell Balance Interval	U1	0	255	20	s	Voltage measurement frequency for cell balancing

14.5 Power

14.5.1 Power

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Power	Valid Update Voltage	I2	0	32767	3500	mV

Description: Min stack voltage threshold for Flash update

14.5.2 Shutdown

14.5.2.1 Shutdown Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	Shutdown Voltage	I2	0	32767	1750	mV

Description: Cell-based shutdown voltage trip threshold

14.5.2.2 Shutdown Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	Shutdown Time	U2	0	255	10	s

Description: Cell-based shutdown voltage trip delay

14.5.2.3 Charger Present Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	Charger Present Threshold	I2	0	32767	3000	mV

Description: Pack pin charger present detect threshold

14.5.3 Sleep

14.5.3.1 Sleep Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Sleep Current	I2	0	32767	10	mA

Description: |*Current()*| threshold to enter SLEEP mode. If this parameter is set to 0, then the ***deadband*** will effectively become the Sleep Current setting because any current blow the ***deadband*** will set the *Current()* = 0 mA.

14.5.3.2 Bus Timeout

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Bus Timeout	U1	0	255	5	s

Description: Bus low or no communication time to enter SLEEP mode

14.5.3.3 Voltage Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Voltage Time	U1	0	255	5	s

Description: *Voltage()* sampling period in SLEEP mode

14.5.3.4 Current Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Current Time	U1	0	255	20	s

Description: *Current()* sampling period in SLEEP mode

14.5.3.5 Wake Comparator

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Wake Comparator	H1	0x00	0xFF	0x00	—

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	WK1	WK0	RSVD	RSVD

RSVD (Bits 7–4): Reserved. Do not use.

WK1, WK0 (Bits 3–2): Wake Comparator Threshold

1,1 = ±5 mV

1,0 = ±2.5 mV

0,1 = ±1.25 mV

0,0 = ±0.625 mV

RSVD (Bits 1–0): Reserved. Do not use.

14.5.4 Ship

14.5.4.1 FET Off Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Ship	FET Off Time	U1	0	127	10	s

Description: Delay time to turn off FETs prior to entering SHUTDOWN mode. This setting should not be longer than the ***Ship Delay*** setting.

14.5.4.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Ship	Delay	U1	0	254	20	s

Description: Delay time to enter SHUTDOWN mode after FETs are turned off.

14.5.4.3 Auto Ship Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Ship	Auto Ship time	U2	0	65535	1440	min

Description: The device will automatically enter SHUTDOWN mode after staying in SLEEP mode without communication for this amount of time when ***Power Config[AUTO_SHIP_EN]*** = 1.

14.5.5 Power Off

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Power Off	Timeout	U2	0	65535	30	min

Description: Timeout to exit the Emergency Shutdown condition

14.5.6 Manual FET Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Manual FET Control	MFC Delay	U1	0	255	60	min

Description: Delay time to turn off FETs through MFC

14.6 LED Support

14.6.1 LED Config

14.6.1.1 LED Flash Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Flash Period	U2	32	65535	512	488 µs

Description: LED Flashing period for alarm display

14.6.1.2 LED Blink Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Blink Period	U2	32	65535	1024	488 µs

Description: LED Blinking period for state-of-charge display

14.6.1.3 LED Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Delay	U2	16	65535	100	488 µs

Description: Delay time from LED to LED for state-of-charge display

14.6.1.4 LED Hold Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Hold Time	U1	1	63	16	0.25 s

Description: LED display active time

14.6.1.5 CHG Flash Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Flash Alarm	I1	0	100	10	%

Description: *RelativeStateOfCharge()* alarm threshold during charging

14.6.1.6 CHG Thresh 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 1	I1	0	100	0	%

Description: *RelativeStateOfCharge()* threshold for LED1 during charging

14.6.1.7 CHG Thresh 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 2	I1	0	100	20	%

Description: *RelativeStateOfCharge()* threshold for LED2 during charging

14.6.1.8 CHG Thresh 3

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 3	I1	0	100	40	%

Description: *RelativeStateOfCharge()* threshold for LED3 during charging

14.6.1.9 CHG Thresh 4

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 4	I1	0	100	60	%

Description: *RelativeStateOfCharge()* threshold for LED4 during charging

14.6.1.10 CHG Thresh 5

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 5	I1	0	100	80	%

Description: *RelativeStateOfCharge()* threshold for LED5 during charging

14.6.1.11 DSG Flash Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Flash Alarm	I1	0	100	10	%

Description: *RelativeStateOfCharge()* alarm threshold during discharging

14.6.1.12 DSG Thresh 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 1	I1	0	100	0	%

Description: *RelativeStateOfCharge()* threshold for LED1 during discharging

14.6.1.13 DSG Thresh 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 2	I1	0	100	20	%

Description: *RelativeStateOfCharge()* threshold for LED2 during discharging

14.6.1.14 DSG Thresh 3

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 3	I1	0	100	40	%

Description: *RelativeStateOfCharge()* threshold for LED3 during discharging

14.6.1.15 DSG Thresh 4

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 4	I1	0	100	60	%

Description: *RelativeStateOfCharge()* threshold for LED4 during discharging

14.6.1.16 DSG Thresh 5

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 5	I1	0	100	80	%

Description: *RelativeStateOfCharge()* threshold for LED5 during discharging

14.7 System Data

14.7.1 Manufacturer Info

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Manufacturer Data	ManufacturerInfo	S33	—	—	abcdefghijklmnopqrstuvwzxy012345	—

Description: *ManufacturerInfo()* value

14.7.2 Static DF Signature

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Integrity	Static DF Signature	H2	0x0	0x7FFF	0x0	Hex

Description: Static data flash signature. Use MAC *StaticDFSignature()* (with MSB set to 0) to initialize this value.

14.7.3 All DF Signature

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Integrity	All DF Signature	H2	0x0	0x7FFF	0x0	Hex

Description: Static data flash signature. Use MAC *AllDFSignature()* (with MSB set to 0) to initialize this value.

14.8 Lifetimes

14.8.1 Voltage

14.8.1.1 Cell 1 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 1 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 1

14.8.1.2 Cell 2 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 2 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 2

14.8.1.3 Cell 3 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 3 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 3

14.8.1.4 Cell 4 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 4 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 4

14.8.1.5 Cell 1 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 1 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 1

14.8.1.6 Cell 2 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 2 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 2

14.8.1.7 Cell 3 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 3 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 3

14.8.1.8 Cell 4 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 4 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 4

14.8.1.9 Max Delta Cell Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Max Delta Cell Voltage	I2	0	32767	0	mV

Description: Maximum reported delta between cell voltages 1..4

14.8.2 Current

14.8.2.1 Max Charge Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Charge Current	I2	0	32767	0	mA

Description: Maximum reported *Current()* in charge direction

14.8.2.2 Max Discharge Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Discharge Current	I2	–32768	0	0	mA

Description: Maximum reported *Current()* in discharge direction

14.8.2.3 Max Avg Dsg Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Avg Dsg Current	I2	–32768	0	0	mA

Description: Maximum reported *AverageCurrent()* in discharge direction

14.8.2.4 Max Avg Dsg Power

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Avg Dsg Power	I2	–32768	0	0	cW

14.8.2.5

Description: Maximum reported Power in discharge direction

14.8.3 Temperature

14.8.3.1 Max Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature	Max Temp Cell	I1	–128	127	–128	°C

Description: Maximum reported cell temperature

14.8.3.2 Min Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature	Min Temp Cell	I1	–128	127	127	°C

Description: Minimum reported cell temperature

14.8.3.3 Max Delta Cell Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature	Max Delta Cell Temp	I1	–128	127	0	°C

Description: Maximum reported temperature delta for TSx inputs configured as cell temperature

14.8.3.4 Max Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature	Max Temp Int Sensor	I1	–128	127	–128	°C

Description: Maximum reported internal temperature sensor temperature

14.8.3.5 Min Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature	Min Temp Int Sensor	I1	–128	127	127	°C

Description: Minimum reported internal temperature sensor temperature

14.8.3.6 Max Temp Fet

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature	Max Temp Fet	I1	–128	127	–128	°C

Description: Maximum reported FET temperature

14.8.4 Safety Events

14.8.4.1 No Of COV Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of COV Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[COV]* events

14.8.4.2 Last COV Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last COV Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[COV]* event in *CycleCount()* cycles

14.8.4.3 No Of CUV Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of CUV Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[CUV]* events

14.8.4.4 Last CUV Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last CUV Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[CUV]* event in *CycleCount()* cycles

14.8.4.5 No Of OCD1 Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of OCD1 Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OCD1]* events

14.8.4.6 Last OCD1 Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last OCD1 Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[OCD1]* event in *CycleCount()* cycles

14.8.4.7 No Of OCD2 Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of OCD2 Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OCD2]* events

14.8.4.8 Last OCD2 Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last OCD2 Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[OCD2]* event in *CycleCount()* cycles

14.8.4.9 No Of OCC1 Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of OCC1 Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OCC1]* events

14.8.4.10 Last OCC1 Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last OCC1 Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[OCC1]* event in *CycleCount()* cycles

14.8.4.11 No Of OCC2 Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of OCC2 Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OCC2]* events

14.8.4.12 Last OCC2 Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last OCC2 Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[OCC2]* event in *CycleCount()* cycles

14.8.4.13 No Of AOLD Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of AOLD Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OLD]* events

14.8.4.14 Last AOLD Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last AOLD Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[OLD]* event in *CycleCount()* cycles

14.8.4.15 No Of ASCD Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of ASCD Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[SCD]* events

14.8.4.16 Last ASCD Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last ASCD Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[SCD]* event in *CycleCount()* cycles

14.8.4.17 No Of ASCC Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of ASCC Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[SCC]* events

14.8.4.18 Last ASCC Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last ASCC Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[SCC]* event in *CycleCount()* cycles

14.8.4.19 No Of OTC Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of OTC Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OTC]* events

14.8.4.20 Last OTC Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last OTC Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[OTC]* event in *CycleCount()* cycles

14.8.4.21 No Of OTD Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of OTD Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OTD]* events

14.8.4.22 Last OTD Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last OTD Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[OTD]* event in *CycleCount()* cycles

14.8.4.23 No Of OTF Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of OTF Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[OTF]* events

14.8.4.24 Last OTF Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last OTF Event	U2	0	32767	0	cycles

Description: *Last SafetyStatus()[OTF]* event in *CycleCount()* cycles

14.8.5 Charging Events

14.8.5.1 No Valid Charge Term

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Charging Events	No Valid Charge Term	U2	0	32767	0	events

Description: Total number of valid charge termination events

14.8.5.2 Last Valid Charge Term

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Charging Events	Last Valid Charge Term	U2	0	32767	0	cycles

Description: Last valid charge termination in *CycleCount()* cycles

14.8.6 Power Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Power Events	No of Shutdowns	U1	0	255	0	events

Description: Total number of shutdown events

14.8.7 Cell Balancing

14.8.7.1 CB Time Cell 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 1	U1	0	255	0	2 h

Description: Total performed cell balancing bypass time Cell 0

14.8.7.2 CB Time Cell 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 2	U1	0	255	0	2 h

Description: Total performed cell balancing bypass time Cell 1

14.8.7.3 CB Time Cell 3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 3	U1	0	255	0	2 h

Description: Total performed cell balancing bypass time Cell 2

14.8.7.4 CB Time Cell 4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 4	U1	0	255	0	2 h

Description: Total performed cell balancing bypass time Cell 3

14.8.8 Time

14.8.8.1 Total Firmware Runtime

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Total Firmware Runtime	U2	0	65535	0	2 h

Description: Total firmware runtime between resets

14.8.8.2 Time Spent in UT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in UT	U2	0	65535	0	2 h

Description: Total firmware runtime spent below T1

14.8.8.3 Time Spent in LT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LT	U2	0	65535	0	2 h

Description: Total firmware runtime spent between T1 and T2

14.8.8.4 Time Spent in STL

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in STL	U2	0	65535	0	2 h

Description: Total firmware runtime spent between T2 and T5

14.8.8.5 Time Spent in RT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in RT	U2	0	65535	0	2 h

Description: Total firmware runtime spent between T5 and T6

14.8.8.6 Time Spent in STH

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in STH	U2	0	65535	0	2 h

Description: Total firmware runtime spent between T6 and T3

14.8.8.7 Time Spent in HT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in HT	U2	0	65535	0	2 h

Description: Total firmware runtime spent between T3 and T4

14.8.8.8 Time Spent in OT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in OT	U2	0	65535	0	2 h

Description: Total firmware runtime spent above T6

14.9 Protections

14.9.1 CUV—Cell Undervoltage

14.9.1.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Threshold	I2	0	32767	2500	mV

Description: Cell undervoltage trip threshold

14.9.1.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Delay	U1	0	255	2	s

Description: Cell undervoltage trip delay

14.9.1.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Recovery	I2	0	32767	3000	mV

Description: Cell undervoltage recovery threshold

14.9.2 COV—Cell Overvoltage

14.9.2.1 Threshold Low Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Threshold Low Temp	I2	0	32767	4300	mV

Description: Cell overvoltage low temperature range trip threshold

14.9.2.2 Threshold Standard Tem

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Threshold Standard Temp	I2	0	32767	4300	mV

Description: Cell overvoltage standard temperature range trip threshold

14.9.2.3 Threshold High Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Threshold High Temp	I2	0	32767	4300	mV

Description: Cell overvoltage high temperature range trip threshold

14.9.2.4 Threshold Rec Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Threshold Rec Temp	I2	0	32767	4300	mV

Description: Cell overvoltage recommended temperature range trip threshold

14.9.2.5 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Delay	U1	0	255	2	s

Description: Cell overvoltage trip delay

14.9.2.6 Recovery Low Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Recovery Low Temp	I2	0	32767	3900	mV

Description: Cell overvoltage low temperature range recovery threshold

14.9.2.7 Recovery Standard Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Recovery Standard Temp	I2	0	32767	3900	mV

Description: Cell overvoltage standard temperature recovery range threshold

14.9.2.8 Recovery High Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Recovery High Temp	I2	0	32767	3900	mV

Description: Cell overvoltage high temperature range recovery threshold

14.9.2.9 Recovery Rec Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Recovery Rec Temp	I2	0	32767	3900	mV

Description: Cell overvoltage recommended temperature range recovery threshold

14.9.3 OCC1—Overcurrent In Charge 1

14.9.3.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC1	Threshold	I2	–32768	32767	6000	mA

Description: Overcurrent in Charge 1 trip threshold

14.9.3.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC1	Delay	U1	0	255	6	s

Description: Overcurrent in Charge 1 trip delay

14.9.4 OCC2—Overcurrent In Charge 2

14.9.4.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC2	Threshold	I2	–32768	32767	8000	mA

Description: Overcurrent in Charge 2 trip threshold

14.9.4.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC2	Delay	U1	0	255	3	s

Description: Overcurrent in Charge 2 trip delay

14.9.5 OCC—Overcurrent In Charge Recovery

14.9.5.1 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC	Recovery Threshold	I2	–32768	32767	–200	mA

Description: Overcurrent in Charge 1 and 2 recovery threshold

14.9.5.2 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC	Recovery Delay	U1	0	255	5	s

Description: Overcurrent in Charge 1 and 2 recovery delay

14.9.6 OCD1—Overcurrent In Discharge 1

14.9.6.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD1	Threshold	I2	–32768	32767	–6000	mA

Description: Overcurrent in Discharge 1 trip threshold

14.9.6.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD1	Delay	U1	0	255	6	s

Description: Overcurrent in Discharge 1 trip delay

14.9.7 OCD2—Overcurrent In Discharge 2

14.9.7.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD2	Threshold	I2	–32768	32767	–8000	mA

Description: Overcurrent in Discharge 2 trip threshold

14.9.7.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD2	Delay	U1	0	255	3	s

Description: Overcurrent in Discharge 2 trip delay

14.9.8 OCD—Overcurrent In Discharge Recovery

14.9.8.1 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD	Recovery Threshold	I2	–32768	32767	200	mA

Description: Overcurrent in Discharge 1 and 2 recovery threshold

14.9.8.2 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD	Recovery Delay	U1	0	255	5	s

Description: Overcurrent in Discharge 1 and 2 recovery delay

14.9.9 AOLD—Overload in Discharge

14.9.9.1 Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOLD	Latch Limit	U1	0	255	0	counts

Description: Overload latch counter trip threshold

14.9.9.2 Counter Dec Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOLD	Counter Dec Delay	U1	0	255	10	s

Description: Overload latch counter decrement delay

14.9.9.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOLD	Recovery	U1	0	255	5	s

Description: Overload recovery time

14.9.9.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOLD	Reset	U1	0	255	15	s

Description: Overload latch reset time

14.9.9.5 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOLD	Threshold	H1	0x0	0xFF	0xF4	Hex

Description: ***AOLD:Threshold*** Setting	
Bits 7–4:	OLDD: AOLD delay time
Bits 3–0:	OLDV: AOLD threshold

14.9.10 ASCC—Short Circuit In Charge

14.9.10.1 Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCC	Latch Limit	U1	0	255	0	—

Description: Short Circuit in Charge Latch counter trip threshold

14.9.10.2 Counter Dec Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCC	Counter Dec Delay	U1	0	255	10	s

Description: Short Circuit in Charge counter decrement delay

14.9.10.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCC	Recovery	U1	0	255	5	s

Description: Short Circuit in Charge recovery time

14.9.10.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCC	Reset	U1	0	255	15	s

Description: Short Circuit in Charge latch reset time

14.9.10.5 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCC	Threshold	H1	0x0	0xFF	0x77	Hex

Description: ***ASCC:Threshold*** Setting	
Bits 7–4:	SCCD: SCC delay time
Bit 3:	Reserved
Bits 2–0:	SCCV: SCC threshold

14.9.11 ASCD—Short Circuit in Discharge

14.9.11.1 Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Latch Limit	U1	0	255	0	—

Description: Short Circuit in Discharge Latch counter trip threshold

14.9.11.2 Counter Dec Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Counter Dec Delay	U1	0	255	10	s

Description: Short Circuit in Discharge counter decrement delay

14.9.11.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Recovery	U1	0	255	5	s

Description: Short Circuit in Discharge recovery time

14.9.11.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Reset	U1	0	255	15	s

Description: Short Circuit in Discharge latch reset time

14.9.11.5 Thresholds 1 and 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Threshold 1	H1	0x0	0xFF	0x77	Hex
Protections	ASCD	Threshold 2	H1	0x0	0xFF	0xE7	Hex

Threshold 1 Description: ***ASCD:Threshold 1*** Setting	
Bits 7–4:	SCD1D–SCD1 delay time
Bit 3:	Reserved
Bits 2–0:	SCD1V: SCD1 threshold

Threshold 2 Description: ***ASCD:Threshold 2*** Setting	
Bits 7–4:	SCD2D–SCD2 delay time
Bit 3:	Reserved
Bits 2–0:	SCD2V: SCD2 threshold

14.9.12 OTC—Overtemperature in Charge

14.9.12.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTC	Threshold	I2	–400	1500	550	0.1°C

Description: Overtemperature in Charge trip threshold

14.9.12.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTC	Delay	U1	0	255	2	s

Description: Overtemperature in Charge Cell trip delay

14.9.12.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTC	Recovery	I2	–400	1500	500	0.1°C

Description: Overtemperature in Charge Cell recovery threshold

14.9.13 OTD—Overtemperature in Discharge

14.9.13.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTD	Threshold	I2	–400	1500	600	0.1°C

Description: Overtemperature in Discharge trip threshold

14.9.13.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTD	Delay	U1	0	255	2	s

Description: Overtemperature in Discharge trip delay

14.9.13.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTD	Recovery	I2	–400	1500	550	0.1°C

Description: Overtemperature in Discharge recovery threshold

14.9.14 OTF—Overtemperature FET

14.9.14.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Threshold	I2	–400	1500	800	0.1°C

Description: Overtemperature FET trip threshold

14.9.14.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Delay	U1	0	255	2	s

Description: Overtemperature FET trip delay

14.9.14.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Recovery	I2	–400	1500	650	0.1°C

Description: Overtemperature FET recovery threshold

14.9.15 UTC—Under Temperature in Charge

14.9.15.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTC	Threshold	I2	–400	1500	0	0.1°C

Description: Undertemperature in Charge trip threshold

14.9.15.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTC	Delay	U1	0	255	2	s

Description: Undertemperature in Charge Cell trip delay

14.9.15.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTC	Recovery	I2	–400	1500	50	0.1°C

Description: Undertemperature in Charge Cell recovery threshold

14.9.16 UTD—Under Temperature in Discharge

14.9.16.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Threshold	I2	–400	1500	0	0.1°C

Description: Under Temperature in Discharge trip threshold

14.9.16.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Delay	U1	0	255	2	s

Description: Under Temperature in Discharge trip delay

14.9.16.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Recovery	I2	–400	1500	50	0.1°C

Description: Under Temperature in Discharge recovery threshold

14.9.17 HWD—Host Watchdog

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	HWD	Delay	U1	0	255	10	s

Description: SBS Host watchdog trip delay

14.9.18 PTO—Precharge mode Time Out

14.9.18.1 Charge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Charge Threshold	I2	–32768	32767	2000	mA

Description: Precharge Timeout Current Threshold

14.9.18.2 Suspend Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Suspend Threshold	I2	–32768	32767	1800	mA

Description: Precharge Timeout Suspend Threshold

14.9.18.3 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Delay	U2	0	65535	1800	s

Description: Precharge Timeout trip delay

14.9.18.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Reset	I2	–32768	32767	2	mA

Description: Precharge Timeout Reset Threshold

14.9.19 CTO—Fast Charge Mode Time Out

14.9.19.1 Charge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Charge Threshold	I2	–32768	32767	2500	mA

Description: Fast-Charge Timeout Current Threshold

14.9.19.2 Suspend Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Suspend Threshold	I2	–32768	32767	2000	mA

Description: Fast-Charge Timeout Suspend Threshold

14.9.19.3 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Delay	U2	0	65535	54000	s

Description: Fast-Charge Timeout trip delay

14.9.19.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Reset	I2	0	32767	2	mA

Description: Fast-Charge Timeout Reset Threshold

14.9.20 OC—Overcharge

14.9.20.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	Threshold	I2	–32768	32767	300	mAh

Description: Overcharge trip threshold

14.9.20.2 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	Recovery	I2	–32768	32767	2	mAh

Description: Overcharge recovery threshold

14.9.20.3 RSOC Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	RSOC Recovery	U1	0	100	90	%

Description: Overcharge *RelativeStateOfCharge()* recovery threshold

14.9.21 CHGV—ChargingVoltage

14.9.21.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Threshold	I2	–32768	32767	500	mV

Description: *ChargingVoltage()* delta trip threshold

14.9.21.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Delay	U1	0	255	30	s

Description: *ChargingVoltage()* delta trip delay

14.9.21.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Recovery	I2	–32768	32767	–500	mV

Description: *ChargingVoltage()* delta recovery threshold

14.9.22 CHGC—ChargingCurrent

14.9.22.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Threshold	I2	–32768	32767	500	mA

Description: *ChargingCurrent()* delta trip threshold

14.9.22.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Delay	U1	0	255	2	s

Description: *ChargingCurrent()* delta trip delay

14.9.22.3 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Recovery Threshold	I2	–32768	32767	100	mA

Description: *ChargingCurrent()* delta recovery threshold

14.9.22.4 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Recovery Delay	U1	0	255	2	s

Description: *ChargingCurrent()* delta recovery delay

14.9.23 PCHGC—Pre-ChargingCurrent

14.9.23.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Threshold	I2	–32768	32767	50	mA

Description: *Pre-ChargingCurrent()* trip threshold

14.9.23.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Delay	U1	0	255	2	s

Description: *Pre-ChargingCurrent()* trip delay

14.9.23.3 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Recovery Threshold	I2	–32768	32767	10	mA

Description: *Pre-ChargingCurrent()* recovery threshold

14.9.23.4 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Recovery Delay	U1	0	255	2	s

Description: *Pre-ChargingCurrent()* recovery delay

14.10 Permanent Fail

14.10.1 SUV—Safety Cell Undervoltage

14.10.1.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SUV	Threshold	I2	0	32767	2200	mV

Description: Safety Cell Undervoltage trip threshold

14.10.1.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SUV	Delay	U1	0	255	5	s

Description: Safety Cell Undervoltage trip delay

14.10.2 SOV—Safety Cell Overvoltage

14.10.2.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOV	Threshold	I2	0	32767	4500	mV

Description: Safety Cell Overvoltage trip threshold

14.10.2.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOV	Delay	U1	0	255	5	s

Description: Safety Cell Overvoltage trip delay

14.10.3 SOCC—Safety Overcurrent in Charge

14.10.3.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOCC	Threshold	I2	–32768	32767	10000	mA

Description: Safety Overcurrent in Charge trip threshold

14.10.3.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOCC	Delay	U1	0	255	5	s

Description: Safety Overcurrent in Charge trip delay

14.10.4 SOCD—Safety Overcurrent in Discharge

14.10.4.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOCD	Threshold	I2	–32768	32767	–10000	mA

Description: Safety Overcurrent in Discharge trip threshold

14.10.4.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOCD	Delay	U1	0	255	5	s

Description: Safety Overcurrent in Discharge trip delay

14.10.5 SOT—Overtemperature Cell

14.10.5.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOT	Threshold	I2	–400	1500	650	0.1°C

Description: Overtemperature Cell trip threshold

14.10.5.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOT	Delay	U1	0	255	5	s

Description: Overtemperature Cell trip delay

14.10.6 SOTF—Overtemperature FET

14.10.6.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOTF	Threshold	I2	–400	1500	1000	0.1°C

Description: Overtemperature FET trip threshold

14.10.6.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOTF	Delay	U1	0	255	5	s

Description: Overtemperature FET trip delay

14.10.7 Open Thermistor—NTC Thermistor Failure

14.10.7.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	Threshold	I2	0	32767	2232	0.1 °K

Description: Temperature threshold for open thermistor

14.10.7.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	Delay	U1	0	255	5	s

Description: Trip delay for open thermistor

14.10.7.3 FET Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	FET Delta	I2	0	–400	1500	0.1 °K

Description: Delta from internal temperature to enable Open Thermistor check for FET thermistors

14.10.7.4 Cell Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	Cell Delta	I2	0	–400	1500	0.1 °K

Description: Delta from internal temperature to enable Open Thermistor check for cell thermistors

14.10.8 VIMR—Voltage Imbalance At Rest

14.10.8.1 Check Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Check Voltage	I2	0	5000	3500	mV

Description: Voltage Imbalance At Rest Check Voltage

14.10.8.2 Check Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Check Current	I2	0	32767	10	mA

Description: Voltage Imbalance At Rest Check Current

14.10.8.3 Delta Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Delta Threshold	I2	0	5000	200	mV

Description: Voltage Imbalance At Rest trip threshold

14.10.8.4 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Delay	U1	0	255	5	s

Description: Voltage Imbalance At Rest Check trip delay

14.10.8.5 Duration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Duration	U2	0	65535	100	s

Description: Voltage Imbalance At Rest Check Duration

14.10.9 VIMA—Voltage Imbalance Active

14.10.9.1 Check Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Check Voltage	I2	0	5000	3700	mV

Description: Voltage Imbalance Active Check voltage

14.10.9.2 Check Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Check Current	I2	0	32767	50	mA

Description: Voltage Imbalance Active Check Current

14.10.9.3 Delta Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Delta Threshold	I2	0	5000	300	mV

Description: Voltage Imbalance active trip threshold

14.10.9.4 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Delay	U1	0	255	5	s

Description: Voltage Imbalance active check trip Delay

14.10.10 CFET—CHG FET Failure

14.10.10.1 OFF Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CFET	OFF Threshold	I2	0	500	5	mA

Description: CHG FET OFF current trip threshold

14.10.10.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CFET	Delay	U1	0	255	5	s

Description: CHG FET OFF trip delay

14.10.11 DFET—DFET Failure

14.10.11.1 OFF Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	DFET	OFF Threshold	I2	–500	0	–5	mA

Description: DSG FET OFF current trip threshold

14.10.11.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	DFET	Delay	U1	0	255	5	s

Description: DSG FET OFF trip delay

14.10.12 FUSE—FUSE Failure

14.10.12.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	FUSE	Threshold	I2	0	255	5	mA

Description: FUSE activation fail trip threshold

14.10.12.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	FUSE	Delay	U1	0	255	5	s

Description: FUSE activation fail trip delay

14.10.13 AFER—AFE Register

14.10.13.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFER	Threshold	U1	0	255	100	—

Description: AFE Register comparison fail trip threshold

14.10.13.2 Delay Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFER	Delay Period	U1	0	255	5	s

Description: AFE Register comparison counter decrement period

14.10.13.3 Compare Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFER	Compare Period	U1	0	255	5	s

Description: AFE Register comparison compare period

14.10.14 AFEC—AFE Communication

14.10.14.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFEC	Threshold	U1	0	255	100	—

Description: AFE Communication fail trip threshold

14.10.14.2 Delay Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFEC	Delay Period	U1	0	255	5	s

Description: AFE Communication counter decrement period

14.10.15 2LVL—2nd Level OV

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	2LVL	Threshold	U1	0	255	5	s

Description: 2nd Level Protector trip detection delay

14.10.16 OPNCELL—Open Cell Connection

14.10.16.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	OPNCELL	Threshold	I2	0	32767	5000	mV

Description: Open Cell Tab Connection trip threshold

14.10.16.2 Delay Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	OPNCELL	Delay Period	U1	0	255	5	s

Description: Open Cell Tab Connection trip delay

14.11 PF Status

The data in this class is saved at the time of the PF event.

14.11.1 Device Status Data

14.11.1.1 Safety Alert A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert A	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.2 Safety Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status A	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.3 Safety Alert B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert B	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.4 Safety Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status B	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.5 Safety Alert C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert C	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.6 Safety Status C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status C	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.7 Safety Alert D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert D	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.8 Safety Status D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status D	H1	0x0	0xFF	0x0	Hex

Description: Accumulated safety flags since PF event

14.11.1.9 PF Alert A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert A	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.10 PF Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status A	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.11 PF Alert B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert B	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.12 PF Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status B	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.13 PF Alert C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert C	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.14 PF Status C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status C	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.15 PF Alert D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert D	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.16 PF Status D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status D	H1	0x0	0xFF	0x0	Hex

Description: Accumulated PF flags since PF event

14.11.1.17 Fuse Flag

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Fuse Flag	H2	0x0	0xFFFF	0x0	Hex

Description: Flag set to indicate fuse blow

14.11.1.18 Operation Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Operation Status A	H2	0x0	0xFFFF	0x0	Hex

Description: *OperationStatus()* data at the time of the PF event

14.11.1.19 Operation Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Operation Status B	H2	0x0	0xFFFF	0x0	Hex

Description: *OperationStatus()* data at the time of the PF event

14.11.1.20 Temp Range

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Temp Range	H1	0x0	0xFF	0x0	Hex

Description: Temperature range status at the time of the PF event. The temperature range information returned by *ChargingStatus()*

14.11.1.21 Charging Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Charging Status A	H1	0x0	0xFF	0x0	Hex

Description: The charging status at the time of the PF event. See Section 13.48 for the bit definitions.

7	6	5	4	3	2	1	0
VCT	MCHG	SU	IN	HV	MV	LV	PV

14.11.1.22 Charging Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Charging Status B	H1	0x0	0xFF	0x0	Hex

Description: The charging status at the time of the PF event. See Section 13.48 for the bit definitions.

7	6	5	4	3	2	1	0
VCT	RSVD	RSVD	RSVD	RSVD	CCC	CVR	CCR

14.11.1.23 Gauging Status

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Gauging Status	H1	0x0	0xFF	0x0	Hex

Description: The gauging status at the time of the PF event.

7	6	5	4	3	2	1	0
CF	DSG	EDV0	BAL_EN	TCA	TDA	FC	FD

14.11.1.24 CEDV Status

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	CEDV Status	H1	0x0	0xFF	0x0	Hex

Description: The CEDV status at the time of the PF event. See Section 13.48for the bit definitions.

7	6	5	4	3	2	1	0
VDQ	EDV2	EDV1	RSVD	RSVD	FCCX	OCVFR	REST

VDQ (Bit 7): Discharge Qualified for Learning (based on RU flag)

1 = Detected

0 = Not Detected

EDV2 (Bit 6): End-of-Discharge Voltage 2 has been reached.

1 = EDV2 point has been reached during discharge.

0 = EDV2 point has not been reached during discharge.

EDV1 (Bit 5): End-of-Discharge Voltage 1 has been reached.

1 = EDV1 point has been reached during discharge.

0 = EDV1 point has not been reached during discharge.

RSVD (Bits 4–3): Reserved. Do not use.

FCCX (Bit 2): When the FCC value is updated on reaching EDV2, then this flag is set (stays on till the end of discharge).

1 = FCC value has been updated.

0 = FCC value has not been updated.

OCVFR (Bit 1): Open Circuit Voltage in Flat Region (During RELAX)

1 = Detected

0 = Not Detected

REST (Bit 0): Rest

1 = OCV Reading Taken

0 = OCV Reading Not Taken or Not in RELAX

14.11.2 Device Voltage Data

14.11.2.1 Cell 1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Cell 1 Voltage	I2	–32768	32767	0	mV

Description: Cell 1 voltage

14.11.2.2 Cell 2 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Cell 2 Voltage	I2	–32768	32767	0	mV

Description: Cell 2 voltage

14.11.2.3 Cell 3 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Cell 3 Voltage	I2	–32768	32767	0	mV

Description: Cell 3 voltage

14.11.2.4 Cell 4 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Cell 4 Voltage	I2	–32768	32767	0	mV

Description: Cell 4 voltage

14.11.2.5 Battery Direct Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Battery Direct Voltage	I2	–32768	32767	0	mV

Description: Battery voltage

14.11.2.6 Pack Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Pack Voltage	I2	–32768	32767	0	mV

Description: Pack pin voltage

14.11.3 Device Current Data

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Current Data	Current	I2	–32768	32767	0	mV

Description: *Current()*

14.11.4 Device Temperature Data

14.11.4.1 Internal Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	Internal Temperature	I2	–32768	32767	0	0.1°K

Description: Internal temperature sensor temperature

14.11.4.2 External 1 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 1 Temperature	I2	–32768	32767	0	0.1°K

Description: External TS1 temperature

14.11.4.3 External 2 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 2 Temperature	I2	–32768	32767	0	0.1°K

Description: External TS2 temperature

14.11.4.4 External 3 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 3 Temperature	I2	–32768	32767	0	0.1°K

Description: External TS3 temperature

14.11.4.5 External 4 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 4 Temperature	I2	–32768	32767	0	0.1°K

Description: External TS4 temperature

14.11.5 AFE Regs

The ***AFE Regs*** data is intended for Texas Instruments' use to help with internal firmware diagnostics.

14.11.5.1 AFE Interrupt Status

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE Interrupt Status	H1	0x00	0xFF	0x00	Hex

Description: AFE Interrupt Status Register Contents

14.11.5.2 AFE FET Status

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE FET Status	H1	0x00	0xFF	0x00	Hex

Description: AFE FET Status Register Contents

14.11.5.3 AFE RXIN

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE RXIN	H1	0x00	0xFF	0x00	Hex

Description: AFE Rxin Register Contents

14.11.5.4 AFE Latch Status

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE Latch Status	H1	0x00	0xFF	0x00	Hex

Description: AFE Latch Status Register Contents

14.11.5.5 AFE Interrupt Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE Interrupt Enable	H1	0x00	0xFF	0x00	Hex

Description: AFE Interrupt Enable Register Contents

14.11.5.6 AFE FET Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE FET Control	H1	0x00	0xFF	0x00	Hex

Description: AFE FET Control Register Contents

14.11.5.7 AFE RXIEN

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE RXIEN	H1	0x00	0xFF	0x00	Hex

Description: AFE RXIEN Register Contents

14.11.5.8 AFE RLOUT

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE RLOUT	H1	0x00	0xFF	0x00	Hex

Description: AFE RLOUT Register Contents

14.11.5.9 AFE RHOUT

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE RHOUT	H1	0x00	0xFF	0x00	Hex

Description: AFE RHOUT Register Contents

14.11.5.10 AFE RHINT

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE RHINT	H1	0x00	0xFF	0x00	Hex

Description: AFE RHINT Register Contents

14.11.5.11 AFE Cell Balance

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE Cell Balance	H1	0x00	0xFF	0x00	Hex

Description: AFE Cell Balance Register Contents

14.11.5.12 AFE AD/CC Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE AD/CC Control	H1	0x00	0xFF	0x00	Hex

Description: AFE AD/CC Control Register Contents

14.11.5.13 AFE ADC Mux

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE ADC Mux	H1	0x00	0xFF	0x00	Hex

Description: AFE ADC Mux Register Contents

14.11.5.14 AFE LED Output

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE LED Output	H1	0x00	0xFF	0x00	Hex

Description: AFE LED Output Register Contents

14.11.5.15 AFE State Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE State Control	H1	0x00	0xFF	0x00	Hex

Description: AFE State Control Register Contents

14.11.5.16 AFE LED/Wake Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE LED/Wake Control	H1	0x00	0xFF	0x00	Hex

Description: AFE LED/Wake Control Register Contents

14.11.5.17 AFE Protection Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE Protection Control	H1	0x00	0xFF	0x00	Hex

Description: AFE Protection Control Register Contents

14.11.5.18 AFE OCD

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE OCD	H1	0x00	0xFF	0x00	Hex

Description: AFE OCD Register Contents

14.11.5.19 AFE SCC

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE SCC	H1	0x00	0xFF	0x00	Hex

Description: AFE SCC Register Contents

14.11.5.20 AFE SCD1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE SCD1	H1	0x00	0xFF	0x00	Hex

Description: AFE SCD1 Register Contents

14.11.5.21 AFE SCD2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	AFE SCD2	H1	0x00	0xFF	0x00	Hex

Description: AFE SCD2 Register Contents

14.12 Black Box

14.12.1 Safety Status

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Black Box	Safety Status	1st Status Status A	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Status Status B	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Safety Status C	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Safety Status D	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Time to Next Event	U1	0	255	0	s	Time from 1st event to 2nd event
Black Box	Safety Status	2nd Status Status A	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	2nd Status Status B	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Black Box	Safety Status	2nd Safety Status C	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	2nd Safety Status D	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	2nd Time to Next Event	U1	0	255	0	s	Time from 2nd event to 3rd event
Black Box	Safety Status	3rd Status Status A	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Status Status B	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Safety Status C	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Safety Status D	H1	0x0	0xFF	0x0	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Time to Next Event	U1	0	255	0	s	Time since 3rd event

14.12.2 PF Status

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Black Box	PF Status	1st PF Status A	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	1st PF Status B	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	1st PF Status C	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	1st PF Status D	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	1st Time to Next Event	U1	0	255	0	s	Time from 1st event to 2nd event
Black Box	PF Status	2nd PF Status A	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	2nd PF Status B	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	2nd PF Status C	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	2nd PF Status D	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	2nd Time to Next Event	U1	0	255	0	s	Time from 2nd event to 3rd event
Black Box	PF Status	3rd PF Status A	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	3rd PF Status B	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	3rd PF Status C	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	3rd PF Status D	H1	0x0	0xFF	0x0	Hex	*PFStatus()* data
Black Box	PF Status	3rd Time to Next Event	U1	0	255	0	s	Time since 3rd event

14.13 Gas Gauging

14.13.1 CEDV Profile 1

Subclass ID	Subclass Name	Name	Type	Min	Max	Default	Unit
Gas Gauging	CEDV Profile 1	Voltage 0% DOD	I2	–32768	32767	4173	mV
Gas Gauging	CEDV Profile 1	Voltage 10% DOD	I2	–32768	32767	4043	mV
Gas Gauging	CEDV Profile 1	Voltage 20% DOD	I2	–32768	32767	3925	mV
Gas Gauging	CEDV Profile 1	Voltage 30% DOD	I2	–32768	32767	3821	mV
Gas Gauging	CEDV Profile 1	Voltage 40% DOD	I2	–32768	32767	3725	mV
Gas Gauging	CEDV Profile 1	Voltage 50% DOD	I2	–32768	32767	3656	mV

Subclass ID	Subclass Name	Name	Type	Min	Max	Default	Unit
Gas Gauging	CEDV Profile 1	Voltage 60% DOD	I2	–32768	32767	3619	mV
Gas Gauging	CEDV Profile 1	Voltage 70% DOD	I2	–32768	32767	3582	mV
Gas Gauging	CEDV Profile 1	Voltage 80% DOD	I2	–32768	32767	3515	mV
Gas Gauging	CEDV Profile 1	Voltage 90% DOD	I2	–32768	32767	3439	mV
Gas Gauging	CEDV Profile 1	Voltage 100% DOD	I2	–32768	32767	2713	mV

Description: Sets the CEDV profile at different DoD points

14.13.2 CEDV Cfg

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	CEDV Cfg	EMF	U2	0	65535	3743	—	This is the no-load cell voltage calculated and based on higher than the highest cell EDV threshold.
Gas Gauging	CEDV Cfg	C0	U2	0	65535	149	—	This value is the no-load capacity related EDV adjustment factor.
Gas Gauging	CEDV Cfg	R0	U2	0	65535	867	—	First order rate dependency factor, accounting for battery impedance adjustment
Gas Gauging	CEDV Cfg	T0	U2	0	65535	4030	—	Adjusts for the variation of impedance with battery temperature
Gas Gauging	CEDV Cfg	R1	U2	0	65535	316	—	Adjusts for the variation of impedance with battery capacity
Gas Gauging	CEDV Cfg	TC	U1	0	255	9	—	Adjusts for the variation of impedance for cold temperature (T < 23°C)
Gas Gauging	CEDV Cfg	C1	U1	0	255	0	—	This value is the desired reserved battery capacity remaining at EDV0.
Gas Gauging	CEDV Cfg	Age factor	H2	0	255	0	—	Allows the algorithm to compensate EDV detection for cell aging
Gas Gauging	CEDV Cfg	Fixed EDV0	H2	0	32767	3031	—	This value is the EDV0 threshold if ***[CEDV]*** is clear in ***CEDV Config.***
Gas Gauging	CEDV Cfg	Fixed EDV0 Delay	U1	0	255	0	—	Delay time enforced before qualifying EDV0 is met.
Gas Gauging	CEDV Cfg	Fixed EDV1	H2	0	32767	3385	—	This value is the EDV1 threshold if ***[CEDV]*** is clear in ***CEDV Config.***
Gas Gauging	CEDV Cfg	Fixed EDV1 Delay	H2	0	255	0	—	Delay time enforced before qualifying EDV1 is met.
Gas Gauging	CEDV Cfg	Fixed EDV2	H2	0	32767	3501	—	This value is the EDV2 threshold if ***[CEDV]*** is clear in ***CEDV Config.***
Gas Gauging	CEDV Cfg	Fixed EDV2 Delay	H2	0	255	0	—	Delay time enforced before qualifying EDV2 is met.
Gas Gauging	CEDV Cfg	Battery Low %	U1	0	65535	700	0.1%	This value should be a capacity value that corresponds to the first or highest voltage point EDV2.
Gas Gauging	CEDV Cfg	Learning Low Temp	U1	0	255	119	0.1C	This is the minimum temperature above which discharge must maintain to qualify for a capacity learning.
Gas Gauging	CEDV Cfg	Overload Current	I2	0	32767	5000	mA	This is the value for upper current range for EDV detection. Beyond this value EDV detection is halted.
Gas Gauging	CEDV Cfg	Self Discharge Rate	U1	0	255	20	0.01%/day	This is an estimation for the self-discharge of the battery.
Gas Gauging	CEDV Cfg	Electronic Load	I2	0	255	0	3 µA	This is the value set to a discharge rate determined by the battery electronics current consumption.
Gas Gauging	CEDV Cfg	Near Full	I2	0	32767	200	mAh	This value sets the discharge condition for qualified capacity learning.
Gas Gauging	CEDV Cfg	Reserve capacity	I2	0	32767	0	mAh	Determines (if Load Mode = 0) how much actual remaining capacity exists when the gas gauge reports zero *RemainingCapacity()* before reaching Termination Voltage.
Gas Gauging	CEDV Cfg	Chg Eff	U1	0	100	100	%	This value compensates for efficiency loss during charging when estimating total capacity value.
Gas Gauging	CEDV Cfg	Dsg Eff	U1	0	100	100	%	This value compensates for efficiency loss during discharging when estimating total capacity value.

14.13.3 CEDV Smoothing Config

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	CEDV Smoothing Config	Smoothing Start Voltage	I2	0	4300	3700	mV	Sets the voltage from where smoothing will start
Gas Gauging	CEDV Smoothing Config	Smoothing Delta Voltage	I2	0	4200	100	mV	Sets the delta voltage for smoothing
Gas Gauging	CEDV Smoothing Config	Max Smoothing Current	U2	0	65535	8000	mA	Sets the max current for smoothing
Gas Gauging	CEDV Smoothing Config	EOC Smooth Current	U1	0	10	2	%	Sets the End Of Charge Smoothing current
Gas Gauging	CEDV Smoothing Config	EOC Smooth Current Time	U1	0	255	60	s	Sets the End Of Charge Smoothing time

14.13.4 Current Thresholds

14.13.4.1 Dsg Current Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Dsg Current Threshold	I2	–32768	32767	100	mA

Description: DISCHARGE mode *Current()* threshold

14.13.4.2 Chg Current Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Chg Current Threshold	I2	–32768	32767	50	mA

Description: CHARGE mode *Current()* threshold

14.13.4.3 Quit Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Quit Current	I2	0	32767	10	mA

Description: |*Current()*| threshold to enter rest mode

14.13.4.4 Dsg Relax Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Dsg Relax Time	U1	0	255	1	mA

Description: Discharge to relax timeout. When discharge is stopped, the device will exit the DISCHARGE mode after this time is passed.

14.13.4.5 Chg Relax Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Chg Relax Time	U1	0	255	60	mA

Description: Charge to relax timeout. When charging is stopped, the device will exit the CHARGE mode after this time is passed.

14.13.5 Design

14.13.5.1 Design Capacity mAh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Design	Design Capacity mAh	I2	0	32767	4400	mAh

Description: Design Capacity in mAh. This is reported by *DesignCapacity()* if ***[CAPM]*** = 0.

14.13.5.2 Design Capacity in cWh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Design	Design Capacity cWh	I2	0	32767	6336	cWh

Description: Design Capacity in cWh. This is reported by *DesignCapacity()* if ***[CAPM]*** = 1.

14.13.5.3 Design Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Design	Design Voltage	I2	0	32767	14400	mV

Description: Design Voltage. This is reported by *DesignVoltage()*.

14.13.6 Cycle

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Cycle	Cycle Count Percentage	U1	0	100	90	%

Description: This is a threshold to increment the ***Cycle Count*** if the accumulated discharge is more than this set percentage of *FullChargeCapacity()* (if ***[CCT]*** = 1) or *DesignCapacity()* (if ***[CCT]*** = 0). Note that a minimum of 10% of *DesignCapacity()* change of the accumulated discharge is required for cycle count increment. This is to prevent an erroneous cycle count increment due to extremely low *FullChargeCapacity()*.

14.13.7 FD

14.13.7.1 Set Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FD	Set Voltage Threshold	I2	0	5000	3000	mV

Description: *GaugingStatus()[FD]* and *BatteryStatus()[FD]* cell voltage set threshold

14.13.7.2 Clear Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FD	Clear Voltage Threshold	I2	0	5000	3100	mV

Description: *GaugingStatus()[FD]* and *BatteryStatus()[FD]* cell voltage clear threshold

14.13.7.3 Set RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FD	Set RSOC % Threshold	U1	0	100	0	%

Description: *GaugingStatus()[FD]* and *BatteryStatus()[FD] RelativeStateOfCharge()* set threshold

14.13.7.4 Clear RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FD	Clear RSOC % Threshold	U1	0	100	5	%

Description: *GaugingStatus()[FD]* and *BatteryStatus()[FD] RelativeStateOfCharge()* clear threshold

14.13.8 FC

14.13.8.1 Set Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FC	Set Voltage Threshold	I2	0	5000	4200	mV

Description: *GaugingStatus()[FC]* and *BatteryStatus()[FC]* cell voltage set threshold

14.13.8.2 Clear Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FC	Clear Voltage Threshold	I2	0	5000	4100	mV

Description: *GaugingStatus()[FC]* and *BatteryStatus()[FC]* cell voltage clear threshold

14.13.8.3 Set RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FC	Set RSOC % Threshold	U1	0	100	100	%

Description: *GaugingStatus()[FC]* and *BatteryStatus()[FC] RelativeStateOfCharge()* set threshold

14.13.8.4 Clear RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	FC	Clear RSOC % Threshold	U1	0	100	95	%

Description: *GaugingStatus()[FC]* and *BatteryStatus()[FC] RelativeStateOfCharge()* clear threshold

14.13.9 TD

GaugingStatus()[TD] is used to set *BatteryStatus()[TDA]* when in DISCHARGE mode.

14.13.9.1 Set Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TD	Set Voltage Threshold	I2	0	5000	3200	mV

Description: *GaugingStatus()[TD]* cell voltage set threshold

14.13.9.2 Clear Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TD	Clear Voltage Threshold	I2	0	5000	3300	mV

Description: *GaugingStatus()[TD]* cell voltage clear threshold

14.13.9.3 Set RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TD	Set RSOC % Threshold	U1	0	100	6	%

Description: *GaugingStatus()[TD] RelativeStateOfCharge()* set threshold

14.13.9.4 Clear RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TD	Clear RSOC % Threshold	U1	0	100	8	%

Description: *GaugingStatus()[TD] RelativeStateOfCharge()* clear threshold

14.13.10 TC

GaugingStatus()[TC] is used to set *BatteryStatus()[TCA]* when in CHARGE mode

14.13.10.1 Set Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TC	Set Voltage Threshold	I2	0	5000	4200	mV

Description:*GaugingStatus()[TC]* cell voltage set threshold

14.13.10.2 Clear Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TC	Clear Voltage Threshold	I2	0	5000	4100	mV

Description:*GaugingStatus()[TC]* cell voltage clear threshold

14.13.10.3 Set RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TC	Set RSOC % Threshold	U1	0	100	100	%

Description:*GaugingStatus()[TC] RelativeStateOfCharge()* set threshold

14.13.10.4 Clear RSOC % Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	TC	Clear RSOC % Threshold	U1	0	100	95	%

Description:*GaugingStatus()[TC] RelativeStateOfCharge()* clear threshold

14.13.11 State

14.13.11.1 Learned Full Charge Capacity

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Learned Full Charge Capacity	I2	0	32767	4400	mAh

Description: This is the full maximum chemical capacity of the battery pack.

14.13.11.2 Cycle Count

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Cycle Count	U2	0	65535	0	—

Description: Value reported by *CycleCount()*. Updated by the gauge automatically based on ***Cycle Count Percentage***.

14.14 SBS Configuration

14.14.1 Data

14.14.1.1 Remaining Ah Capacity Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Remaining Ah Capacity Alarm	U2	0	700	300	mAh

Description: *RemainingCapacityAlarm()* value in mAh

14.14.1.2 Remaining Wh Capacity Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Remaining Wh Capacity Alarm	U2	0	1000	432	cWh

Description: *RemainingCapacityAlarm()* value in 10 mWh

14.14.1.3 Remaining Time Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Remaining Time Alarm	U2	0	30	10	min

Description: *RemainingTimeAlarm()* value

14.14.1.4 Initial Battery Mode

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Initial Battery Mode	H2	0x0000	0xFFFF	0x0081	—

15	14	13	12	11	10	9	8
CAPM	CHGM	AM	RSVD	RSVD	RSVD	PB	CC

7	6	5	4	3	2	1	0
CF	RSVD	RSVD	RSVD	RSVD	RSVD	PBS	ICC

CAPM (Bit 15): Capacity_Mode (R/W)

1 = Report in 10 mW or 10 mWh

0 = Report in mA or mAh (default)

CHGM (Bit 14): Charger_Mode (R/W)

1 = Disable *ChargingVoltage()* and *ChargingCurrent()* broadcasts to host and smart battery charger (default)

0 = Enable *ChargingVoltage()* and *ChargingCurrent()* broadcasts to host and smart battery charger

AM (Bit 13): ALARM Mode (R/W)

1 = Disable AlarmWarning broadcasts to host and smart battery charger

0 = Enable AlarmWarning broadcasts to host and smart battery charger (default)

RSVD (Bits 12–10): Reserved. Do not use.

PB (Bit 9): Primary_Battery (R/W)

1 = Battery operating in its primary role

0 = Battery operating in its secondary role (default)

CC (Bit 8): Charge_Controller_Enabled (R/W)

1 = Internal charge control enabled

0 = Internal charge control disabled (default)

CF (Bit 7): Condition_Flag (R)

1 = Conditioning cycle requested

0 = Battery OK

RSVD (Bits 6–2): Reserved. Do not use.

PBS (Bit 1): Primary_Battery_Support (R)

1 = Primary or secondary battery support

0 = Function not supported (default)

ICC (Bit 0): Internal_Charge_Controller (R)

1 = Function supported

0 = Function not supported (default)

14.14.1.5 Specification Information

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Specification Information	H2	0x0000	0xFFFF	0x0031	—

15	14	13	12	11	10	9	8
IPScale	IPScale	IPScale	IPScale	VScale	VScale	VScale	VScale

7	6	5	4	3	2	1	0
Version	Version	Version	Version	Revision	Revision	Revision	Revision

SpecificationInformation() values

IPScale (Bits 15–12): IP Scale Factor

0,0,0,0 = Reported currents and capacities scaled by 10E0 except *ChargingVoltage()* and *ChargingCurrent()*

0,0,0,1 = Reported currents and capacities scaled by 10E1 except *ChargingVoltage()* and *ChargingCurrent()*

0,0,1,0 = Reported currents and capacities scaled by 10E2 except *ChargingVoltage()* and *ChargingCurrent()*

0,0,1,1 = Reported currents and capacities scaled by 10E3 except *ChargingVoltage()* and *ChargingCurrent()*

VScale (Bits 11–8): Voltage Scale Factor

0,0,0,0 = Reported voltages scaled by 10E0

0,0,0,1 = Reported voltages scaled by 10E1

0,0,1,0 = Reported voltages scaled by 10E2

0,0,1,1 = Reported voltages scaled by 10E3

Version (Bits 7–4): Version

0,0,0,1 = Version 1.0

0,0,1,1 = Version 1.1

0,0,1,1 = Version 1.1 with optional PEC support

Revision (Bits 3–0): Revision

0,0,0,1 = Version 1.0 and 1.1 (default)

14.14.1.6 Manufacturer Date

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Manufacturer Date	U2	0	65535	01/01/80	—

Description: *ManufacturerDate()* value in the following format: Day + Month*32 + (Year–1980) * 512

14.14.1.7 Serial Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Serial Number	H2	0x0000	0xFFFF	0x0001	—

Description: *SerialNumber()* value

14.14.1.8 Manufacturer Name

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Manufacturer Name	S20+1	—	—	Texas Instruments	ASCII

Description: *ManufacturerName()* value

14.14.1.9 Device Name

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Device Name	S20+1	—	—	BQ4050	ASCII

Description: *DeviceName()* value

14.14.1.10 Device Chemistry

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Device Chemistry	S4+1	—	—	LION	ASCII

Description: *DeviceChemistry()* value

14.15 Data Flash Summary

Table 14-1. Data Flash Summary

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Calibration	Voltage	0x4000	I2	Cell Gain	–32767	32767	12101	—
Calibration	Voltage	0x4002	U2	Pack Gain	0	65535	49669	—
Calibration	Voltage	0x4004	U2	BAT Gain	0	65535	48936	—
Calibration	Current	0x4006	F4	CC Gain	1.00E–01	4.00E+00	3.58422	—
Calibration	Current	0x400a	F4	Capacity Gain	2.98E+04	1.19E+06	1069035.256	—
Calibration	Current Offset	0x400e	I2	CC Offset	–32767	32767	0	—
Calibration	Current Offset	0x4010	U2	Coulomb Counter Offset Samples	0	65535	64	—
Calibration	Current Offset	0x4012	I2	Board Offset	–32768	32767	0	—
Calibration	Current Offset	0x40c0	H1	CC Auto Config	0x00	0x07	0x03	Hex
Calibration	Current Offset	0x40c1	I2	CC Auto Offset	–10000	10000	0	—
Calibration	Temperature	0x4014	I1	Internal Temp Offset	–128	127	0	0.1°C
Calibration	Temperature	0x4015	I1	External1 Temp Offset	–128	127	0	0.1°C
Calibration	Temperature	0x4016	I1	External2 Temp Offset	–128	127	0	0.1°C
Calibration	Temperature	0x4017	I1	External3 Temp Offset	–128	127	0	0.1°C
Calibration	Temperature	0x4018	I1	External4 Temp Offset	–128	127	0	0.1°C
Calibration	Internal Temp Model	0x4380	I2	Int Gain	–32768	32767	–12143	—
Calibration	Internal Temp Model	0x4382	I2	Int base offset	–32768	32767	6232	—
Calibration	Internal Temp Model	0x4384	I2	Int Minimum AD	–32768	32767	0	—
Calibration	Internal Temp Model	0x4386	I2	Int Maximum Temp	–32768	32767	6232	0.1°K
Calibration	Cell Temperature Model	0x4388	I2	Coeff a1	–32768	32767	–11130	—

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Calibration	Cell Temperature Model	0x438a	I2	Coeff a2	–32768	32767	19142	—
Calibration	Cell Temperature Model	0x438c	I2	Coeff a3	–32768	32767	–19262	—
Calibration	Cell Temperature Model	0x438e	I2	Coeff a4	–32768	32767	28203	—
Calibration	Cell Temperature Model	0x4390	I2	Coeff a5	–32768	32767	892	—
Calibration	Cell Temperature Model	0x4392	I2	Coeff b1	–32768	32767	328	—
Calibration	Cell Temperature Model	0x4394	I2	Coeff b2	–32768	32767	–605	—
Calibration	Cell Temperature Model	0x4396	I2	Coeff b3	–32768	32767	–2443	—
Calibration	Cell Temperature Model	0x4398	I2	Coeff b4	–32768	32767	4696	—
Calibration	Cell Temperature Model	0x439a	I2	Rc0	–32768	32767	11703	—
Calibration	Cell Temperature Model	0x439c	I2	Adc0	–32768	32767	11703	—
Calibration	Cell Temperature Model	0x439e	I2	Rpad	–32768	32767	0	—
Calibration	Cell Temperature Model	0x43a0	I2	Rint	–32768	32767	0	—
Calibration	Fet Temperature Model	0x43a2	I2	Coeff a1	–32768	32767	–11130	—
Calibration	Fet Temperature Model	0x43a4	I2	Coeff a2	–32768	32767	19142	—
Calibration	Fet Temperature Model	0x43a6	I2	Coeff a3	–32768	32767	–19262	—
Calibration	Fet Temperature Model	0x43a8	I2	Coeff a4	–32768	32767	28203	—
Calibration	Fet Temperature Model	0x43aa	I2	Coeff a5	–32768	32767	892	—
Calibration	Fet Temperature Model	0x43ac	I2	Coeff b1	–32768	32767	328	—
Calibration	Fet Temperature Model	0x43ae	I2	Coeff b2	–32768	32767	–605	—
Calibration	Fet Temperature Model	0x43b0	I2	Coeff b3	–32768	32767	–2443	—
Calibration	Fet Temperature Model	0x43b2	I2	Coeff b4	–32768	32767	4696	—
Calibration	Fet Temperature Model	0x43b4	I2	Rc0	–32768	32767	11703	—
Calibration	Fet Temperature Model	0x43b6	I2	Adc0	–32768	32767	11703	—
Calibration	Fet Temperature Model	0x43b8	I2	Rpad	–32768	32767	0	—
Calibration	Fet Temperature Model	0x43ba	I2	Rint	–32768	32767	0	—
Calibration	Current Deadband	0x43c6	U1	Deadband	0	255	3	mA
Calibration	Current Deadband	0x43c7	U1	Coulomb Counter Deadband	0	255	9	116 nV
Settings	Protection	0x447c	H1	Protection Configuration	0x0	0x03	0x0	Hex
Settings	Protection	0x447d	H1	Enabled Protections A	0x0	0xff	0xff	Hex
Settings	Protection	0x447e	H1	Enabled Protections B	0x0	0xff	0x3f	Hex
Settings	Protection	0x447f	H1	Enabled Protections C	0x0	0xff	0xd5	Hex
Settings	Protection	0x4480	H1	Enabled Protections D	0x0	0xff	0x0f	Hex
Settings	Permanent Failure	0x44f5	H1	Enabled PF A	0x0	0xff	0x0	Hex

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Settings	Permanent Failure	0x44f6	H1	Enabled PF B	0x0	0xff	0x0	Hex
Settings	Permanent Failure	0x44f7	H1	Enabled PF C	0x0	0xff	0x0	Hex
Settings	Permanent Failure	0x44f8	H1	Enabled PF D	0x0	0xff	0x0	Hex
Settings	Configuration	0x4407	H1	FET Options	0x0	0xff	0x20	Hex
Settings	Configuration	0x4408	H1	Sbs Gauging Configuration	0x0	0x0f	0x04	Hex
Settings	Configuration	0x4409	H1	Sbs Configuration	0x0	0xff	0x20	Hex
Settings	Configuration	0x440b	H1	Power Config	0x0	0x81	0x00	Hex
Settings	Configuration	0x440c	H1	IO Config	0x0	0x03	0x00	Hex
Settings	Configuration	0x442e	H2	LED Configuration	0x0	0x01ff	0x00d0	Hex
Settings	Configuration	0x4455	H2	SOC Flag Config A	0x0	0x0fff	0x0c8c	Hex
Settings	Configuration	0x4457	H1	SOC Flag Config B	0x0	0xff	0x8c	Hex
Settings	Configuration	0x4470	H1	CEDV Smoothing Config	0x0	0xff	0x08	Hex
Settings	Configuration	0x4534	H1	Charging Configuration	0x0	0x3f	0x0	Hex
Settings	Configuration	0x4579	H1	Temperature Enable	0x0	0x1f	0x06	Hex
Settings	Configuration	0x457a	H1	Temperature Mode	0x0	0x1f	0x04	Hex
Settings	Configuration	0x457b	H1	DA Configuration	0x0	0xff	0x12	Hex
Settings	Configuration	0x458e	H2	CEDV Gauging Configuration	0x0	0x1fff	0x0200	Hex
Settings	Configuration	0x460f	H1	Balancing Configuration	0x0	0xff	0x01	Hex
Settings	AFE	0x457d	H1	AFE Protection Control	0x0	0xff	0x70	Hex
Settings	AFE	0x4583	I2	ZVCHG Exit Threshold	0	8000	2200	mV
Settings	Fuse	0x4400	H1	PF Fuse A	0x0	0xff	0x0	Hex
Settings	Fuse	0x4401	H1	PF Fuse B	0x0	0xff	0x0	Hex
Settings	Fuse	0x4402	H1	PF Fuse C	0x0	0xff	0x0	Hex
Settings	Fuse	0x4403	H1	PF Fuse D	0x0	0xff	0x0	Hex
Settings	Fuse	0x4404	I2	Min Blow Fuse Voltage	0	65535	3500	mV
Settings	Fuse	0x4406	U1	Fuse Blow Timeout	0	255	30	s
Settings	BTP	0x440d	I2	Init Discharge Set	0	32767	150	mAh
Settings	BTP	0x440f	I2	Init Charge Set	0	32767	175	mAh
Settings	SMBus	0x4411	H1	Address	0x0	0xff	0x16	—
Settings	SMBus	0x4412	H1	Address Check	0x0	0xff	0xea	—
Settings	Manufacturing	0x4340	H2	Mfg Status init	0x0	0xffff	0x0000	Hex
Protections	CUV	0x4481	I2	Threshold	0	32767	2500	mV
Protections	CUV	0x4483	U1	Delay	0	255	2	s
Protections	CUV	0x4484	I2	Recovery	0	32767	3000	mV
Protections	COV	0x4486	I2	Threshold Low Temp	0	32767	4300	mV
Protections	COV	0x4488	I2	Threshold Standard Temp	0	32767	4300	mV
Protections	COV	0x448a	I2	Threshold High Temp	0	32767	4300	mV
Protections	COV	0x448c	I2	Threshold Rec Temp	0	32767	4300	mV
Protections	COV	0x448e	U1	Delay	0	255	2	s
Protections	COV	0x448f	I2	Recovery Low Temp	0	32767	3900	mV
Protections	COV	0x4491	I2	Recovery Standard Temp	0	32767	3900	mV
Protections	COV	0x4493	I2	Recovery High Temp	0	32767	3900	mV
Protections	COV	0x4495	I2	Recovery Rec Temp	0	32767	3900	mV
Protections	OCC1	0x4497	I2	Threshold	–32768	32767	6000	mA
Protections	OCC1	0x4499	U1	Delay	0	255	6	s
Protections	OCC2	0x449a	I2	Threshold	–32768	32767	8000	mA
Protections	OCC2	0x449c	U1	Delay	0	255	3	s
Protections	OCC	0x449d	I2	Recovery Threshold	–32768	32767	–200	mA
Protections	OCC	0x449f	U1	Recovery Delay	0	255	5	s
Protections	OCD1	0x44a0	I2	Threshold	–32768	32767	–6000	mA

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Protections	OCD1	0x44a2	U1	Delay	0	255	6	s
Protections	OCD2	0x44a3	I2	Threshold	–32768	32767	–8000	mA
Protections	OCD2	0x44a5	U1	Delay	0	255	3	s
Protections	OCD	0x44a6	I2	Recovery Threshold	–32768	32767	200	mA
Protections	OCD	0x44a8	U1	Recovery Delay	0	255	5	s
Protections	AOLD	0x44a9	U1	Latch Limit	0	255	0	—
Protections	AOLD	0x44aa	U1	Counter Dec Delay	0	255	10	s
Protections	AOLD	0x44ab	U1	Recovery	0	255	5	s
Protections	AOLD	0x44ac	U1	Reset	0	255	15	s
Protections	AOLD	0x457e	H1	Threshold	0x0	0xff	0xf4	Hex
Protections	ASCC	0x44ad	U1	Latch Limit	0	255	0	—
Protections	ASCC	0x44ae	U1	Counter Dec Delay	0	255	10	s
Protections	ASCC	0x44af	U1	Recovery	0	255	5	s
Protections	ASCC	0x44b0	U1	Reset	0	255	15	s
Protections	ASCC	0x457f	H1	Threshold	0x0	0xff	0x77	Hex
Protections	ASCD	0x44b1	U1	Latch Limit	0	255	0	—
Protections	ASCD	0x44b2	U1	Counter Dec Delay	0	255	10	s
Protections	ASCD	0x44b3	U1	Recovery	0	255	5	s
Protections	ASCD	0x44b4	U1	Reset	0	255	15	s
Protections	ASCD	0x4580	H1	Threshold 1	0x0	0xff	0x77	Hex
Protections	ASCD	0x4581	H1	Threshold 2	0x0	0xff	0xe7	Hex
Protections	OTC	0x44b5	I2	Threshold	–400	1500	550	0.1°C
Protections	OTC	0x44b7	U1	Delay	0	255	2	s
Protections	OTC	0x44b8	I2	Recovery	–400	1500	500	0.1°C
Protections	OTD	0x44ba	I2	Threshold	–400	1500	600	0.1°C
Protections	OTD	0x44bc	U1	Delay	0	255	2	s
Protections	OTD	0x44bd	I2	Recovery	–400	1500	550	0.1°C
Protections	OTF	0x44bf	I2	Threshold	–400	1500	800	0.1°C
Protections	OTF	0x44c1	U1	Delay	0	255	2	s
Protections	OTF	0x44c2	I2	Recovery	–400	1500	650	0.1°C
Protections	UTC	0x44c4	I2	Threshold	–400	1500	0	0.1°C
Protections	UTC	0x44c6	U1	Delay	0	255	2	s
Protections	UTC	0x44c7	I2	Recovery	–400	1500	50	0.1°C
Protections	UTD	0x44c9	I2	Threshold	–400	1500	0	0.1°C
Protections	UTD	0x44cb	U1	Delay	0	255	2	s
Protections	UTD	0x44cc	I2	Recovery	–400	1500	50	0.1°C
Protections	HWD	0x44ce	U1	Delay	0	255	10	s
Protections	PTO	0x44cf	I2	Charge Threshold	–32768	32767	2000	mA
Protections	PTO	0x44d1	I2	Suspend Threshold	–32768	32767	1800	mA
Protections	PTO	0x44d3	U2	Delay	0	65535	1800	s
Protections	PTO	0x44d5	I2	Reset	0	32767	2	mAh
Protections	CTO	0x44d7	I2	Charge Threshold	–32768	32767	2500	mA
Protections	CTO	0x44d9	I2	Suspend Threshold	–32768	32767	2000	mA
Protections	CTO	0x44db	U2	Delay	0	65535	54000	s
Protections	CTO	0x44dd	I2	Reset	0	32767	2	mAh
Protections	OC	0x44df	I2	Threshold	–32768	32767	300	mAh
Protections	OC	0x44e1	I2	Recovery	–32768	32767	2	mAh
Protections	OC	0x44e3	U1	RSOC Recovery	0	100	90	%
Protections	CHGV	0x44e4	I2	Threshold	–32768	32767	500	mV
Protections	CHGV	0x44e6	U1	Delay	0	255	30	s

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Protections	CHGV	0x44e7	I2	Recovery	–32768	32767	–500	mV
Protections	CHGC	0x44e9	I2	Threshold	–32768	32767	500	mA
Protections	CHGC	0x44eb	U1	Delay	0	255	2	s
Protections	CHGC	0x44ec	I2	Recovery Threshold	–32768	32767	100	mA
Protections	CHGC	0x44ee	U1	Recovery Delay	0	255	2	s
Protections	PCHGC	0x44ef	I2	Threshold	–32768	32767	50	mA
Protections	PCHGC	0x44f1	U1	Delay	0	255	2	s
Protections	PCHGC	0x44f2	I2	Recovery Threshold	–32768	32767	10	mA
Protections	PCHGC	0x44f4	U1	Recovery Delay	0	255	2	s
Permanent Fail	SUV	0x44f9	I2	Threshold	0	32767	2200	mV
Permanent Fail	SUV	0x44fb	U1	Delay	0	255	5	s
Permanent Fail	SOV	0x44fc	I2	Threshold	0	32767	4500	mV
Permanent Fail	SOV	0x44fe	U1	Delay	0	255	5	s
Permanent Fail	SOCC	0x44ff	I2	Threshold	–32768	32767	10000	mA
Permanent Fail	SOCC	0x4501	U1	Delay	0	255	5	s
Permanent Fail	SOCD	0x4502	I2	Threshold	–32768	32767	–10000	mA
Permanent Fail	SOCD	0x4504	U1	Delay	0	255	5	s
Permanent Fail	SOT	0x4505	I2	Threshold	–400	1500	650	0.1°C
Permanent Fail	SOT	0x4507	U1	Delay	0	255	5	s
Permanent Fail	SOTF	0x4508	I2	Threshold	–400	1500	1000	0.1°C
Permanent Fail	SOTF	0x450a	U1	Delay	0	255	5	s
Permanent Fail	Open Thermistor	0x450b	I2	Threshold	0	32767	2232	0.1°K
Permanent Fail	Open Thermistor	0x450d	U1	Delay	0	255	5	s
Permanent Fail	Open Thermistor	0x450e	I2	Fet Delta	–400	1500	200	0.1°C
Permanent Fail	Open Thermistor	0x4510	I2	Cell Delta	–400	1500	200	0.1°C
Permanent Fail	VIMR	0x4512	I2	Check Voltage	0	5000	3500	mV
Permanent Fail	VIMR	0x4514	I2	Check Current	0	32767	10	mA
Permanent Fail	VIMR	0x4516	I2	Delta Threshold	0	5000	500	mV
Permanent Fail	VIMR	0x4518	U1	Delta Delay	0	255	5	s
Permanent Fail	VIMR	0x4519	U2	Duration	0	65535	100	s
Permanent Fail	VIMA	0x451b	I2	Check Voltage	0	5000	3700	mV
Permanent Fail	VIMA	0x451d	I2	Check Current	0	32767	50	mA
Permanent Fail	VIMA	0x451f	I2	Delta Threshold	0	5000	200	mV
Permanent Fail	VIMA	0x4521	U1	Delay	0	255	2	s
Permanent Fail	CFET	0x4522	I2	OFF Threshold	0	500	5	mA
Permanent Fail	CFET	0x4524	U1	OFF Delay	0	255	5	s
Permanent Fail	DFET	0x4525	I2	OFF Threshold	–500	0	–5	mA
Permanent Fail	DFET	0x4527	U1	OFF Delay	0	255	5	s
Permanent Fail	FUSE	0x4528	I2	Threshold	0	255	5	mA
Permanent Fail	FUSE	0x452a	U1	Delay	0	255	5	s
Permanent Fail	AFER	0x452b	U1	Threshold	0	255	100	—
Permanent Fail	AFER	0x452c	U1	Delay Period	0	255	2	s
Permanent Fail	AFER	0x452d	U1	Compare Period	0	255	5	s
Permanent Fail	AFEC	0x452e	U1	Threshold	0	255	100	—
Permanent Fail	AFEC	0x452f	U1	Delay Period	0	255	5	s
Permanent Fail	2LVL	0x4530	U1	Delay	0	255	5	s
Permanent Fail	OPNCELL	0x4531	I2	Threshold	0	32767	5000	mV
Permanent Fail	OPNCELL	0x4533	U1	Delay	0	255	5	s
Advanced Charge Algorithm	Temperature Ranges	0x4535	I1	T1 Temp	–128	127	0	°C

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Advanced Charge Algorithm	Temperature Ranges	0x4536	I1	T2 Temp	–128	127	12	°C
Advanced Charge Algorithm	Temperature Ranges	0x4537	I1	T5 Temp	–128	127	20	°C
Advanced Charge Algorithm	Temperature Ranges	0x4538	I1	T6 Temp	–128	127	25	°C
Advanced Charge Algorithm	Temperature Ranges	0x4539	I1	T3 Temp	–128	127	30	°C
Advanced Charge Algorithm	Temperature Ranges	0x453a	I1	T4 Temp	–128	127	55	°C
Advanced Charge Algorithm	Temperature Ranges	0x453b	I1	Hysteresis Temp	0	127	1	°C
Advanced Charge Algorithm	Low Temp Charging	0x453c	I2	Voltage	0	32767	4000	mV
Advanced Charge Algorithm	Low Temp Charging	0x453e	I2	Current Low	0	32767	132	mA
Advanced Charge Algorithm	Low Temp Charging	0x4540	I2	Current Med	0	32767	352	mA
Advanced Charge Algorithm	Low Temp Charging	0x4542	I2	Current High	0	32767	264	mA
Advanced Charge Algorithm	Standard Temp Charging	0x4544	I2	Voltage	0	32767	4200	mV
Advanced Charge Algorithm	Standard Temp Charging	0x4546	I2	Current Low	0	32767	1980	mA
Advanced Charge Algorithm	Standard Temp Charging	0x4548	I2	Current Med	0	32767	4004	mA
Advanced Charge Algorithm	Standard Temp Charging	0x454a	I2	Current High	0	32767	2992	mA
Advanced Charge Algorithm	High Temp Charging	0x454c	I2	Voltage	0	32767	4000	mV
Advanced Charge Algorithm	High Temp Charging	0x454e	I2	Current Low	0	32767	1012	mA
Advanced Charge Algorithm	High Temp Charging	0x4550	I2	Current Med	0	32767	1980	mA
Advanced Charge Algorithm	High Temp Charging	0x4552	I2	Current High	0	32767	1496	mA
Advanced Charge Algorithm	Rec Temp Charging	0x4554	I2	Voltage	0	32767	4100	mV
Advanced Charge Algorithm	Rec Temp Charging	0x4556	I2	Current Low	0	32767	2508	mA
Advanced Charge Algorithm	Rec Temp Charging	0x4558	I2	Current Med	0	32767	4488	mA
Advanced Charge Algorithm	Rec Temp Charging	0x455a	I2	Current High	0	32767	3520	mA
Advanced Charge Algorithm	Pre-Charging	0x455c	I2	Current	0	32767	88	mA
Advanced Charge Algorithm	Maintenance Charging	0x455e	I2	Current	0	32767	44	mA
Advanced Charge Algorithm	Voltage Range	0x4560	I2	Precharge Start Voltage	0	32767	2500	mV
Advanced Charge Algorithm	Voltage Range	0x4562	I2	Charging Voltage Low	0	32767	2900	mV
Advanced Charge Algorithm	Voltage Range	0x4564	I2	Charging Voltage Med	0	32767	3600	mV
Advanced Charge Algorithm	Voltage Range	0x4566	I2	Charging Voltage High	0	32767	4000	mV
Advanced Charge Algorithm	Voltage Range	0x4568	U1	Charging Voltage Hysteresis	0	255	0	mV
Advanced Charge Algorithm	SoC Range	0x4569	U1	Charging SoC Med	0	100	50	%

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Advanced Charge Algorithm	SoC Range	0x456a	U1	Charging SoC High	0	100	75	%
Advanced Charge Algorithm	SoC Range	0x456b	U1	Charging SoC Hysteresis	0	100	1	%
Advanced Charge Algorithm	Termination Config	0x456c	I2	Charge Term Taper Current	0	32767	250	mA
Advanced Charge Algorithm	Termination Config	0x4570	I2	Charge Term Voltage	0	32767	75	mV
Advanced Charge Algorithm	Charging Rate of Change	0x4573	U1	Current Rate	1	255	1	steps
Advanced Charge Algorithm	Charging Rate of Change	0x4574	U1	Voltage Rate	1	255	1	steps
Advanced Charge Algorithm	Charge Loss Compensation	0x4575	I2	CCC Current Threshold	0	32767	3520	mA
Advanced Charge Algorithm	Charge Loss Compensation	0x4577	I2	CCC Voltage Threshold	0	32767	4200	mV
Advanced Charge Algorithm	Cell Balancing Config	0x4610	I2	Cell Balance Threshold	0	5000	3900	mV
Advanced Charge Algorithm	Cell Balancing Config	0x4612	I2	Cell Balance Window	0	5000	100	mV
Advanced Charge Algorithm	Cell Balancing Config	0x4614	U1	Cell Balance Min	0	255	40	mV
Advanced Charge Algorithm	Cell Balancing Config	0x4615	U1	Cell Balance Interval	0	255	20	s
Gas Gauging	Current Thresholds	0x4586	I2	Dsg Current Threshold	–32768	32767	100	mA
Gas Gauging	Current Thresholds	0x4588	I2	Chg Current Threshold	–32768	32767	50	mA
Gas Gauging	Current Thresholds	0x458a	I2	Quit Current	0	32767	10	mA
Gas Gauging	Current Thresholds	0x458c	U1	Dsg Relax Time	0	255	1	s
Gas Gauging	Current Thresholds	0x458d	U1	Chg Relax Time	0	255	60	s
Gas Gauging	Design	0x444d	I2	Design Capacity mAh	0	32767	4400	mAh
Gas Gauging	Design	0x444f	I2	Design Capacity cWh	0	32767	6336	cWh
Gas Gauging	Design	0x4451	I2	Design Voltage	0	32767	14400	mV
Gas Gauging	Cycle	0x4453	U1	Cycle Count Percentage	0	100	90	%
Gas Gauging	FD	0x4458	I2	Set Voltage Threshold	0	5000	3000	mV
Gas Gauging	FD	0x445a	I2	Clear Voltage Threshold	0	5000	3100	mV
Gas Gauging	FD	0x445c	U1	Set % RSOC Threshold	0	100	0	%
Gas Gauging	FD	0x445d	U1	Clear % RSOC Threshold	0	100	5	%
Gas Gauging	FC	0x445e	I2	Set Voltage Threshold	0	5000	4200	mV
Gas Gauging	FC	0x4460	I2	Clear Voltage Threshold	0	5000	4100	mV
Gas Gauging	FC	0x4462	U1	Set % RSOC Threshold	0	100	100	%
Gas Gauging	FC	0x4463	U1	Clear % RSOC Threshold	0	100	95	%
Gas Gauging	TD	0x4464	I2	Set Voltage Threshold	0	5000	3200	mV
Gas Gauging	TD	0x4466	I2	Clear Voltage Threshold	0	5000	3300	mV
Gas Gauging	TD	0x4468	U1	Set % RSOC Threshold	0	100	6	%
Gas Gauging	TD	0x4469	U1	Clear % RSOC Threshold	0	100	8	%
Gas Gauging	TC	0x446a	I2	Set Voltage Threshold	0	5000	4200	mV
Gas Gauging	TC	0x446c	I2	Clear Voltage Threshold	0	5000	4100	mV
Gas Gauging	TC	0x446e	U1	Set % RSOC Threshold	0	100	100	%
Gas Gauging	TC	0x446f	U1	Clear % RSOC Threshold	0	100	95	%
Gas Gauging	State	0x4100	I2	Learned Full Charge Capacity	0	32767	4400	mAh

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Gas Gauging	State	0x4140	U2	Cycle Count	0	65535	0	—
Gas Gauging	CEDV cfg	0x4590	U2	EMF	0	65535	3743	—
Gas Gauging	CEDV cfg	0x4592	U2	C0	0	65535	149	—
Gas Gauging	CEDV cfg	0x4594	U2	R0	0	65535	867	—
Gas Gauging	CEDV cfg	0x4596	U2	T0	0	65535	4030	—
Gas Gauging	CEDV cfg	0x4598	U2	R1	0	65535	316	—
Gas Gauging	CEDV cfg	0x459a	U1	TC	0	255	9	—
Gas Gauging	CEDV cfg	0x459b	U1	C1	0	255	0	—
Gas Gauging	CEDV cfg	0x459c	U1	Age Factor	0	255	0	—
Gas Gauging	CEDV cfg	0x459d	I2	Fixed EDV 0	0	32767	3031	—
Gas Gauging	CEDV cfg	0x459f	U1	EDV 0 Hold Time	1	255	1	s
Gas Gauging	CEDV cfg	0x45a0	I2	Fixed EDV 1	0	32767	3385	—
Gas Gauging	CEDV cfg	0x45a2	U1	EDV 1 Hold Time	1	255	1	s
Gas Gauging	CEDV cfg	0x45a3	I2	Fixed EDV 2	0	32767	3501	—
Gas Gauging	CEDV cfg	0x45a5	U1	EDV 2 Hold Time	1	255	1	s
Gas Gauging	CEDV cfg	0x45ec	U2	Battery Low %	0	65535	700	0.01%
Gas Gauging	CEDV cfg	0x45f0	I2	Min Delta V Filter	0	32767	10	mV
Gas Gauging	CEDV cfg	0x45f9	U1	Learning Low Temp	0	255	119	0.1°C
Gas Gauging	CEDV cfg	0x4602	I2	OverLoad Current	0	32767	5000	mA
Gas Gauging	CEDV cfg	0x4606	U1	Self Discharge Rate	0	255	20	0.01%/day
Gas Gauging	CEDV cfg	0x4607	I2	Electronics Load	0	255	0	3 µA
Gas Gauging	CEDV cfg	0x4609	I2	Near Full	0	32767	200	mAh
Gas Gauging	CEDV cfg	0x460b	I2	Reserve Capacity	0	32767	0	mAh
Gas Gauging	CEDV cfg	0x460d	U1	Chg Eff	0	100	100	%
Gas Gauging	CEDV cfg	0x460e	U1	Dsg Eff	0	100	100	%
Gas Gauging	CEDV Profile 1	0x45a6	I2	Voltage 0% DOD	–32768	32767	4173	mV
Gas Gauging	CEDV Profile 1	0x45a8	I2	Voltage 10% DOD	–32768	32767	4043	mV
Gas Gauging	CEDV Profile 1	0x45aa	I2	Voltage 20% DOD	–32768	32767	3925	mV
Gas Gauging	CEDV Profile 1	0x45ac	I2	Voltage 30% DOD	–32768	32767	3821	mV
Gas Gauging	CEDV Profile 1	0x45ae	I2	Voltage 40% DOD	–32768	32767	3725	mV
Gas Gauging	CEDV Profile 1	0x45b0	I2	Voltage 50% DOD	–32768	32767	3656	mV
Gas Gauging	CEDV Profile 1	0x45b2	I2	Voltage 60% DOD	–32768	32767	3619	mV
Gas Gauging	CEDV Profile 1	0x45b4	I2	Voltage 70% DOD	–32768	32767	3582	mV
Gas Gauging	CEDV Profile 1	0x45b6	I2	Voltage 80% DOD	–32768	32767	3515	mV
Gas Gauging	CEDV Profile 1	0x45b8	I2	Voltage 90% DOD	–32768	32767	3439	mV
Gas Gauging	CEDV Profile 1	0x45ba	I2	Voltage 100% DOD	–32768	32767	2713	mV
Gas Gauging	CEDV Smoothing Config	0x4471	I2	Smoothing Start Voltage	0	4300	3700	mV
Gas Gauging	CEDV Smoothing Config	0x4473	I2	Smoothing Delta Voltage	0	4200	100	mV
Gas Gauging	CEDV Smoothing Config	0x4475	U2	Max Smoothing Current	0	65535	8000	mA
Gas Gauging	CEDV Smoothing Config	0x447a	U1	EOC Smooth Current	0	10	2	0.10%
Gas Gauging	CEDV Smoothing Config	0x447b	U1	EOC Smooth Current Time	0	255	60	s
Power	Power	0x4413	I2	Valid Update Voltage	0	32767	3500	mV
Power	Shutdown	0x4415	I2	Shutdown Voltage	0	32767	1750	mV
Power	Shutdown	0x4417	U1	Shutdown Time	0	255	10	s
Power	Shutdown	0x4418	I2	PF Shutdown Voltage	0	32767	1750	mV
Power	Shutdown	0x441a	U1	PF Shutdown Time	0	255	10	s

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Power	Shutdown	0x441b	I2	Charger Present Threshold	0	32767	3000	mV
Power	Sleep	0x441d	I2	Sleep Current	0	32767	10	mA
Power	Sleep	0x441f	U1	Bus Timeout	0	255	5	s
Power	Sleep	0x4424	U1	Voltage Time	0	255	5	s
Power	Sleep	0x4425	U1	Current Time	0	255	20	s
Power	Sleep	0x4426	H1	Wake Comparator	0x0	0xff	0x0	Hex
Power	Ship	0x4427	U1	FET Off Time	0	127	10	s
Power	Ship	0x4428	U1	Delay	0	254	20	s
Power	Ship	0x4429	U2	Auto Ship Time	0	65535	1440	min
Power	Power Off	0x442b	U2	Timeout	0	65535	30	min
Power	Manual FET Control	0x442d	U1	MFC Delay	0	255	60	s
PF Status	Device Status Data	0x4240	H1	Safety Alert A	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4241	H1	Safety Status A	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4242	H1	Safety Alert B	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4243	H1	Safety Status B	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4244	H1	Safety Alert C	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4245	H1	Safety Status C	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4246	H1	Safety Alert D	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4247	H1	Safety Status D	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4248	H1	PF Alert A	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4249	H1	PF Status A	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x424a	H1	PF Alert B	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x424b	H1	PF Status B	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x424c	H1	PF Alert C	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x424d	H1	PF Status C	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x424e	H1	PF Alert D	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x424f	H1	PF Status D	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4250	H2	Fuse Flag	0x0	0xffff	0x0	Hex
PF Status	Device Status Data	0x4252	H2	Operation Status A	0x0	0xffff	0x0	Hex
PF Status	Device Status Data	0x4254	H2	Operation Status B	0x0	0xffff	0x0	Hex
PF Status	Device Status Data	0x4256	H1	Temp Range	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4257	H1	Charging Status A	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4258	H1	Charging Status B	0x0	0xff	0x0	Hex
PF Status	Device Status Data	0x4259	H1	Gauging Status	0x0	0xff	0x0	Hex

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
PF Status	Device Status Data	0x425a	H1	CEDV Status	0x0	0xff	0x0	Hex
PF Status	Device Voltage Data	0x425b	I2	Cell 1 Voltage	–32768	32767	0	mV
PF Status	Device Voltage Data	0x425d	I2	Cell 2 Voltage	–32768	32767	0	mV
PF Status	Device Voltage Data	0x425f	I2	Cell 3 Voltage	–32768	32767	0	mV
PF Status	Device Voltage Data	0x4261	I2	Cell 4 Voltage	–32768	32767	0	mV
PF Status	Device Voltage Data	0x4263	I2	Battery Direct Voltage	–32768	32767	0	mV
PF Status	Device Voltage Data	0x4265	I2	Pack Voltage	–32768	32767	0	mV
PF Status	Device Current Data	0x4267	I2	Current	–32768	32767	0	mA
PF Status	Device Temperature Data	0x4269	I2	Internal Temperature	–32768	32767	0	0.1°K
PF Status	Device Temperature Data	0x426b	I2	External 1 Temperature	–32768	32767	0	0.1°K
PF Status	Device Temperature Data	0x426d	I2	External 2 Temperature	–32768	32767	0	0.1°K
PF Status	Device Temperature Data	0x426f	I2	External 3 Temperature	–32768	32767	0	0.1°K
PF Status	Device Temperature Data	0x4271	I2	External 4 Temperature	–32768	32767	0	0.1°K
PF Status	AFE Regs	0x4273	H1	AFE Interrupt Status	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4274	H1	AFE FET Status	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4275	H1	AFE RXIN	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4276	H1	AFE Latch Status	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4277	H1	AFE Interrupt Enable	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4278	H1	AFE FET Control	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4279	H1	AFE RXIEN	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x427a	H1	AFE RLOUT	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x427b	H1	AFE RHOUT	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x427c	H1	AFE RHINT	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x427d	H1	AFE Cell Balance	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x427e	H1	AFE AD/CC Control	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x427f	H1	AFE ADC Mux	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4280	H1	AFE LED Output	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4281	H1	AFE State Control	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4282	H1	AFE LED/Wake Control	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4283	H1	AFE Protection Control	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4284	H1	AFE OCD	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4285	H1	AFE SCC	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4286	H1	AFE SCD1	0x0	0xff	0x0	Hex
PF Status	AFE Regs	0x4287	H1	AFE SCD2	0x0	0xff	0x0	Hex
System Data	Manufacturer Data	0x4040	U1	Manufacturer Info A Length	1	32	32	—
System Data	Manufacturer Data	0x4041	H1	Manufacturer Info Block A01	0x0	0xff	0x61	Hex
System Data	Manufacturer Data	0x4042	H1	Manufacturer Info Block A02	0x0	0xff	0x62	Hex
System Data	Manufacturer Data	0x4043	H1	Manufacturer Info Block A03	0x0	0xff	0x63	Hex
System Data	Manufacturer Data	0x4044	H1	Manufacturer Info Block A04	0x0	0xff	0x64	Hex
System Data	Manufacturer Data	0x4045	H1	Manufacturer Info Block A05	0x0	0xff	0x65	Hex
System Data	Manufacturer Data	0x4046	H1	Manufacturer Info Block A06	0x0	0xff	0x66	Hex

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
System Data	Manufacturer Data	0x4047	H1	Manufacturer Info Block A07	0x0	0xff	0x67	Hex
System Data	Manufacturer Data	0x4048	H1	Manufacturer Info Block A08	0x0	0xff	0x68	Hex
System Data	Manufacturer Data	0x4049	H1	Manufacturer Info Block A09	0x0	0xff	0x69	Hex
System Data	Manufacturer Data	0x404a	H1	Manufacturer Info Block A10	0x0	0xff	0x6a	Hex
System Data	Manufacturer Data	0x404b	H1	Manufacturer Info Block A11	0x0	0xff	0x6b	Hex
System Data	Manufacturer Data	0x404c	H1	Manufacturer Info Block A12	0x0	0xff	0x6c	Hex
System Data	Manufacturer Data	0x404d	H1	Manufacturer Info Block A13	0x0	0xff	0x6d	Hex
System Data	Manufacturer Data	0x404e	H1	Manufacturer Info Block A14	0x0	0xff	0x6e	Hex
System Data	Manufacturer Data	0x404f	H1	Manufacturer Info Block A15	0x0	0xff	0x6f	Hex
System Data	Manufacturer Data	0x4050	H1	Manufacturer Info Block A16	0x0	0xff	0x70	Hex
System Data	Manufacturer Data	0x4051	H1	Manufacturer Info Block A17	0x0	0xff	0x71	Hex
System Data	Manufacturer Data	0x4052	H1	Manufacturer Info Block A18	0x0	0xff	0x72	Hex
System Data	Manufacturer Data	0x4053	H1	Manufacturer Info Block A19	0x0	0xff	0x73	Hex
System Data	Manufacturer Data	0x4054	H1	Manufacturer Info Block A20	0x0	0xff	0x74	Hex
System Data	Manufacturer Data	0x4055	H1	Manufacturer Info Block A21	0x0	0xff	0x75	Hex
System Data	Manufacturer Data	0x4056	H1	Manufacturer Info Block A22	0x0	0xff	0x76	Hex
System Data	Manufacturer Data	0x4057	H1	Manufacturer Info Block A23	0x0	0xff	0x77	Hex
System Data	Manufacturer Data	0x4058	H1	Manufacturer Info Block A24	0x0	0xff	0x7a	Hex
System Data	Manufacturer Data	0x4059	H1	Manufacturer Info Block A25	0x0	0xff	0x78	Hex
System Data	Manufacturer Data	0x405a	H1	Manufacturer Info Block A26	0x0	0xff	0x79	Hex
System Data	Manufacturer Data	0x405b	H1	Manufacturer Info Block A27	0x0	0xff	0x30	Hex
System Data	Manufacturer Data	0x405c	H1	Manufacturer Info Block A28	0x0	0xff	0x31	Hex
System Data	Manufacturer Data	0x405d	H1	Manufacturer Info Block A29	0x0	0xff	0x32	Hex
System Data	Manufacturer Data	0x405e	H1	Manufacturer Info Block A30	0x0	0xff	0x33	Hex
System Data	Manufacturer Data	0x405f	H1	Manufacturer Info Block A31	0x0	0xff	0x34	Hex
System Data	Manufacturer Data	0x4060	H1	Manufacturer Info Block A32	0x0	0xff	0x35	Hex
System Data	Manufacturer Info B	0x4062	H1	Manufacturer Info Block B01	0x0	0xff	0x01	Hex
System Data	Manufacturer Info B	0x4063	H1	Manufacturer Info Block B02	0x0	0xff	0x23	Hex
System Data	Manufacturer Info B	0x4064	H1	Manufacturer Info Block B03	0x0	0xff	0x45	Hex
System Data	Manufacturer Info B	0x4065	H1	Manufacturer Info Block B04	0x0	0xff	0x67	Hex
System Data	Integrity	0x4066	H2	Static DF Signature	0x0	0x7fff	0x0	Hex
System Data	Integrity	0x4068	H2	Static Chem DF Signature	0x0	0x7fff	0x6c98	Hex
System Data	Integrity	0x406a	H2	All DF Signature	0x0	0x7fff	0x0	Hex
SBS Configuration	Data	0x406c	U2	Manufacture Date	0	65535	0	date
SBS Configuration	Data	0x406e	H2	Serial Number	0x0	0xffff	0x0001	Hex
SBS Configuration	Data	0x4070	S21	Manufacturer Name	x	x	Texas Instruments	—
SBS Configuration	Data	0x4085	S21	Device Name	x	x	BQ4050	—
SBS Configuration	Data	0x409a	S5	Device Chemistry	x	x	LION	—
SBS Configuration	Data	0x4443	I2	Remaining AH Cap. Alarm	0	32767	300	mAh
SBS Configuration	Data	0x4445	I2	Remaining WH Cap. Alarm	0	32767	432	cWh
SBS Configuration	Data	0x4447	U2	Remaining Time Alarm	0	65535	10	min
SBS Configuration	Data	0x4449	H2	Initial Battery Mode	0x0	0xffff	0x0081	Hex
SBS Configuration	Data	0x444b	H2	Specification Information	0x0	0xffff	0x0031	Hex
LED Support	LED Config	0x4430	U2	LED Flash Period	32	65535	512	488 µs
LED Support	LED Config	0x4432	U2	LED Blink Period	32	65535	1024	488 µs
LED Support	LED Config	0x4434	U2	LED Delay	16	65535	100	488 µs

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
LED Support	LED Config	0x4436	U1	LED Hold Time	1	63	16	0.25 s
LED Support	LED Config	0x4437	I1	CHG Flash Alarm	0	100	10	%
LED Support	LED Config	0x4438	I1	CHG Thresh 1	0	100	0	%
LED Support	LED Config	0x4439	I1	CHG Thresh 2	0	100	20	%
LED Support	LED Config	0x443a	I1	CHG Thresh 3	0	100	40	%
LED Support	LED Config	0x443b	I1	CHG Thresh 4	0	100	60	%
LED Support	LED Config	0x443c	I1	CHG Thresh 5	0	100	80	%
LED Support	LED Config	0x443d	I1	DSG Flash Alarm	0	100	10	%
LED Support	LED Config	0x443e	I1	DSG Thresh 1	0	100	0	%
LED Support	LED Config	0x443f	I1	DSG Thresh 2	0	100	20	%
LED Support	LED Config	0x4440	I1	DSG Thresh 3	0	100	40	%
LED Support	LED Config	0x4441	I1	DSG Thresh 4	0	100	60	%
LED Support	LED Config	0x4442	I1	DSG Thresh 5	0	100	80	%
Black Box	Safety Status	0x4200	H1	1st Status Status A	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4201	H1	1st Status Status B	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4202	H1	1st Safety Status C	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4203	H1	1st Safety Status D	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4204	U1	1st Time to Next Event	0	255	0	s
Black Box	Safety Status	0x4205	H1	2nd Status Status A	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4206	H1	2nd Status Status B	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4207	H1	2nd Safety Status C	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4208	H1	2nd Safety Status D	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x4209	U1	2nd Time to Next Event	0	255	0	s
Black Box	Safety Status	0x420a	H1	3rd Status Status A	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x420b	H1	3rd Status Status B	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x420c	H1	3rd Safety Status C	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x420d	H1	3rd Safety Status D	0x0	0xff	0x0	Hex
Black Box	Safety Status	0x420e	U1	3rd Time to Next Event	0	255	0	s
Black Box	PF Status	0x420f	H1	1st PF Status A	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4210	H1	1st PF Status B	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4211	H1	1st PF Status C	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4212	H1	1st PF Status D	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4213	U1	1st Time to Next Event	0	255	0	s
Black Box	PF Status	0x4214	H1	2nd PF Status A	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4215	H1	2nd PF Status B	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4216	H1	2nd PF Status C	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4217	H1	2nd PF Status D	0x0	0xff	0x0	Hex
Black Box	PF Status	0x4218	U1	2nd Time to Next Event	0	255	0	s
Black Box	PF Status	0x4219	H1	3rd PF Status A	0x0	0xff	0x0	Hex
Black Box	PF Status	0x421a	H1	3rd PF Status B	0x0	0xff	0x0	Hex
Black Box	PF Status	0x421b	H1	3rd PF Status C	0x0	0xff	0x0	Hex
Black Box	PF Status	0x421c	H1	3rd PF Status D	0x0	0xff	0x0	Hex
Black Box	PF Status	0x421d	U1	3rd Time to Next Event	0	255	0	s
Lifetimes	Voltage	0x4180	I2	Cell 1 Max Voltage	0	32767	0	mV
Lifetimes	Voltage	0x4182	I2	Cell 2 Max Voltage	0	32767	0	mV
Lifetimes	Voltage	0x4184	I2	Cell 3 Max Voltage	0	32767	0	mV
Lifetimes	Voltage	0x4186	I2	Cell 4 Max Voltage	0	32767	0	mV
Lifetimes	Voltage	0x4188	I2	Cell 1 Min Voltage	0	32767	32767	mV
Lifetimes	Voltage	0x418a	I2	Cell 2 Min Voltage	0	32767	32767	mV
Lifetimes	Voltage	0x418c	I2	Cell 3 Min Voltage	0	32767	32767	mV

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Lifetimes	Voltage	0x418e	I2	Cell 4 Min Voltage	0	32767	32767	mV
Lifetimes	Voltage	0x4190	I2	Max Delta Cell Voltage	0	32767	0	mV
Lifetimes	Current	0x4192	I2	Max Charge Current	0	32767	0	mA
Lifetimes	Current	0x4194	I2	Max Discharge Current	–32768	0	0	mA
Lifetimes	Current	0x4196	I2	Max Avg Dsg Current	–32768	0	0	mA
Lifetimes	Current	0x4198	I2	Max Avg Dsg Power	–32768	0	0	cW
Lifetimes	Temperature	0x419a	I1	Max Temp Cell	–128	127	–128	°C
Lifetimes	Temperature	0x419b	I1	Min Temp Cell	–128	127	127	°C
Lifetimes	Temperature	0x419c	I1	Max Delta Cell Temp	–128	127	0	°C
Lifetimes	Temperature	0x419d	I1	Max Temp Int Sensor	–128	127	–128	°C
Lifetimes	Temperature	0x419e	I1	Min Temp Int Sensor	–128	127	127	°C
Lifetimes	Temperature	0x419f	I1	Max Temp Fet	–128	127	–128	°C
Lifetimes	Safety Events	0x41a0	U2	No Of COV Events	0	32767	0	events
Lifetimes	Safety Events	0x41a2	U2	Last COV Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41a4	U2	No Of CUV Events	0	32767	0	events
Lifetimes	Safety Events	0x41a6	U2	Last CUV Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41a8	U2	No Of OCD1 Events	0	32767	0	events
Lifetimes	Safety Events	0x41aa	U2	Last OCD1 Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41ac	U2	No Of OCD2 Events	0	32767	0	events
Lifetimes	Safety Events	0x41ae	U2	Last OCD2 Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41b0	U2	No Of OCC1 Events	0	32767	0	events
Lifetimes	Safety Events	0x41b2	U2	Last OCC1 Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41b4	U2	No Of OCC2 Events	0	32767	0	events
Lifetimes	Safety Events	0x41b6	U2	Last OCC2 Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41b8	U2	No Of AOLD Events	0	32767	0	events
Lifetimes	Safety Events	0x41ba	U2	Last AOLD Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41bc	U2	No Of ASCD Events	0	32767	0	events
Lifetimes	Safety Events	0x41be	U2	Last ASCD Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41c0	U2	No Of ASCC Events	0	32767	0	events
Lifetimes	Safety Events	0x41c2	U2	Last ASCC Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41c4	U2	No Of OTC Events	0	32767	0	events
Lifetimes	Safety Events	0x41c6	U2	Last OTC Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41c8	U2	No Of OTD Events	0	32767	0	events
Lifetimes	Safety Events	0x41ca	U2	Last OTD Event	0	32767	0	cycles
Lifetimes	Safety Events	0x41cc	U2	No Of OTF Events	0	32767	0	events
Lifetimes	Safety Events	0x41ce	U2	Last OTF Event	0	32767	0	cycles
Lifetimes	Charging Events	0x41d0	U2	No Valid Charge Term	0	32767	0	events
Lifetimes	Charging Events	0x41d2	U2	Last Valid Charge Term	0	32767	0	cycles
Lifetimes	Power Events	0x41d4	U1	No Of Shutdowns	0	255	0	events
Lifetimes	Cell Balancing	0x41d8	U1	CB Time Cell 1	0	255	0	2h
Lifetimes	Cell Balancing	0x41d9	U1	CB Time Cell 2	0	255	0	2h
Lifetimes	Cell Balancing	0x41da	U1	CB Time Cell 3	0	255	0	2h
Lifetimes	Cell Balancing	0x41db	U1	CB Time Cell 4	0	255	0	2h
Lifetimes	Time	0x41dc	U2	Total Fw Runtime	0	65535	0	2h
Lifetimes	Time	0x41de	U2	Time Spent In UT	0	65535	0	2h
Lifetimes	Time	0x41e0	U2	Time Spent In LT	0	65535	0	2h
Lifetimes	Time	0x41e2	U2	Time Spent In STL	0	65535	0	2h
Lifetimes	Time	0x41e4	U2	Time Spent In RT	0	65535	0	2h
Lifetimes	Time	0x41e6	U2	Time Spent In STH	0	65535	0	2h
Lifetimes	Time	0x41e8	U2	Time Spent In HT	0	65535	0	2h

Table 14-1. Data Flash Summary (continued)

Class	Subclass	Address	Type	Name	Min	Max	Default	Units
Lifetimes	Time	0x41ea	U2	Time Spent In OT	0	65535	0	2h

15.1 Overload in Discharge Protection (AOLD)

Table 15-1. Overload in Discharge Protection Threshold (Settings:AFE:AFE Protection Control [RSNS] = 0)

OLD Threshold ([RSNS] = 0)			
Setting	**Threshold**	**Setting**	**Threshold**
0x00	–8.30 mV	0x08	–30.54 mV
0x01	–11.08 mV	0x09	–33.32 mV
0x02	–13.86 mV	0x0A	–36.10 mV
0x03	–16.64 mV	0x0B	–38.88 mV
0x04	–19.42 mV	0x0C	–41.66 mV
0x05	–22.20 mV	0x0D	–44.44 mV
0x06	–24.98 mV	0x0E	–47.22 mV
0x07	–27.76 mV	0x0F	–50.00 mV

Table 15-2. Overload in Discharge Protection Threshold (Settings:AFE:AFE Protection Control [RSNS] = 1)

OLD Threshold ([RSNS] = 1)			
Setting	**Threshold**	**Setting**	**Threshold**
0x00	–16.60 mV	0x08	–61.08 mV
0x01	–22.16 mV	0x09	–66.64 mV
0x02	–27.72 mV	0x0A	–72.20 mV
0x03	–33.28 mV	0x0B	–77.76 mV
0x04	–38.84 mV	0x0C	–83.32 mV
0x05	–44.40 mV	0x0D	–88.88 mV
0x06	–49.96 mV	0x0E	–94.44 mV
0x07	–55.52 mV	0x0F	–100.00 mV

Table 15-3. Overload in Discharge Protection Delay

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

15.2 Short Circuit in Charge (ASCC)

Table 15-4. Short Circuit in Charge Threshold (Settings:AFE:AFE Protection Control [RSNS] = 0)

Setting	Threshold	Setting	Threshold
0x00	22.2 mV	0x04	66.65 mV

Table 15-4. Short Circuit in Charge Threshold (Settings:AFE:AFE Protection Control [RSNS] = 0) (continued)

Setting	Threshold	Setting	Threshold
0x01	33.3 mV	0x05	77.75 mV
0x02	44.4 mV	0x06	88.85 mV
0x03	55.5 mV	0x07	100 mV

Table 15-5. Short Circuit in Charge Threshold (Settings:AFE:AFE Protection Control [RSNS] = 1)

Setting	Threshold	Setting	Threshold
0x00	44.4 mV	0x04	133.3 mV
0x01	66.6 mV	0x05	155.5 mV
0x02	88.8 mV	0x06	177.7 mV
0x03	111.1 mV	0x07	200 mV

Table 15-6. Short Circuit in Charge Delay

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

15.3 Short Circuit in Discharge (ASCD1 and ASCD2)

Table 15-7. Short Circuit in Discharge Threshold (Settings:AFE:AFE Protection Control [RSNS] = 0)

Setting	Threshold	Setting	Threshold
0x00	–22.2 mV	0x04	–66.65 mV
0x01	–33.3 mV	0x05	–77.75 mV
0x02	–44.4 mV	0x06	–88.85 mV
0x03	–55.5 mV	0x07	–100 mV

Table 15-8. Short Circuit in Discharge Threshold (Settings:AFE:AFE Protection Control [RSNS] = 1)

Setting	Threshold	Setting	Threshold
0x00	–44.4 mV	0x04	–133.3 mV
0x01	–66.6 mV	0x05	–155.5 mV
0x02	–88.8 mV	0x06	–177.7 mV
0x03	–111.1 mV	0x07	–200 mV

Table 15-9. Short Circuit in Discharge 1 Delay (Settings:AFE:AFE Protection Control [SCDDx2] = 0)

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

Table 15-10. Short Circuit in Discharge 1 Delay (Settings:AFE:AFE Protection Control [SCDDx2] = 1)

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	488 µs	0x08	976 µs	0x0C	1464 µs

Table 15-10. Short Circuit in Discharge 1 Delay (Settings:AFE:AFE Protection Control [SCDDx2] = 1) (continued)

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x01	122 µs	0x05	610 µs	0x09	1098 µs	0x0D	1586 µs
0x02	244 µs	0x06	732 µs	0x0A	1220 µs	0x0E	1708 µs
0x03	366 µs	0x07	854 µs	0x0B	1342 µs	0x0F	1830 µs

Table 15-11. Short Circuit in Discharge 2 Delay (Settings:AFE:AFE Protection Control [SCDDx2] = 0)

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	122 µs	0x08	244 µs	0x0C	366 µs
0x01	31 µs	0x05	153 µs	0x09	275 µs	0x0D	396 µs
0x02	61 µs	0x06	183 µs	0x0A	305 µs	0x0E	427 µs
0x03	92 µs	0x07	214 µs	0x0B	335 µs	0x0F	458 µs

Table 15-12. Short Circuit in Discharge 2 Delay (Settings:AFE:AFE Protection Control [SCDDx2] = 1)

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	244 µs	0x08	488 µs	0x0C	732 µs
0x01	62 µs	0x05	306 µs	0x09	550 µs	0x0D	792 µs
0x02	122 µs	0x06	366 µs	0x0A	610 µs	0x0E	854 µs
0x03	184 µs	0x07	428 µs	0x0B	670 µs	0x0F	916 µs

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Appendix A
Sample Filter Settings

A.1

Table A-1. Sample V/I/P Filter Settings and Associated Low-Pass Filter Time Constants

Average V/I/P Filter	Effective Low-Pass Time Constant
10	0.25 seconds
50	0.5 seconds
145	1 second
200	3 seconds

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Appendix B
Glossary

ACK	Acknowledge character
ADC	Analog-to-digital converter
BCA	Board calibration
BI	Battery insert
CC	Coulomb counter
CCA	Coulomb counter calibration
CE	Chip enable
CHARGE Mode	Refers to a mode to where the gauge read *Current()* > ***Chg Current Threshold*** for at least 1 second.
Clear	Refers to a bit in a register becoming a logic LOW or 0. The Battery Management Studio (BQStudio) software represents a clear bit with the color green.
cWh	Centiwatt-hour
CMT	Current measurement time
DISCHARGE Mode	Refers to a mode where the gauge read *Current()* < (–)***Dsg Current Threshold*** for at least 1 second.
DOD	Depth of discharge in percent as related to Qmax. 100% corresponds to empty battery.
DOD0	Depth of discharge that was looked up in the DOD (OCV) table based on OCV measurement in relaxed state.
EOC	End of charge
FC	Fully charged
FCC	Full charge capacity. Total capacity of the battery compensated for present load current, temperature, and aging effects (reduction in chemical capacity and increase in internal impedance).
FIFO	First in, first out
Flag	This word usually represents a read-only status bit that indicates some action has occurred or is occurring. This bit typically cannot be modified. The flags are set and cleared automatically by the fuel gauge.
FVCA	Fast voltage and current acquisition
GPIO	General-purpose input output
HDQ	High-speed data queue
IC	Integrated circuit
ID	Identification
IO	Input or output
I^2C	Inter-integrated circuit
LDO	Low dropout
LSB	Least significant bit
LT	Lifetime
MAC	Manufacturer Access Control
mAh	Milliamp-hour
MSB	Most significant bit
mWh	Milliwatt-hour
NACK	Negative acknowledge character
NTC	Negative temperature coefficient
OCV	Open-circuit voltage. Voltage measured on fully-relaxed battery with no load applied.

OTC	Overtemperature in charge
OTD	Overtemperature in discharge
PFC	Pin function code
POR	Power-on reset
Qmax	Maximum chemical capacity
QC	Qualification and calculation
QT	Qualification time
RELAXATION Mode	Refers to a mode to where the gauge read *Current()* < ***Quit Current*** for at least 60 seconds.
RM	Remaining capacity
RW	Read or write
SCL	Serial clock: programmable serial clock used in the I^2C interface
SDA	Serial data: serial data bus in the I^2C interface
SE	Shutdown enable
Set	Refers to a bit in a register becoming a logic HIGH or 1. The Battery Management Studio (BQStudio) software represents a set bit with the color red.
SOC	State-of-charge in percent related to FCC
SOC1	State-of-charge initial
SOCF	State-of-charge final
System	The word system is sometimes used in this document. When used, it always means a host system that is consuming current from the battery pack.
TCA	Terminate charge alarm
TMT	Temperature measurement time
TS	Temperature status
TTE	Time-to-empty
TTF	Time-to-full
VIT	Voltage, current, temperature
VMT	Voltage measurement time

Appendix C

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (March 2016) to Revision A (October 2022)	Page
• Changed the description of VIMA	126

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