Technical Reference Manual

BQ27Z855

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About This Manual

This manual discusses the modules and peripherals of the BQ27Z855 device, and how each is used to build a complete battery pack gas gauge and protection solution. For electrical specifications, refer to the ***BQ27Z855 Dynamic Z-Track™ Gauge with Integrated Protection and Authentication for 1 Cell Battery Packs***

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)

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Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

1 IO Options

1.1 Configuration of the INT Pin

The INT pin can be optionally configured as a digital output for a host interrupt signal using ***HOSTINT_EN*** . When enabled, the INT pin operates as an open-drain output that is asserted by firmware when an interrupt condition is detected. When not configured for host interrupt, two independent GPIO output features are available through ***IO Config*** : Permanent Failure (PF) indication (***IO Config*** [***GPIO_PF***]) and general-purpose Flag Map Setup outputs (***IO Config*** [***GPIO_EN***]). See ***IO Config*** for details.

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

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

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

HOSTINT_EN (Bit 0): Enables the INT pin as an open-drain host interrupt output. When set, the firmware asserts the INT pin when an interrupt condition is detected. For details on interrupt sources, polarity, and output driver configuration, see Section 11.

1 = Enabled

0 = Disabled (default)

Note

By default, the host interrupt option is not selected. If the host interrupt option is selected, see Section 11 for host interrupt configuration details.

Note

When ***HOSTINT_EN*** = 0, two independent GPIO output features are configurable through ***IO Config*** :

- Set ***IO Config*** [***GPIO_PF***] = 1 to enable Permanent Failure (PF) indication. A designated package pin is asserted when any PF condition is detected. This feature is independent of ***GPIO_EN*** .
- Set ***IO Config*** [***GPIO_EN***] = 1 to enable Flag Map Setup outputs. Up to four firmware status flags — from registers such as *BatteryStatus()*, charging temperature range, charging voltage range, gauging status, or safety status — can each be routed to a designated GPIO output pin. See IO Config for *Flag Map Setup* configuration details.

Note

The ENAB pin is a separate, dedicated active-low digital input with a weak internal pull-up to BAT, used exclusively for device wake-up/enable functions while in Shutdown mode (see the chapter on power modes and device enable for details). It has no configurable options.

2 Basic Measurement System

2.1 Introduction

The gauge contains an integrated Coulomb counter (CCADC) for current measurement and a second order delta-sigma ADC for cell voltage and temperature measurements.

2.2 Current and Coulomb Counting

The integrating delta-sigma ADC in the gauge measures the charge/discharge flow of the battery by measuring the voltage drop across a small-value sense resistor between the SRP and SRN pins. The 18-bit integrating ADC measures bipolar signals from –0.10 V to 0.10 V with 923nV resolution. The gauge reports charge activity when $V_{SR} = V_{(SRP)} – V_{(SRN)}$ is positive, and discharge activity when $VSR = V_{(SRP)} – V_{(SRN)}$ is negative. This data is scaled and translated into mA using ***CC Gain*** and reported through *Current()*. The gauge uses this information for gauging and lifetime data logging functions. In NORMAL and SLEEP modes, the gauge continuously monitors the measured current and integrates the digital signal over time using an internal coulomb counter (also known as the integrated ADC), which handles the gauging.

In addition, the integrating ADC (CC2 filter of CCADC) is sampled during voltage measurements and converted to mA in the same manner. This data is used for gauging (but not coulomb counting) and reported through Cell 1 Current in *DAStatus1()*.

2.3 Voltage

2.3.1 Cell Voltage

The second order delta-sigma ADC in the gauge measures the cell voltage at 250-ms intervals in NORMAL mode, and ***Voltage Time*** -second intervals in SLEEP mode. This data is scaled and translated into mV using ***Cell Gain*** and reported through *Voltage()*. The gauge uses this information for gauging and lifetime data logging functions.

2.3.2 Pack Voltage

The second order delta-sigma ADC in the gauge measures the pack voltage (at the PACK pin) at 250-ms intervals in NORMAL mode, and ***Voltage Time*** -second intervals in SLEEP mode. This data is scaled and translated into mV using ***Pack Gain*** and reported through PACK pin voltage in *DAStatus1()*. The gauge uses this information for entry to SHUTDOWN mode, and zero-volt charging.

2.4 Temperature

2.4.1 Internal Temperature

The second order delta-sigma ADC in the gauge measures internal temperature at 250-ms intervals in NORMAL mode and ***Voltage Time*** -second intervals in SLEEP mode. This data is translated into 0.1 K using the parameters in ***Internal Temp Model*** and reported through *InternalTemperature()*. The internal temperature can be used for gauging and lifetime data logging functions, and reported through *Temperature()* if ***Temperature Enable[TSInt]*** = 1.

2.4.2 Cell Temperature

The second order delta-sigma ADC in the gauge measures cell temperature via an external thermistor at 250-ms intervals in NORMAL mode and ***Voltage Time*** -second intervals in SLEEP mode. This data is translated into 0.1 K using the parameters in ***Cell Temp Model*** and reported through *Temperature()* if ***Temperature Enable[TS]*** = 1. The cell temperature can be used for gauging and lifetime data logging functions if ***Temperature Enable[TS]*** = 1.

The cell temperature measurement requires an external 10-kΩ negative temperature coefficient (NTC) thermistor, such as the Semitec 103AT–2, connected between VSS and the TS pin.

2.4.3 Temperature Configuration

The following data flash parameter enables/disables the available temperature sensor options.

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	Temperature Enable	H1	0x00	0x0F	0x03	Determines whether the internal temperature (TSInt) or the external temperature (TS1 on TS pin) is reported with *Temperature()*. Bit 0: TSInt–Enables internal TS Bit 1: TS1–Enables external TS pin 0, 0: Neither enabled, *Temperature()* reports −273.2K. 0, 1: Enables internal TS, *Temperature()* reports the internal temperature. 1, 0: Enables TS1, *Temperature()* reports the value determined by the thermistor on the TS pin. 1, 1: TSInt and TS1 are enabled, *Temperature()* reports the higher of the two values.

3 Protections

3.1 Introduction

The device provides recoverable protection, which includes firmware-based protecion and hardware-based protection. Firmware-based protections requires one additional second to react when the trigger condition is detected. 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. Section 13.8 provides a summary of the various alarms flags' set conditions.

3.2 Cell Undervoltage Protection

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

Status	Condition	Action
Normal	cell voltage > ***CUV:Threshold***	*SafetyAlert()[CUV]* = 0 *BatteryStatus()[TDA]* = 0
Alert	cell voltage ≤ ***CUV:Threshold***	*SafetyAlert()[CUV]* = 1 *BatteryStatus()[TDA]* = 1
Trip	cell voltage ≤ ***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 cell voltage ≥ ***CUV:Recovery*** AND ***Protection Configuration[CUV_RECOV_CHG]*** = 0 OR Condition 2: *SafetyStatus()[CUV]* = 1 AND cell voltage ≥ ***CUV:Recovery*** AND ***Protection Configuration[CUV_RECOV_CHG]*** = 1 AND PACK voltage > ***Charger Present Threshold*** for ***[Protections][CUV][Recovery Charger Present Time]***	*SafetyStatus()[CUV]* = 0 *BatteryStatus()[FD]* = 0, *[TDA]* = 0 *OperationStatus()[XDSG]* = 0

3.3 Cell Undervoltage Compensated Protection

The device can detect cell undervoltage in batteries and protect cells from damage by preventing further discharge. The protection is compensated by the *Current()* × cell resistance.

Status	Condition	Action
Normal	cell voltage – *Current()* × cell resistance > ***CUVC: Threshold***	*SafetyAlert()[CUVC]* = 0 *BatteryStatus()[TDA]* = 0
Alert	cell voltage – *Current()* × cell resistance ≤ ***CUVC: Threshold***	*SafetyAlert()[CUVC]* = 1 *BatteryStatus()[TDA]* = 1
Trip	cell voltage – *Current()* × cell resistance ≤ ***CUVC: Threshold*** for ***CUVC:Delay*** duration	*SafetyAlert()[CUVC]* = 0 *SafetyStatus()[CUVC]* = 1 *BatteryStatus()[FD]* = 1, *[TDA]* = 0 *OperationStatus()[XDSG]* = 1

Status	Condition	Action
Recovery	Condition 1: *SafetyStatus()[CUVC]* = 1 AND cell voltage – *Current()* × cell resistance > ***CUVC: Recovery*** AND ***Protection Configuration[CUV_RECOV_CHG]*** = 0	*SafetyStatus()[CUVC]* = 0 *BatteryStatus()[FD]* = 0, *[TDA]* = 0 *OperationStatus()[XDSG]* = 0
	OR Condition 2: *SafetyStatus()[CUVC]* = 1 AND cell voltage – *Current()* × cell resistance ≥ ***CUVC: Recovery*** AND ***Protection Configuration[CUV_RECOV_CHG]*** = 1 AND PACK voltage > ***Charger Present Threshold*** for ***[Protections]*** ***[CUV][Recovery Charger Present Time]***	

3.4 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. Additionally, this protection feature can be enabled to create a PF by setting the ***[COVL]*** bit in the ***Enabled PF A*** register.

Status	Condition	Action
Normal, *ChargingStatus()[UT] or [LT]* = 1	cell voltage < ***COV:Threshold Low Temp***	*SafetyAlert()[COV]* = 0 *PFAlert()[COVL]* = 0 Decrement COVL counter by one after each ***COV:Counter Dec Delay*** period if COVL counter > 0
Normal, *ChargingStatus()[STL] or [STH]* = 1	cell voltage < ***COV:Threshold***	
Normal, *ChargingStatus()[HT]* = 1	cell voltage < ***COV:Threshold High Temp***	
Normal, *ChargingStatus()[RT]* = 1	cell voltage < ***COV:Threshold Rec Temp***	
Normal, Degrade condition = 1	cell voltage < ***COV:Threshold*** - Degrade	
Alert, *ChargingStatus()[UT] or [LT]* = 1	cell voltage ≥ ***COV:Threshold Low Temp***	*SafetyAlert()[COV]* = 1 Increment COVL counter by one each 1s during cell overvoltage detection.
Alert, *ChargingStatus()[STL] or [STH]* = 1	cell voltage ≥ ***COV:Threshold***	
Alert, *ChargingStatus()[HT]* = 1	cell voltage ≥ ***COV:Threshold High Temp***	
Alert, *ChargingStatus()[RT]* = 1	cell voltage ≥ ***COV:Threshold Rec Temp***	
Alert, Degrade condition = 1	cell voltage ≥ ***COV:Threshold*** - Degrade	
Trip	*SafetyAlert()[COV]* = 1 for ***COV:Delay***	*SafetyStatus()[COV]* = 1 *OperationStatus()[XCHG]* = 1
Latch Trip	COVL counter ≥ ***Protections:COVL Counter***	*SafetyStatus()[COVL]* = 1
Recovery	*SafetyStatus()[COV]* = 1 AND cell voltage < ***COV:Recovery***	*SafetyStatus()[COV]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[COVL]* = 0
Latch Reset	*SafetyStatus()[COVL]* = 1 for ***COV:Reset*** time	*SafetyStatus()[COVL]* = 0 Reset COVL counter. *OperationStatus[XCHG]* = 0 if *SafetyStatus()[COV]* = 0

3.5 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

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

3.6 Overcurrent in Discharge Protection

The device has two independent overcurrent in discharge protections that can be set to current and delay thresholds to accommodate different load behaviors. Additionally, this protection feature can be enabled to create a PF by setting the ***[OCDL]*** bit in ***Enabled PF C*** register.

Status	Condition	Action
Normal	*Current()* > ***OCD1:Threshold***	*SafetyAlert()[OCD1]* = 0 *SafetyAlert()[OCDL]* = 0 *PFAlert()[SOCDL]* = 0 Decrement OCDL1 counter by one after each ***OCD:Counter Dec Delay*** period, if OCDL1 counter > 0
Normal	*Current()* > ***OCD2:Threshold***	*SafetyAlert()[OCD2]* = 0 *SafetyAlert()[OCDL]* = 0 *PFAlert()[SOCDL]* = 0 Decrement OCDL2 counter by one after each ***OCD:Counter Dec Delay*** period if OCDL2 counter > 0
Alert	*Current()* ≤ ***OCD1:Threshold***	*SafetyAlert()[OCD1]* = 1 *BatteryStatus()[TDA]* = 1
Alert	*Current()* ≤ ***OCD2:Threshold***	*SafetyAlert()[OCD2]* = 1 *BatteryStatus()[TDA]* = 1
Trip	*Current()* ≤ ***OCD1:Threshold*** for ***OCD1:Delay*** duration	*SafetyAlert()[OCD1]* = 0 *SafetyStatus()[OCD1]* = 1 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 1 Increment OCDL1 counter
Trip	*Current()* ≤ ***OCD2:Threshold*** for ***OCD2:Delay*** duration	*SafetyAlert()[OCD2]* = 0 *SafetyStatus()[OCD2]* = 1 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 1 Increment OCDL2 counter
Recovery	*SafetyStatus()[OCD1]* = 1 AND *Current()* ≥ ***OCD:Recovery Threshold*** for ***OCD:Recovery Delay*** time	*SafetyStatus()[OCD1]* = 0 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 0
Recovery	*SafetyStatus()[OCD2]* = 1 AND *Current()* ≥ ***OCD:Recovery Threshold*** for ***OCD:Recovery Delay*** time	*SafetyStatus()[OCD2]* = 0 *BatteryStatus()[TDA]* = 0 *OperationStatus()[XDSG]* = 0
Latch Alert	OCDL counter > 0	*SafetyAlert()[OCDL]* = 1 if *SafetyEnable[OCDL]* is set. *PFAlert()[SOCDL]* = 1 if *PFEnable()[AOCDL]* is set.
Latch Trip	OCDL counter ≥ ***OCD:Latch limit***	*SafetyStatus()[OCDL]* = 1 if *SafetyEnable[OCDL]* is set. *PFStatus()[SOCDL]* = 1 if *PFEnable()[SCOV]* is set. *SafetyAlert()[OCDL]* = *PFAlert()[SOCDL]* = 0
Latch Reset	*SafetyStatus()[OCDL]* = 1 for ***OCD:Reset*** time	*SafetyStatus()[OCDL]* = 0 Reset OCDL counter. *OperationStatus[XDSG]* = 0 if *SafetyStatus()[OCD1]* = 0 and *SafetyStatus()[OCD2]* = 0

3.7 Hardware-Based Protection

The device has five main hardware-based protections—AOCD, AOCC, ASCD, ACUV, and ACOV—with adjustable thresholds and delay times. For current-based protections (AOCD, AOCC, ASCD), 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. For voltage-based protections (ACUV, ACOV), the thresholds are configured in mV.

For details on how to configure the AFE hardware protection, refer to the registers in the AFE section.

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, the 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 device uses embedded pack configuration (***[NR]*** = 1). The latch reset condition is based on the ***Reset*** time parameter.

3.7.1 Analog Over Current Charge Protection (AOCC)

The device has a hardware-based Analog Over Current Charge protection (AOCC) with adjustable current and delay time. Additionally, this protection feature can be enabled to create a PF by setting the ***[AOCCL]*** bit in the ***Enabled PF B*** register.

Status	Condition	Action
Normal	*Current()* < (*AOCC Voltage Threshold*/R_{SENSE})	*SafetyAlert()[AOCCL]* = 0, if AOCCL counter = 0 *PFAlert()[AOCCL]* = 0 Decrement AOCCL counter by one after each ***AOCC:Counter Dec Delay*** period, if AOCCL counter > 0
Trip	*Current()* ≥ (*AOCC Voltage Threshold*/R_{SENSE}) for *AOCC Delay* duration	*SafetyStatus()[AOCC]* = 1 *OperationStatus()[XCHG]* = 1 Increment AOCCL counter
Recovery	*SafetyStatus()[AOCC]* = 1 for ***AOCC:Recovery*** time	*SafetyStatus()[AOCC]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[AOCCL]* = 0.
Latch Alert	AOCCL counter > 0	*SafetyAlert()[AOCCL]* = 1 *PFAlert()[AOCCL]* = 1, if *PFEnable()[AOCCL]* is set.
Latch Trip	AOCCL counter ≥ ***AOCC:Latch Limit***	*SafetyAlert()[AOCCL]* = 0 *SafetyStatus()[AOCCL]* = 1 *OperationStatus()[XCHG]* = 1 *PFAlert()[AOCCL]* = 0 *PFStatus()[AOCCL]* = 1, if *PFEnable()[AOCCL]* is set.
Latch Reset	*SafetyStatus()[AOCCL]* = 1 for ***AOCC:Reset*** time	*SafetyStatus()[AOCCL]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[AOCC]* = 0.

3.7.2 Analog Over Current Discharge Protection (AOCD)

The device has a hardware-based over current in discharge protection with adjustable current and delay time. Additionally, this protection feature can be enabled to create a PF by setting the ***[AOCDL]*** bit in the ***Enabled PF B*** register.

Status	Condition	Action
Normal	*Current()* < (*AOCD Voltage Threshold*/R_{SENSE})	*SafetyAlert()[AOCDL]* = 0, if AOCDL counter = 0 *PFAlert()[AOCDL]* = 0 Decrement AOCDL counter by one after each ***AOCD:Counter Dec Delay*** period, if AOCDL counter > 0

Status	Condition	Action
Trip	*Current()* ≥ (*AOCD Voltage Threshold*/R_{SENSE}) for *AOCD Delay* duration	*SafetyStatus()[AOCD]* = 1 *OperationStatus()[XDSG]* = 1 increment AOCDL counter
Recovery	*SafetyStatus()[AOCD]* = 1 for ***AOCD:Recovery*** time	*SafetyStatus()[AOCD]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[AOCDL]* = 0.
Latch Alert	AOCDL counter > 0	*SafetyAlert()[AOCDL]* = 1 *PFAlert()[AOCDL]* = 1, if *PFEnable()[AOCDL]* is set.
Latch Trip	AOCDL counter ≥ ***AOCD:Latch Limit***	*SafetyAlert()[AOCDL]* = 0 *SafetyStatus()[AOCDL]* = 1 *OperationStatus()[XDSG]* = 1 *PFAlert()[AOCDL]* = 0 *PFStatus()[AOCDL]* = 1, if *PFEnable()[AOCDL]* is set.
Latch Reset	*SafetyStatus()[AOCDL]* = 1 for ***AOCD:Reset*** time	*SafetyStatus()[AOCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[AOCD]* = 0

3.7.3 Short Circuit in Discharge Protection

The device has a hardware-based short circuit in discharge protection with adjustable current and delay time. Additionally, this protection feature can be enabled to create a PF by setting the ***[ASCDL]*** bit in the ***Enabled PF B*** register.

Status	Condition	Action
Normal	*Current()* < (*ASCD Voltage Threshold*/R_{SENSE})	*SafetyAlert()[ASCDL]* = 0 if ASCDL counter = 0 *PFAlert()[ASCDL]* = 0 Decrement ASCDL counter by one after each ***ASCD:Counter Dec Delay*** period, if ASCDL counter > 0
Trip	*Current()* ≥ (*ASCD Voltage Threshold*/R_{SENSE}) for *ASCD Delay* duration	*SafetyStatus()[ASCD]* = 1 *OperationStatus()[XDSG]* = 1 Increment ASCDL counter
Recovery	*SafetyStatus()[ASCD]* = 1 for ***ASCD:Recovery*** time	*SafetyStatus()[ASCD]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[ASCDL]* = 0.
Latch Alert	ASCDL counter > 0	*SafetyAlert()[ASCDL]* = 1 *PFAlert()[ASCDL]* = 1, if *PFEnable()[ASCDL]* is set.
Latch Trip	ASCDL counter ≥ ***ASCD:Latch Limit***	*SafetyAlert()[ASCDL]* = 0 *SafetyStatus()[ASCDL]* = 1 *OperationStatus()[XDSG]* = 1 *PFAlert()[ASCDL]* = 0 *PFStatus()[ASCDL]* = 1, if *PFEnable()[ASCDL]* is set.
Latch Reset	*SafetyStatus()[ASCDL]* = 1 for ***ASCD:Reset*** time	*SafetyStatus()[ASCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[ASCD]* = 0

3.7.4 ACUV (Cell Under Voltage)

Overview

The ACUV (Analog Cell Under Voltage) protection is a hardware-based protection that monitors individual cell voltages using the AFE (Analog Front End) hardware comparator. This protection provides faster response than firmware-based CUV protection because it operates directly in hardware without firmware intervention.

Unlike the current-based hardware protections (AOCD, AOCC, ASCD), ACUV is a voltage-based protection that monitors cell voltages against a configurable threshold.

Protection Trigger

ACUV protection triggers when any cell voltage falls below the ***Settings AFE Under Voltage*** threshold configured in the AFE hardware registers.

When triggered:

- **SafetyStatus()[ACUV]** bit (bit 6 of SafetyStatus byte 3) is set
- The DSG (Discharge) FET is disabled to prevent further cell damage

Note

ACUV does NOT have an alert stage - it triggers directly to protection status. This differs from current-based hardware protections which use Trip/Latch Alert/Recovery cycles.

Recovery Behavior

As of firmware v0.03 (BMSFW-11409), ACUV uses **threshold-based recovery** instead of time-based recovery:

- The ACUV SafetyStatus flag clears **immediately** (no time delay) when the minimum cell voltage rises to or above the ***Protections ACUV Recovery*** threshold
- Upon recovery, the AFE hardware BATUV latch is also cleared
- The DSG FET is re-enabled (if no other protections are active)

Configuration Note: Configure the Recovery threshold higher than the associated ***Settings AFE Under Voltage*** threshold to provide hysteresis and prevent oscillation near the threshold.

SafetyStatus Bit

Flag	Description
ACUV	AFE cell under voltage condition detected

3.7.5 ACOV (Cell Over Voltage)

Overview

The ACOV (Analog Cell Over Voltage) protection is a hardware-based protection that monitors individual cell voltages using the AFE (Analog Front End) hardware comparator. This protection provides faster response than firmware-based COV protection because it operates directly in hardware without firmware intervention.

Unlike the current-based hardware protections (AOCD, AOCC, ASCD), ACOV is a voltage-based protection that monitors cell voltages against a configurable threshold.

Protection Trigger

ACOV protection triggers when any cell voltage rises above the ***Settings AFE Over Voltage*** threshold configured in the AFE hardware registers.

When triggered:

- **SafetyStatus()[ACOV]** bit (bit 7 of SafetyStatus byte 3) is set
- The CHG (Charge) FET is disabled to prevent further cell damage

Note

ACOV does NOT have an alert stage - it triggers directly to protection status. This differs from current-based hardware protections which use Trip/Latch Alert/Recovery cycles.

Recovery Behavior

As of firmware v0.03 (BMSFW-11409), ACOV uses **threshold-based recovery** instead of time-based recovery:

- The ACOV SafetyStatus flag clears **immediately** (no time delay) when the maximum cell voltage falls to or below the ***Protections ACOV Recovery*** threshold
- Upon recovery, the AFE hardware BATOV latch is also cleared
- The CHG FET is re-enabled (if no other protections are active)

Configuration Note: Configure the Recovery threshold lower than the associated ***Settings AFE Over Voltage*** threshold to provide hysteresis and prevent oscillation near the threshold.

SafetyStatus Bit

Flag	Description
ACOV	AFE cell over voltage condition detected

3.8 Temperature Protections

The device provides overtemperature and undertemperature protections, based on cell and FET temperature measurements. The cell temperature-based protections are further divided into CHARGE and DISCHARGE conditions. This section describes in detail each of the protection functions.

The device supports a external thermistor and one internal temperature sensor for measuring temperature. Unused temperature sensors must be disabled by clearing the corresponding flag in ***Settings:Temperature Enable[USER_TS][TS1][TSInt]*** .

Each of the temperature sensors can be used as a source for cell or FET temperature measurement. Setting the corresponding flag in ***Settings:Temperature Mode[USER_TS Mode][TS1 Mode][TSInt Mode]*** configures the sensor to measure FET temperature. Clearing the corresponding flag configures the sensor to measure cell temperature.

The average temperature among the sensors set for FET measurement is used when ***Settings:DA Configuration[FTEMP]*** is set. The maximum temperature is used when ***[FTEMP]*** is cleared.

Under cell temperature protections use the minimum cell temperature sensor. Over cell temperature protections use the maximum cell temperature sensor.

The *Temperature()* command returns the cell temperature measurement. Setting ***Settings:DA Configuration[CTEMP1][CTEMP0]*** to 1, 1 uses the smart temperature sensor. Setting ***Settings:DA Configuration[CTEMP1][CTEMP0]*** to 1, 0 uses the lowest cell temperature sensor. Setting ***[CTEMP1][CTEMP0]*** to 0, 1 uses the average of the sensors. A setting of 0, 0 uses the maximum cell temperature sensor.

Smart temperature sensor scheme ***[CTEMP1][CTEMP0]*** = 1, 1 determine the cell temperature as:

- Cell temperature = minimum cell temp, if [minimum cell temp] - [***Mid Point Temp]*** ≤ [maximum cell temp] – ***Mid Point Temp***]
- Cell temperature = maximum cell temp, if [minimum cell temp] - [***Mid Point Temp***] > [maximum cell temp] – [***Mid Point Temp***]

ManufacturerBlockAccess() command *DAStatus2()* returns all the temperature measurements.

The ***Settings:Temperature Mode[USER_TS]*** bit enables the host to write the user temperature with the MAC command *WriteTemp()*. When this feature is used, the temperature must be written in 0.1°K. This feature is helpful on PCBs that do not have the area or height to include thermistors, but do have a host that is capable of using its own onboard measurement of cell temperature. If ***[USER_TS]*** = 1, like other ***[TS1 Mode]*** options cell or FET temperature is selected as per ***Settings:DA Configuration[CTEMP1][CTEMP0]*** settings. To enable writing the temperature with MAC command ***WriteTemp()*** , first a two-word override MAC sequence is required. The two-word key is programmable using *ManufacturerAccess() 0x0035* Security Keys. Both keys must be sent within 4 seconds of each other. Once the correct two-word MAC sequence is received, *ManufacturerAccess() 0x3008 WriteTemp()* can be used.

The cell-based overtemperature and undertemperature safety provides protections in CHARGE and DISCHARGE conditions. The battery pack is in CHARGE mode when *Current()* > ***Chg Current Threshold*** and *BatteryStatus()[DSG]* = 0. The overtemperature and undertemperature in CHARGE protections are active in this mode. *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 7.3 for detailed descriptions of the gas gauge modes.

3.8.1 Overtemperature in Charge Protection

The device has an overtemperature protection for cells under charge.

Status	Condition	Action
Normal	Cell Temp < ***OTC:Threshold*** OR not charging	*SafetyAlert()[OTC]* = 0

Status	Condition	Action
Alert	Cell Temp ≥ ***OTC:Threshold*** AND charging	*SafetyAlert()[OTC]* = 1 *BatteryStatus()[TCA]* = 1
Trip	Cell Temp ≥ ***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 Cell Temp ≤ ***OTC:Recovery***	*SafetyStatus()[OTC]* = 0 *BatteryStatus()[OTA]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

3.8.2 Overtemperature in Discharge Protection

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

Status	Condition	Action
Normal	Cell Temp < ***OTD:Threshold*** OR charging	*SafetyAlert()[OTD]* = 0
Alert	Cell Temp ≥ ***OTD:Threshold*** AND Not charging (that is, *BatteryStatus[DSG]* = 1)	*SafetyAlert()[OTD]* = 1 *BatteryStatus()[TDA]* = 1
Trip	Cell Temp ≥ ***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 Cell Temp ≤ ***OTD:Recovery***	*SafetyStatus()[OTD]* = 0 *BatteryStatus()[OTA]* = 0 *OperationStatus()[XDSG]* = 0 *BatteryStatus()[TDA]* = 0

3.8.3 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 *DAStatus2()* ≥ ***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

3.8.4 Undertemperature in Charge Protection

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

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

3.8.5 Undertemperature in Discharge Protection

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

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

3.9 Host Watchdog Protection

The device can check periodic communication over I2C and prevent usage of the battery pack if no valid communication is detected.

Status	Condition	Action
Trip	No valid I2C transaction for ***HWD:Delay*** duration	*SafetyStatus()[HWDF]* = 1 *OperationStatus()[XCHG]* = 1
Recovery	Valid I2C transaction detected	*SafetyStatus()[HWD]* = 0 *OperationStatus()[XCHG]* = 0

3.10 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 *OperationStatus()[XCHG]* = 1
Reset	*SafetyStatus()[PTO]* = 1 AND Discharge by an amount of ***PTO:Reset***	Stop and reset PTO timer *SafetyAlert()[PTOS]* = 0 *SafetyStatus()[PTO]* = 0 *OperationStatus()[XCHG]* = 0

Note

The PTO timer resets when battery is detected fully charged (***BatteryStatus()[FC]*** = 1).

3.11 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

Status	Condition	Action
Reset	*SafetyStatus()[CTO]* = 1 AND Discharge by an amount of ***CTO:Reset***	Stop and reset CTO timer *SafetyAlert()[CTOS]* = 0 *SafetyStatus()[CTO]* = 0 *OperationStatus()[XCHG]* = 0

Note

The CTO timer resets when the battery is detected as fully charged (***BatteryStatus()[FC]*** = 1).

3.12 Overcharge Protection

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

Status	Condition	Action
Normal	*RelativeStateOfCharge()* < 100%	*SafetyAlert()[OC]* = 0
Alert	*RelativeStateOfCharge()* ≥ 100% AND Internal charge counter > 0	*SafetyAlert()[OC]* = 1
Trip	*RelativeStateOfCharge()* ≥ 100% AND Internal charge counter ≥ ***OC:Threshold***	*SafetyAlert()[OC]* = 0 *SafetyStatus()[OC]* = 1 , *[OCA]* = 1 if the device is in the CHARGE state (that is, *BatteryStatus[DSG]* = 0). *OperationStatus()[XCHG]* = 1
Recovery	Condition 1: *SafetyStatus()[OC]* = 1 AND discharge of ***Recovery***	*SafetyStatus()[OC]* = 0 , *[OCA]* = 0 *OperationStatus()[XCHG]* = 0
	OR Condition 2: *SafetyStatus()[OC]* = 1 AND *RelativeStateOfCharge()* < ***OC:RSOC Recovery***	

3.13 OverCharging Voltage Protection

The device can stop charging if it measures a difference between the requested *ChargingVoltage()* and the delivered voltage from the charger.

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 voltage in *DAStatus1()* < *ChargingVoltage()* + ***CHGV:Threshold***	*SafetyAlert()[CHGV]* = 0
Alert	PACK voltage in *DAStatus1()* ≥ *ChargingVoltage()* + ***CHGV:Threshold***	*SafetyAlert()[CHGV]* = 1 *BatteryStatus()[TCA]* = 1
Trip	PACK voltage in *DAStatus1()* ≥ *ChargingVoltage()* + ***CHGV:Threshold*** for ***CHGV:Delay*** period	*SafetyAlert()[CHGV]* = 0 *SafetyStatus()[CHGV]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1
Recovery	*SafetyStatus()[CHGV]* = 1 AND PACK voltage in *DAStatus1()* ≤ intended *ChargingVoltage()* + ***CHGV Recovery***	*SafetyStatus()[CHGV]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

3.14 OverCharging Current 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

Status	Condition	Action
Trip	*Current()* ≥ *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

3.15 OverPrecharging Current 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()* ≥ *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

4 Integrated Short-Circuit Indication (ISI)

4.1 Introduction

The device integrates an algorithm to aid in detection of a battery internal short. Internal shorts in Lithium-ion batteries are caused in many ways, including, but not limited to, formation of lithium dendrites, manufacturing defects inside battery cells, and compressive shock. Once formed, the internal short may become stronger over time. Internal shorts can be estimated through an observed elevated rate of self-discharge.

Since shorts can occur in each phase of the battery life (manufacturing, shipping, end application use), monitoring of the battery should be done throughout its lifetime.

4.2 Configuration

The following parameters configure the performance of the ISI algorithm.

4.2.1 Self-Discharge Current

Self-discharge current includes not only the battery self-discharge and gauge operating current, but any other currents that do not flow through the sense resistor. Each design needs to be evaluated to account for any of these sources that could leech current from the battery. The current aggregate of all these sources are not included in the estimate of the internal short. This parameter should contain the sum of the currents. Otherwise, it should not be changed from the default value.

4.2.2 Low Internal Short Threshold

Current threshold used for detecting a small internal short in the battery, specified as a negative value. The threshold is negative since internal shorts discharge the battery. This threshold should be set to 50% of the desired small internal short current to be detected.

4.2.3 High Internal Short Threshold

Current threshold used for detecting a large internal short in the battery, specified as a negative value. The threshold is negative since internal shorts discharge the battery. This threshold should be set to 50% of the desired large internal short current to be detected.

4.2.4 Threshold Passes to Completion

Minimum number of passes on ***Low Internal Short Threshold*** and ***High Internal Short Threshold*** to allow the algorithm to complete and temporarily timeout for the present relaxation.

4.2.5 Manufacturing Completion Timeout

Duration that the algorithm goes into timeout for the Manufacturing/Storage mode. This timeout starts when the ISI algorithm completes, but will end if RELAX mode is reentered. The gauge is allowed to enter SLEEP mode(s) and reduce its power consumption while the ISI algorithm is timed out. A smaller value allows for more frequent monitoring of the battery during this stage but at the cost of power consumption.

4.3 ISI Configuration Parameters

The following parameters configure the interaction of the ISI algorithm with the Permanent Failure engine.

4.3.1 ISI Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
ISI	Configuration	Self-Discharge Current	I2	–32768	0	–6	0.1 mA	Calculated system self-discharge
ISI	Configuration	Low Internal Short Threshold	I2	–32768	–40	–40	0.1 mA	Threshold setting for lower Internal Short
ISI	Configuration	High Internal Short Threshold	I2	–32768	–300	–300	0.1 mA	
ISI	Configuration	Threshold Passes to Completion	U2	3	65535	3	–	
ISI	Configuration	Manufacturing Completion Timeout	U1	0	255	1	hours	

5 Permanent Fail

5.1 Introduction

The device can permanently disable the use of the battery pack in case of a significant failure. The permanent failure checks, except for IFC and DFW, can be enabled or disabled individually 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 under ***PF Status: AFE Regs*** : ***OCC*** , ***OCD*** , , ***Short Circuit Discharge*** , ***Current Dischareg Wake*** , ***Current Charge Wake*** , ***OCC 1 Delay 2*** , ***OCC 1 Delay 1*** , ***OCD 1 Delay 2*** , ***OCD 1 Delay 1*** , ***Short Circuit Discharge Delay*** , ***Over Temperature Delay*** , ***OCD Wake Delay 2*** , ***OCD Wake Delay 1*** , ***OCC Wake Delay 2*** , ***OCC Wake Delay 1*** .
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 1^{st} *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, and TS1from *DAStatus2()*
- Cell DOD0 and passed charge

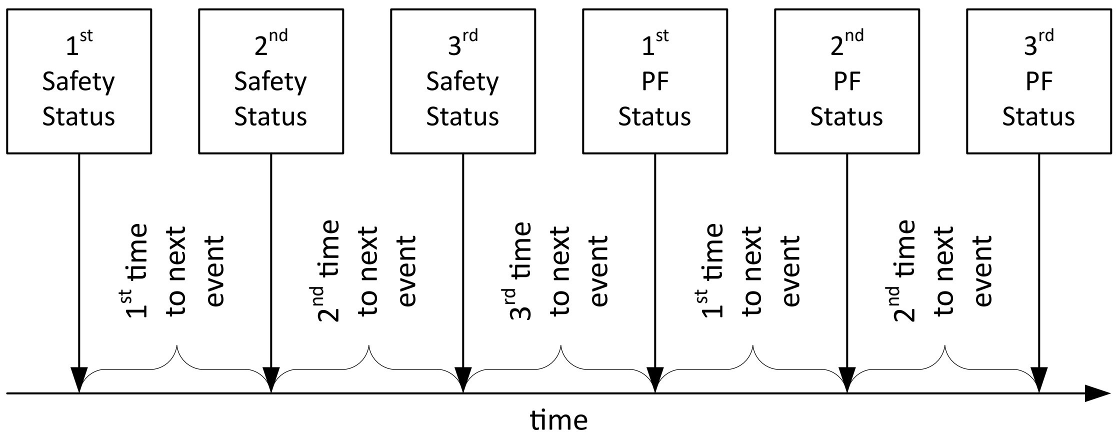
7. Data flash writing is disabled (except to store subsequent *PFStatus()* flags).

Note

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. In addition, new *PFStatus()* flags are recorded in the Black Box Recorder 2nd and 3rd PF Status entries.

5.1.1 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.

5.2 Safety Cell Undervoltage Permanent Fail

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

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

5.2.1 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.

5.3 Safety Cell Overvoltage Permanent Fail

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

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

5.4 Safety Overcurrent in Charge Permanent Fail

The device can permanently disable the battery in the case of significant overcurrent in the CHARGE state.

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

5.5 Safety Overcurrent in Discharge Permanent Fail

The device can permanently disable the battery in the case of significant overcurrent in the DISCHARGE or RELAX state.

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

5.6 Safety Overtemperature Cell Permanent Fail

The device can permanently disable the battery pack in case of significant overtemperature of the cells detected using the external TS1 temperature sensor, which are configured to report as cell temperature, *Temperature()*. For ***Safety Overtemperature Cell Permanent Fail*** , the temperature sensor with the highest temperature is used.

Status	Condition	Action
Normal	CHARGE mode: All *Temp()* < ***SOTC:Threshold*** DISCHARGE or RELAX mode: All *Temp()* < ***SOTD:Threshold***	*PFAlert()[SOT]* = 0
Alert	CHARGE mode: A *Temp()* ≥ ***SOTC:Threshold*** DISCHARGE or RELAX mode: A *Temp()* ≥ ***SOTD:Threshold***	*PFAlert()[SOT]* = 1 *BatteryStatus()[OTA]* = 0
Trip	CHARGE mode: A *Temp()* ≥ ***SOTC:Threshold*** for ***SOTC:Delay*** duration DISCHARGE or RELAX mode: A *Temp()* ≥ ***SOTD:Threshold*** for ***SOTD:Delay*** duration	*PFAlert()[SOT]* = 0 *PFStatus()[SOT]* = 1 *BatteryStatus()[OTA]* = 1

5.7 Safety Overtemperature FET Permanent Fail

The device can permanently disable the battery pack in case of significant 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]* = 0
Trip	FET Temperature in *DAStatus2()* ≥ ***SOTF:Threshold*** for ***SOTF:Delay*** duration	*PFAlert()[SOTF]* = 0 *PFStatus()[SOTF]* = 1 *BatteryStatus()[OTA]* = 1

5.8 Capacity Degradation Permanent Fail

The device can permanently disable the battery pack in case the capacity of the battery is degraded below a threshold.

Status	Condition	Action
Normal	QMax pack > ***CD:Threshold***	*PFAlert()[CD]* = 0
Alert	QMax pack ≤ ***CD:Threshold***	*PFAlert()[CD]* = 1
Trip	QMax pack ≤ ***CD:Threshold*** for ***CD:Delay*** (1) cycles	*PFAlert()[CD]* = 0 *PFStatus()[CD]* = 1

(1) The delay for this check is counted each time ***QMax Cycle Count*** is updated.

5.9 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()* ≥ ***CFET:OFF Threshold*** for ***CFET:OFF Delay*** duration	*PFAlert()[CFETF]* = 0 *PFStatus()[CFETF]* = 1

5.10 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()* ≤ ***DFET:OFF Threshold*** for ***DFET:OFF Delay*** duration	*PFAlert()[DFETF]* = 0 *PFStatus()[DFETF]* = 1

5.11 Battery Swelling Detection Permanent Fail

This device can permanently disable the battery pack in case battery swelling has been detected. In the event of a large change in cell impedance, the device will generate an Alert signal and subsequently trigger the Protection Fault (PF) status, resulting in permanent disablement of the battery pack.

Following flowchart provides the logic flow for the battery swelling detection (BSD) algorithm:

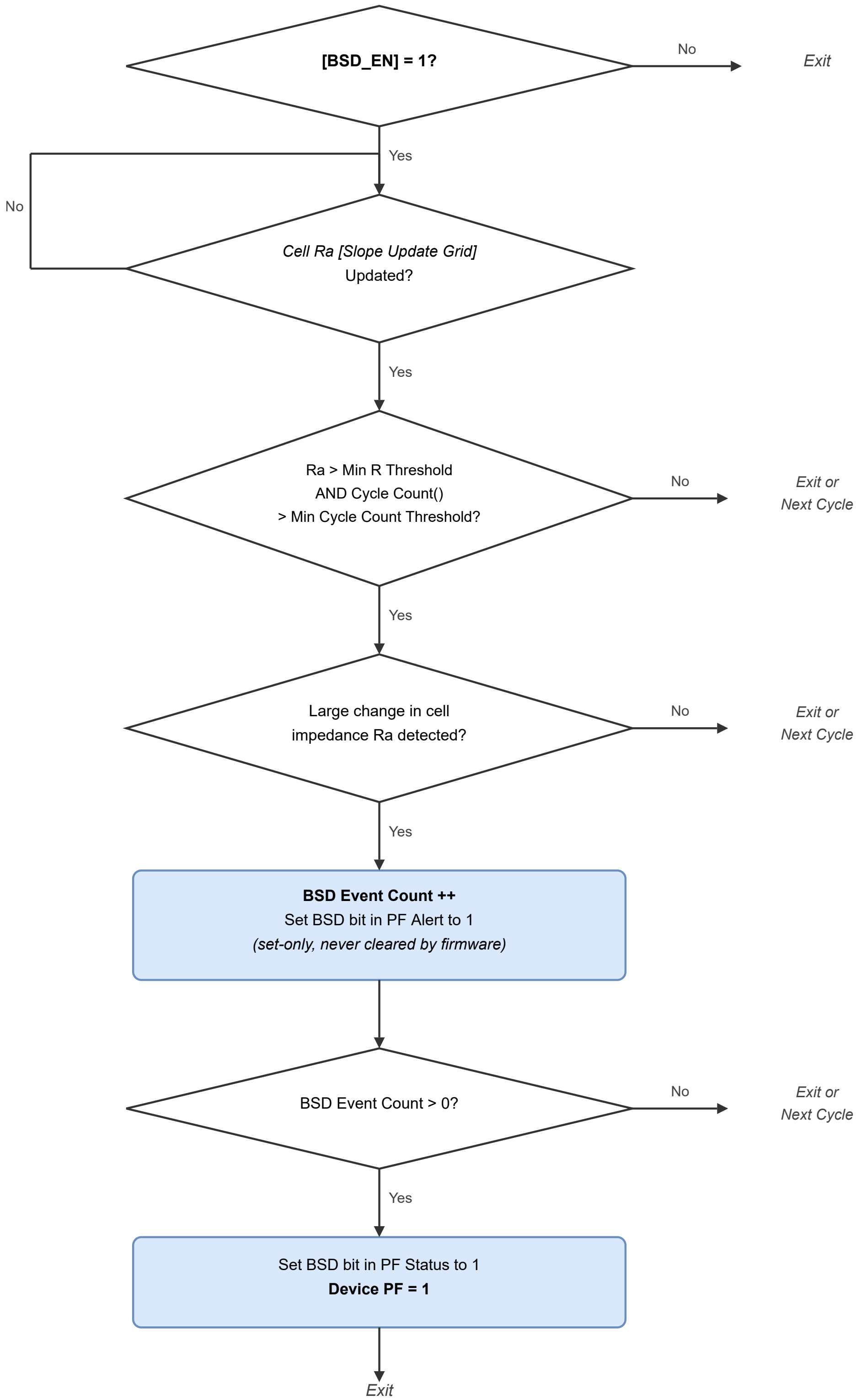


Figure 5-1. BSD Algorithm

Note

The ***BSD Event Count*** parameter is tracked per cell and persists across power cycles.

Status	Condition	Action
Normal	***Cellx Ra[Slope Update Grid]*** ≤ ***Min R Threshold*** OR *Cycle Count()* ≤ ***Min Cycle Count Threshold*** OR No large change in cell impedance Ra detected	*PFAlert()[BSD]* = 0
Alert	***BSD Enable*** = 1 AND ***Cellx Ra[Slope Update Grid]*** > ***Min R Threshold*** AND *Cycle Count()* > ***Min Cycle Count Threshold*** AND Large change in cell impedance Ra detected	*PFAlert()[BSD]* = 1 ***BSD Event Count*** ++
Trip	*PFAlert()[BSD]* = 1 AND ***BSD Event Count*** > 0	*PFAlert()[BSD]* = 0 *PFStatus()[BSD]* = 1

5.12 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	The data flash write is successful.	—
Trip	The data flash write is not successful.	*PFStatus()[DFW]* = 1

5.13 Cell Overvoltage Latch Permanent Failure

The device can permanently disable the battery in the case of repeated cell overvoltage events. *PFAlert()[COVL]* and *PFStatus()[COVL]* use the same logic and data flash settings as *SafetyAlert()[COVL]* and *SafetyStatus()[COVL]* with the exception of there being no recovery mechanism. It is recommended to not have both *PFStatus()[COVL]* and *SafetyStatus()[COVL]* enabled at the same time.

5.14 Manual Permanent Failure

The device can permanently disable the battery upon receipt of a two-word MAC sequence. The two-word key is programmable via *ManufacturerAccess()* 0x0035 security keys. Both keys must be sent within 4 s of each other for ***[FORCE]*** to activate.

5.15 Permanent Fail ISI

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	ISI	Low Fault Count Threshold	U1	3	255	5	–	Number of fails against ***Low Internal Short Threshold*** to trigger a permanent failure when ***Enabled PF D[ISI_LO]*** = 1
Permanent Fail	ISI	High Fault Count Threshold	U1	3	255	5	–	

5.16 Internal Short-Circuit Indication Low Permanent Fail

The device provides a flag which gives the host the ability to permanently disabling the battery pack if the ISI algorithm produces enough fails on its small internal short threshold.

Table 5-1. ISI Low PF

Status	Condition	Action
Normal	ISI Low Fail Count in *ISIData()* = 0	*PFAlert()[ISI_LO]* = 0
Alert	ISI Low Fail Count in *ISIData()* > 0	*PFAlert()[ISI_LO]* = 1
Trip	ISI Low Fail Count in *ISIData()* ≥ ***Low Fault Count Threshold***	*PFAlert()[ISI_LO]* = 0 *PFStatus()[ISI_LO]* = 1

5.17 Internal Short-Circuit Indication High Permanent Fail

The device provides a flag which gives the host the ability to permanently disabling the battery pack if the ISI algorithm produces enough fails on its large internal short threshold.

Table 5-2. ISD High PF

Status	Condition	Action
Normal	ISI High Fail Count in *ISIData()* = 0	*PFAlert()[ISI_HI]* = 0
Alert	ISI High Fail Count in *ISIData()* > 0	*PFAlert()[ISI_HI]* = 1
Trip	ISI High Fail Count in *ISIData()* ≥ ***High Fault Count Threshold***	*PFAlert()[ISI_HI]* = 0 *PFStatus()[ISI_HI]* = 1

6 Power Modes

6.1 NORMAL Mode

In Normal mode, the device samples voltage and temperature readings at 250-ms intervals, current measurements at 1-s intervals, and performs protection/gauging calculations, SBS data updates, and status decisions every 1 s. The device enters a low-power state during the intervening periods of inactivity.

6.1.1 System Present Detection Configuration

The operates in embedded pack configuration with ***DA Configuration[NR]*** = 1. In this configuration, pack removal detection is disabled.

The configurable GPIO pins (C1, C2, C3) can be assigned to other functions such as $\overline{\text{SHUTDN}}$ for emergency shutdown or $\overline{\text{PRES}}$ for system disconnect detection via the ***IO Config*** data flash settings.

6.1.1.1 System Present

The $\overline{\text{PRES}}$ pin is sampled every 250 ms, and if the $\overline{\text{PRES}}$ pin is high for ***SYS_PRES Delay*** samples, the *OperationStatus[PRES]* flag is cleared. If the $\overline{\text{PRES}}$ pin is low for ***SYS_PRES Delay*** samples, the *OperationStatus [PRES]* flag is set, indicating the system is present (the battery is inserted).

6.1.1.2 Battery Pack Removed

The default configuration is an embedded (non-removable) pack (***[NR]*** = 1). The Battery Pack Removed mode applies when ***[NR]*** is set to 0 (removable pack configuration).

When ***[NR]*** = 0, the firmware actively monitors the $\overline{\text{PRES}}$ pin for system presence. The following behavior applies:

- **Pack removed** ($\overline{\text{PRES}}$ deasserts): All CHG and DSG FETs are immediately forced off. Removable-reset safety fault counters are cleared to allow clean FET recovery on reinsertion.
- **Pack inserted** ($\overline{\text{PRES}}$ asserts): The $\overline{\text{PRES}}$ pin state is debounced for approximately 1 second. After debounce, FETs are re-enabled based on the normal safety state.
- **Sleep mode**: The gauge does not enter sleep while the system is connected ($\overline{\text{PRES}}$ asserted) unless **IN_SYSTEM_SLEEP** is also set.
- **EMSHUT_EN and DISCONN_EN**: These features are not functional when ***[NR]*** = 0. They require non-removable mode (***[NR]*** = 1) to operate.

For DA Configuration bit definitions, see ***DA Configuration*** register.

6.2 SLEEP Mode

6.2.1 Device Sleep

When the sleep conditions are met, the device enters SLEEP mode with periodic wakeups for voltage, temperature, and current measurements to reduce power consumption.

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

In SLEEP mode, the device wakes up every ***Sleep Measure Time*** (8s) to measure voltage, and temperature, and every ***Current Measure Time*** (16s) to read current.

Status	Condition	Action
Activate	SMBus low for ***Bus Timeout*** if ***[IN_SYSTEM_SLEEP]*** = 0, or no communication for ***Bus Timeout*** if ***[IN_SYSTEM_SLEEP]*** = 1 AND ***DA Config[SLEEP]*** = 1 AND |*Current()*| ≤ ***Sleep Current*** AND *OperationStatus()[SDM]* = 0 AND No *PFAlert()* bits set AND No *PFStatus()* bits set AND No *SafetyAlert()* bits set AND No [AOCD], [AOCDL], [AOCC], [AOCCL], [ASCD], [ASCDL] set in *SafetyStatus()*	Turn off CHG FET and PCHG FET if ***FET Options[SLEEPCHG]*** = 0. The device goes to sleep. The device wakes up every ***Sleep:Measure Time*** period to measure voltage and temperature.
Exit	SMBus connected OR SMBus command received OR |*Current()*| > ***Sleep Current*** OR Wake comparator activates OR *OperationStatus()[SDM]* = 1 OR *PFAlert()* bits set OR *PFStatus()* bits set OR *SafetyAlert()* bits set OR *[AOCD], [AOCDL], [AOCC], [AOCCL], [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. The CHG FET and PCHG FET remains on in SLEEP mode if ***[SLEEPCHG]*** = 1.
4. The wake comparator threshold is set through ***AFE:Current Charge Wake[3:0]*** and ***AFE:Current Discharge Wake[3:0]*** .
5. *SafetyAlert()[PTO]*, *[PTOS]*, *[CTO]*, *[CTOS]* or *PFAlert()[QIM]*, *[OC]*, *[IMP]*, *[CB]* will not prevent the gauge to enter SLEEP mode.
6. It is required that CHG FET and DSG FET should be turned on within 250ms when gauge exits from SLEEP mode to NORMAL mode.

Note

The status of CHG FET and DSG FET in SLEEP mode is shown below based on the DFs setting.

Table 6-1. CHG/DSG FETs in SLEEP mode

[SLEEPCHG]	*[IN_SYSTEM_SLEEP]*	CHG FET	DSG FET
0	X	OFF	ON
1	X	ON	ON

Note

The status here may not be the actual status since there are many others functions can interfere the control of FETs like protection and pre-charge.

6.2.2 IN SYSTEM SLEEP Mode

The device provides an option to enter SLEEP mode in-system. When the ***DA Config[IN_SYSTEM_SLEEP]*** = 1, the device will turn off CHG FET and PCHG FET if ***FET Options[SLEEPCHG]*** = 0 and enter SLEEP mode. In this option, the SMBus low state is not a condition to enter SLEEP mode (instead, communication must not occur for ***Bus Timeout*** to enter SLEEP). All the other sleep conditions must be met for the device to enter SLEEP mode.

Note

Setting the ***Bus Timeout*** = 0 with ***[IN_SYSTEM_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.

6.2.3 ManufacturerAccess() MAC Sleep

The SLEEP MAC command can override the requirement for bus low to enter sleep. In this case, the 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.

6.2.4 Current 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 ***Current Charge Wake*** and ***Current Discharge Wake*** . 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*** . Refers to *Current Wake Detector* for details.

6.3 SHIP Mode

In SHIP mode, the device measures voltage and temperature at periodic intervals and current is not measured or coulomb counted. Current is assumed to be and reported as 0 mA. The device enters RELAX mode for gauging calculations using the standard configured SOC algorithm. All measurements are performed simultaneously at each interval (no rotation or selective skipping). The measurements performed at each interval are:

1. Cell voltage
2. Temperature (TSInt and TS1 if enabled)
3. PACK voltage

Note

SHIP mode is designed for ultra-low power shelf storage. The periodic measurement interval is fixed at 60 seconds on this hardware to minimize current draw and extend battery shelf life during extended storage periods.

Firmware processing is minimized in SHIP mode by disabling coulomb counting and current measurement. Some calculations are performed less frequently than in normal operation. These less frequent calculations include updating firmware-based protections, lifetime data, and the voltage and temperature range of the advanced charge algorithm. Other calculations, such as updating *RemainingCapacity()* and *FullChargeCapacity*, are not performed at all with the assumption the system is off and will not communicate with the gauge.

SHIP mode is entered based on voltage through SLEEP or by command through NORMAL or SLEEP. Exit from this mode is through a current level (I-WAKE threshold) or command.

Status	Condition	Action
Activate	(*OperationStatusA()[SLEEP]* = 1 AND *Voltage()* < ***Shipmode Voltage Threshold*** for ***Shipmode Voltage Delay***) OR (*OperationStatusB()[SHIPM]* = 1 for ***Shipmode Command Delay*** AND |*Current()*| ≤ ***Sleep Current***)	*OperationStatusA()[SHIP]* = 1 The device enters RELAX mode. *Current()* = 0 mA, *AverageCurrent()* = 0 mA The device wakes up every ***Shipmode Measure Time*** to measure voltage and temperature.(1) The device does NOT coulomb count or measure current.

Status	Condition	Action
Exit	(Hardware-based IWAKE threshold surpassed AND ***DA Configuration[IWAKE_EXIT]*** = 1) OR (*Voltage()* ≥ ***Shipmode Voltage Threshold*** AND *OperationStatusB()[SHIPM]* = 0) OR (*OperationStatusB()[SHIPM]* = 1 AND MAC *ShipmodeDisable()* received)	*OperationStatusA()[SHIP]* = 0 *OperationStatusB()[SHIPM]* = 0 Return to NORMAL mode

(1) For best performance, the device wakes up every 1 second to measure voltage and temperature when an OCV is in progress (*GaugingStatus()[SLPQMAX]* = 1) or a firmware-based protection entered the alert state (that is, *SafetyAlert()* ≠ 0).

Note

If the gauge is UNSEALED and the MAC *ShipmodeEnable()* command is sent twice in a row, the gauge enters SHIP mode immediately and skips the normal delay sequence.

The configuration options for SHIP are in the following data flash.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Power	Shipmode	Shipmode Voltage Threshold	I2	0	32767	2300	mV	Cell based SHIP voltage trip threshold
Power	Shipmode	Shipmode Voltage Delay	U2	0	255	10	s	Cell based SHIP voltage trip delay
Power	Shipmode	Shipmode Measure Time	U1	60	60	60	s	Fixed wake interval for voltage and temperature measurements in SHIP mode. Hardware limited to 60 seconds; not user configurable on this device.
Power	Shipmode	Shipmode Command Delay	U1	0	255	0	s	Delay time to enter SHIP mode after MAC ShipmodeEnable() is received. Default of 0 = immediate entry. Send MAC 0x0015 twice in UNSEALED mode to bypass delay and enter immediately.

6.4 SHUTDOWN Mode

6.4.1 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.

Status	Condition	Action
Enable	cell voltage < ***Shutdown Voltage***	*OperationStatus()[SDV]* = 1
Trip	cell voltage < ***Shutdown Voltage*** for ***Shutdown Time***	Turn DSG FET off
Shutdown	Voltage at PACK pin < ***Charger Present Threshold*** AND ENAB is high	Send device into SHUTDOWN mode
Exit	Voltage at PACK pin > $V_{STARTUP}$ OR /ENAB pin pulled LOW for ***Startup ENAB Hold Time***	*OperationStatus()[SDV]* = 0 Return to NORMAL mode

Note

The /ENAB pin is an active-low hardware GPIO input (pin D2). When pulled LOW (to GND or PACK−), the device exits SHUTDOWN mode.

During ENAB software debounce, FETs are off until ***Startup ENAB Hold Time*** expires. ENAB hold feature is ignored if charger is connected.

Note

The device goes through a full reset when exiting from SHUTDOWN mode, which means the device will reinitialize. 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.

If 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 reinitialized (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.

6.4.2 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. ***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 ***FET Off Time*** . The device returns to NORMAL mode when the voltage at the PACK pin > $V_{STARTUP}$ or the ENAB pin is pulled low. The device can be sent to this mode with the *ManufacturerAccess() Shutdown* command. Charger voltage must not be present and the ENAB pin must be high for the device to enter SHUTDOWN mode.

Note

If the gauge is sealed and the MAC *Shutdown()* command is sent twice in a row, the gauge will execute the shutdown sequence with a delay determined by ***Power: Ship: Delay*** dataflash value.

6.4.3 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 ***Auto Ship Time*** . Setting ***PowerConfig[AUTO_SHIP_EN]*** enables this feature. Any communication to the device restarts the timer. When the timer reaches ***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 > $V_{STARTUP}$ or the ENAB pin is pulled low.

6.4.4 Low RSOC Time-Based Shutdown

The device can be configured to shut down when the RSOC is less than the RSOC threshold specified in ***Low RSOC SD Threshold*** for more than the time interval specified in ***Low RSOC SD Time*** . Setting ***PowerConfig[RSOC_SD]*** = 1 enables this feature. Once the timer start, only a charge current detection event will restart the timer. When the timer reaches ***Low RSOC SD 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 > $V_{STARTUP}$.

Note

When *[LT_TEST]* is enabled, 1 minute in real time counts as 1 hour in firmware time.

6.4.5 Power Save Shutdown

Power Save Shutdown is enabled when ***[PWR_SAVE_VSHUT]*** is set. The enters ***Power Save Shutdown*** when the lowest cell voltage is below ***PS Shutdown Voltage*** and:
NoLoadRemCap() < ***PS NoLoadResCapThreshold*** .

Status	Condition	Action
Enable	cell voltage < ***PS Shutdown Voltage***	*OperationStatus()[PSSHUT]* = 1
Trip	cell voltage < ***PS Shutdown Voltage*** AND *NoLoadRemCap()* < ***PS No Load Res Cap*** AND RSOC = 0% AND the ***[REST]*** bit must be set.	Turn DSG FET off
Shutdown	Voltage at PACK pin < ***Charger Present Threshold***	Send device into SHUTDOWN mode.

Status	Condition	Action
Exit	Voltage at PACK pin > $V_{STARTUP}$	*OperationStatus()[PSSHUT]* = 0 Return to NORMAL mode

6.4.6 IO Based Shutdown

The device can shut down upon the assertion of the INT pin (pad C2) when configured via ***Settings GPIO IO Shutdown*** and the configuration bit ***[IO_SHUT]*** = 1. When the pin is asserted for ***IO Shutdown Delay*** , the gas gauge opens its DSG FET, then shuts down once PACK voltage < ***Charger Present Threshold*** . If the pin is deasserted or ***[IO_TIMEOUT]*** is set and ***IO Shutdown Timeout*** expires following activation before PACK voltage < ***Charger Present Threshold*** , then the shutdown is stopped and the DSG FET turns back on and returns to the state it was in before the pin was asserted. An active low signal is detected when ***[IO_POL]*** = 0. An active high signal is detected when ***[IO_POL]*** = 1. An internal pullup is enabled when ***[IO_PUL_DIS]*** = 0. The pullup is disabled when ***[IO_PUL_DIS]*** = 1. The pin is sampled every 250 ms.

Status	Condition	Action
Trip	INT pin (pad C2) asserted AND the ***[IO_SHUT]*** bit is set.	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()[IOSHUT]* = 0 Return to NORMAL mode.

6.5 Startup ENAB Hold Time

Overview

The Startup ENAB Hold Time parameter configures a debounce/hold delay for the ENAB pin condition during wakeup from Shutdown Mode. This feature helps prevent false wakeups due to noise or transient signals on the ENAB pin.

Parameter Definition

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Power	Startup ENAB Hold Time	U1	0	255	0	s

Description: This parameter configures a hold delay for the ENAB pin condition during wakeup from Shutdown Mode. When set to a non-zero value, the device will wait the specified number of seconds after detecting the ENAB pin condition before fully waking up.

Behavior

- The hold delay is **ignored** if a charger is connected - the device wakes immediately when charger is present
- FETs remain **disabled** during the hold delay period for safety
- Set to **0** to disable the debounce/hold feature (default behavior)
- Set to any non-zero value (**1-255 seconds**) to enable the feature

Note

This parameter was added in firmware version v0.03 (BMSFW-11223). It is not available in earlier firmware versions.

6.6 Option to Manage Unintended Wakeup from Shutdown

In some user systems, there can be glitches on the supply line during mass production. This can result in a glitch getting to the PACK pin (V_{PACK}), which can then unintentionally wake up a device that was in shutdown.

The feature to manage an unintended wakeup from shutdown, if enabled (with the ***[CHECK_WAKE]*** bit), manages a shutdown of the gauge by any allowed shutdown process (except for VOLTAGE BASED SHUTDOWN and POWER SAVE SHUTDOWN, both of which are excluded from this feature). This feature does not function on a wake/start up from a reset.

When this feature is active on wake up from shutdown, the gauge starts a ***Delay*** timer (with the default of 2 s) and looks for communication to the gauge during this time—with CHG and DSG FETs remaining off. If during the ***Delay*** timer period there is no valid communication with the device, then the device goes back into shutdown (with FETs turned off). If there is valid communication within the ***Delay*** timer period, then the device stays in wake and continues like a normal wakeup. Valid communication means the gauge receives a valid address and a command. (It does not matter if the command is invalid. Invalid commands are OK with a valid address.)

One variant to this is the wake up from an IATA shutdown. In this case, each time the gauge wakes up, the IATA function will be called as usual. However, if the gauge then goes back into shutdown (because it was an unintended wakeup from shutdown), then the ***[IATA_SHUT]*** bit will be set before going into shutdown again and the FCC and RemCap stored during the original IATA shutdown will still be kept for the next wakeup.

Additionally, the number of times the gauge wakes up from shutdown unintentionally is recorded. This "unintentional wakeup" counter is reset when the gauge wakes up and sees valid communication. If this count exceeds a threshold (***Count*** , with the default of 3), then the next time the gauge wakes up from shutdown, it will execute a normal wakeup without looking for valid communication (and the counter recording wakeup will be reset). If the ***Count*** is set to 0, then no threshold exists and the gauge will only wake up with valid communications.

Note

If this feature is enabled (***[CHECK_WAKE]*** set high), then by default the CHG and DSG FETs are off on wake up from SHUTDOWN (during the ***Delay*** timer period); thus, the FETs will turn on only if the gauge enters a normal wakeup. However, if the ***[CHECK_WAKE_FET]*** bit is set (default is cleared), then the FETs will not be forced off during the ***Delay*** timer period.

6.7 Emergency FET Shutdown (EMSHUT)

The Emergency FET Shutdown function provides an option to disable the battery power to the system by opening up the CHG and DSG FETs before removing an embedded battery pack. There are two ways to enter the EMERGENCY FET 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()*. The FETs open after a configurable ***MFC Delay*** (default 15 seconds) following receipt of the MFC command.

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

Note

Emergency FET Shutdown turns off the FETs but does not power off the device.

Note

Feature prerequisites: The Emergency FET Shutdown feature is active only when all of the following conditions are met:

- ***[NR]*** = 1 (non-removable/embedded pack mode, DA Configuration bit 2). This feature is not available in removable pack configuration (***[NR]*** = 0).
- ***EMShutEn*** = 1 (DA Configuration bit 5).
- A GPIO pin must be assigned to the $\overline{\text{SHUTDN}}$ function via ***IO Config*** data flash settings.

Mutual exclusivity: Setting ***EMShutEn*** = 1 disables the System Disconnect feature. The two features cannot be active at the same time.

The gauge exits the EMERGENCY FET SHUTDOWN state when any of the following conditions occur:

1. **Timeout:** After ***EmShut Timeout*** minutes (default 30 minutes) the state is cleared automatically. Setting ***EmShut Timeout*** to 0 disables the timeout exit.

2. **Pin released:** When the SHUTDN pin returns HIGH, the state is cleared. This exit path can be disabled by setting the ***[EMSHUT_PEXIT_DIS]*** configuration bit.
3. **Charger detected** (optional, ***[EMSHUT_EXIT_VPACK]***): When *PackVoltage()* ≥ ***Charger Present*** threshold for two consecutive samples while the DSG FET is open.
4. **Communication activity** (optional, ***[EMSHUT_EXIT_COMM]***): When communication is detected on the bus.

Note

SHUTDN pin is a configurable option that is disabled by default. The user can assign the SHUTDN function to either the C1 (if it is not configured as a TS pin), C2, or C3 pin. Configure via the ***IO Config*** data flash settings.

6.7.1 Enter Emergency FET Shutdown Through SHUTDN

When a high-to-low transition on the SHUTDN pin is detected with a debounce delay of ***SYS_PRES Delay*** samples (each sample is taken at 250-ms interval) for the low-level threshold, the gauge turns off the CHG and DSG FETs immediately. This entry method applies when ***DA Configuration[EMSHUT]*** = 1.

Note

The SHUTDN function is a configurable option that is disabled by default. The user can assign the SHUTDN function to either the C1 (if it is not configured as a TS pin), C2, or C3 pin via IO Config settings.

6.7.2 Enter Emergency FET Shutdown Through MFC

Alternatively, sending a manual FET control (MFC) sequence using the steps below also puts the gauge to the EMERGENCY FET SHUTDOWN state.

1. Send word 0x270C 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 ***Manual FET Control Delay*** .

6.7.3 Exit Emergency FET 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 any one of the following conditions:

- A high-to-low transition on the SHUTDN pin is detected with a debounce delay of 1 s for the low level threshold. For example, a push button is pressed again. This exit condition can be disabled by setting the ***[EMSHUT_PEXIT_DIS]*** bit in the ***DA Configuration*** register.
- Send word 0x23A7 to *ManufacturerAccess()* (0x00).
- PACK voltage > ***Charger Present Threshold*** for two sample periods (that is, ~500 ms). This exit condition requires the ***[EMSHUT_EXIT_VPACK]*** bit to be set.
- Valid SMBus communication is received. Valid SMBus communication means a valid gauge address and any command is received (that is, an invalid command with a valid address is OK). This exit condition requires the ***[EMSHUT_EXIT_COMM]*** bit to be set. When using this exit option, the ***Manual FET Control (MFC) Delay*** should be set to a minimum of 4 seconds.

In EMSHUT mode, to detect the voltage level at the PACK pin quickly (even while in SLEEP), the AD conversion will occur every second.

6.8 STORAGE Mode

STORAGE mode is activated with command 0x000A. When the STORAGE mode command is received, bit 10 (the *[STORAGEM]* bit) in *Operation Status B* is set.

1. After ***Storage Delay*** time since *[STORAGEM]* bit set, the CHG and DSG FETs are turned off.

2. After ***Storage Ignore SMB Delay*** time since *[STORAGEM]* bit set, gauge will exit STORAGE mode if one of the following conditions is met:
   a. if gauge is not in SLEEP mode (either not entered or exited) OR
   b. if SMBus high is detected
3. After STORAGE mode is exited, *[STORAGEM]* bit will be reset, then CHG and DSG FETs disable (turned off) will be lifted. (The FETs can still be turned off by other features)

Note

The gauge needs to be in SLEEP to stay in STORAGE mode, so the ***Storage Delay*** time and ***Storage Ignore SMB Delay*** time, though not limited, should practically be set higher than the ***Chg Relax Time*** and ***Dsg Relax Time*** thresholds.

Storage Ignore SMB Delay time can be set smaller than ***Storage Delay*** time in test setup with communication disconnected after sending the command, but in practical setup, ***Storage Ignore SMB Delay*** time might need to be larger to let the disabled FETs turn off communication, so that there would not be any SMBus high to cause the exit from STORAGE mode.

6.9 System Disconnect

The system can signal the gas gauge via the $\overline{\text{PRES}}$ function to open the CFET and DFET, disconnecting the battery power to the host. The device operates in embedded pack configuration (***[NR]*** = 1).

Note

Feature prerequisites: The System Disconnect feature is active only when all of the following conditions are met:

- ***[NR]*** = 1 (non-removable/embedded pack mode,) — the feature is completely disabled when ***[NR]*** = 0.
- ***DISCONN_EN*** = 1 .
- ***EMShutEn*** = 0 . System Disconnect and Emergency FET Shutdown are mutually exclusive; the feature is suppressed when ***EMShutEn*** is set.
- A GPIO pin must be assigned to the disconnect function via ***IO Config*** data flash settings.

The internal pullup of the $\overline{\text{PRES}}$ function is enabled for this feature when assigned to a GPIO pin. Entry to the SYSTEM DISCONNECT mode occurs when the gas gauge detects a high-to-low transition of the configured $\overline{\text{PRES}}$ pin ($\overline{\text{PRES}}$ pin debounce is used). The gauge opens the CFET and DFET in SYSTEM DISCONNECT mode. The *OperationStatus()[DISCONN]* = 1.

Note

Because the system is shutdown in this mode, the gas gauge enters SLEEP mode after a bus timeout. Regardless if the ***[SLEEPCHG]*** flag sets, the CFET and DFET will remain off in the SYSTEM DISCONNECT mode.

The $\overline{\text{PRES}}$ pin state is sampled in 250-ms intervals. A "low" is detected by receiving ***SYS_PRES Delay*** consecutive low samples. The debounce time ranges from ***SYS_PRES Delay*** − 1 samples (if the pin state is changed just before a sample is taken) to ***SYS_PRES Delay*** samples (if the pin state is changed just after a sample is taken).

It exits from the SYSTEM DISCONNECT mode when:

- It detects a charger is present AND
- The configured $\overline{\text{PRES}}$ pin returns to high (indicating system reconnection).

The gauge then returns to NORMAL mode and closes the CFET and DFET.

Note

Pin Configuration: The $\overline{\text{PRES}}$ function can be assigned to pin C1 (if it is not configured as a TS pin), C2, or C3. Configure via the ***IO Config*** data flash settings.

7 Gauging

7.1 Introduction

The device measures individual cell voltages, pack voltage, temperature, and current. It determines battery state-of-charge by analyzing individual cell voltages when a certain relax time has passed since the last charge or discharge activity of the battery.

The device measures charge and discharge activity by monitoring the voltage across a small-value series sense resistor (0.5mΩ minimum) between the negative terminal of the cell stack and the negative terminal of the battery pack. The battery state-of-charge is subsequently adjusted during a load or charger application using the integrated charge passed through the battery. The device is capable of supporting a maximum battery pack capacity of 32 Ah.

The default for gauging is *off*. To enable the gauging function, set ***Manufacturing Status[GAUGE_EN]*** = 1. The gauging function will be enabled after a reset or a seal command is set. Alternatively, the *Gauging()* MAC command can be used to turn on and off the gauging function. The *Gauging()* command will take effect immediately and the ***[GAUGE_EN]*** will be updated accordingly.

The *GaugeStatus1()*, *GaugeStatus2()*, and *GaugeStatus3()* commands return various gauging related information that is useful for problem analysis.

7.2 Dynamic Z-Track Configuration

Load Mode

During normal operation, the battery-impedance profile compensation of the Dynamic Z-Track algorithm can provide more accurate full-charge and remaining state-of-charge information if the typical load type is known. The two selectable options are constant current (***Load Mode*** = 0) and constant power (***Load Mode*** = 1).

Load Select

To compensate for the I × R drop near the end of discharge, the device must be configured for the current (or power) that will flow in the future. While it cannot be exactly known, the device can use load history, such as the average current of the present discharge, to make a sufficiently accurate prediction.

The device can be configured to use several methods of this prediction by setting the ***Load Select*** value. Because this estimate has only a second-order effect on remaining capacity accuracy, different measurement-based methods (methods 0–3 and method 7) result in only minor differences in accuracy. However, methods 4–6, where an estimate is arbitrarily user-assigned, can result in a significant error if a fixed estimate is far from the actual load. For highly variable loads, selection 7 provides the most conservative estimate and is preferable.

	Constant Current (***Load Mode*** = 0)	Constant Power (***Load Mode*** = 1)
0 =	***Avg I Last Run***	***Avg P Last Run***
1 =	Present average discharge current	Present average discharge power
2 =	*Current()*	*Current()* × *Voltage()*
3 =	*AverageCurrent()*	*AverageCurrent()* × average *Voltage()*
4 =	***Design Capacity*** /5	***Design Capacity cWh*** /5
5 =	*AtRate()* (mA)	*AtRate()* (cW)
6 =	***User Rate-mA***	***User Rate-mW***
7 =	***Max Avg I Last Run*** (default)	***Max Avg P Last Run***

Pulsed Load Compensation and Termination Voltage

To take into account pulsed loads while calculating remaining capacity until ***Term Voltage*** threshold is reached, the device monitors not only the average load but also the short load spikes. The maximum voltage deviation during a load spike is continuously updated during discharge and stored in ***Delta Voltage*** . ***Delta Voltage*** is then added to **Termination Voltage** artificially raising it as part of the capacity simulation to account for the sudden voltage drop that potentially could be seen. With ***Delta Voltage*** being a learned parameter, to protect the gauge from over or under compensating, limits are put on ***Delta Voltage*** to cap the compensation. This range is defined by ***Min Delta Voltage*** and ***Max Delta Voltage*** . In addition, to avoid a rapid change in ***Delta Voltage*** the max it can change in any single step is limited to ***DeltaV Max Voltage Delta*** .

Table 7-1. Min DeltaV

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Gas Gauging	IT-DZT Cfg	Min Delta Voltage	Int	2	–32768	32767	0	mV

Table 7-2. Max DeltaV

Class	Subclass	Name	Format	Min Value	Max Value	Default Value	Unit
Gas Gauging	IT-DZT Cfg	Max Delta Voltage	I2	–32768	32767	200	mV

Reserve Battery Capacity

The device allows an amount of capacity to be reserved in either mAh (***Reserve Cap-mAh*** , ***Load Mode*** = 0) or cWh (***Reserve Cap-cWh*** , ***Load Mode*** = 1) units between the point where the *RemainingCapacity()* function reports zero capacity and the absolute minimum battery stack voltage, ***Term Voltage*** . This enables a system to report zero energy, but still have enough reserve energy to perform a controlled shutdown or provide an extended sleep period for the host system.

The reserve capacity is compensated at the present discharge rate as selected by ***Load Select*** .

Termination Voltage

The device forces *RemainingCapacity()* to 0 mAh when the battery stack voltage reaches the ***Term Voltage*** for a period of ***Term V Hold Time*** .

7.3 Gas Gauge Modes

Resistance updates take place only in DISCHARGE mode, while open circuit voltage (OCV) and QMax updates only take place in RELAX mode. If ***Fast Qmax*** is enabled, the Qmax also updates at the end of discharge given a minimum of 37% delta change of charge. Entry and exit of each mode is controlled by data flash parameters in the subclass ***Gas Gauging: Current Thresholds*** section. When the device is determined to be in RELAX mode and OCV is taken, the *GaugingStatus()[REST]* flag is set. In RELAX or DISCHARGE mode, the DSG flag in *BatteryStatus()* is set.

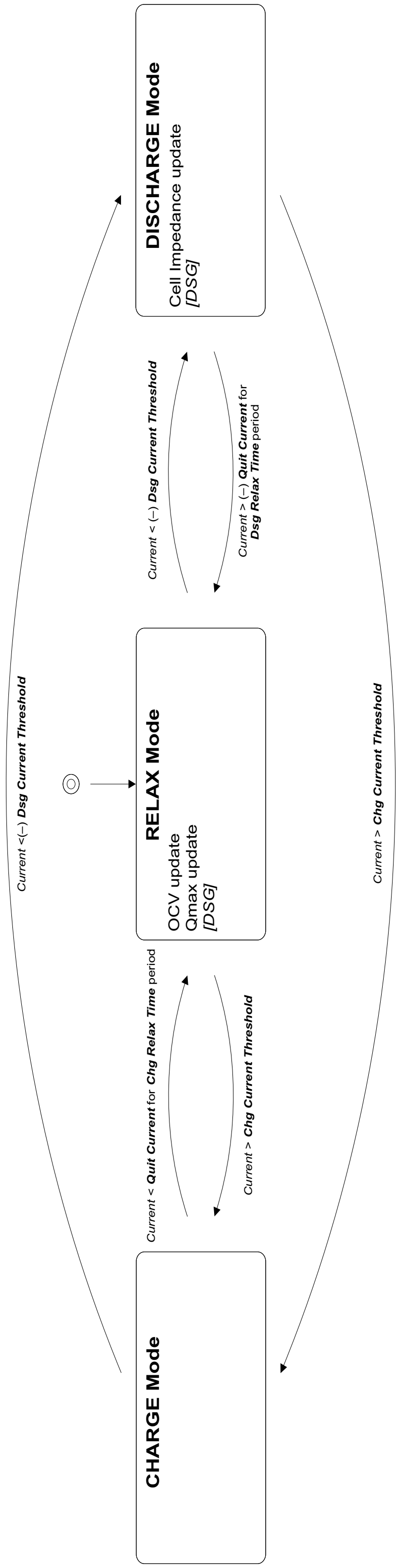


Figure 7-1. Gas Gauge Operating Modes

- 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*** .

- CHARGE mode is entered when current goes above ***Chg Current Threshold*** .

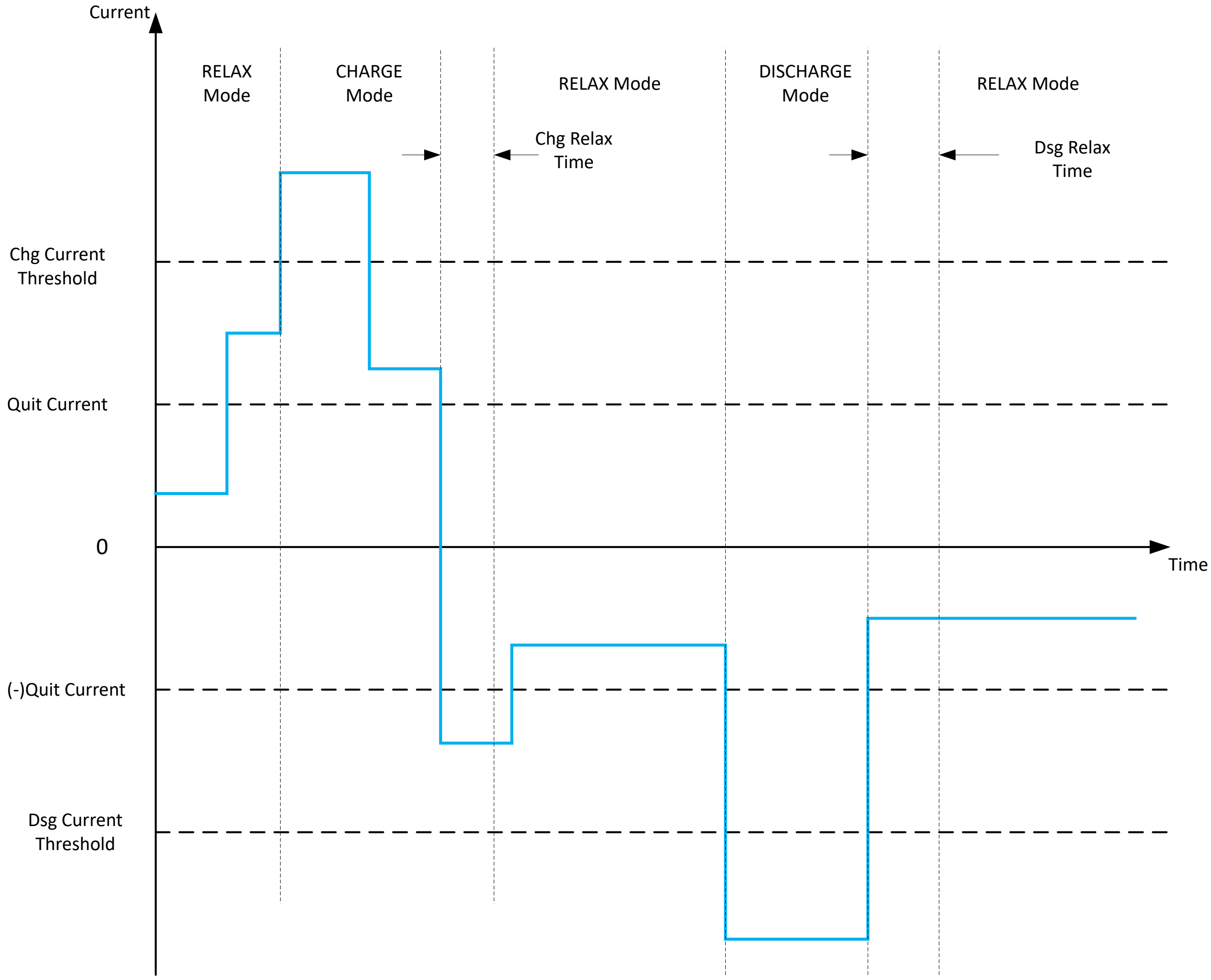


Figure 7-2. Gas Gauge Operating Mode Example

7.4 QMax and Ra

The total battery capacity is found by comparing states of charge before and after charge and discharge with the amount of charge passed. When an applications load is applied, the impedance of each cell is measured by comparing the open circuit voltage (OCV) obtained from a predefined function for present state-of-charge with the measured voltage under load.

Measurements of OCV and charge integration determine chemical state-of-charge and chemical capacity (*QMax*).

The device acquires and updates the battery-impedance profile during normal battery usage. It uses this profile, along with state-of-charge and the *QMax* values, to determine *FullChargeCapacity* and *RelativeStateOfCharge* specifically for the present load and temperature. *FullChargeCapacity* reports a capacity or energy available from a fully charged battery reduced by ***Reserve Cap-mAh*** or ***Reserve Cap-cWh*** under the present load and present temperature until voltage reaches the ***Term Voltage*** .

7.4.1 QMax Initial Values

The initial ***QMax Pack*** , ***QMax Cell 0*** values should be taken from the cell manufacturers' data sheet multiplied by the number of parallel cells, and are used for the *DesignCapacity* function value in the ***Design Capacity*** data flash value.

7.4.2 QMax Update Conditions

A QMax update is enabled when gauging is enabled. This is indicated by the *GaugingStatus()[QEN]* flag. The device updates the no-load full capacity (QMax) when two open circuit voltage (OCV) readings are taken. These OCV readings are taken when the battery is in a relaxed state before and after charge or discharge activity. A relaxed state is achieved if the battery voltage has a dV/dt of < 4 µV/s. Typically, it takes two hours in a charged state and five hours in a discharged state to ensure that the dV/dt condition is satisfied. If five hours is exceeded, a reading is taken even if the dV/dt condition was not satisfied. The *GaugingStatus()[REST]* flag is set when a valid OCV reading occurs. If a valid DOD0 (taken at the previous QMax update) is available, then QMax will also be updated when a valid charge termination is detected.

The flag is cleared at the exit of a relaxed state. A QMax update is disqualified under the following conditions:

Temperature If *Temperature()* is outside of the range 10°C to 40°C.

Delta Capacity If the capacity change between suitable battery rest periods is less than 37%.

Voltage If *CellVoltage()* is inside a flat voltage region. (See the *Support of Multiple Li-Ion Chemistries with Dynamic Z-Track Gas Gauges Application Report* (SLUA372) for the voltage ranges of other chemistries.) This flat region is different with different chemistry. The *GaugingStatus()[OCVFR]* flag indicates if the cell voltage is inside this flat region.

Offset Error If offset error accumulated during time passed from previous OCV reading exceeds 1% of *Design Capacity*, update is disqualified. Offset error current is calculated as ***CC Deadband*** / sense resistor value.

Several flags in *GaugingStatus()* are helpful to track for QMax update conditions. The *[REST]* flag indicates an OCV is taken in RELAX mode. The *[VOK]* flag indicates the last OCV reading is qualified for the QMax update. The *[VOK]* is set when charge or discharge starts. It clears when the QMax update occurs, when the offset error for a QMax disqualification is met, or when there is a full reset. The *[QMax]* flag will be toggled when the QMax update occurs. *GaugeStatus3()* returns the QMax and DOD (depth of discharge, corresponding to the OCV reading) data.

7.4.3 OCV Prediction

Another method available in the gauge is to estimate an accurate OCV reading. After a set wait time (***OCV Pred Transient T***) in RELAX mode, the gauge begins to accumulate voltage readings. Once ***OCV Pred Measure Time*** has passed, the gauge uses a fast OCV algorithm to predict the final OCV value. This fast OCV method is enabled by setting ***IT Gauging Ext[FOCV_EN]*** = 1. This method provides the benefit of reduced relaxation requirements for QMax updates. If at any time the requirements for the conventional OCV method are achieved (dV/dt of < 1 µV/s requirement) after a fast OCV estimation, the device updates the OCV measurement accordingly. For a fast OCV estimate, entry into RELAX mode must be preceded by at least ***OCV Pred Active T Limit*** of a charge or discharge current large enough for the device to exit RELAX mode.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	IT-DZT Cfg	OCV Pred Active T Limit	U2	100	65535	200	s	This is the minimum time the gauge must be in CHARGE or DISCHARGE mode before entering into RELAX mode for a fast OCV estimate.
Gas Gauging	IT-DZT Cfg	OCV Pred Transient T	U2	100	65535	300	s	This is the minimum time the gauge must be in RELAX mode before fast OCV voltage readings start to accumulate.
Gas Gauging	IT-DZT Cfg	OCV Pred Measure Time	U2	0	65535	200	s	This is the time in RELAX mode when fast OCV voltage readings are accumulated and fast OCV is predicted.

7.4.4 Fast Qmax Update Conditions

The Fast Qmax update conditions are very similar to the QMax update conditions with the following differences:

- Instead of taking two OCV readings for QMax update, a Fast Qmax update requires only one OCV reading AND
- The battery pack should discharge below 10% RSOC.

The differences in requirements allow the Fast Qmax feature to have a QMax update at the end of discharge (given one OCV reading is already available and discharge below 10% RSOC) without a longer relax time after a discharge event. Typically, it can take up to 5 hours in a DISCHARGE state to ensure the dV/dt < 4 μV/s condition is satisfied. The temperature, delta capacity, voltage, and offset error requirements for QMax update are still required for the Fast Qmax update.

This feature is particularly useful for reducing production QMax learning cycle time or for an application that is mostly in charge or discharge stage with infrequent relaxation. Setting ***IT Gauging Configuration[FAST_QMAX_LRN]*** = 1 enables Fast Qmax during production learning only (that is, ***Update Status*** = 6). When setting ***IT Gauging Configuration[FAST_QMAX_FLD]*** = 1, Fast Qmax is enabled when gauging is enabled and ***Update Status*** ≥ 6.

7.4.5 QMax and Fast Qmax Update Boundary Check

The device implements a QMax and Fast Qmax check prior to saving the value to data flash. This improves the robustness of the QMax update in case of potential QMax corruption during the update process.

The verifications are as follows:

1. Verify that the updating QMax or Fast Qmax value is within ***Qmax Delta Percent*** , which is the maximum allowed QMax change for each update. If the updating value is outside of this data flash parameter, the device caps the change to ***Qmax Delta Percent*** of the ***Design Capacity*** .
2. Bound the absolute QMax value, ***Qmax Upper Bound*** . This is the maximum allowed QMax value over the lifetime of the pack.
3. Ensure that QMax is greater than 0 before saving to data flash.

7.4.6 Ra Table Initial Values

The Ra table is part of the impedance profile that updates during discharge when gauging is enabled. The initial ***Cell 0 R_a0...14*** ,values should be programmed by selecting the correct chemistry data during data flash configuration. A chemistry database is constantly updating, and can be downloaded from the Gas Gauge Chemistry Updater product web page (http://www.ti.com/tool/gasgaugechem-sw).

The ***Cell 0 R_a Flag*** , indicates the validity of the cell impedance table for each cell.

Note

FW updates these values: It is not recommended to change them manually.

High Byte		Low Byte	
0x00	Cell impedance and QMax updated	0x00	The table is not used and QMax updated.
0x05	RELAX mode and QMax update in progress	0x05	RSVD
0x55	DISCHARGE mode and cell impedance updated	0x55	The table is used.
0xFF	Cell impedance never updated	0xFF	A Fast Qmax update without OCV read will also clear the R_DIS flag. The table is never used, no QMax or cell impedance update.

7.4.7 Ra Table Update Conditions

The impedance is different across different DOD states. Each cell has 15 Ra grid points presenting the impedance from 0%–100% DOD. In general, the Ra table is updated during discharge. The *GaugingStatus()[RX]* flag will toggle when the Ra grid point is updated. The Ra update is disabled if any of the following conditions are met. The *GaugingStatus()[R_DIS]* is set to indicate the Ra update is disabled.

- During the optimization cycle, the Ra update is disabled until QMax is updated (that is, Ra will not be updated if ***Update Status*** = 4) OR

- Ra update is disabled if the charge accumulation error > 2% of ***Design Capacity*** OR
- During a discharge, a bad Ra value is calculated:
  - A negative Ra is calculated or
  - A bad RaScale value is calculated.

A valid OCV reading during RELAX mode or a Fast Qmax update without an OCV read will clear the *[R_DIS]* flag.

7.4.8 Application of Resistance Scaling

As a part of the Dynamic Z-Track algorithm, the device calculates an RScale value. The RScale value can be applied in two ways:

- When DOD_RSCALE_EN = 0 in ***IT Gauging Configuration*** and when the new RScale is calculated, it is applied across all DODs.
- When DOD_RSCALE_EN = 1 in ***IT Gauging Configuration*** , the new RScale is only applied to DODs higher than the DOD where the new RScale was calculated.

This can prevent early termination of certain simulations, as the RScale will not be applied in computing voltages at DODs below RScale DOD. As a result, sensitivity to passed charge error is drastically decreased for low resistance and high resistance cells.

7.5 FullChargeCapacity(FCC), RemainingCapacity(RemCap), and RelativeStateOfCharge(RSOC)

The Dynamic Z-Track algorithm applies QMax, impedance, temperature, voltage, and current data to predict the runtime *FullChargeCapacity()*, *RemainingCapacity()*, and *RelativeStateOfCharge()*. These values are updated if any of the following conditions are met, reflecting the battery capacity at real time.

- Power on reset
- QMax update occurs
- Ra update occurs
- At onset of charge and discharge
- At exit of discharge
- Every five hours in RELAX mode
- If temperature changes more than 5°C
- Valid charge termination

FullChargeCapatity() and *Remaining Capacity()* are also updated at the end of discharge termination. Under this condition, *FullChargeCapatity()* is recalculated as the sum of the initial charge and DOD passes charge, and *Remaining Capacity()* is cleared to 0.

7.6 Dynamic Z-Track Configuration Options

The device provides several Dynamic Z-Track (DZT) configuration options to fine-tune the gauging performance. These configurations can be turned on or off through the corresponding flags in ***SBS Gauging Configuration*** or ***IT Gauging Configuration*** .

[LOCK0] : After a discharge event, cell voltage will usually recover to a slightly higher voltage during RELAX state. A new OCV reading during this time can result in a slightly higher state-of-charge. This flag provides an option to keep *RemainingCapacity()* and *RelativeStateOfCharge()* from jumping back during relaxation after 0% and FD are reached during discharge.

[RSOC_HOLD] : An IT simulation will run at the onset of discharge. If charge terminates at a low temperature and a discharge occurs at a higher temperature, the difference in temperature could cause a small rise of RSOC for a short period of time at the beginning of discharge. This flag option prevents RSOC rises during discharge. RSOC will be held until the calculated value falls below the actual state.

[RSOC_HOLD] should not be used when ***[SMOOTH]*** is set.

[RSOCL] : When set, RSOC will be held at 99% until charge termination is detected. See Section 13.6 for more details.

[RFACTSTEP] : The gauge keeps track of an Ra factor of the (old Ra)/(new Ra) during the Ra update. This factor is used for Ra scaling. It is limited to three max. During an Ra update, if (old Ra)/(new Ra) is > 3, the gauge can take on two different actions based on the setting of this flag.

If this flag is set (default), the gauge allows Ra to update once using the max factor of 3, then disables the Ra update. If this flag is set to 0, the gauge will not update Ra and also disables the Ra update. It is recommended to keep the default setting.

[OCVFR] : An OCV reading is taken when a dV/dt condition is met. This is not the case if charging stops within the flat voltage region.

By default, this flag is set. The device will take a 48-hour wait before taking an OCV reading if charge stops below the FlatVoltMax. A discharge will not cancel this 48-hour wait. The 48-hour wait will only be cleared if charging stops above the FlatVoltMax level. Setting this flag to 0 removes the 48-hour wait requirement, and OCV is taken when the dV/dt condition is met. Removing the 48-hour requirement can be useful sometimes to reduce test time during evaluation.

[DOD0EW] : DOD0 readings have an associated error based on the elapsed time since the reading, the conditions at the time of the reading (reset, charge termination, and so on), the temperature, and the amount of relax time at the time of the reading, among others. This flag provides an option to take into account both the previous and new calculated DOD0, which are weighted according to their respective accuracies. This can result in improved accuracy and in a reduction of RSOC jumps after relaxation.

[LFP_RELAX] : This is an option for LiFePO4 chemistry. This flag can be enabled even if non-LiFePO4 chemistry is programmed. The device will check for the chemistry ID (that is, ChemID = 4xx series) before activating this function.

LiFePO4 chemistry has a unique slow relaxation time near full charge. Detailed, in-house test data suggests that the relaxation after a full charge takes a few days to settle. The slow decaying voltage causes RSOC to continue to drop every 5 hours. Depending on the full charge taper current, the fully relaxed voltage could be close to or even below FlatVoltMax. For the chemID 4xx (LiFePO4) series, the condition to exit the long RELAX mode is if the pack had previously charged to full or near full state, and then either a significant long relaxation or a non-trivial discharge has happened, such that when in relaxation, the OCV < ***FlatVoltMax*** .

The QMax update is disabled because DOD will not be taken as long as it is in LFP_relax mode. By the time the gas gauge exits the LFP_relax mode, the OCV is already in the flat zone. Therefore, the QMax update takes an alternative approach: Once full charge occurs (***[FC]*** bit set), DOD0=Dod_at_EOC is automatically assigned and valid for a QMax update. ***[VOK]*** is set if there is no QMax update. If QMax is updated, ***[VOK]*** is cleared. The DOD error as a result of this action is zero or negligible because in the LiFePO4 table, OCV voltage corresponding to DOD= 0 is much lower.

[Fast_QMAX_LRN] and ***[Fast_QMAX_FLD]*** : The first flag enables Fast Qmax during the learning cycle when ***Update Status*** = 06. The second flag enables Fast Qmax in the field when ***Update Status*** ≥ 06. See Section 7.4.4 for more details.

[RSOC_CONV] : This function is also called fast scaling. It is an option to address the convergence of RSOC to 0% at a low temperature and a very high rate of discharge. Under such conditions, it is possible to have a drop of RSOC to 0%, especially if the termination voltage is reached at the DOD region with a higher Ra grid interval. To account for the error caused by the high granularity of the impedance grid interval, the ***[RSOC_CONV]*** , when enabled, applies a scale factor to impedance, allowing more frequent impedance data updates used for RemCap simulation leading up to 0% RSOC.

If ***[RSOC_CONV]*** is enabled, it is recommended to start this function around the knee region of the discharge curve. This is usually around 10% of RSOC or around 3.3 V–3.5 V. This function will check for the cell voltage and RSOC status and start the function when either condition is met. The RSOC and cell voltage setting can be configured through ***Fast Scale Start SOC*** or ***Term Voltage Delta*** .

[FF_NEAR_EDV] : Fast Filter Near EDV. If this flag is set, the gauge applies an alternative filter, ***Near EDV Ra Param Filter*** , for an Ra update in the fast scaling region (starting around 10% RSOC). This flag should be kept to 1 as default. When this flag is 0, the gauge uses the regular Ra filter, ***Resistance Parameter Filter*** . Both of the DF filters should not be changed from the default.

[SMOOTH] : A change in temperature or current rate can cause a significant change in remaining capacity (RemCap) and full charge capacity (FCC), resulting in a jump or drop in the Relative State-of-Charge (RSOC). This function provides an option to prevent an RSOC jump or drop during charge and discharge.

If a jump or drop of RSOC occurs, the device examines the amount of RSOC jump or drop versus the expected end point (that is, the charge termination for the charging condition or the EDV for the discharge condition) and automatically smooths the change of RSOC, and always converges with the filtered (or smoothed) value to the actual charge termination or EDV point. The actual and filtered values are always available. The ***[SMOOTH]*** flag selects whether actual or filtered values are returned by the SBS commands.

[RELAX_JUMP_OK] and ***[RELAX_SMOOTH_OK]*** : When the battery enters RELAX mode from CHARGE or DISCHARGE mode, the transient voltage may change RSOC as the battery goes into its RELAX state. Once the battery is in RELAX mode, a change in temperature or self-discharge may also cause a change in RSOC.

If ***[RELAX_JUMP_OK]*** = 1, this allows the RSOC jump to occur during RELAX mode. Otherwise, RSOC holds constant during RELAX mode and any RSOC jump will be passed into the onset of the charge or discharge phase.

If ***[RELAX_SMOOTH_OK]*** = 1, this allows the amount of the RSOC jump to be smoothed out over a period of ***Smooth Relax Time*** . Otherwise, the additional RSOC jump amount will be passed into the onset of charge or discharge phase.

If both flags are set, the ***[RELAX_JUMP_OK]*** = 1 takes higher priority and the RSOC jump is allowed during RELAX mode.

[TDELAV] : This flag determines how the ***Delta Voltage*** is calculated. By setting this flag, the gauge will calculate ***Delta Voltage*** that corresponds to the power spike defined in ***Min Turbo Power*** . This flag must be set to 1 if TURBO BOOST mode is used. Otherwise, leaving this flag cleared as default enables the gauge to calculate ***Delta Voltage*** by using the maximal difference between instantaneous and average voltage.

[CELL_TERM] : This flag provides an option to have a cell voltage based discharge termination. If the minimum cell voltage reaches ***Term Min Cell V*** , *RemainingCapacity()* will be forced to 0 mAh. For more details, see the *Pack Based and Cell Based Termination* section in Section 7.2.

[CSYNC] : This flag, if set, will synchronize *RemainingCapacity()* to *FullChargeCapacity()* at valid charge termination.

[CCT] : This flag provides an option to use *FullChargeCapacity()* (***[CCT]*** = 1) or *DesignCapacity()* (***[CCT]*** = 0) for cycle count threshold calculation. If *FullChargeCapacity()* is selected for cycle count threshold calculation, the minimum cycle count threshold is always 10% of ***Design Capacity*** . This is to avoid any erroneous cycle count increment caused by extremely low *FullChargeCapacity()*.

[CHG_100_SMOOTH_OK] : This handles smoothing in the charge direction to 100%. For jumps to 100% during charge, this feature uses the taper termination detection logic to predict when charge termination will occur. The taper termination logic requires two consecutive 40-s windows that meet all taper conditions. After the first 40-s window is satisfied, time-based smoothing will be initiated, smoothing RemCap to smoothed FCC over the next 40-s window. It is important to note that smoothed RemCap will converge to smoothed FCC and not True RemCap.

[DSG_0_SMOOTH_OK] : Allows smoothing in the discharge direction when there is a jump to 0%. Set this flag to prevent jumps to 0% during discharge, two DF parameters are used: ***Term Smooth Start Cell V Delta*** and ***Term Smooth Time*** . Once battery stack voltage is below ***Term Smooth Start Cell V Delta*** and discharging, time-based smoothing is initiated. This smooths RemCap to 0 mAh over the next ***Term Smooth Time*** seconds. ***Term Smooth Start Cell V Delta*** is a per cell voltage delta. This value is multiplied by the number of cells, added to ***Terminate Voltage*** , and checked against *Voltage()*. Smoothing will continue to 0% unless charging starts (even in RELAX mode).

To assure that the gauge reports 0% in low voltage situations, the DF ***Term Smooth Final Cell V Delta*** is used. This value is multiplied by the number of cells, subtracted from ***Terminate Voltage*** , and checked against *Voltage()*. Once voltage passes this threshold, 0% will be forced even if smoothing was not completed.

[VeryLowBattery] : When enabled, this feature holds *RemainingCapacity()* at a configured target near the end of discharge. Once the minimum cell voltage falls below ***VLB Voltage*** while *RemainingCapacity()* still exceeds ***VLB Remaining Cap. mAH*** (or ***VLB Remaining Cap. cWH*** in energy mode) during discharge, and this condition persists for ***VLB Hold Time*** seconds, *GaugingStatus()[VLB]* is set and *RemainingCapacity()* is held at the VLB target. The hold is released when current becomes non-negative, a CUV or CUVC safety alert is detected, or ***VLB Timeout*** seconds elapse, after which *RemainingCapacity()* smoothly transitions toward the actual value.

[FOCV_EN] : If this bit is set to 1, the gauge enables a fast OCV algorithm to predict the final OCV value, which reduces relaxation requirements for QMax updates.

[EDV_CONV] : To prevent the jump in the reported SOC towards the end of discharge before the cell voltage reaches terminate voltage due to any inaccuracies in the battery model parameters, the EVCS algorithm guarantees that zero SOC is reported only when the measured voltage reaches terminate voltage. This glorithm can be activated by setting ***[EDV_CONV]*** bit to 1.

[SOH_LEARN_EN] : *StateOfHealth()* is a function of ***Design Capacity*** and if ***Design Capacity*** is set low, *StateOfHealth()* starts at greater than 100% and does not reflect degradation from the true starting point. This bit provides an option to learn maximum SOH FCC(***SOH FCC Max***), and if learned SOH FCC is larger than ***Design Capacity*** , uses learned SOH FCC for the *StateOfHealth()* calculation instead of ***Design Capacity*** . Any time SOH FCC calculates a larger value, learned SOH FCC is updated with a larger value. The initial values of learned SOH FCC ***SOH FCC Max*** should be set to ***Design Capacity*** .

[DELAY_DROP_TO_0] : If a IT simulation produces zero remaining capacity during DISCHARGE mode, fast scaling is activated before reporting 0% on *RelativeStateofCharge()* using ***[DELAY_DROP_TO_0]*** = 1. If the drop in capacity is caused by an error in the Ra table, it is corrected by the scale and IT simulation from fast scaling. If ***[SMOOTH]*** = 0, this would prevent reporting 0% on *RelativeStateofCharge()* briefly. If ***[SMOOTH]*** = 1, this would prevent *RelativeStateofCharge()* from being held at or smoothed to 0% (depending on the setting of ***[DSG_0_SMOOTH_OK]***). This feature only works if ***[RSOC_CONV]*** = 1.

Note

Term Smooth Final Cell V Delta can be disabled by setting to 0 and is typically expected to be set low enough to enable the system to shut down properly (without brownout).

7.7 State of Health (SOH)

The device 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, is not an adequate 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.

The device implementation of state-of-health addresses these issues. It provides the SOH of the battery through an SBS command, *StateOfHealth()*. The *StateOfHealth()* is calculated using the FCC simulated at 25°C at ***Rec Temp Charging:Voltage*** with current specified by ***SOH Load Rate*** . The ***SOH Load Rate*** can be set to the typical current of the application, and it is specified in hour-rate (that is, ***Design Capacity*** / ***SOH Load Rate*** will be the current used for the SOH simulation). Separate thermal model temperature factor ***SOH Temp k*** and thermal model temperature ***SOH Temp a*** are used for SOH simulation. ***SOH Load Rate*** , ***SOH Temp k*** and ***SOH Temp a*** data flash settings are used for *StateOfHealth()* calculation only. This SOH FCC is updated at the same time ASOC and RSOC are updated. Since this implementation removes the variation of current, temperature or voltage, it is a better representation of a battery's state-of-health. The SOH FCC is available on MAC *StateOfHealth()*. SOH FCC is initialized with lifetime ***Min FCC-SOH*** until SOH simulation is completed on POR. Lifetime data ***Min FCC-SOH mAh/cWh*** is the minmum SOH FCC calculated from IT algorithm by now.

7.8 RSOC Rounding Option

By default, if there is an RSOC of 20.1 through 20.9, then the RSOC becomes 21 (ceiling function). However, the following shows how the RSOC rounding feature works when enabled by setting ***[RSOC_RND_OFF]*** = 1 (default is 0) in the ***SBS Gauging Configuration*** register:

Round-off applies to charging and discharging between an RSOC 0% to 99% if, for example:

There is an RSOC of 20.1 through 20.4, then the RSOC becomes 20 (round off).

There is an RSOC of 20.5 through 20.9, then the RSOC becomes 21 (round off).

Round-down applies for charging and discharging between an RSOC of 99% to 99.9% if:

There is an RSOC of 99.1 or 99.9, then the RSOC becomes 99 (round down).

In charge, RSOC is set to 100% only when FC is set.

7.9 RSOC 1% Hold

When ***[1PERCENT_HOLD]*** is set, RSOC is prevented from going below 1% until ***Terminate Voltage*** is detected.

7.10 Accumulated Charge Measurement

The device includes an accumulated charge function that measures the integrated current passed in or out of the battery. This function can be used to generate an alert to the host when a programmable threshold of accumulated charge is achieved.

The device also integrates the elapsed time since the current integration began, assuming the timer has not been interrupted by a power cycle or put into SHUTDOWN mode. This time is read using the command *AccumulatedTimeCharge()*. If an event has occurred that interrupted the timer, the value of *AccumulatedTimeCharge()* will be fixed unchanging at 0 until the integration is reset.

The current and time integration is started at initial power up or upon issue of the *AccumulationStart()* command. The current and time integration is stopped upon issue of the *AccumulationStop()* command. The current and time integration is reset at initial power up or upon issue of the *AccumulationReset()* command.

While the battery is DISCHARGING, then the current integration counter decreases. If the battery starts CHARGING then the current integration counter increases. The integrated charge value in mAh (or cWh if *BatteryMode()[CAPM]* = 1) and the elapsed time (which does not decrease in value) can be read by the host using the command *AccumulatedTimeCharge()*.

The Accumulated Charge calculation uses the current measured across the sense resistor and, similar to the coulomb counter integration, ignores currents below a programmed level controlled by ***CC Deadband*** . In periods when the device is in SLEEP mode, the Accumulated Charge integration includes an estimate of the charge integrated based on analysis of the periodic measured current if ***[SLP_ACCUM]*** is enabled.

The current integration can also be limited to only include positive (charging) currents, only negative (discharging) currents, or both, through setting the ***[ACCHG_EN]*** and ***[ACDSG_EN]*** configuration bits. If both ***[ACCHG_EN]*** and ***[ACDSG_EN]*** are cleared, then the timer is halted. These bits can be set using the *AccumulationChargeEnable()* and *AccumulationDischargeEnable()* commands.

The user can set thresholds to alert the host when accumulated charge reaches a particular level in both the charge (positive) and discharge (negative) directions. These thresholds are set by ***AccumulationChargeThreshold*** and ***AccumulationDischargeThreshold*** , which can be changed in SEALED mode with *AccumulationChargeThreshold()* and *AccumulationDischargeThreshold()*. Setting one or both of these to zero will disable the associated threshold.

AccumulatedTimeCharge() does not reset when a threshold is reached, the data is only reset by the host using the *AccumulationReset()* command. When a threshold is passed, a flag is set in *OperationStatus()[ACTHR]*.

Due to the current integration and timer information being stored in RAM, any power cycle of the device or putting the device into SHUTDOWN will result in the loss of *AccumulatedTimeCharge()* data.

8 Gauging for Silicon Anode Battery

8.1 Introduction

Due to the high energy density, silicon anode battery is being gradually used in more and more battery systems. However, since silicon degrades faster than graphite, silicon anode battery's OCV (open circuit voltage) curve drifts with the aging, especially for the batteries containing small amount of silicon (up to 20%). Thanks to the advanced battery modeling and prediction technology, DZT(Dynamic Z-Track) algorithm is able to track the OCV curve drift and has the capability to gauge silicon anode batteries (including both small and dominant silicon type batteries) accurately.

8.2 Capacity Loss And OCV Drift

Capacity loss is an important indicator of battery degradation and defined as the ratio between Qmax reduction and the Design (original) Qmax. There are three main factors impacting on capacity loss: Temperature, Cycle Count, and Running Time.

OCV curve drift can be seen as an external manifestation of the capacity loss. To continuously track and compensate the OCV curve drift caused by capacity loss, a real-time model is corrected from the results of an off-line computation combined with physical modeling of the voltage change at different temperatures performed over the life of the battery.

8.3 Silicon Anode Battery Gauging

Si-anode gauging algorithm is enabled when ***Settings: Configuration: ZT SiAnode Gauging Configuration [SI_ENABLE]*** = 1

The silicon anode battery gauging can be separated into two parts:

- Initial Design Qmax Calculation
- Capacity Loss Update and OCV drift correction

Design Qmax Learning Process

During a normal learning cycle, the ***Design Qmax Cell x*** parameter (accessible via ***Gas Gauging: IT Cfg: Design Qmax Cell x***) is automatically updated when the standard Impedance Track learning cycle completes successfully and the update status transitions to 0x06 (or higher).

Upon succesful learning, the flag ***Gas Gauging: IT Cfg: Design Qmax Status[DesignQmaxLearned]*** is set to 1.

Note

- ***Design Qmax Cell x*** is updated only if ***DesignQmaxLearned*** = 0 prior to the learning cycle. This ensures that ***Design Qmax Cell x*** is normally updated only once in the device lifetime.
- To force a re-learning of ***Design Qmax Cell x*** (e.g. after cell replacement or for test purposes), the user must manually clear the ***DesignQmaxLearned*** bit by writing 0 to it. After this operation, the next valid learning cycle will update ***Design Qmax Cell x*** again and re-set the ***DesignQmaxLearned flag*** to 1.

Initial Capacity Loss Calculation

The Initial Capacity Loss value is calculated automatically after a RESET under the following conditions:

- Both ***Design Qmax Cell x*** and cell ***Qmax Cell x***have been successfully learned.
- Update status is ≥ 0x06

  If these conditions are not met at the time of reset, Initial Capacity Loss calculation is postponed until the required parameters become available.

Note

Each cell has its unique ***Design Qmax Cell x*** value

Silicon Anode Chemistry Requirement

For optimal performance and highest accuracy when using silicon anode batteries, a specific chemistry profile (ChemID) characterized by Texas Instruments must be programmed into the device. This is mandatory for proper SiAnode operation. The characterized chemistry enables offline modeling, which in turn provides the necessary OCV (Open Circuit Voltage) tables, Qmax parameters, and accurate Initial Capacity Loss calculation.

Capacity Loss Update and OCV Drift Correction

During system operation, the algorithm predicts the capacity loss through the model in real time. When the Qmax is updated, the capacity loss is calculated based on the latest Qmax and Design Qmax. Meanwhile, since the capacity loss is impacted by running time, temperature, and cycle count, the modeling also performs statistics on these factors and includes their influence into capacity loss calculation. When an OCV reading is requested, the algorithm will use the latest capacity loss to correct OCV drift and provide an accurate OCV reading.

Note

The gauge will compute the Capacity loss for each unique cell. See ***Caploss Cell x*** parameter description for more details.

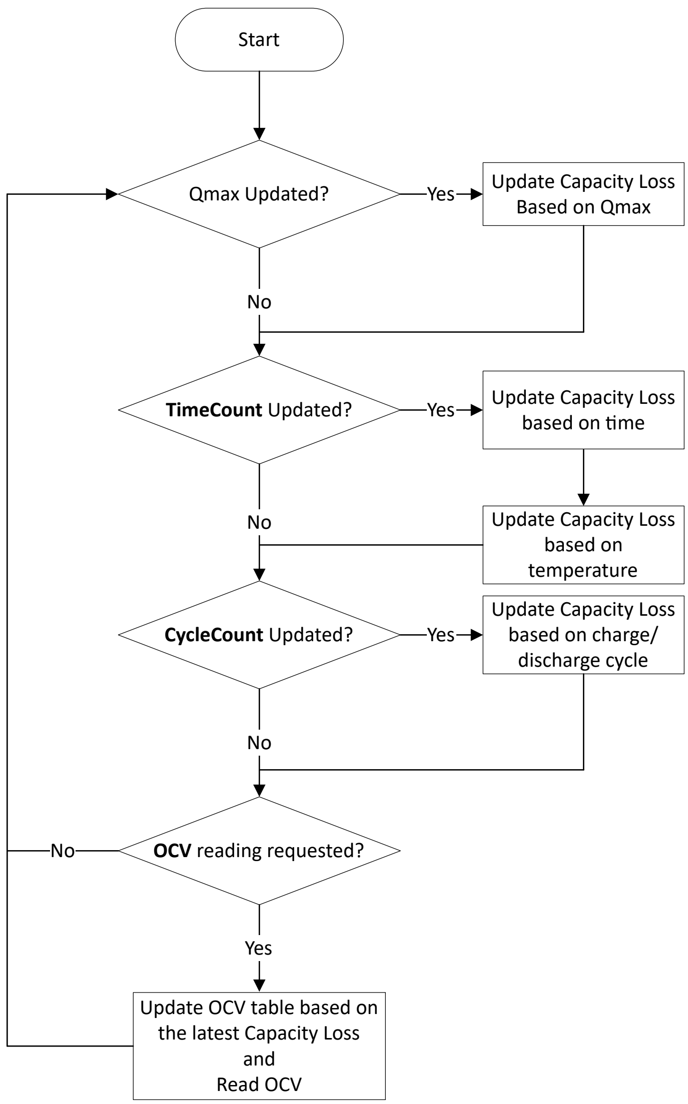


Figure 8-1. Capacity Loss Update and OCV Drift Correction

8.4 Silicon Anode Gauging Parameters

To have an accurate gauging for silicon anode batteries, the following parameters should be configured based on the real condition of battery system, which defines the operation range of the silicon anode gauging algorithm.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	IT Cfg	End of Life Capacity	U2	0	100	20	%	The capacity loss at the end of battery lifetime.
Gas Gauging	IT Cfg	Cycle Count Max	U2	0	65535	1000	count	Charge/Discharge Cycle count to reach end of battery lifetime at room temperature specified by T_room.
Gas Gauging	IT Cfg	Cycle Count Max High	U2	0	65535	500	count	Charge/Discharge Cycle count to reach end of battery lifetime at high temperature specified by T_high.
Gas Gauging	IT Cfg	Time Count	U2	0	65535	0	days	The number of days since the last Si Anode activation. It is used to calculate the effective temperature based on the time-counted caploss.
Gas Gauging	IT Cfg	Time Count Max	U2	0	65535	1800	days	Time to reach end of battery lifetime at room temperature specified by T_room.
Gas Gauging	IT Cfg	Time Count Max High	U2	0	65535	720	days	Time to reach end of battery lifetime at high temperature specified by T_high.
Gas Gauging	IT Cfg	Room Temp	U2	0	65535	25	℃	Room temperature.
Gas Gauging	IT Cfg	High Temp	U2	0	65535	45	℃	High temperature.
Gas Gauging	IT Cfg	Design Qmax Cell	U2	0	65535	4400	mAh	Original Qmax for cell 1. It should be updated at completion of learning cycle.
Gas Gauging	IT Cfg	Caploss Cell	I2	0	16383	0	-	Indicates the capacity loss for cell 1. Capacity loss is the difference between the Design Capacity and the current actual capacity.

8.5 Design Qmax

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT Cfg	Design Qmax Cell 0	I2	0	32767	4400	mAh

Description: Initial value updated after learning cycle is successfully completed (Update Status >= 0x06). **Design Qmax Cell x** is used to calculate capacitor loss. Reference to SiAnode section for more details.

8.6 ManufacturerAccess() 0x0040 SiAnode Status

This command returns the *SiAnode Status()*

The *ACTIVE* bit indicates that the Silicon-Anode specific gauging algorithm is fully enabled and operational for the current battery pack.

The *ACTIVE* bit is set to 1 when all of the following conditions are simultaneously true:

- ***Settings: Configuration: ZT SiAnode Gauging Configuration [SI_ENABLE]*** = 1
- Settings: Configuration: Mfg Status init: [GAUGE_EN] = 1
- ***Gas Gauging: IT Cfg: Design Qmax Status[DesignQmaxLearned]*** = 1
- SiAnode ChemID has succesfully been programmed to the device.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	ACTIVE

RSVD (Bit 15-1): Reserved. Do not use.

ACTIVE (Bit 0): Status of SiAnode Algorithm

1 = The gauge operates in Silicon-Anode mode and uses the dedicated Si-Anode OCV, impedance, and gauging models

0 = The gauge falls back to standard (non-Si-Anode) gauging behavior, even if Silicon-Anode features are partially configured.

8.7 ZT SiAnode Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	DA Configuration	H2	0x0	0xFFFF	0x0000	Hex

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

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

RSVD (Bits 15–1): Reserved. Do not use.

SI_ENABLE (Bit 0): Enables SiAnode Algorithm

1 = SiAnode algorithm enabled

0 = SiAnode algorithm disabled

9 Lifetime Data Collection

9.1 Description

The device has the capability to log events over the life of the battery, which is useful for analysis. Lifetime data collection is enabled by setting ***ManufacturingStatus[LF_EN]*** = 1. The data is collected in RAM and only written to data flash under the following conditions to avoid wear out of the data flash:

- Every 10 hours if RAM content is different from data flash.
- 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 ***Valid Update Voltage*** .

The lifetime data stops collecting under the following conditions:

- Lifetime data collection is disabled by setting ***ManufacturingStatus[LF_EN]*** = 0.

When the gauge is unsealed, the following *ManufacturingStatus()* can be used for testing lifetime data.

- *LifetimeDataReset()* can reset the lifetime data (RAM and data flash) to the default values.
- *LifetimeDataFlush()* can force an update of the RAM lifetime data to data flash.
- *LifetimeDataSpeedupMode()* can increase the rate the lifetime data is incremented.

The following lifetime data is collected when ***ManufacturingStatus[LF_EN]*** = 1.

- Voltage
  - Maximum or minimum cell voltage
- Current
  - Maximum charge/discharge current
  - Maximum average discharge current
  - Maximum average discharge power
- Safety events that trigger *SafetyStatus()*
  - 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 Valid Charge Termination
- Discharging events
  - Number of full discharges (That is, the number of times *[FD]* is set.)
  - ***Cycle Count*** at last Full Discharge
- Gauging events

  - Number of QMax updates
  - ***Cycle Count*** at Last QMax update
  - Number of RA updates and disable
  - ***Cycle Count*** at Last RA update and disable
- Power events
  - Number of full resets, partial resets, and watchdog resets
  - Number of shutdowns
- Temperature
  - Max/Min Cell Temperature
  - Max/Min Int Temperature Sensor
- Time (This data is stored with a resolution of 1 second up to over 100 years.)
  - Total runtime
  - Total time spent charging
  - Total time spent discharging
  - Time spent in different *RelativeStateOfCharge() – Temperature()* ranges
    - Eight *RelativeStateOfCharge()* ranges for each of the seven charge temperature ranges
    - 56 *RelativeStateOfCharge() – Temperature()* runtime values

Table 9-1. Time Spent in *RelativeStateOfCharge() – Temperature()* Ranges

	RSOC ≥ 95% [default]	RSOC ≥ 90%	RSOC ≥ 80%	RSOC ≥ 60%	RSOC ≥ 40%	RSOC ≥ 20%	RSOC ≥ 10%	RSOC ≥ 0%
Under Temperature								
Low Temperature								
Standard Temperature Low								
Recommended Temperature								
Standard Temperature High								
High Temperature								
Over Temperature								

9.2 Reset

In addition to the *ManufacturerAccess() 0x0028 Lifetime Data Reset*, ***Lifetime Data Collection*** can also be reset when ***[SEALED_RESET]*** is set using a two-word MAC sequence available in SEALED and UNSEALED modes. The two-word key is programmable using *ManufacturerAccess() 0x0035 Security Keys*. Both keys must be sent within 4 seconds of each other for ***LIfetimes*** data to reset.

10 Linear Charging Functions

10.1 Introduction

The BQ27Z855 supports the Linear Charging function. The firmware provides programmable current set point for constant current (CC) mode, voltage set point for constant voltage (CV) charging mode, as well as programmable voltage thresholds for zero volt charging (ZVCHG), precharging, and advance charging. In addition, the firmware enables the device to control the mode switching of the charging function between normal charging, linear charging with MinSys mode, linear charging with supplement mode, and ideal diode modes. Reference to BQ27Z855 Datasheet for more description on MinSys, Supplement Mode, and Ideal Diode mode.

When ***[LINCHGR]*** is set to 0, the device assumes normal charging function and broadcast charging voltage and current values through I2C communication. When ***[LINCHGR]*** is set to 1, linear charging function will be enabled for BQ27Z855, and the advance charging algorithm will control the charging current and voltage of the integrated linear charger.

Linear Charger Design Considerations:

When designing with the BQ27Z855 linear charger, the following parameters must be configured based on the application hardware:

- **Current Gain:** The ***Current Gain*** parameter in data flash must be configured based on the external sense resistor value (R_{SENSE}) connected between SRP and SRN pins. The formula is:

  Current Gain = 5294 × (R_{SENSE} / 20 mΩ)

  The default value of 2646 is configured for a 10 mΩ sense resistor. Incorrect configuration will result in charging current errors.
- **Precharge Current:** Set in ***Advanced Charging Algorithm PCHG Current*** . Actual current depends on correct Current Gain configuration.
- **Fast Charge Current:** Set in ***Advanced Charging Algorithm CHGC Current*** . Actual current depends on correct Current Gain configuration.

10.2 Charger Detect (CHGR_DET) Functionality

Overview

The *CHGR_DET* bit is a status indicator reflecting whether a valid upstream charger is attached. The device firmware monitors the voltage difference between PACK+ (VPACK) and the battery (VBAT) using configurable thresholds with hysteresis to prevent noise-induced toggling.

Entry Condition (CHGR_DET = 1): When (VPACK - VBAT) >= ***CHGR_DET On Voltage*** (default 150 mV), the CHGR_DET bit sets, indicating a valid charger is attached.

Exit Condition (CHGR_DET = 0): When (VBAT - VPACK) >= ***CHGR_DET Off Voltage*** (default 10 mV), the CHGR_DET bit clears, indicating the charger is removed or invalid.

The separate On and Off voltage thresholds create a hysteresis window that prevents rapid toggling of the CHGR_DET, LIN, and ID status bits due to measurement noise. This is particularly important during Ideal Diode mode with no charger attached or during supplement mode transitions where PACK voltage may briefly drop below BAT voltage.

CHGR_DET State Machine

The CHGR_DET status serves as a primary input to the CHG FET finite state machine and the linear charge profile state machine, enabling immediate transition into Linear mode to initiate battery charging upon detection (provided the linear charger is enabled and no protections are active), while forcing exit to Ideal Diode or OFF states when the charger is removed.

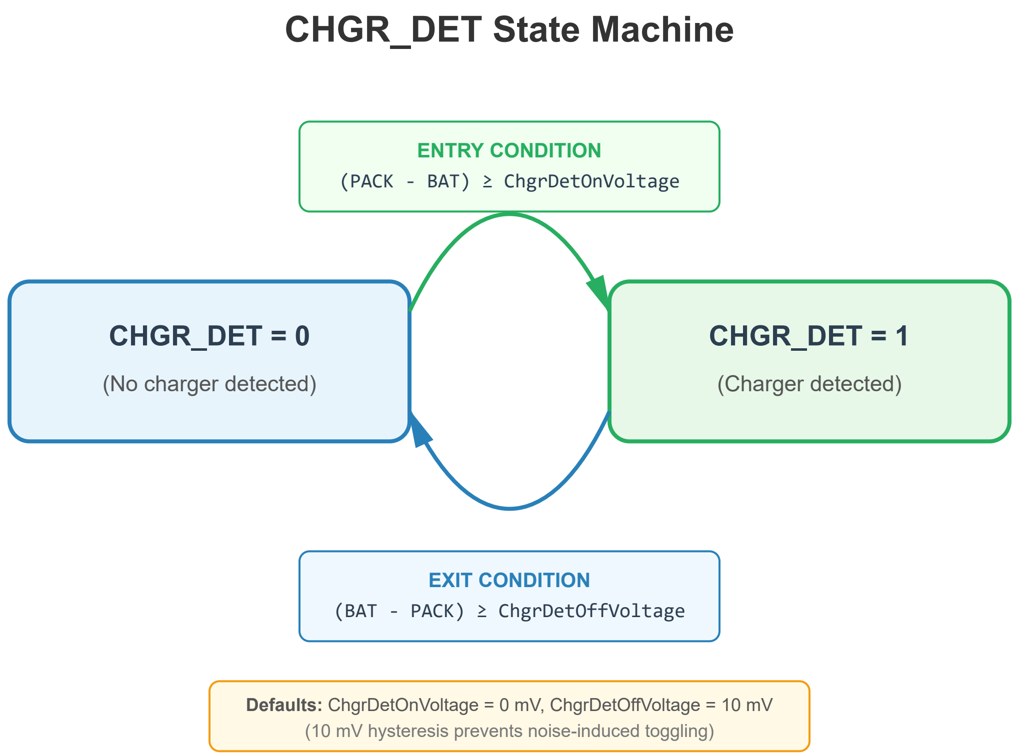


Figure 10-1. CHGR_DET State Machine

Example with default settings (On = 0 mV, Off = 10 mV):

- CHGR_DET enters (sets to 1) when: VPACK >= VBAT
- CHGR_DET exits (clears to 0) when: VPACK <= VBAT - 10 mV
- Between these thresholds, CHGR_DET maintains its previous state

Data Flash Parameters

The charger detection thresholds are configured via the following Data Flash parameters in **Advanced Charge Algorithm > Charger**:

Parameter	Default	Unit	Description
CHGR_DET On Voltage	150	mV	Threshold to enter CHGR_DET state (NEW)
CHGR_DET Off Voltage	10	mV	Threshold to exit CHGR_DET state (renamed from Vacp Hysteresis)

CHGR_DET On Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charger	CHGR_DET On Voltage	I2	-32768	32767	0	mV

Description: This parameter sets the voltage threshold for entering the CHGR_DET state. When the voltage difference (VPACK - VBAT) is greater than or equal to this threshold, the CHGR_DET bit in *ChargerStatus()* will be set to 1, indicating that an upstream charger is detected.

Entry Condition: CHGR_DET = 1 when (VPACK - VBAT) >= *CHGR_DET On Voltage*

Default Value: 0 mV. With the default setting, CHGR_DET will set as soon as VPACK >= VBAT.

Configuration Notes: Increasing this value requires a larger voltage difference before charger detection occurs. This can be useful in applications where a voltage margin is needed before activating the linear charger.

CHGR_DET Off Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charger	CHGR_DET Off Voltage	I2	-32768	32767	10	mV

Description: This parameter sets the voltage threshold for exiting the CHGR_DET state. When the voltage difference (VBAT - VPACK) is greater than or equal to this threshold, the CHGR_DET bit in *ChargerStatus()* will be cleared to 0, indicating that the upstream charger is no longer detected.

Exit Condition: CHGR_DET = 0 when (VBAT - VPACK) >= *CHGR_DET Off Voltage*

Equivalent: CHGR_DET = 0 when VPACK <= VBAT - *CHGR_DET Off Voltage*

Default Value: 10 mV. This provides a 10 mV hysteresis band to prevent noise-induced toggling.

Configuration Notes: This parameter was previously named *Vacp Hysteresis* with a default of 0 mV. The renamed parameter with 10 mV default provides improved noise immunity.

Parameter Renamed: In firmware version v0.03 (BMSFW-11389), the parameter *Charger Vacp Hysteresis* was renamed to *Charger CHGR_DET Off Voltage* and the default value was changed from 0 mV to 10 mV.

Hysteresis Behavior

The combination of *CHGR_DET On Voltage* and *CHGR_DET Off Voltage* creates a hysteresis window that provides stable charger detection even in the presence of voltage measurement noise.

Benefit: This hysteresis prevents rapid toggling of the CHGR_DET, LIN, and ID status bits when VPACK is approximately equal to VBAT, which commonly occurs during:

- Ideal Diode mode operation with no upstream charger attached
- Supplement mode transitions where PACK voltage drops below BAT voltage
- Charger connect/disconnect events with voltage transients

Related Parameters and Status

The CHGR_DET detection interacts with the following status bits and configuration parameters:

Parameter/Status	Location	Description
SBS:ManufacturerAccess(0x00B5) [CHGR_DET]	Bit 1	Reflects the current charger detection state. Automatically controlled by firmware in automatic mode (***Advanced Charge Algorithm: Charger: Configuration[PAR_PACK]*** =0). Host-writable in parallel pack mode (***Advanced Charge Algorithm: Charger: Configuration[PAR_PACK]*** =1)
SBS:ManufacturerAccess(0x00B5) [LIN]	Bit 2	Linear mode active. Requires *[CHGR_DET]* = 1 and *[LINCHGR]* = 1
SBS:ManufacturerAccess(0x00B5) [ID]	Bit 3	Ideal Diode mode active. Typically active when *[CHGR_DET]* = 0
SBS:ManufacturerAccess(0x00B5) [LINCHGR]	Bit 0	Reflects if linear charger is enabled in configuration
Advanced Charge Algorithm: Charger: Configuration[LINCHGR]	Settings: Configuration	Must be enabled (=1) for linear charger functionality
Advanced Charge Algorithm: Charger: Configuration[PAR_PACK]	Settings: Configuration	When enabled (=1), disables automatic *[CHGR_DET]* detection and enables host control via SBS:ManufacturerAccess(0x00B5) writes. See Parallel Pack (PAR_PACK) Mode section

Parallel Pack (PAR_PACK) Mode

When the ***Advanced Charge Algorithm: Charger: Configuration[PAR_PACK]*** configuration bit is enabled (set to 1), the CHGR_DET functionality transitions from automatic voltage-based detection to host-controlled mode. This mode is designed for applications using parallel pack configurations where hardware-based charger detection may not be reliable or where the host system requires direct control over charger detection state.

Behavior Change:

- When ***[PAR_PACK]*** = 0 (default): Firmware automatically controls the *[CHGR_DET]* bit based on voltage hysteresis (VPACK - VBAT comparison). SBS:ChargerStatus(0x00B5)[CHGR_DET] is read-only.
- When ***[PAR_PACK]*** = 1: Firmware disables automatic voltage-based detection. The host system controls *[CHGR_DET]* state directly by writing to SBS:ManufacturerAccess(0x00B5).

Host Control via SBS:ManufacturerAccess(0x00B5): In parallel pack mode, the host writes the desired *[CHGR_DET]* state by sending a command. The command includes the data byte, checksum, and length fields.

```
// MAC 0x00B5 Commands for CHGR_DET control in parallel pack mode

// Enable CHGR_DET (set bit 1):
B5 00 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 48 06
// Byte 0-1: B5 00 (MAC address)
// Byte 2: 02 (data byte with CHGR_DET bit 1 set)
// Bytes 3-33: 00 (padding)
// Byte 34: 48 (I2C checksum)
// Byte 35: 06 (command length)

// Disable CHGR_DET (clear bit 1):
B5 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 4a 06
// Byte 0-1: B5 00 (MAC address)
// Byte 2: 00 (data byte with CHGR_DET bit 1 clear)
// Bytes 3-33: 00 (padding)
// Byte 34: 4a (I2C checksum)
// Byte 35: 06 (command length)
```

Only the *[CHGR_DET]* bit (Bit 1) is writable in parallel pack mode via SBS:ManufacturerAccess(0x00B5) command. All other bits in SBS:ChargerStatus(0x00B5) remain read-only and reflect firmware-determined states (*[LIN]*, *[ID]*, *[LINCHGR]*). The I2C checksum and length fields must be included in the command for proper delivery.

Use Cases: Parallel pack mode is essential for applications with multiple battery packs in parallel, such as:

- **Parallel Battery Packs:** When two or more battery packs are connected in parallel, each gauge cannot reliably distinguish between a charger adapter connected to PACK+ and another battery pack at a higher voltage. Without ***[PAR_PACK]*** enabled, the gauge might incorrectly detect *[CHGR_DET]* based on voltage from the parallel pack instead of an actual charger, leading to cross-charging and potential safety violations.

Interaction with Other Features: Even in parallel pack mode, the automatic charging state machine (LIN/ID transition logic) operates normally based on the host-written *[CHGR_DET]* state:

- When host sets *[CHGR_DET]*=1 and *[LINCHGR]*=1, the device may enter LINEAR mode (if no protections are active)
- When host clears *[CHGR_DET]*=0, the device exits LINEAR mode and returns to IDEAL DIODE or OFF modes as appropriate
- The voltage thresholds (***CHGR_DET On Voltage*** and ***CHGR_DET Off Voltage***) are not used in parallel pack mode; the host directly controls the bit state

10.3 CHG FET FSM and Mode-to-mode Switching (Linear Charger Modes)

When the integrated linear charger in BQ27Z855 is not enabled (***[LINCHGR]*** = 0), and both charging and discharging are not disabled due to triggering of safety protection or fault conditions, the firmware will assume interaction with a smart charger and report the values of *ChargingVoltage()* and *ChargingCurrent()* according to the charging algorithm described under the #unique_140 chapters.

When the integrated linear charger in BQ27Z855 is enabled (***[LINCHGR]*** = 1), the firmware will control the state of the linear charger between the charging modes described below:

- **Linear Charging mode** - When *ChargerStatus()*[**CHGR_DET**] = 1 (valid charger detected based on PACK vs BAT voltage comparison using configurable ***CHGR_DET On Voltage*** and ***CHGR_DET Off Voltage*** thresholds), the linear charger activates to perform linear regulation of *ChargingVoltage()* or *ChargingCurrent()* depending on the current state of the Charge Profile FSM
  – with MINSYS Regulation: When the input current through the PACK pin is shared between charging the battery and powering the system load. The dynamic power path management will control the CHG FET to adjust the charging current in order to regulate the PACK voltage to the programmed MINSYS Voltage Threshold.
  – with Supplement: When the sum of the charging and load currents is > the input current limit of the upstream charger and causes the voltage at the PACK pin to fall below the VTH_ON threshold, the linear charger will switch into supplement mode and disable charge termination.
- **Ideal Diode Mode** - When *ChargerStatus()*[**CHGR_DET**] = 0 (charger not detected, i.e., PACK voltage has dropped below BAT voltage by at least ***CHGR_DET Off Voltage***), the linear charger will switch to ideal diode mode to allow the battery to supply the system load.

Note

When operating in Ideal Diode mode, the CHG FET pin may be HIGH (ID_ON state) regardless of the device operating mode. This includes when the device is in SLEEP mode with ***[SLEEPCHG]*** = 0, or when *OperationStatus()*[**CHG**] is clear and *OperationStatus()*[**XCHG**] is set. In Ideal Diode mode, the CHG FET is controlled by the hardware DCOMP comparator (V_{PACK} - V_{BAT} vs V_{TH_ON}/V_{TH_OFF}) rather than by firmware charging enable flags.

CHGR_DET and Mode Selection: The *ChargerStatus()*[CHGR_DET] bit is the primary input that determines whether the device operates in Linear mode or Ideal Diode mode. The CHGR_DET bit is set or cleared based on the voltage difference between PACK and BAT:

- **CHGR_DET = 1** (Entry): When (VPACK - VBAT) >= ***CHGR_DET On Voltage*** (default 0 mV)
- **CHGR_DET = 0** (Exit): When (VBAT - VPACK) >= ***CHGR_DET Off Voltage*** (default 10 mV)

The separate On and Off voltage thresholds provide hysteresis to prevent rapid toggling between Linear and Ideal Diode modes due to measurement noise, particularly during supplement mode transitions or when no charger is attached.

The BQ27Z855 CHG FET output is controlled by CHG FET FSM logic when ***LINCHGR*** = 1.

There are 4 distinct modes device firmware transitions between depending on programmable settings in device data flash and system parameters: OFF, ON, Linear, and Ideal Diode. Depending on the current mode the device is operating in, the device can operate in a particular state and make hardware-based transitions between states within modes.

The BQ27Z855 determines the mode the device operates in while device digital hardware determines the state within a mode the device operates in.

Firmware Mode Transition Logic: The firmware evaluates the following conditions to determine the operating mode:

1. If **LINCHGR = 0** (linear charger disabled) → **OFF mode**, use standard FET control
2. If **CHGR_DET = 1** AND CHG FET enabled AND no CFETF permanent failure → **Linear mode**
3. If DSG FET disabled OR device is in Zero Volt Charging (ZVCHG) mode → **OFF mode**

   Note: During Zero Volt Charging of a deeply discharged battery, the linear charger is disabled and the AFE hardware controls charging directly.
4. Otherwise → **Ideal Diode mode**

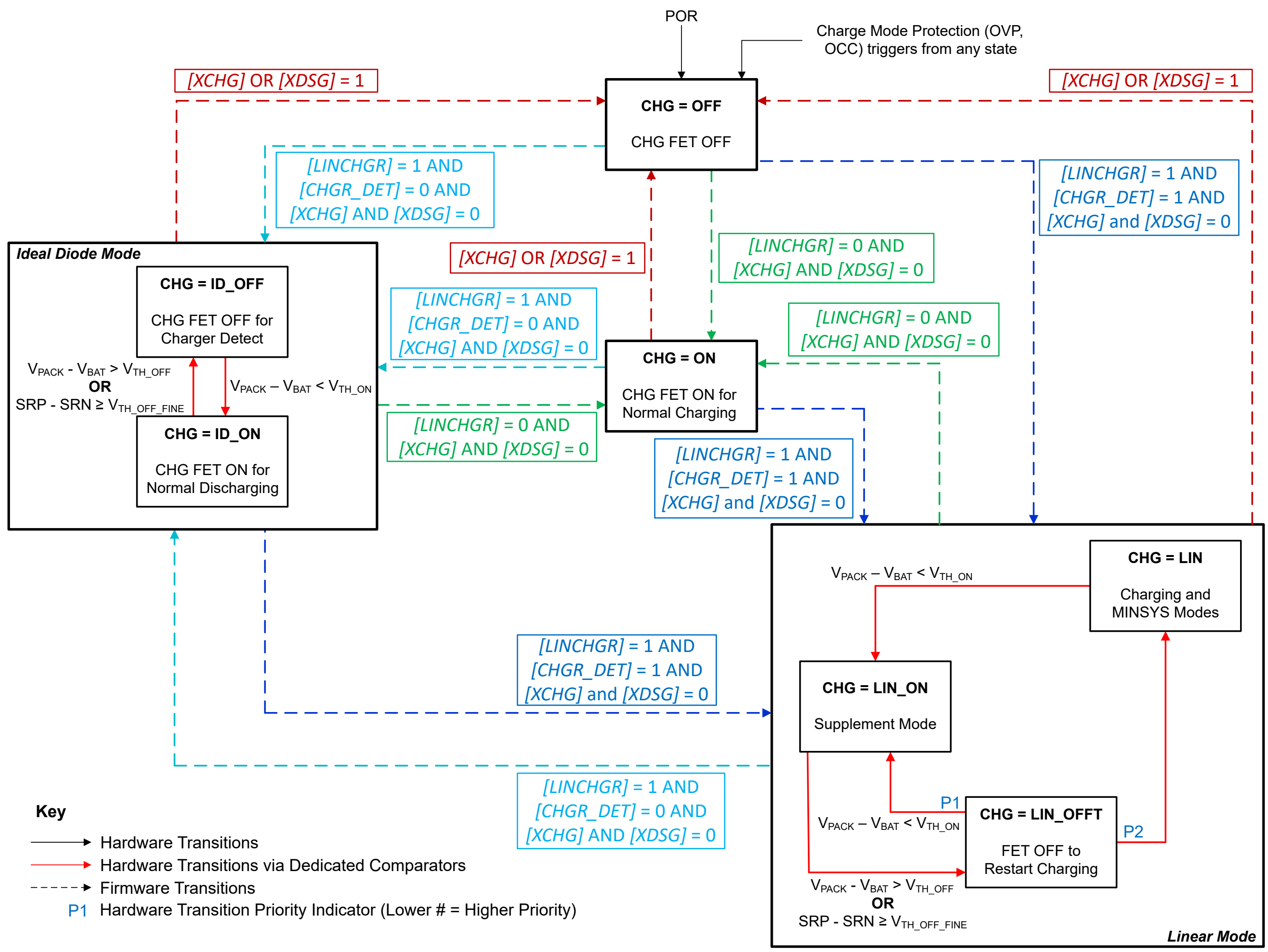


Figure 10-2. CHG FET FSM

The CHG FET FSM logic controls the state of the CHG FET with the following key considerations:

1. Firmware transitions override hardware transitions and takes highest priority after hardware-based protection circuits
2. Available hardware transitions in Linear and Ideal Diode modes check several system parameters to ensure proper device and system operation:
   a. A dedicated voltage comparator (DCOMP) between the PACK and BAT pin voltages detects when V_{PACK} - V_{BAT} < V_{TH_ON} to turn the CHG FET ON and V_{PACK} - V_{BAT} > V_{TH_OFF} to turn the CHG FET OFF
   b. A Coulomb counter-based charger current measurement digital filter (CC3) detects when V_{SRP} - V_{SRN} >= $V_{TH\_OFF\_FINE}$ to turn the CHG FET OFF
3. State exit transition priorities are indicated as P1, P2, and so on where P1 is the highest priority transition
4. The HFO is automatically enabled when the device is in all states except OFF, ON, and ID_ON to reduce device power consumption.

Table 10-1. CHG FET FSM Modes and States

Modes	States	Charger Function	CHGR_DET Condition
OFF	OFF	Zero Volt Charging (deeply discharged battery), Charging Disabled	N/A (linear charger disabled or protection active)
ON	ON	Normal Charging or Discharging (external charger control)	N/A (linear charger disabled)

Table 10-1. CHG FET FSM Modes and States (continued)

Modes	States	Charger Function	CHGR_DET Condition
Linear	LIN	Precharge, Constant Current, Constant Voltage, MINSYS regulation	CHGR_DET = 1 (charger detected)
	LIN_ON	Supplement Mode (battery assists system load)	
	LIN_OFFT		
Ideal Diode	ID_OFF	Waiting for charger detection, Valid Charge Termination	CHGR_DET = 0 (no charger detected)
	ID_ON	Normal Discharging (battery powering system, charger removed). CHG FET pin is HIGH; persists in SLEEP mode regardless of ***[SLEEPCHG]*** setting.	

10.4 Linear Charge Profile

When integrated linear charger is enabled, the firmware in BQ27Z855 will enable the integrated linear charger to charge the battery under the following phases or mode:

- Disabled - The device can inhibit the start of charging at high and low temperatures to prevent damage of the cells, or disable charging when certain safety conditions are detected. More details can be found under the Section 13.13 and the Section 13.14 sections.
- Zero-Volt Charging (ZVCHG) - When the linear charger is active, but the battery voltage is < ***ZVCHG Exit Threshold*** and the PACK voltage is ≥ ***ZVCHG PACK Threshold*** , the device will enter the zero-volt charging phase. Details are under the Linear Charge Profile State Machine section and Section 13.9.
- Precharging (PCHG) - When the linear charger exits the zero-votlage charging phase, or if battery voltage falls < ***Precharge Start Voltage*** during charging, the device will enter the precharging phase. Details are under the Section 13.10 and the Linear Charge Profile State Machine sections.
- Constant Current (CC) Charging - The linear charger enters the constant current charging phase after precharing when the battery voltage is ≥ ***Charghing Voltage Low*** and Prechage Timeout Protection did not trip. After a charge termination event, if the battery voltage falls below ***Recharge Voltage*** or the *RSOC()* falls below ***Recharge RSOC*** , the linear charger will resume charging by entering the constant current charging phase to recharge the battery.
- Constant Voltage (CV) Charging - The linear charger exits the constant current charging phase and enters the constant voltage chaging phase after the battery voltage is ≥ the *charging voltage* () value that is determined by the temperature range, and the the Fast Charge Timeout Protection did not trip. Details regarding the Fast Charge Timeout Protection is under the Section 3.11 section.
- Charge Termination - Charging can be terminated based on several criterias. Details can be found under the Valid Charge Terminationsection.

Typical CC-CV Battery Charge Profile and Linear Charge Profile State Machine illustrates the charging profile and firmware flow chart moving between the different charging phases.

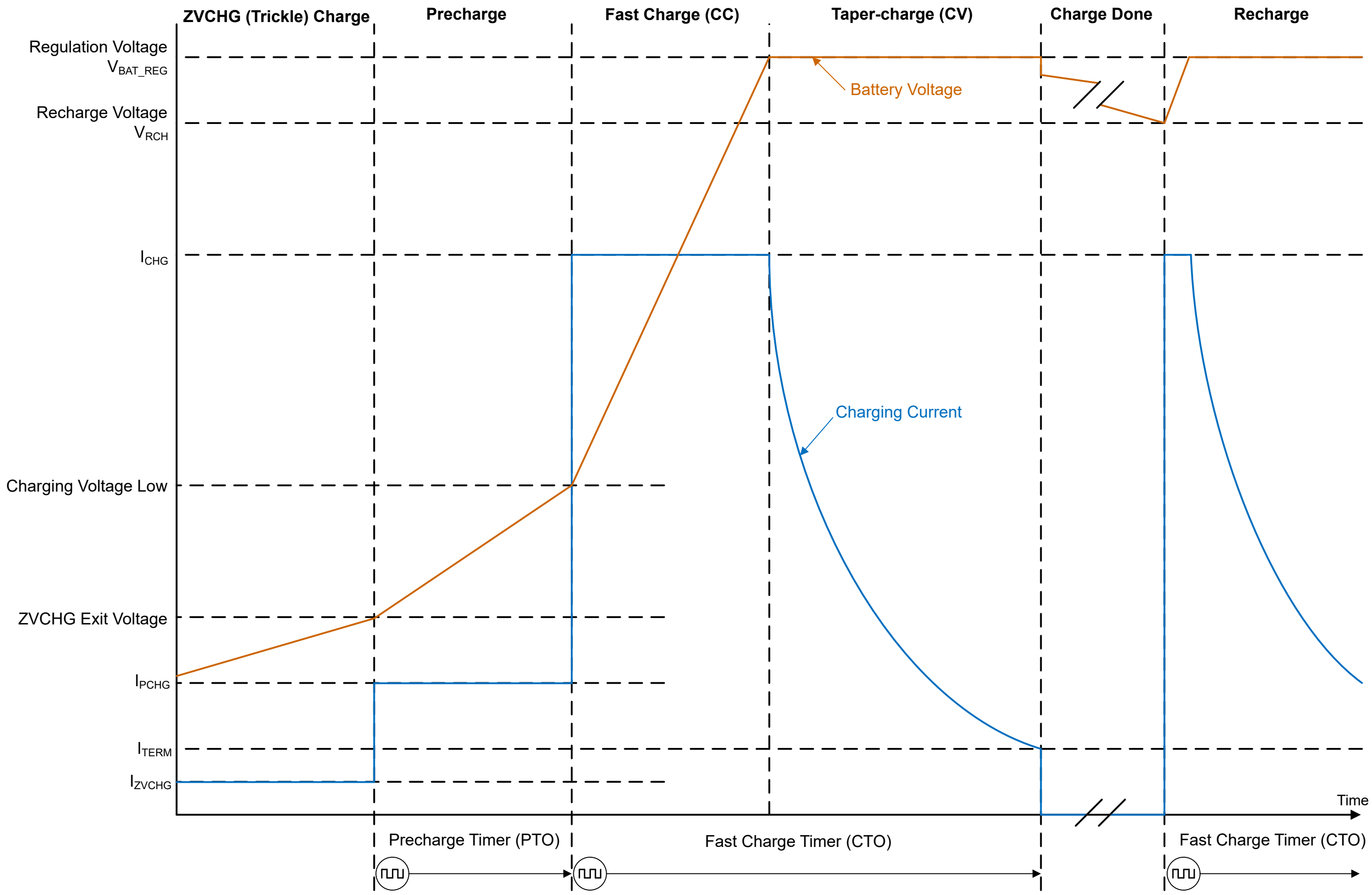


Figure 10-3. Typical CC-CV Battery Charge Profile

Linear Charge Profile State Machine illustrates a CC-CV battery charge cycle the BQ27Z855 device steps through and tracks via a state machine regardless of the state of the *[CHGR_DET]* bit. The device controls what charge profile state the battery is currently operating at in parallel to controlling what state the CHG FET is in via the CHG FET FSM.

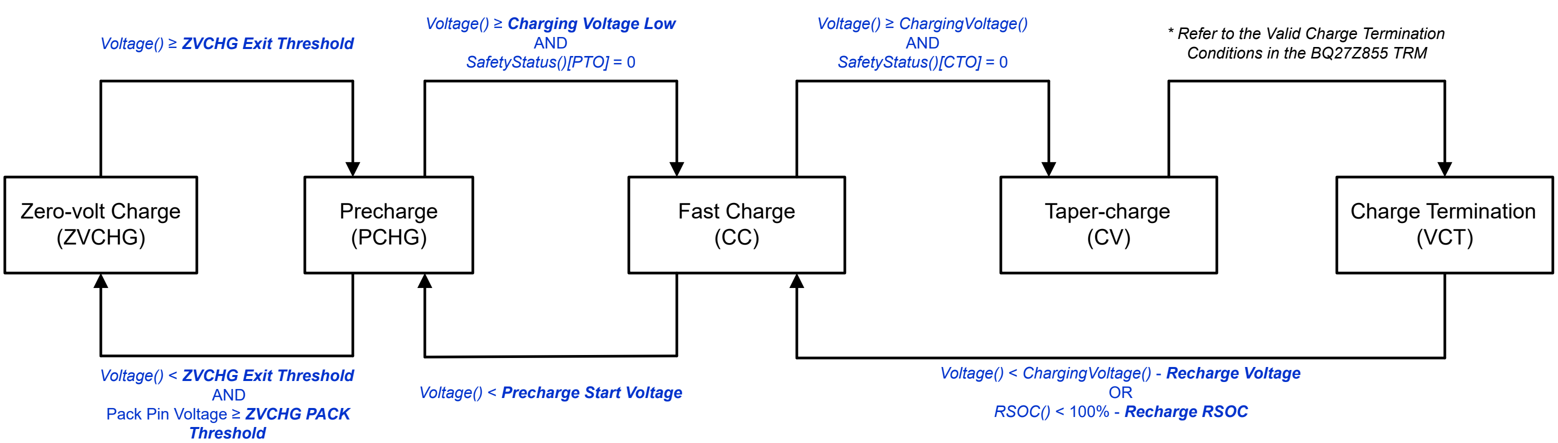


Figure 10-4. Linear Charge Profile State Machine

11 Host Interrupts

11.1 Description

The device can generate an interrupt to the host processor on the BTP pin when a Battery Trip Point (BTP) threshold crossing is detected. The ***IO Config[BTP_EN]*** bit enables assertion of the BTP pin when a BTP threshold is crossed. The ***IO Config[BTP_MODE]*** bit selects whether the threshold is compared against remaining capacity in mAh (***IO Config[BTP_MODE]*** = 0) or relative state of charge in % (***IO Config[BTP_MODE]*** = 1). The active-high or active-low polarity of the BTP pin is configured separately in the BTP GPIO data flash parameters.

The BTP discharge and charge thresholds (***BTPDsgSet*** and ***BTPChgSet***) are RAM-only registers. They are initialized at power-up from the data flash parameters ***Init Discharge Set*** and ***Init Charge Set*** (or their RSOC-based equivalents when ***IO Config[BTP_MODE]*** = 1). The interrupt is cleared when the host re-writes ***BTPDsgSet*** or ***BTPChgSet*** . For full BTP interrupt behavior, see the BTP chapter.

11.2 Host Interrupts Configuration

BTP interrupt behavior is configured through the ***IO Config*** data flash parameter. The two BTP-relevant bits are ***BTP_EN*** (bit 0), which enables assertion of the BTP pin on a threshold crossing, and ***BTP_MODE*** (bit 2), which selects the threshold comparison source.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Settings	Configuration	IO Config	H1	0x00	0x1D	0x00	—	Bit 0: BTP_EN 0 = BTP pin not asserted on threshold crossing 1 = BTP pin asserted when BTP threshold is crossed Bit 1: RSVD Bit 2: BTP_MODE 0 = BTP threshold compared against *RemainingCapacity()* in mAh 1 = BTP threshold compared against *RelativeSoC()* in % Bits 4–3: GPIO_EN, GPIO_PF (see IO Config chapter) Bits 7–5: RSVD

Note

BTPDsgSet and ***BTPChgSet*** are RAM-only registers. They are loaded at power-up from the data flash parameters ***Init Discharge Set*** / ***Init Discharge Set RSOC*** and ***Init Charge Set*** / ***Init Charge Set RSOC*** depending on ***BTP_MODE*** . Writing a new value to ***BTPDsgSet*** or ***BTPChgSet*** via the SBS interface updates the RAM threshold only and clears the active interrupt; it does not modify the data flash init values.

12 Device Security

12.1 Description

There are three levels of secured operation within the device: SEALED, UNSEALED, and FULL ACCESS. To switch between the levels, different operations are needed with different access keys. The device also supports SHA-256 HMAC authentication with the host system. Additionally, lifetime data is protected by an access key.

12.2 SHA-256 Authentication

Overview

The device uses SHA-256 for authentication, implementing HMAC-SHA256 (Hash-based Message Authentication Code with SHA-256) to verify the authenticity of the battery pack. This cryptographic method ensures that only genuine battery packs with the correct secret key can be authenticated by the host system.

HMAC-SHA256 Authentication

HMAC (Hash-based Message Authentication Code) is a mechanism for calculating a message authentication code using a cryptographic hash function (SHA-256) in combination with a secret key. The authentication process uses:

- **Secret Key**: A 256-bit (32-byte) authentication key stored in the device. This key is shared between the gauge and the host system.
- **Message (Challenge)**: A 256-bit (32-byte) random number generated by the host processor and sent to the gauge.
- **Output (Response)**: A 256-bit (32-byte) HMAC digest computed by the gauge using the secret key and challenge.

The host computes the same HMAC using the shared secret key and compares it with the response from the gauge. A match confirms the battery pack is authentic.

Challenge Size

The HMAC-SHA256 challenge size is configurable via the ***HMAC-SHA2 Challenge Size*** parameter in data flash. By default (value = 1), the device accepts any challenge size from 8 to 32 bytes. The random number should be generated from the host processor system using a cryptographically secure random number generator.

The challenge is written to the gauge as a block (up to 32 bytes) to addresses 0x40–0x5F via *AltManufacturerAccess()*.

Configuration Options:

- **0:** Disable HMAC-SHA256 authentication
- **1:** Auto-select mode - accept any challenge size from 8 to 32 bytes (Default)
- **8-32:** Fixed challenge size - only accept challenges of exactly this size

See ***HMAC-SHA2 Challenge Size*** parameter documentation for detailed configuration information.

Reference Standards

- SHA-256 preprocessing is described in the *SHA-1 Preprocessing* section in FIPS 180-4.
- The hash computation is described in the *SHA-1 Hash Computation* section in FIPS 180-4.
- The HMAC implementation is described in FIPS 198-1.

Detailed information about the SHA-256 algorithm can be found here:

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

Authentication Status

The authentication status can be monitored using the **[AUTH]** bit (Bit 18) in *OperationStatus()*:

- **[AUTH] = 1**: Authentication is in progress. This bit is set when the gauge receives a valid authentication challenge and begins computing the HMAC-SHA256 response.
- **[AUTH] = 0**: Authentication is inactive. This bit clears when the HMAC computation completes and the response is ready to be read from *MACData()*.

The host should wait for [AUTH] to clear (or wait approximately 200 ms) after sending the challenge before reading the response.

12.2.1 Authentication Flow

The authentication procedure is described in the following steps:

1. The host writes 0x00 to 0x3E.
2. The host writes 0x00 to 0x3F.

3. Write the random challenge as a 32-byte block to address 0x40–0x5F. The challenge should be a 256-bit (32-byte) random number generated from a cryptographically secure source on the host processor.
4. Write the checksum (1's complement sum of (1), (2), and (3)) to address 0x60.
5. Write the length 0x24 to address 0x61.
6. The gauge will compute the HMAC using SHA-256 after step (5). The *[AUTH]* bit in *OperationStatusB()* is set to 1 during computation. Wait 200 ms. (60 ms is how long authentication takes, but extra margin is added).
7. The *MACData()* command will contain the computed HMAC result using SHA-256. The response format depends on *Settings:Configuration:Auth Config[SPLIT_RESPONSE]*:
   - **[SPLIT_RESPONSE] = 0**: Single 60-byte response containing command echo (2 bytes) + HMAC (32 bytes) + challenge echo (26 bytes).
   - **[SPLIT_RESPONSE] = 1**: Response split into two 30-byte fields. Host must read twice to get complete response.
8. *[AUTH]* = 0 in *OperationStatusB()* when computation completes and response is ready.

Authentication Timing

The following timing details apply to the authentication process:

- **Recommended Wait Time**: 200 ms to ensure reliable operation across all conditions.
- **Polling Method**: Alternatively, poll *OperationStatusB()[AUTH]* until it clears (0) to detect completion.

Host Verification

To verify authentication:

1. The host computes HMAC-SHA256 using the same 32-byte challenge and the shared 256-bit secret key.
2. The host reads the HMAC response from *MACData()*.
3. The host compares its computed HMAC with the gauge's response.
4. If the HMACs match, the battery pack is authenticated as genuine.

12.3 Security Modes

As shipped, the device is in FULL ACCESS mode. For device security after manufacture, the device should be set to the SEALED access operational mode. To do this, send the MAC seal 0x0030 to the gauge. After the device is set to the SEALED mode, any device resets will cause the device to enter the SEALED mode. See the following sections for instructions on how to return to the other access modes.

For security mode access keys, the device ships with factory defaults. The manufacturer should change the keys to their proprietary keys using the MAC 0x0035. See *AltManufacturerAccess() 0x0035 Security Keys*.

12.3.1 SEALING and UNSEALING Data Flash

The gas gauge has a key access scheme to transition between SEALED, UNSEALED, and FULL ACCESS modes. Each transition requires that a unique set of two keys be sent to the gas gauge via the *AltManufacturerAccess()* command. The keys must be sent consecutively, with no other data being written to the *AltManufacturerAccess()* register. The *Seal Device* command instructs the device to limit access to the registers, functions, and data flash space, and sets the *[SEC1][SEC0]* flags. In SEALED mode, standard register information is accessible. Extended MAC Command functions and data flash are not accessible. Once in SEALED mode, the device can never permanently return to UNSEALED or FULL ACCESS modes. *AltManufacturerAccess() 0x0054 OperationStatus*, the *OperationStatusB()* register, shows the status of the device using the *[SEC1][SEC0]* bits.

12.3.2 SEALED to UNSEALED

SEALED to UNSEALED instructs the device to extend access to the standard and extended registers and data flash space and clears the *[SEC1][SEC0]* flags. In UNSEALED mode, all data, standard and extended registers and DF have read/write access. Unsealing is a two-step command performed by writing the first word of the unseal key to *AltManufacturerAccess() (MAC)*, followed by the second word of the unseal key to *AltManufacturerAccess()*. The unseal key can be read and changed via the *MAC SecurityKey()* command when in 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.

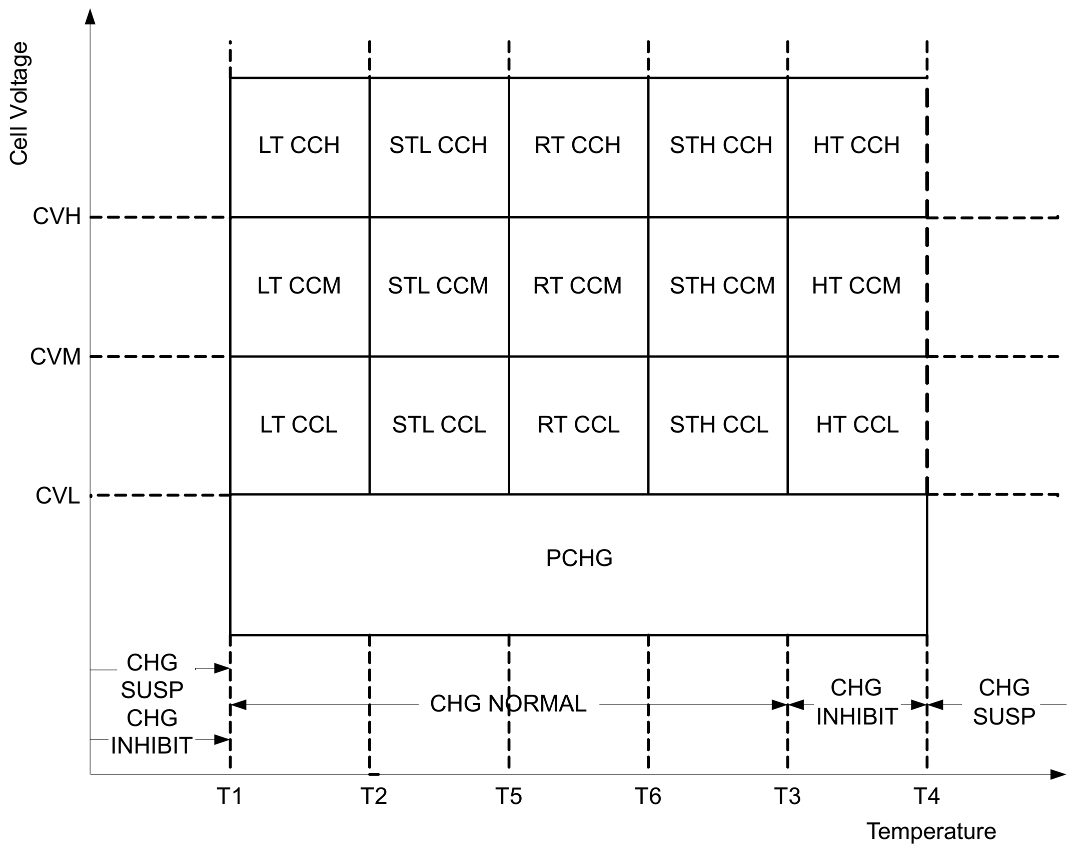
12.3.3 UNSEALED to FULL ACCESS

UNSEALED to FULL ACCESS instructs the device to allow full access to all standard and extended registers 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 *AltManufacturerAccess()* command, by writing the first word of the Full Access Key to *AltManufacturerAccess()*, followed by the second word of the Full Access Key to *AltManufacturerAccess()*. In FULL ACCESS mode, the command to go to boot ROM can be sent.

13 Advanced Charge Algorithm

13.1 Introduction

The device can change the values of *ChargingVoltage()* and *ChargingCurrent()* based on *Temperature()* and cell voltage1..4 . 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.



The Charging Current and Charging Voltage used for different purposes flow the priority sequence in Charging Current and Charging Voltage Priority Sequence.

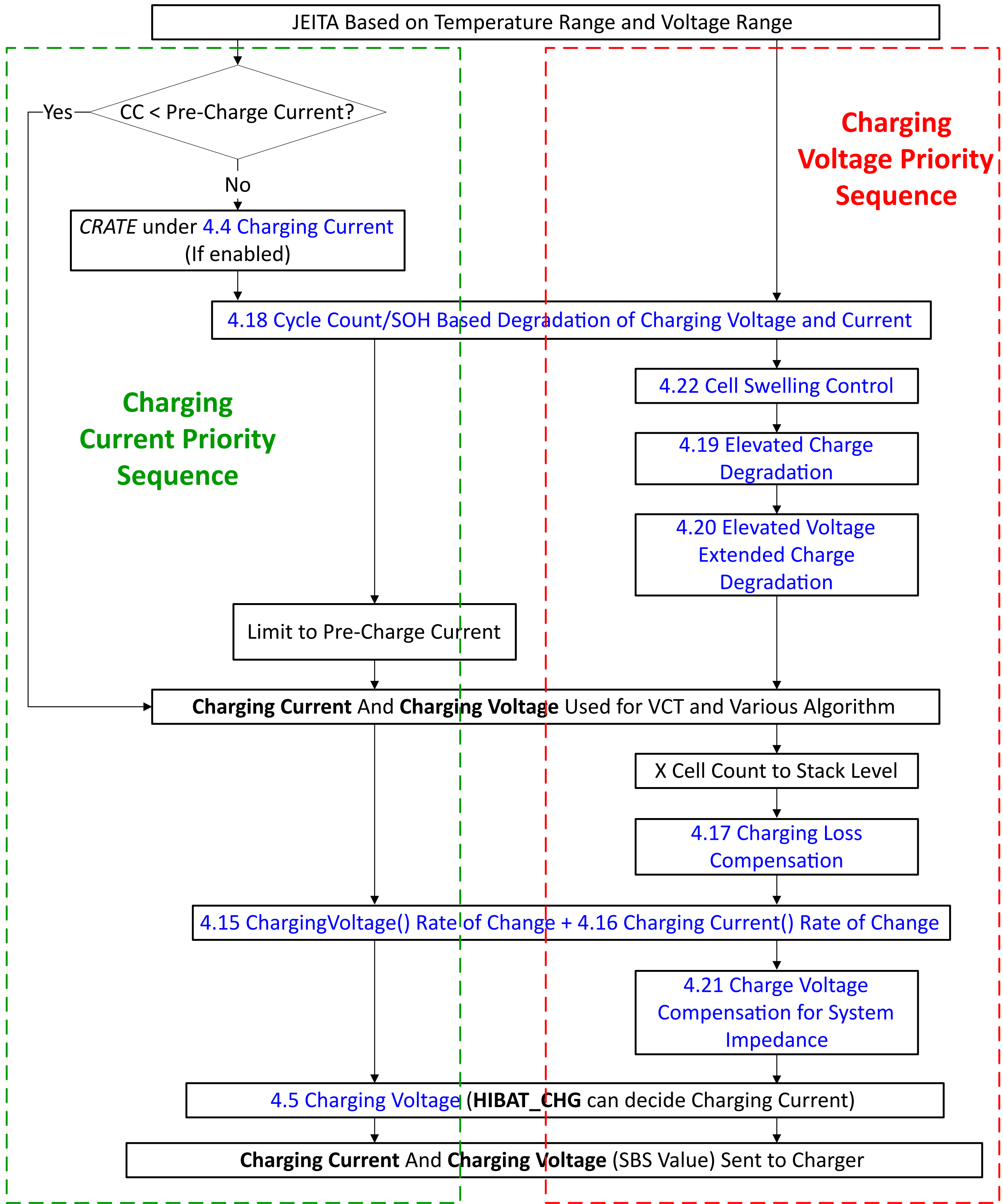
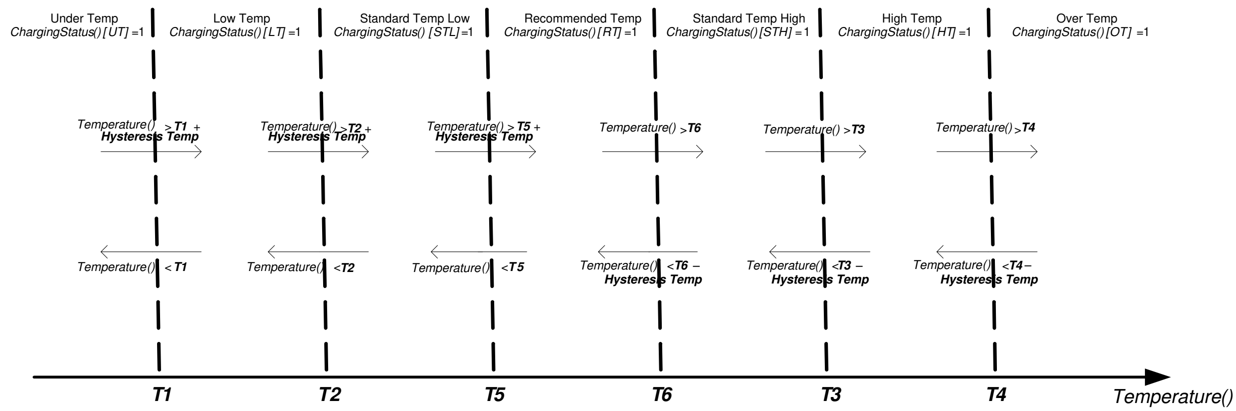


Figure 13-1. Charging Current and Charging Voltage Priority Sequence

13.2 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* .**



13.3 Voltage Range

The measured cell voltage is segmented into several voltage ranges. The charging algorithm adjusts *ChargingCurrent()* according to the temperature 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 recommended. 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. . Cell Voltage below is used when ***Settings:Charging Configuration Ext[CELL_VAL1][CELL_VAL0]*** is set to 0, 0.

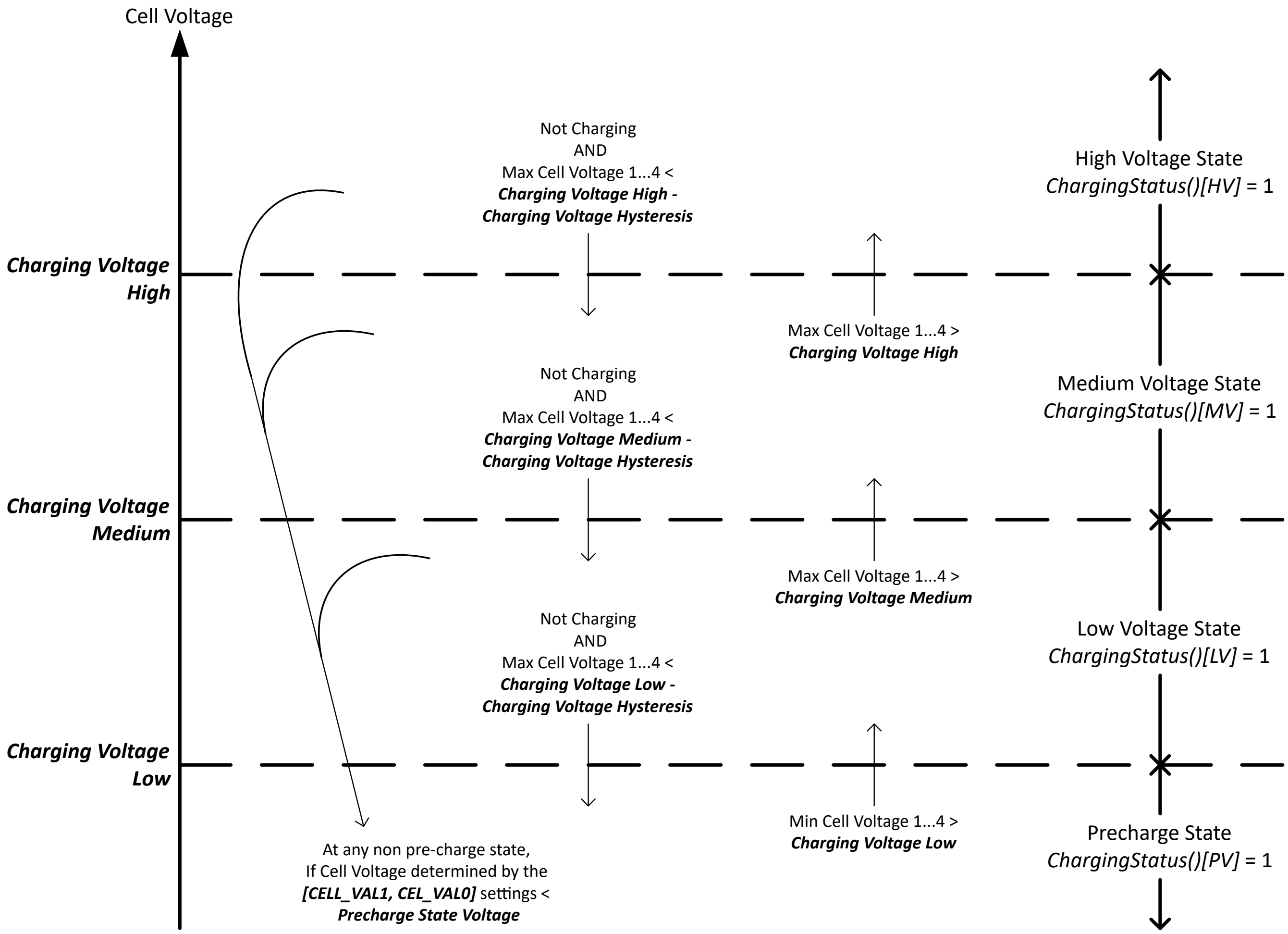


Figure 13-2. Cell Voltage Based Charging State Profile

13.3.1 Voltage or RelativeStateofCharge() Range

If ***[V_SOC_CHARGE]*** in ***Charging Configuration*** is set to '1', then a combination of the cell voltage level range and the device RSOC percentage range are considered to determine the state of charging.

The cell voltage range is categorized the same way as defined in Voltage Range:

- CHV: Cell voltage in High Voltage State
- CMV: Cell voltage in Medium Voltage State
- CLV: Cell voltage in Low Voltage State

The V-RSOC range and the state of the charge is determined by the formulas shown in the table below.

Table 13-1. Voltage level and RSOC range based Charging State Transition

Current Cell Voltage Range	RSOC Range	[DSG]	Charging State
CHV	Any RSOC range	0	High Voltage State *ChargingStatus()[HV]* = 1
CHV	>= ***Charging SOC Mid*** − ***Charging SOC Hysteresis***	1	High Voltage State *ChargingStatus()[HV]* = 1
CHV	< ***Charging SOC Mid*** − ***Charging SOC Hysteresis***	1	Medium Voltage State *ChargingStatus()[MV]* = 1
CMV	>= ***Charging SOC High***	0	High Voltage State *ChargingStatus()[HV]* = 1
CMV	< ***Charging SOC High***	0	Medium Voltage State *ChargingStatus()[MV]* = 1

Table 13-1. Voltage level and RSOC range based Charging State Transition (continued)

Current Cell Voltage Range	RSOC Range	[DSG]	Charging State
CMV	any RSOC range	1	Medium Voltage State *ChargingStatus()[MV]* = 1
CLV	>= ***Charging SOC High***	0	High Voltage State *ChargingStatus()[HV]* = 1
CLV	< ***Charging SOC High*** and >= ***Charging SOC Mid***	0	Medium Voltage State *ChargingStatus()[MV]* = 1
CLV	< ***Charging SOC Mid***	0	Low Voltage State *ChargingStatus()[LV]* = 1
CLV	>= ***Charging SOC High*** − ***Charging SOC Hysteresis***	1	Medium Voltage State *ChargingStatus()[MV]* = 1
CLV	< ***Charging SOC High*** − ***Charging SOC Hysteresis***	1	Low Voltage State *ChargingStatus()[LV]* = 1

The charging state matrix broken down by cell voltages and the RSOC ranges defined below:

Note

[DSG] refers to the DSG bit in *BatteryStatus()*. This bit indicates the discharge direction: [DSG] = 1 when the battery is discharging (negative current), [DSG] = 0 when charging or at rest with positive current direction.

When *[DSG]* = 0 (Charging/Rest):

- RSOC_High: *RelativeStateOfCharge()* >= ***Charging SOC High***
- RSOC_Mid: ***Charging SOC High*** > *RelativeStateOfCharge()* >= ***Charging SOC Mid***
- RSOC_Low: ***Charging SOC Mid*** > *RelativeStateOfCharge()*

When *[DSG]* = 1 (Discharging):

- RSOC_High: *RelativeStateOfCharge()* >= ***Charging SOC High*** − ***Charging SOC Hysteresis***
- RSOC_Mid: ***Charging SOC High*** − ***Charging SOC Hysteresis*** > *RelativeStateOfCharge()* >= ***Charging SOC Mid*** − ***Charging SOC Hysteresis***
- RSOC_Low: ***Charging SOC Mid*** − ***Charging SOC Hysteresis*** > *RelativeStateOfCharge()*

Table 13-2. Voltage Level and RSOC Range Based Charging State Matrix

	***[DSG]* = 0**			***[DSG]* = 1**		
	RSOC_High	**RSOC_Mid**	**RSOC_Low**	**RSOC_High**	**RSOC_Mid**	**RSOC_Low**
CHV	[HV]	[HV]	[HV]	[HV]	[HV]	[MV]
CMV	[HV]	[MV]	[MV]	[MV]	[MV]	[MV]
CLV	[HV]	[MV]	[LV]	[MV]	[LV]	[LV]

13.4 Charging Current

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

In order to prevent the charging degradation algorithms from reducing and causing the *ChargingCurrent()*to fall below ***Pre-Charging:Current*** , following conditions are applied to determine the *ChargingCurrent()*:

- If the JEITA current for the present operating conditions is ≥ ***Pre-Charging:Current*** , then *ChargingCurrent()* will be limited by ***Pre-Charging:Current*** in the event *ChargingCurrent()* degradation would cause it to fall below ***Pre-Charging:Current*** .
- If the JEITA current for the present operating conditions is < ***Pre-Charging:Current*** , then *ChargingCurrent()* will be set to the exact JEITA value, regardless of degradation.

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

For example, with ***[CRATE]*** = 1, if ***StateofHealth()*** = 90% and ***Rec Temp Charging: Current Med*** is active per the charging algorithm, then *ChargingCurrent()* = ***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	LV	—	*ChargingCurrent()* = ***Standard Temp Low Charging:Current Low***
	MV	—	*ChargingCurrent()* = ***Standard Temp Low Charging:Current Med***
	HV	—	*ChargingCurrent()* = ***Standard Temp Low Charging:Current High***
STH	LV	—	*ChargingCurrent()* = ***Standard Temp High Charging:Current Low***
	MV	—	*ChargingCurrent()* = ***Standard Temp High Charging:Current Med***
	HV	—	*ChargingCurrent()* = ***Standard Temp High 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***
HT	LV	—	*ChargingCurrent()* = ***High Temp Charging:Current Low***
	MV	—	*ChargingCurrent()* = ***High Temp Charging:Current Med***
	HV	—	*ChargingCurrent()* = ***High Temp Charging:Current High***

13.5 Charging Voltage

ChargingVoltage() is dependent on cell temperature per the charge algorithm. If cell temperature reduces *ChargingVoltage()* below the stack voltage, it can be held unchanged while *ChargingCurrent()* is held at 0 by setting ***[HIBAT_CHG]*** . This action continues until the desired *ChargingVoltage()* is above the stack voltage.

Note

Table priority is top to bottom.

Temp Range	Condition	Action
Any	*OperationStatus()[XCHG]* = 1	*ChargingVoltage()* = 0
UT or OT	—	*ChargingVoltage()* = 0

Temp Range	Condition	Action
LT	—	*ChargingVoltage()* = ***Low Temp Charging:Voltage*** × Cell Count
STL	—	*ChargingVoltage()* = ***STL:Voltage*** × Cell Count
STH	—	*ChargingVoltage()* = ***STH:Voltage*** × Cell Count
RT	—	*ChargingVoltage()* = ***Rec Temp Charging:Voltage*** × Cell Count
HT	—	*ChargingVoltage()* = ***High Temp Charging:Voltage*** × Cell Count

13.6 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 ***IT 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 cell voltage + ***Charge Term Voltage Offset*** ≥ *ChargingVoltage()* AND ***[TAPER_VOLT]*** = 0 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()[TC]* = 1 if ***SOCFlagConfig A[TCSETVCT]*** = 1

Note

Setting ***[TAPER_VOLT]*** = 1 causes ***Charge Term Charging Voltage*** to be used in place of *ChargingVoltage()* for a valid charge termination condition.

13.7 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*** . If both RSOC-based and cell voltage-based conditions are enabled, RSOC-based condition takes priority.

The *BatteryStatus()[TCA][FC][TDA][FD]* flags will be set and cleared according to the *GaugingStatus() [TC][FC][TD][FD]* flags, as well as the safety and permanent failure protections status. For more information, see Section 13.8.

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

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

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

Flag	Clear Criteria	Clear Condition	Enable
[TC]	cell voltage	cell voltage ≤ ***TC: Clear Voltage Threshold***	***SOC Flag Config A[TCClearV]*** = 1
	RSOC (enabled by default)	*RelativeStateOfCharge()* ≤ ***TC: Clear % RSOC Threshold***	***SOC Flag Config A[TCClearRSOC]*** = 1
[FC]	cell voltage	cell voltage ≤ ***FC: Clear Voltage Threshold***	***SOC Flag Config B[FCClearV]*** = 1
	RSOC (enabled 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 also depends on some safety conditions (CUV, SUV, and so on).

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

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

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

13.8 Terminate Charge and Discharge Alarms

When the protections and permanent fails are triggered, *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]* , *[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

13.9 Zero Volt Charging (ZVCHG)

The device supports charging of a severely depleted battery, including batteries at or near 0 V. This feature is called Zero-Volt Charging (ZVCHG) or 0-V charging.

When the battery voltage (*Voltage ()*) is below the internal ***ZVCHG Exit Threshold*** , and a valid charger is detected at the PACK+ terminal (***ZVCHG PACK Threshold***), the device provides an internal low-current charging path from the PACK pin to the BAT pin. This allows a controlled trickle current (IZVCHG) to flow into the battery even when the voltage is too low for normal FET operation. The maximum ZVCHG current and related electrical specifications are provided in the Zero-Volt Charging Specifications table in the device Datasheet (SLUSG59).

During ZVCHG operation:

- Both CHG and DSG FETs are disabled. OperationStatus()[XCHG] = 1 AND OperationStatus()[XDSG] = 1.
- The normal FET drivers are disabled.
- Charging current is limited by the external resistor between PACK+ and the PACK pin (if present) and by the device's internal IZVCHG(MAX) limit.

ZVCHG remains active until Voltage() rises above the programmed exit threshold (***ZVCHG Exit Threshold***). Once exited, the device performs normal protection and FET control evaluation before enabling the CHG and/or DSG FETs as appropriate.

The ZVCHG path is also active when the device is below its power-on reset (POR) threshold or in SHUTDOWN mode, provided a charger voltage is present at PACK+.

Note

Some battery manufacturers do not recommend charging severely depleted cells. The device is intended to be used with at least one additional secondary protector that includes a ZVCHG inhibit function for safety. Refer to the battery manufacturer's recommendations and to the device Datasheet for detailed electrical characteristics, recommended external component values, and safety considerations related to zero-volt charging.

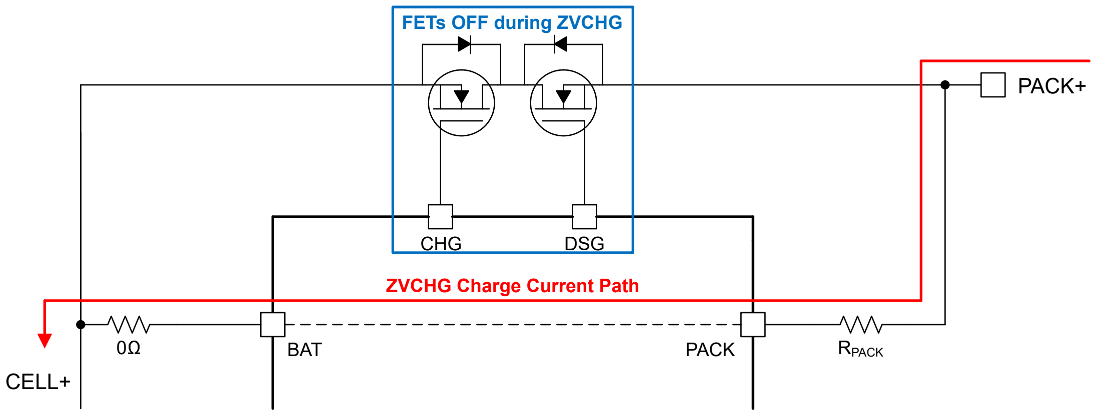


Figure 13-3. Zero-volt Charging Path

Status	Condition	Action
Activate	*Voltage()* < ***ZVCHG Exit Threshold*** AND Pack Pin Voltage ≥ ***ZVCHG PACK Threshold***	*OperationStatus()[ZVCHG]* = 1 *OperationStatus()[CHG]* = 0 *OperationStatus()[XCHG] = 1*
Exit	*Voltage()* ≥ ***ZVCHG Exit Threshold*** OR Pack Pin Voltage < ***ZVCHG PACK Threshold***	*OperationStatus()[ZVCHG]* = 0 *OperationStatus()[CHG]* = 1 *OperationStatus()[XCHG]* = 0

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	ZVCHG Exit Threshold	I2	0	32,767	3500	mV
Settings	AFE	ZVCHG PACK Threshold	I2	0	32,767	1500	mV

13.10 Precharge

The gauge enters PRECHARGE mode if,

1. Cell voltage < ***Precharge Start Voltage*** OR
2. Cell voltage < ***Charging Voltage Low – Charging Voltage Hysteresis*** and not in CHARGE mode

13.11 Maintenance Charge

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

If overcharge protection is enabled, ***Enabled Protections C[OC]*** = 1, an 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()[TC]* = 1	*ChargingStatus()[MCHG]* = 1 *ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm
Clear	*ChargingStatus()[IN]* = 1 OR *ChargingStatus()[SU]* = 1 OR *ChargingStatus()[PV]* = 1 OR *GaugingStatus()[TC]* = 0	*ChargingStatus()[MCHG]* = 0 *ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm

13.12 Charge Disabled

The device disables charging by opening the charge FET when certain safety conditions are detected. In this case the FW will set *OperationStatus()[XCHG]* = 1.

Status	Condition	Action
Normal	*ALL PFStatus()* = 0 AND *SafetyStatus()[COV]* = 0 AND *SafetyStatus()[OCC1][OCC2]* = 0,0 AND *SafetyStatus()[AOCC]* = 0 AND *SafetyStatus()[AOCCL]* = 0 AND *SafetyStatus()[CTO]* = 0 AND *SafetyStatus()[PTO]* = 0 AND *OperationStatus()[PRES]* = 1 AND *GaugingStatus()[TCA]* = 0 if ***FET Options[CHGFET]*** = 1	*ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm *OperationStatus()[XCHG]* = 0
Trip	*ManufacturingStatus()[FET_EN]* = 0 OR *ANY PFStatus()[]* = 1 OR *SafetyStatus()[COV]* = 1 OR *SafetyStatus()[OCC1]* = 1 OR *SafetyStatus()[OCC2]* = 1 OR *SafetyStatus()[AOCC]* = 1 OR *SafetyStatus()[AOCCL]* = 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 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 ***[SLEEPCHG]*** = 0 OR *OperationStatus()[EMSHUT]* = 1 OR *OperationStatus()[PRES]* = 0 OR *GaugingStatus()[TCA]* = 1 if ***FET Options[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 *[AOCD]* or *[AOCDL]* 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***

13.13 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. High Temperature charge inhibit can be disabled by setting ***[HT_INHIB_DIS]*** .

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

Status	Condition	Action
Trip	Not charging AND *(ChargingStatus()[HT]* = 1 OR (*ChargingStatus()[OT]* = 1 AND ***[HT_INHIB_DIS]*** = 0) OR *ChargingStatus()[UT]* = 1	*ChargingStatus()[IN]* = 1 *ChargingStatus()[SU]* = 0 *ChargingVoltage()* = 0 *ChargingCurrent()* = 0 *OperationStatus()[XCHG]* = 1 if ***FET Options[CHGIN]*** = 1

13.14 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

13.15 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 will change to n = 1.. ***Voltage Rate*** , increments in steps of one per second.

13.16 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. When ***[SLOW_CRATE]*** = 1, ***Current Rate*** will be multiplied by 5, effectively making the current step size smaller, and taking 5 times more 1-second steps to transition to the target *Charging Current()*.

13.17 Charging Loss Compensation

The device can modify *ChargingVoltage()* and *ChargingCurrent()* to compensate losses caused by the FETs, 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 + (PACK voltage – *Voltage()*)
Limit	(PACK voltage in *DAStatus1()* – *Voltage()*) > ***CCC Voltage Threshold***	*ChargingVoltage()* = Charging Algorithm + ***CCC Voltage Threshold***

13.18 Cycle Count/SOH Based Degradation of Charging Voltage and Current

This feature, if enabled by setting either ***[Cycle_Degrade]*** , ***[SOH_Degrade]*** or ***[RUNTIME_DEGRADE]*** in the charging configuration register, reduces the *ChargingVoltage()* and/or *ChargingCurrent()* levels based on cycle count or SOH. This helps to reduce the *ChargingVoltage()* and/or *ChargingCurrent()* as the battery pack ages in order to increase the longevity of the battery pack. These degradations are at the cell level.

Note

These degradations work in conjunction with other degradation features; therefore, use with care.

13.18.1 Degradation Modes

13.18.1.1 Cycle Count Based Degradation

When ***[CYCLE_DEGRADE]*** = 1, ***Cycle Count*** can be used as a selector for voltage degradation. There are four programmable stages/levels of cycle count based degradation modes:

NORMAL mode (***Cycle Count*** < ***Cycle Threshold*** for Mode 1)

Degradation Mode 1 (***Cycle Count*** ≥ ***Cycle Threshold*** for Mode 1 and < Mode 2)

Degradation Mode 2 (***Cycle Count*** ≥ ***Cycle Threshold*** for Mode 2 and < Mode 3)

Degradation Mode 3 (***Cycle Count*** ≥ ***Cycle Threshold*** for Mode 3)

Note

- Cycle Count based degradation cannot be enabled together with SOH based degradation.
- Cycle Count based degradation can be enabled with Runtime based degradation together only when ***[RTORCC]*** is set.
- If ***[Degrade_CC]*** sets, charging current can also be degraded.

13.18.1.2 SOH Based Degradation

In addition, when ***[SOH_DEGRADE]*** = 1, SOH can be used as a selector for voltage degradation. There are four programmable stages/levels of SOH based degradation modes:

NORMAL mode (SOH > ***SOH Threshold*** for Mode 1)

Degradation Mode 1 (SOH ≤ ***SOH Threshold*** for Mode 1 and > Mode 2)

Degradation Mode 2 (SOH ≤ ***SOH Threshold*** for Mode 2 and > Mode 3)

Degradation Mode 3 (SOH ≤ ***SOH Threshold*** for Mode 3)

Note

- SOH based degradation cannot be enabled together with either Runtime based degradation or Cycle Count based degradation.
- If ***[Degrade_CC]*** sets, charging current can also be degraded.

13.18.1.3 Runtime Based Degradation

In addition, when ***[RUNTIME_DEGRADE]*** = 1, runtime counted when ***Cycle Count*** is above ***Cycle Count Start Runtime*** can be used as a selector for voltage degradation. There are four programmable stages/levels of rungtime based degradation modes:

NORMAL mode (***Accumulated Runtime*** < ***Runtime Threshold*** for Mode 1)

Degradation Mode 1 (***Accumulated Runtime*** ≥ ***Runtime Threshold*** for Mode 1 and < Mode 2)

Degradation Mode 2 (***Accumulated Runtime*** ≥ ***Runtime Threshold*** for Mode 2 and < Mode 3)

Degradation Mode 3 (***Accumulated Runtime*** ≥ than ***Runtime Threshold*** for Mode 3)

When the configuration bits ***[RUNTIME_DEGRADE]*** , ***[CYCLE_DEGRADE]*** , and ***[RTORCC]*** are all set, then degradation occurs according to the runtime or cycle count criteria first met.

Note

- Runtime based degradation can be enabled with Cycle Count based degradation together only when ***[RTORCC]*** is set.
- Runtime based degradation cannot be enabled together with SOH based degradation.
- If ***[Degrade_CC]*** sets, charging current can also be degraded.

13.18.2 Degradation Process

13.18.2.1 Charging Voltage Degradation Process

The following is the charging voltage degradation process:

When a Degradation Mode is entered, whether though cycle count based, SOH based, or runtime based degradation, the highest degradation mode determines the level of *ChargingVoltage()* adjustment.

In NORMAL mode, no *ChargingVoltage()* adjustment is applied.

Entering Degradation Mode 1, *ChargingVoltage()* is reduced by ***Voltage Degradation*** for Mode 1. Enterning Degradation Mode 2, *ChargingVoltage()* is reduced by ***Voltage Degradation*** for Mode 2. Similarly for entering Degradation Mode 3, as the *ChargingVoltage()* is reduced by ***Voltage Degradation*** for Mode 3. The charging voltage mode reduction is a one-way transition. The gauge only goes from Normal → Lvl1 → Lvl2 → Lvl3. The three degradation points each occur one time when the Degradation Mode is reached due to any of the cycle count, SOH, or runtime based degradation criterias.

This charging voltage degradation scheme (if enabled) works in conjunction with any other existing degradation/increments (such as charging loss compensation).

13.18.2.2 Charging Current Degradation Process

When ***[DEGRADE_CC]*** = 1, charging current can also be degraded in addition to charging voltage degradation. The following is the charging current degradation process:

When a Degradation Mode is entered, whether though cycle count based, SOH based, or runtime based degradation, the highest degradation mode determines the level of *ChargingCurrent()* adjustment.

In NORMAL mode, no *ChargingCurrent()* adjustment is applied.

Entering Degradation Mode 1, *ChargingCurrent()* is reduced by ***Current Degradation*** for Mode 1. Enterning Degradation Mode 2, *ChargingCurrent()* is reduced by ***Current Degradation*** for Mode 2. Similarly for entering Degradation Mode 3, as the *ChargingCurrent()* is reduced by ***Current Degradation*** for Mode 3. The charging current mode reduction is a one-way transition. The gauge only goes from Normal → Lvl1 → Lvl2 → Lvl3. The three degradation points each occur one time when the Degradation Mode is reached due to any of the cycle count, SOH, or runtime based degradation criterias.

This charging current degradation scheme (if enabled) works in conjunction with any other existing degradation/increments (such as charge loss compensation).

The following table shows how charging voltage and charging current are degraded at different points:

Cycle Count (in counts)/SOH (in %)/ Runtime (in hrs) (One or the other must be enabled.(1))	Charging Voltage (CV) (CV degradation is available by default.)	Charging Current (CC) (CC degradation is available if enabled *[Degrade_CC]* .(2))
Degradation Normal	No ***Voltage Degradation***	No ***Current Degradation***
Degradation Mode 1	***Voltage Degradation*** (default 10 mV / cell)	***Current Degradation*** (default 10%)
Degradation Mode 2	***Voltage Degradation*** (default 40 mV / cell)	***Current Degradation*** (default 20%)
Degradation Mode 3	***Voltage Degradation*** (default 70 mV / cell)	***Current Degradation*** (default 40%)

(1) Only SOH or ***Cycle Count*** can be used at a time. Both must not be enabled together.
(2) Only [Degrade CC] or [CRATE] can be used at a time. Both must not be enabled together.

13.19 Elevated Charge Degradation

The device includes a monitoring scheme that notifies the host when the battery spends a prolonged period of time at an elevated RSOC level with or without respect to temperature, depending on the configuration. The temperature used for this feature is the maximum temperature source configured for cell temperature. This feature uses the counter ***Accumulated ERM Time*** that is incremented once for every hour that *RelativeStateOfCharge()* ≥ ***ERM RSoC Threshold*** . For periods where ***ERM Reset RSoC Threshold*** < *RelativeStateOfCharge()* < ***ERM RSoC Threshold*** , the ***Accumulated ERM Time*** is held unchanged at its present value.

When the ***Accumulated ERM Time*** ≥ ***ERM Time Threshold*** , an *[ERM]* flag is set, signaling to the host that ELEVATED RSOC mode has been entered.

Recovery occurs if *RelativeStateOfCharge()* < ***ERM Reset RSoC Threshold*** , at which point ***Accumulated ERM Time*** and *[ERM]* are cleared to their default state of 0.

To use voltage-based thresholds (***ERM Voltage Threshold*** and ***ERM Reset Voltage Threshold***) in place of RSOC-based ones for this mode, the configuration bit ***[ERM_MODE]*** must be set (the default value is 0).

The separate counter ***Accumulated ERETM Time*** is used to track time at the elevated temperature, as well as *RelativeStateOfCharge()*, and can be used to reduce *ChargingVoltage()*. This counter is incremented once for every hour that *RelativeStateOfCharge()* ≥ ***ERETM RSoC Threshold*** and temperature ≥ ***ERETM Temperature Threshold*** . For periods where *RelativeStateOfCharge()* < ***ERETM RSoC Threshold*** or temperature < ***ERETM Temperature Threshold*** , the ***Accumulated ERETM Time*** is held unchanged at its present value.

When the ***Accumulated ERETM Time*** ≥ ***ERETM Time Threshold*** , an *[ERETM_ACTIVE]* flag is set, signaling to the host that ***Elevated RSOC and Temperature Mode*** has been entered, and *ChargingVoltage()* for all temperature ranges is permanently set to ***ERETM Charging Voltage*** without further degradation, starting from the next charge cycle along with the flag ***[ERETM_DEGRADE]*** setting.

If at any point *RelativeStateOfCharge()* > ***ERETM RSoC Threshold*** and temperature > ***ERETM Temperature Max Threshold*** , the *[ERETM_ACTIVE]* flag is immediately set, bypassing the counter threshold. Once active, exit from this mode is prohibited and the gauge stays in this mode for the remaining life of the pack. This ***ERETM Temperature Max Threshold*** related trigger can be disabled by clearing the ***[ERETM_MAX_T]*** configuration bit.

Since ***Elevated RSOC and Temperature Mode*** supersedes ELEVATED RSOC mode, the latter and its associated *[ERM]* flag are deactivated once the former is triggered.

To use voltage-based thresholds (***ERETM Voltage Threshold***) in place of *RelativeStateOfCharge()*-based ones for this mode, the configuration bit ***[ERETM_MODE]*** must be set (default is cleared).

To disable each mode, clear its respective enable bit (***[ERM_TIME]*** and/or ***[ERETM_TIME]***).

13.20 Elevated Voltage Extended Charge Degradation

The device includes an extension of the elevated charge degradation function described in Section 13.19, which notifies the host when any cell voltage is ≥ the specified EVTM voltage threshold and the battery spends a prolonged period of time under the specified EVTM temperature range. This feature provide a method to reduce battery aging by providing multiple degradation steps to reduce *ChargingVoltage()* before the *[ERETM_ACTIVE]* flag is set and the device enters ***Elevated RSOC and Temperature Mode*** . When ***[ERETM_MODE]*** = 1, this feature can be enabled by setting ***[EVTM_EXT_MODE]*** = 1.

As shown in Table 13-3, lifetimes counters are incremented once every hour to track the time under each of the 3 temperature and 3 voltage ranges. The lifetimes counters are held unchanged at its present value for periods when the cell voltage or temperature is outside of the specified ranges for the corresponding lifetimes counter.

Table 13-3. Accumulated Time Spent in Elevated Voltage and Temperature Ranges

Lifetimes Counter	Temperature Range	Temperature Condition
Accumulated EVLTM Time	EVLTM	***EVTM Temperature Low Threshold*** ≤ temperature < ***EVTM Temperature Mid Threshold*** and cell voltage ≥ ***EVTM Voltage Low Threshold***
Accumulated EVMTM Time	EVMTM	***EVTM Temperature Mid Threshold*** ≤ temperature < ***EVTM Temperature High Threshold*** and cell voltage ≥ ***EVTM Voltage Mid Threshold***
Accumulated EVHTM Time	EVHTM	***EVTM Temperature High Threshold*** ≤ temperature and cell voltage ≥ ***EVTM Voltage High Threshold***

Under each temperature range, *ChargingVoltage()* can be reduced down by a programmable delta voltage if the value of the accumulated time counter falls between the corresponding time ranges as shown in Table 13-4. The bits in the ***EVTM ACTIVE*** register are asserted to indicate which degradation conditions which are met. Once the device enters CHARGE mode, the corresponding delta degradation will be applied to the *ChargingVoltage()*, and the corresponding bit in the ***EVTM Degrade*** register will be asserted.

Table 13-4. Charge Voltage Degradation due to Time Spent under Elevated Voltage and Temperature

Degradation Steps	Temperature Range = *EVLTM*		Temperature Range = *EVMTM*		Temperature Range = *EVHTM*	
	Time Range	*ChargingVoltage()* Degradation	Time Range	*ChargingVoltage()* Degradation	Time Range	*ChargingVoltage()* Degradation
1	***EVLTM TTH1*** ≤ ***Accumulated EVLTM Time*** < ***EVLTM TTH2***	*ChargingVoltage()* - ***EVLTM CV Delta1***	***EVMTM TTH1*** ≤ ***Accumulated EVMTM Time*** < ***EVMTM TTH2***	*ChargingVoltage()* - ***EVMTM CV Delta1***	***EVHTM TTH1*** ≤ ***Accumulated EVHTM Time*** < ***EVHTM TTH2***	*ChargingVoltage()* - ***EVHTM CV Delta1***
2	***EVLTM TTH2*** ≤ ***Accumulated EVLTM Time*** < ***EVLTM TTH3***	*ChargingVoltage()* - ***EVLTM CV Delta2***	***EVMTM TTH2*** ≤ ***Accumulated EVMTM Time*** < ***EVMTM TTH3***	*ChargingVoltage()* - ***EVMTM CV Delta2***	***EVHTM TTH2*** ≤ ***Accumulated EVHTM Time*** < ***EVHTM TTH3***	*ChargingVoltage()* - ***EVHTM CV Delta2***

Table 13-4. Charge Voltage Degradation due to Time Spent under Elevated Voltage and Temperature (continued)

Degradation Steps	Temperature Range = *EVLTM*		Temperature Range = *EVMTM*		Temperature Range = *EVHTM*	
	Time Range	*ChargingVoltage()* Degradation	Time Range	*ChargingVoltage()* Degradation	Time Range	*ChargingVoltage()* Degradation
3	***EVLTM TTH3*** ≤ ***Accumulated EVLTM Time*** < ***EVLTM TTH4***	*ChargingVoltage()* - ***EVLTM CV Delta3***	***EVMTM TTH3*** ≤ ***Accumulated EVMTM Time*** < ***EVMTM TTH4***	*ChargingVoltage()* - ***EVMTM CV Delta3***	***EVHTM TTH3*** ≤ ***Accumulated EVHTM Time*** < ***EVHTM TTH4***	*ChargingVoltage()* - ***EVHTM CV Delta3***
4	***EVLTM TTH4*** ≤ ***Accumulated EVLTM Time*** < ***EVLTM TTH5***	*ChargingVoltage()* - ***EVLTM CV Delta4***	***EVMTM TTH4*** ≤ ***Accumulated EVMTM Time*** < ***EVMTM TTH5***	*ChargingVoltage()* - ***EVMTM CV Delta4***	***EVHTM TTH4*** ≤ ***Accumulated EVHTM Time*** < ***EVHTM TTH5***	*ChargingVoltage()* - ***EVHTM CV Delta4***
5	***EVLTM TTH5*** ≤ ***Accumulated EVLTM Time***	*ChargingVoltage()* - ***EVLTM CV Delta5***	***EVMTM TTH5*** ≤ ***Accumulated EVMTM Time***	*ChargingVoltage()* - ***EVMTM CV Delta5***	***EVHTM TTH5*** ≤ ***Accumulated EVHTM Time***	*ChargingVoltage()* - ***EVHTM CV Delta5***

Note

This degradation works in conjunction with other degradation features; therefore, use with care.

13.21 Charge Voltage Compensation for System Impedance

The design of some battery charging systems may have a not insignificant impedance between the charger and battery terminals. In this case a voltage compensation feature handles system level IR drops to ensure the correct charging voltage is supplied at the battery terminals. Program the ***System Resistance*** register with the measured resistance in milliohms (mΩ) between the battery terminals and charger terminals. This feature is enabled by setting the configuration bit ***[COMP_IR]*** in (default 0) the ***Charging Configuration*** register.

This feature works as follows:

SBS.ChargingVoltage = Charging_Voltage + *AverageCurrent()* × ***System Resistance***

where Charging_Voltage has been computed as a result of a selected configuration.

13.22 Cell Swelling Control (via Charging Voltage Degradation)

Cell swelling can occur when the cell temperature and cell voltage are above certain thresholds. In these situations, the charging voltage can be stepped down gradually until the cell temperature moves back down.

This scheme works (as shown in Figure 13-4) when enabled by setting ***[CS_CV]*** (default is cleared) in the ***Charging Configuration*** register. When the cell voltage and cell temperature are above the ***Voltage Threshold*** and ***Temperature Threshold*** , respectively, for the period defined by ***Time Interval*** , then the charging voltage is stepped down by ***Delta Voltage*** . This step down continues until either the cell voltage and cell temperature conditions go away (that is, cell swelling reduces) or the step down reaches ***Min CV*** .

The charging voltage reduction/degradation resulting from this feature is reset when exiting CHARGE mode.

Note

This degradation works in conjunction with other degradation features; therefore, use with care.

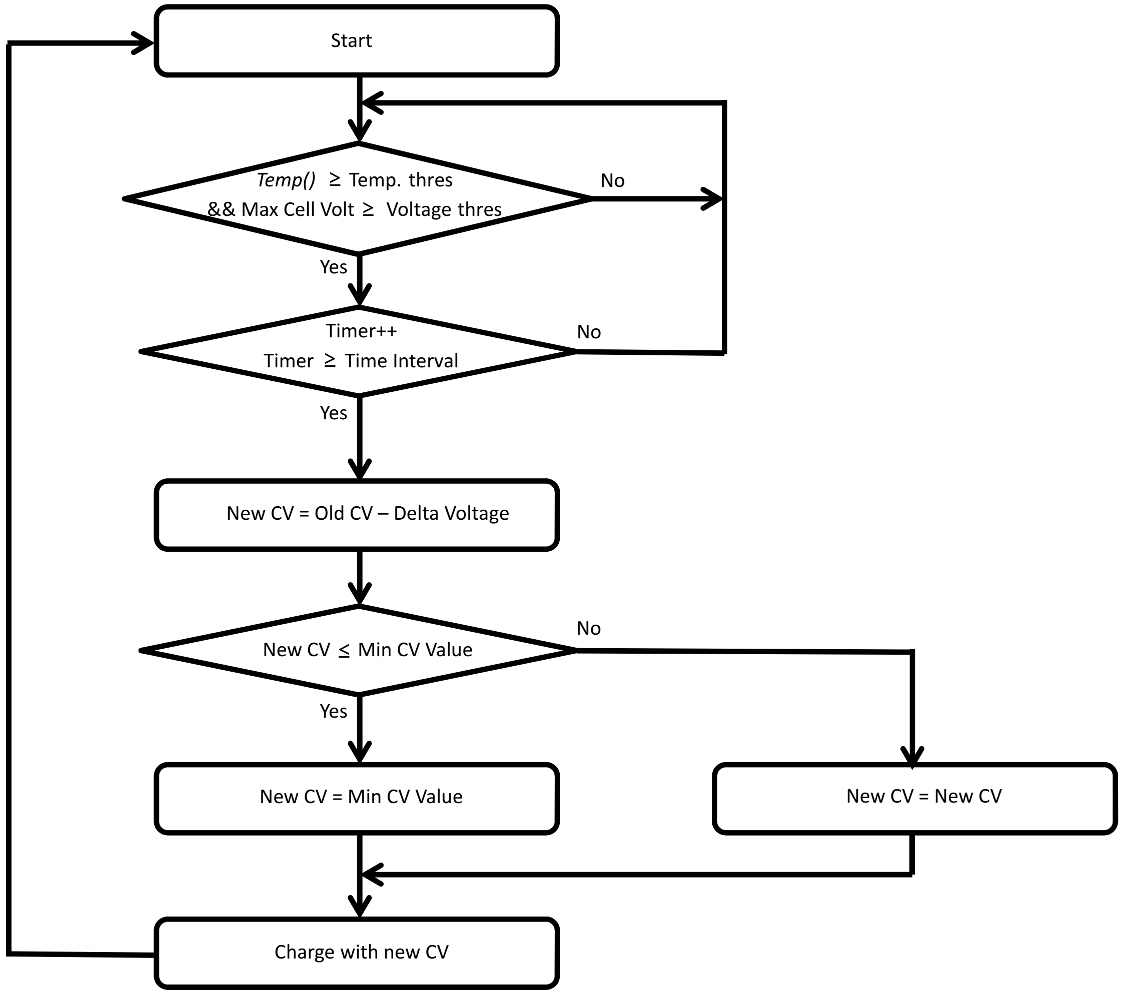


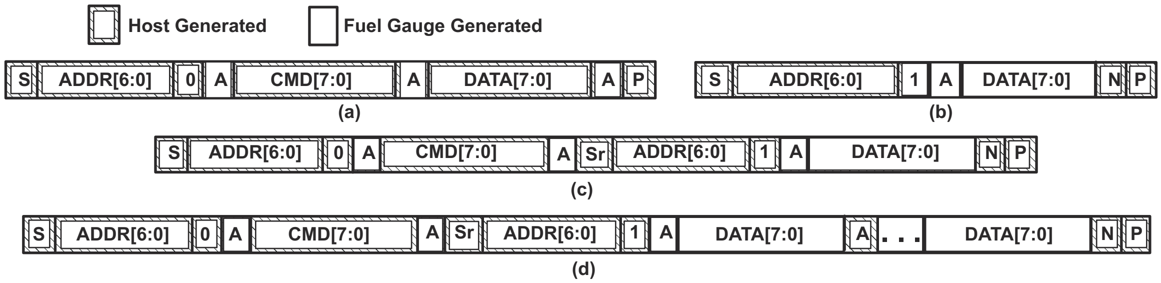
Figure 13-4. Cell Swelling Control

14 Communications

14.1 I²C Interface

The gauge supports the standard I²C read, incremental read, one-byte write, quick read, and functions. The 7-bit device address (ADDR) is the most significant 7 bits of the hex address and defaults to 1010101, or 0x55. The 8-bit device address therefore defaults to 0xAA or 0xAB for write or read, respectively.

The 7-bit device address can be configured by setting ***Alt I2C Address*** to the desired address and ***Alt I2C Addr Chk*** to the 2's complement of ***Alt I2C Address*** . If ***Alt I2C Address*** and ***Alt I2C Addr Chk*** are updated, a reset is required for the gauge to use the new device address. However, the gauge defaults to 0x55 if ***Alt I2C Address*** is 0x00 or 0xFF or ***Alt I2C Addr Chk*** is not set correctly.



a. 1-byte write
b. Quick read
c. 1-byte read
d. Incremental read

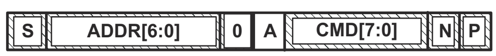
Figure 14-1. Supported I²C Formats

(S = Start, Sr = Repeated Start, A = Acknowledge, N = No Acknowledge, and P = Stop)

The quick read returns data at the address indicated by the address pointer. The address pointer, a register internal to the I²C communication engine, increments when data is acknowledged by the fuel gauge or the I²C master. Quick writes function in the same way and are a convenient means of sending multiple bytes to consecutive command locations (such as two-byte commands that require two bytes of data).

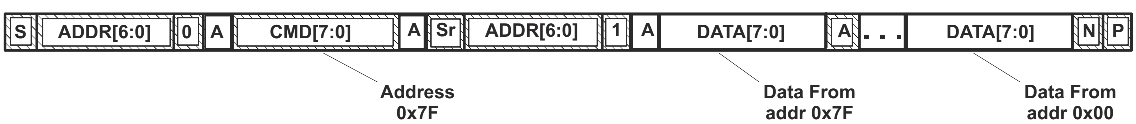
Attempt to write a read-only address (NACK after data sent by master):

Attempt to read an address above 0x7F (NACK command):



Attempt at incremental writes (NACK all extra data bytes sent):

Incremental read at the maximum allowed read address:



14.1.1 I²C Clock Frequency

The gauge supports different maximum clock frequencies for the I²C engine. The desired maximum clock frequency can be configured via ***Settings.Configuration.I2C Configuration*** .

14.1.2 I²C Time Out

The I²C engine releases SDA and SCL if the I²C bus is held low for about two seconds. If the fuel gauge were holding the lines, releasing them frees the master to drive the lines.

14.1.3 I²C Command Waiting Time

To ensure the correct results of a command with the 400-kHz / 1-MHz I²C operation, there must be a proper waiting time between issuing the command and reading the results. For *AltManufacturerAccess()* commands, the following diagram shows the waiting time required between issuing the *AltManufacturerAccess()* command and reading the status. For read-only standard commands, there is no waiting time required, but the host must not issue all standard commands more than two times per second. If thousands of I²C transactions are sent to the gauge in one second, then it could adversely impact the CPU and cause a watchdog reset.

Note

Reference to Datasheet for I2C communication timing details.

Table 14-1. Command Waiting Times

14.1.4 I²C Clock Stretching

I²C clock stretches can occur during all modes of fuel gauge operation. In SLEEP mode, a short clock stretch occurs on all I²C traffic, as the device must wake up to process the packet. In NORMAL and SLEEP modes, clock stretching only occurs for packets addressed for the fuel gauge. The timing of stretches varies as interactions between the communicating host and the gauge are asynchronous. The I²C clock stretches may occur after start bits, the ACK/NACK bit, and first data bit transmit on a host read cycle. The majority of clock stretch periods are small (≤ 4 ms), as the I²C interface peripheral and CPU firmware perform normal data flow control. However, less frequent but more significant clock stretch periods may occur when data flash is written by the CPU to update the Ra tables and other data flash parameters, such as QMax. Due to the organization of data flash, updates need to be written in data blocks consisting of multiple data bytes.

For example, an Ra table update requires erasing a single page of data flash and programming the updated Ra table. The potential I²C clock stretching time is 40.08 ms maximum. This includes a 40-ms page erase and 40-µs row programming time (×2 rows). The Ra table updates occur during the discharge cycle and at up to 15 resistance grid points that occur during the discharge cycle.

15 Calibration

Note

All calibration steps that require accessing data on *MACData()* must begin read operations starting at *AltManufacturerAccess()* to ensure the data portion of the block is properly refreshed per the intended *AltManufacturerAccess()* subcommand (in this case 0xF081). The first two bytes returned are the *AltManufacturerAccess()* subcommand followed by the counter, status, and raw ADC values, as shown in *AltManufacturerAccess() Descriptions*.

Note

The new calibration process is outlined in the release notes. This method does not require the host to calculate the calibration constants and send them to the device, the constants are automatically calculated and stored by the device upon command.

15.1 Voltage Calibration

15.1.1 Cell (BAT) Voltage Calibration

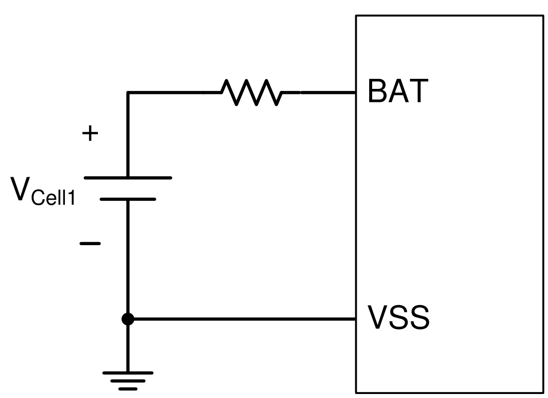
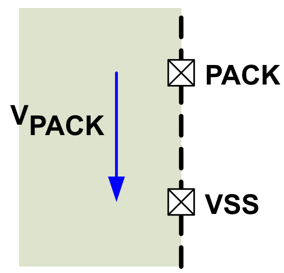


Figure 15-1. Cell Voltage Calibration

1. Apply known voltage in mV to the cell voltage inputs:
   - V_{CELL1} between BAT terminal and VSS terminal
2. If *ManufacturingStatus()[CAL_EN]* = 0, send 0x002D to *AltManufacturerAccess()* to enable the *[CAL_EN]* flag.
3. Send 0xF081 to enable OpStat[CALACT]. OpStat[CALACT] ensures the device does not go to SLEEP during calibration.
4. Write applied cell voltage in step-1 to ***ManufacturerAccess() 0x0341 Cell Voltage***
   a. Send the command in this format: **[Device_Address + Start Address + Length + CAL_COMMAND + applied cell voltage]**
5. Recheck the cell voltage reading and if it is not accurate, repeat Step4.
6. Send 0x002D to *AltManufacturerAccess()* to clear the *[CAL_EN]* flag if all calibration is complete.

15.1.2 Pack (PACK) Voltage Calibration



1. Apply known voltages in mV to the voltage input:
   - V_{PACK} between PACK terminal and VSS terminal
2. If *ManufacturerStatus()[CAL_EN]* = 0, send 0x002D to *AltManufacturerAccess()* to enable the *[CAL_EN]* flag.
3. Send 0xF081 to enable OpStat[CALACT]. OpStat[CALACT] ensures the device does not go to SLEEP during calibration.
4. Write applied pack voltage in step-1 to ***ManufacturerAccess() 0x0342 Pack Voltage***
   a. Send the command in this format: **[Device_Address + Start Address + Length + CAL_COMMAND + applied pack voltage]**
5. Recheck pack voltage reading and if they are not accurate, repeat Step 4.
6. Send 0x002D to *AltManufacturerAccess()* to clear the *[CAL_EN]* flag if all calibration is complete.

15.1.3 Voltage Calibration Data Flash

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Calibration	Voltage	Cell Gain	I2	–32768	32767	12101[(1)]	—	BAT – VSS gain
Calibration	Voltage	Pack Gain	U2	0	65536	24835[(1)]	—	Pack – VSS gain

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

15.2 Current Calibration

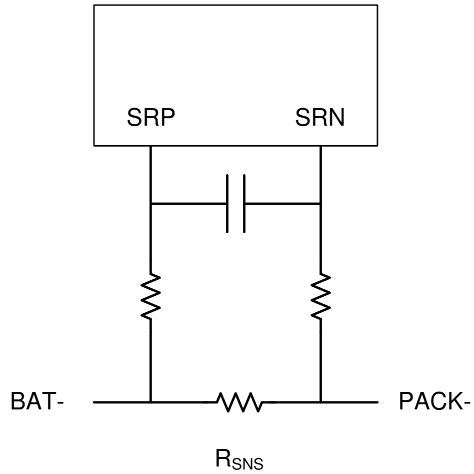


Figure 15-2. Current Calibration (Charge Current Flow Is BAT– to PACK–)

Note

CC offset and board offset are no longer calibrations required by the device due to hardware improvements.

15.2.1 CC Gain/Capacity Gain Calibration

1. Apply a known current (typically 1 A to 2 A), and ensure I_{CC} is flowing through the sense resistor connected between the SRP and SRN pins.
2. If *ManufacturingStatus()[CAL_EN]* = 0, send 0x002D to *AltManufacturerAccess()* to enable the *[CAL_EN]* flag.
3. Send 0xF081 to *AltManufacturerAccess()* to enable raw CC output on *MACData()*.
4. Write applied known current in step-1 to ***ManufacturerAccess() 0x0343 Pack Current***
   a. Send the command in this format: **[Device_Address + Start Address + Length + CAL_COMMAND + applied current]**
5. Recheck the current reading. If the reading is not accurate, repeat the step 4.
6. Send 0x002D to *AltManufacturerAccess()* to clear the *[CAL_EN]* flag if all calibration is complete.

15.2.2 Deadbands

The gauge can be configured to ignore current and coulomb measurements below individually programmable levels.

15.2.2.1 Current Deadband

When current measures to a value less than the value programmed in ***Deadband*** , *Current()* will report 0. This has no effect on the coulomb counting for the gas gauging functionality. The value of ***Deadband*** should be selected based on the characterization of the battery electronics design combined with the environment in which the battery will be used. If the PCB senses noise causing a real no-current condition to report a non-zero value, then ***Deadband*** could be adjusted accordingly.

15.2.2.2 Coulomb Counter Deadband

During normal operation, there could be noise generated in the battery electronics environment that could cause the gauge to accumulate incorrectly (positively or negatively). To filter out this noise, the ***Coulomb Counter Deadband*** setting is used. Any input below this threshold is not accumulated.

15.2.3 Current Calibration Data Flash

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Calibration	Current	CC Gain	I	1.00E–001	4.00E+000	3.68	—	Coulomb Counter Gain
Calibration	Current	Calibration Current Period	I	0x08	0x40	08	hex	This is the period of time (in seconds) that the battery current is sampled to calculate the battery's capacity. The period is determined by the hex value of this field. For example, if the value is set to 0x08, the battery current is sampled every 8 seconds.
Calibration	Current Offset	CC Offset	I	-32767	32767	0	—	CC offset is the offset to be added to the calculated coulomb counter value to get the accurate value. It is typically used to account for the internal battery voltage differences.
Calibration	Current Offset	Coulomb Counter Offset Samples	U	0	65535	64	—	CC_OffsetSamples is a number of samples that are used to calculate the average Coulomb Counter offset. The offset is used to correct the Coulomb Counter measurement. The offset is calculated as the average of a number of samples. The number of samples is specified by the CC_OffsetSamples variable.
Calibration	Current Offset	Board Offset	I	-32768	32767	0	—	The Board Offset is used to compensate for the voltage measured by the board. It is typically used to account for the voltage drop across the board's components.
Calibration	Current Offset	VG CC Offset	I	-32768	32767	0	—	The device will compute this value automatically upon first device POR. Leave as 0 in your golden image.
Calibration	Current Offset	VG CC Offset	I	-32768	32767	0	—	The device will compute this value automatically upon first device POR. Leave as 0 in your golden image.
Calibration	Current Deadband	Deadband	U1	0	255	3	mA	Cell-based deadband to report 0 mA
Calibration	Current Deadband	Coulomb Counter Deadband	U1	0	255	9	116 nV	Coulomb counter deadband to report 0 charge (This setting should not be modified.)

15.3 Temperature Calibration

Note

For temperature calibration, only an offset is determined and then applied to the gauge's measured temperatures.

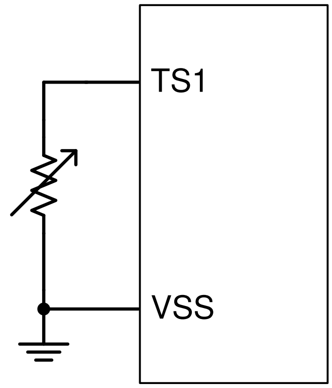


Figure 15-3. Temperature Calibration

15.3.1 TS Calibration

1. Apply a known temperature in 0.1°C, and ensure the temperature $TEMP_{TS}$ is applied to the thermistor connected to the TS terminal.
2. If *ManufacturingStatus()[CAL_EN]* = 0, send 0x002D to *AltManufacturerAccess()* to enable the *[CAL_EN]* flag.
3. Send 0xF081 to *AltManufacturerAccess()* to enable raw CC output on *MACData()*.
4. Write applied known temperature in step-1 to ***ManufacturerAccess() 0x0344 Temperature***
   a. Send the command in this format: **[Device_Address + Start Address + Length + CAL_COMMAND + applied temperature]**
5. Recheck the *DAStatus2()* reading. If the reading is not accurate, repeat the step 4.

15.3.2 Temperature Calibration Data Flash

It is not necessary to adjust these offsets. These offsets can be used to improve temperature accuracy at temperatures away from the calibration temperature of the models below; however, they can reduce accuracy across the range of temperatures.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Calibration	Temperature	Internal Temp Offset	I	-32768	32767	0	0.1 °C	Internal temperature sensor reading offset
Calibration	Temperature	External1 Temp Offset	I	-32768	32767	0	0.1 °C	TS pin temperature sensor reading offset
Calibration	Internal Temp Model	Int Gain	I	-32768	32767	-20189	-	Int Gain is a scaling factor used to convert the raw count value from the internal temperature sensor to a voltage. It is typically a fixed value provided by the sensor manufacturer.
Calibration	Internal Temp Model	Int base offset	I	-32768	32767	6142	-	This is the DC offset of the voltage measured across the internal temperature sensor.
Calibration	Internal Temp Model	Int Minimum AD	I	-32768	32767	0	-	The minimum voltage the internal temperature sensor can measure. This is used to prevent the internal temperature calculation from going below zero.
Calibration	Internal Temp Model	Int Maximum Temp	I	-32768	32767	5754	0.1 K	Int MaxTemp is the maximum temperature (in Kelvin) at which the internal temperature sensor is guaranteed to be accurate. It is used to calculate the temperature offset for the internal temperature sensor.

15.3.3 Cell Temp Model

The parameters in the following table are used for the Semitec 103AT-2 thermistor; default for the TS pin. These parameters will only need to be updated if a different thermistor is used. See the application report to calculate coefficients for other thermistors.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Calibration	Cell Temp Model	Coefficient a1	I2	–32768	32767	–17447	—	Cell Temperature calculation polynomial a1
Calibration	Cell Temp Model	Coefficient a2	I2	–32768	32767	29332	—	Cell Temperature calculation polynomial a2
Calibration	Cell Temp Model	Coefficient a3	I2	–32768	32767	–25430	—	Cell Temperature calculation polynomial a3

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Calibration	Cell Temp Model	Coefficient a4	I2	–32768	32767	29836	—	Cell Temperature calculation polynomial a4
Calibration	Cell Temp Model	Coefficient a5	I2	–32768	32767	1200	—	Cell Temperature calculation polynomial a5
Calibration	Cell Temp Model	Coefficient b1	I2	–32768	32767	–293	—	Cell Temperature calculation polynomial b1
Calibration	Cell Temp Model	Coefficient b2	I2	–32768	32767	552	—	Cell Temperature calculation polynomial b2
Calibration	Cell Temp Model	Coefficient b3	I2	–32768	32767	–2887	—	Cell Temperature calculation polynomial b3
Calibration	Cell Temp Model	Coefficient b4	I2	–32768	32767	4591	—	Cell Temperature calculation polynomial b4
Calibration	Cell Temp Model	Rc0	I2	–32768	32767	11703	—	Resistance at 25°C
Calibration	Cell Temp Model	Adc0	I2	–32768	32767	11703	—	ADC reading at 25°C
Calibration	Cell Temp Model	Rpad	I2	–32768	32767	1(1)	Ω	Pad Resistance (0 to use factory calibration)
Calibration	Cell Temp Model	Rint	I2	–32768	32767	18000(1)	Ω	Pullup resistor resistance (0 to use factory calibration)

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

15.3.4 Internal Temp Model

Values in this table should not be modified, as the voltage-based sensor in the device was factory trimmed for these model parameters.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Calibration	Internal Temp Model	Int Gain	I2	–32768	32767	–13908	—	Internal temperature gain
Calibration	Internal Temp Model	Int Base Offset	I2	–32768	32767	6959	—	Internal temperature base offset
Calibration	Internal Temp Model	Int Minimum AD	I2	–32768	32767	0	—	Minimum AD count used for calculation
Calibration	Internal Temp Model	Int Maximum Temp	I2	–32768	32767	6959	0.1 K	Maximum Temperature boundary

16 Data Commands

16.1 Standard Data Commands

The device uses a series of 2-byte standard commands to enable system reading and writing of battery information. Each standard command has an associated command code pair, as indicated in Table 16-1, *Standard Commands*. The LSB of the command code corresponds to the LSB register data. The LSB should be read first to keep the register data synchronized. For some host systems, the host should change the byte order so that the order corresponds to the host's native endianness. The I^2C protocol has methods to access the data for each command code. The gauge updates and/or reads the standard command registers once per second.

Table 16-1. Standard Commands

Name		Register Code (LSB/MSB)	Description
ManufacturerAccess/ControlStatus()	CNTL	0x00/0x01	Control Register (See Section 16.1.1.)
AtRate()	AR	0x02/0x03	Read/write. The value is a signed integer with the negative value indicating a discharge current value. The default value is 0 and forces *AtRateTimeToEmpty()* to return 65,535.
AtRateTimeToEmpty()	ARTTE	0x04/0x05	This read-only function returns an unsigned integer value to predict remaining operating time based on battery discharge at the *AtRate()* value in minutes with a range of 0 to 65,534. A value of 65,535 indicates *AtRate()* = 0. The gas gauge updates the *AtRateTimeToEmpty()* within 1 s after the system sets the *AtRate()* value. The gas gauge updates these parameters every 1 s. The commands are used in NORMAL mode.
Temperature()	TEMP	0x06/0x07	This read-only function returns an unsigned integer value of temperature measured by the gas gauge and is used for the gauging algorithm. Values are reported in units 0.1 K. It reports either internal temperature or external thermistor temperature, depending on the setting of the ***[TS]*** and ***[TSInt]*** bits in ***Temperature Enable*** .
Voltage()	VOLT	0x08/0x09	This read-only function returns an unsigned integer value of the measured cell pack in mV with a range of 0 to 6000 mV.
BatteryStatus()	FLAGS	0x0A/0x0B	This read-only function returns various battery status information.
Current()	INSTCURR	0x0C/0x0D	This read-only function returns a signed integer value that is the instantaneous current flow through the sense resistor. The value is updated every 1 s. Units are mA.
RemainingCapacity()	RM	0x10/0x11	This read-only command returns the predicted remaining capacity, based on rate (per configured ***Load Select***), temperature, present depth-of-discharge, and stored impedance. Values are reported in mAh.
FullChargeCapacity()	FCC	0x12/0x13	This read-only command returns the predicted capacity of the battery at full charge, based on rate (per configured ***Load Select***), temperature, present depth-of-discharge, and stored impedance. Values are reported in mAh.
AverageCurrent()	AI	0x14/0x15	This read-only function returns a signed integer value that is the average current flow through the sense resistor. The value is updated every 1 s. Units are mA.
AverageTimeToEmpty()	TTE	0x16/0x17	Uses average current value with a time constant of 15 s for this method. A value of 65,535 means the battery is not being discharged.

Table 16-1. Standard Commands (continued)

Name		Register Code (LSB/MSB)	Description
AverageTimeToFull()	TTF	0x18/0x19	This read-only function returns a unsigned integer value, predicting time to reach full charge for the battery in units of minutes based on *AverageCurrent()*. The computation accounts for the taper current time extension from a linear TTF computation based on a fixed *AverageCurrent()* rate of charge accumulation. A value of 65,535 indicates the battery is not being charged.
MaxLoadCurrent()	MLI	0x1E/0x1F	This read-only function returns a signed integer value in units of mA of the maximum load current. The *MaxLoadCurrent()* is an adaptive measurement which is initially reported as the maximum load current programmed in ***Max Load Current*** . If the measured current is ever greater than ***Max Load Current*** , then the *MaxLoadCurrent()* updates to the new current. *MaxLoadCurrent()* is reduced to the average of the previous value and ***Max Load Current*** whenever the battery is charged to full after a previous discharge to an RSOC of less than ***Max Load Rsoc*** . This will prevent the reported value from maintaining an unusually high value.
MaxLoadTimeToEmpty()	MLTTE	0x20/0x21	This read-only function returns a unsigned integer value, predicting remaining battery life at the maximum discharge load current rate in units of minutes. A value of 65,535 indicates that the battery is not being discharged.
AveragePower()	AP	0x22/0x23	This read-only function returns a signed integer value of average power during battery charging and discharging. It is negative during discharge and positive during charge. A value of 0 indicates that the battery is not being discharged. The value is reported in units of mW.
BTPDischargeSet()	BTP	0x24/0x25	This read-/write-word command updates the BTP set threshold for DISCHARGE mode for the next BTP interrupt, deasserts the present BTP interrupt, and clears the *OperationStatus()[BTP_INT]* bit.
BTPChargeSet()	BTP	0x26/0x27	The read-/write-word command updates the BTP set threshold for CHARGE mode for the next BTP interrupt, deasserts the present BTP interrupt, and clears the *OperationStatus()[BTP_INT]* bit.
InternalTemperature()	INT_TEMP	0x28/0x29	This read-only function returns an unsigned integer value of the measured internal temperature of the device in 0.1 K units measured by the gas gauge.
CycleCount()	CC	0x2A/0x2B	This read-only function returns an unsigned integer value of the number of cycles the battery has experienced a discharge (range 0 to 65,535). One cycle occurs when accumulated discharge greater than or equal to the cycle count threshold.
RelativeStateOfCharge()	RSOC	0x2C/0x2D	This read-only function returns an unsigned integer value of the predicted remaining battery capacity expressed as percentage of *FullChargeCapacity()* with a range of 0% to 100%.
StateOfHealth()	SOH	0x2E/0x2F	This read-only function returns an unsigned integer value of the battery state-of-health expressed as a percentage of the ratio of predicted FCC (simulated with ***SOH Load Rate*** at 25°C) over the *DesignCapacity()*. The range is 0% to 100%.
ChargingVoltage()	CV	0x30/0x31	Returns the desired charging voltage in mV to the charger
ChargingCurrent()	CC	0x32/0x33	Returns the desired charging current in mA to the charger
TerminateVoltage()		0x34/0x35	Returns or updates the value of ***Terminate Voltage***
TimeStampUpper()		0x36/0x37	Returns or updates the upper 16 bits of the time stamp in seconds
TimeStampLower()		0x38/0x39	Returns or updates the lower 16 bits of the time stamp in seconds
QmaxCycles()		0x3A/0x3B	Returns cycle count at the last QMax update
DesignCapacity()		0x3C/0x3D	In SEALED and UNSEALED access: This command returns the value stored in ***Design Capacity mAh*** . This is intended to be a theoretical or nominal capacity of a new pack, but should have no bearing on the operation of the gas gauge functionality.
AltManufacturerAccess()		0x3E/0x3F	MAC data block command
MACData()		0x40/0x5F	MAC data block
MACDataSum()		0x60	MAC data block checksum
MACDataLen()		0x61	MAC data block length
VoltHiSetThreshold()		0x62/0x63	This read/write function is a signed integer in units of mV for the high voltage level threshold, which sets *InterruptStatus()[VOLT_HI]*.
VoltHiClearThreshold()		0x64/0x65	This read/write function is a signed integer in units of mV for the high voltage level threshold, which clears *InterruptStatus()[VOLT_HI]*.
VoltLoSetThreshold()		0x66/0x67	This read/write function is a signed integer in units of mV for the low voltage level threshold, which sets *InterruptStatus()[VOLT_LO]*.
VoltLoClearThreshold()		0x68/0x69	This read/write function is a signed integer in units of mV for the low voltage level threshold, which clears *InterruptStatus()[VOLT_LO]*.
TempHiSetThreshold()		0x6A	This read/write function is a signed integer in units of °C for the high temperature level threshold, which sets *InterruptStatus()[TEMP_HI]*.
TempHiClearThreshold()		0x6B	This read/write function is a signed integer in units of °C for the high temperature level threshold, which clears *InterruptStatus()[TEMP_HI]*.
TempLoSetThreshold()		0x6C	This read/write function is a signed integer in units of °C for the low temperature level threshold, which sets *InterruptStatus()[TEMP_LO]*.
TempLoClearThreshold()		0x6D	This read/write function is a signed integer in units of °C for the low temperature level threshold, which clears *InterruptStatus()[TEMP_LO]*.
InterruptStatus()		0x6E	This read-only function returns the status of the interrupt including cause of interrupt.
SOCDeltaSetThreshold()		0x6F	This read/write function is an unsigned char in units of % for the SOC delta level threshold, which clears *InterruptStatus()SOC_DELTA*.

16.1.1 0x00/01 ManufacturerAccess()/ControlStatus()

This read/write word function returns the control bits when read and is an interface to the manufacturer access system (MAC) when written. This command is provided for backward compatibility/ease of use, as all of the control bits except *ControlStatus()[CheckSumValid]* are available in *OperationStatusA()* and *OperationStatusB()* in addition to *AltManufacturerAccess()* being the recommended interface for MAC (as discussed in *0x00, 0x01 ManufacturerAccess() and 0x3E, 0x3F AltManufacturerAccess()*).

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	FAS	SS	RSVD	RSVD	RSVD	Check Sum Valid	RSVD	RSVD	RSVD	RSVD	RSVD	LDMD	RDIS	VOK	QEN

RSVD (Bit 15): Reserved

FAS, SS (Bits 14–13): Legacy SECURITY mode

0, 0 = Full Access

0, 1 = Reserved

1, 0 = Unsealed

1, 1 = Sealed

RSVD (Bit 12): Reserved

RSVD (Bits 11–10): Reserved

CheckSumValid (Bit 9): Checksum valid

1 = Flash Writes are enabled.

0 = Flash Writes are disabled due to low voltage or PF condition.

RSVD (Bits 8–4): Reserved

LDMD (Bit 3): LOAD mode

1 = Constant power

0 = Constant current

RDIS (Bit 2): Resistance updates

1 = Disabled

0 = Enabled

VOK (Bit 1): Voltage OK for QMax update

1 = Detected

0 = Not detected

QEN (Bit 0): Dynamic Z-Track Gauging (Ra and QMax updates are enabled.)

16.1.2 0x02/03 AtRate()

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

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Default	Unit
		SE	US	FA						
0x02/03	*AtRate()*	R/W			Word	I2	–32768	32767	0	mA

16.1.3 0x04/05 AtRateTimeToEmpty()

This read-word function returns the remaining time to fully discharge the battery based on *AtRate()*.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x04/05	*AtRateTimeToEmpty()*	R			Word	U2	0	65535	min	65535 indicates not being charged

16.1.4 0x06/07 Temperature()

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

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x06/07	*Temperature()*	R			Word	I2	0	32767	0.1 K

16.1.5 0x08/09 Voltage()

This read-word function returns the measured cell voltage.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x08/09	*Voltage()*	R			Word	I2	0	32767	mV

16.1.6 0x0A/0B BatteryStatus()

This read-word function returns various battery status information.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	TCA	RSVD	RSVD	TDA	RSVD	RCA	RSVD	INIT	DSG	FC	FD	RSVD	RSVD	RSVD	RSVD

RSVD (Bit 15): Reserved

TCA (Bit 14): Terminate Charge Alarm

0 = Inactive

1 = Active

RSVD (Bits 13–12): Reserved

TDA (Bit 11): Terminate Discharge Alarm

0 = Inactive

1 = Active

RSVD (Bit 10): Reserved

RCA (Bit 9): Remaining Capacity Alarm

0 = Inactive

1 = Active

RSVD (Bit 8): Reserved

INIT (Bit 7): Initialization

0 = Complete

1 = Active

DSG (Bit 6): Discharging

0 = The battery is charging.

1 = The battery is discharging.

FC (Bit 5): Fully Charged

0 = The battery is not fully charged.

1 = The battery is fully charged.

FD (Bit 4): Fully Discharged

0 = The battery is okay.

1 = The battery is fully depleted.

RSVD (Bits 3–0): Reserved

16.1.7 0x0C/0D Current()

This read-word function returns the measured current from the coulomb counter.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x0C/0D	*Current()*	R			Word	I2	–32768	32767	mA

16.1.8 0x10/11 RemainingCapacity()

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

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x10/11	*RemainingCapacity()*	R			Word	U2	0	32767	mAh

16.1.9 0x12/13 FullChargeCapacity()

This read-word function returns the predicted battery capacity when fully charged.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x12/13	*FullChargeCapacity()*	R			Word	I2	0	32767	mAh

16.1.10 0x14/15 AverageCurrent()

This read-word function provides the filtered/average current.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x14/15	*AverageCurrent()*	R			Word	I2	–32767	32768	mA

16.1.11 0x16/17 AverageTimeToEmpty()

This read-word function returns the predicted remaining time to fully discharge the battery based on *AverageCurrent()*.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x16/17	*AverageTimeToEmpty()*	R			Word	U2	0	65535	min	65535 = The battery is not being discharged.

16.1.12 0x18/19 AverageTimeToFull()

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

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x18/19	*AverageTimeToFulll()*	R			Word	U2	0	65535	min	

16.1.13 0x20/21 MaxLoadTimeToEmpty()

This read-word function returns the remaining time to fully discharge the battery based on *MaxLoadCurrent()*.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x20/21	*MaxLoadTimeToEmpty()*	R			Word	I2	0	65535	min

16.1.14 0x22/23 AveragePower()

This read-word function returns the average power [*Voltage()* × *AverageCurrent()*] during battery charging or discharging. It is negative due to discharge and positive due to charge. A 0 value indicates the battery is not being discharged.

I²C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit
		SE	US	FA					
0x22/23	*AveragePower()*	R			Word	I2	–32768	32767	mW

16.1.15 0x28/29 InternalTemperature()

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

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x28/29	*InternalTemperature()*	R			Word	I2	0	32767	0.1 K

16.1.16 0x2A/2B CycleCount()

This read-word function returns the number of discharge cycles the battery has experienced.

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x2A/2B	*CycleCount()*	R	R		Word	U2	0	65535	cycles

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	Cycle	Cycle Count Percentage	U1	0	100	90	%	Percentage of *DesignCapacity()* or *FullChargeCapacity()* (determined by ***IT Gauging Configuration[CCT]***) to be used for the cycle count threshold
Gas Gauging	State	Cycle Count	U2	0	65535	0	—	Value reported by *CycleCount()*. Updated by the gauge automatically based on ***Cycle Count Percentage***
Gas Gauging	State	QMax Cycle Count	U2	0	65535	0	—	The *CycleCount()* when QMax last updated

16.1.17 0x2C/2D RelativeStateOfCharge()—RSOC

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

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x2C/2D	*RelativeStateOfCharge()*	R			Word	U1	0	100	%

16.1.18 0x2E/2F StateOfHealth()

This command returns the state-of-health (SOH) information of the battery in percentage of ***Design Capacity mAh*** . It is a read-only command.

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Unit
		SE	US	FA					
0x2E/2F	*StateOfHealth()*	R			Word	U1	0	100	%

16.1.19 0x30/31 ChargingVoltage()

This read-word function returns the desired charging voltage.

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x30/31	*ChargingVoltage()*	R	R	R	Word	I2	0	32767	mV	32767 = Request maximum voltage

16.1.20 0x32/33 ChargingCurrent()

This read-word function returns the desired charging current.

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x32/33	*ChargingCurrent()*	R	R	R	Word	I2	0	32767	mA	32767 = Request maximum current

16.1.21 0x34/35 TerminateVoltage()

This reads or writes the voltage level at which the state-of-charge goes to 0. See ***Term Voltage*** in *Dynamic Z-Track Configuration*.

I2C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x34/35	*TerminateVoltage()*	RW	RW	RW	Word	I2	0	32767	mV	

16.1.22 0x36/0x37/0x38/0x39 Timestamp()

This 4-byte value, which is the system runtime in seconds, can be read or written. Always begin the read operation at 0x36 (the LSB) to keep the bytes synchronized during the read by copying the gauge clock to the time stamp registers. The host should read bytes into its 32-byte unsigned integer format in the appropriate endianness. When written by the host, the gauge will update its internal clock on the write to register 0x39.

I2C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x36/37	*TimeStampUpper()*	R	RW	RW	Word	U2	0	65535	s	

I2C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x38/39	*TimeStampLower()*	R	RW	RW	Word	U2	0	65535	s	

16.1.23 QMax Cycles() 0x3A/3B

This returns the cycle count when QMax was last updated. It is helpful for a host system to compare this to the present *CycleCount()*.

I2C Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x3A/3B	*QmaxCycles()*	R	R	R	Word	U2	0	65535	—	

16.1.24 0x3C/3D DesignCapacity()

This read-word function returns the theoretical or nominal maximum pack capacity.

I2C Cmd	Name	Access			Proto-col	Type	Min	Max	Default	Unit
		SE	US	FA						
0x3C/3D	*DesignCapacity()*	R	R/W	R/W	Word	I2	0	32767	5300	mAh
									2040	cWh

16.1.25 0x3E/3F AltManufacturerAccess()

Writes to this command are interchangeable with *AltManufacturerAccess()*. This command is provided to enable an easy way to verify the active MAC command while reading the *MACData()* returned by the MAC. The host may simply read from *AltManufacturerAccess()* to *MACDataLength()* with one block read. For a description of returned data values, see the *AltManufacturerAccess()* version of same command in *0x00, 0x01 ManufacturerAccess() and 0x3E, 0x3F AltManufacturerAccess()*.

I2C Cmd	Name	Access			Proto-col	Type	Min	Max	Default	Unit
		SE	US	FA						
0x3E/3F	*AltManufacturerAccess()*	R	R	R	Word	—	—	—	—	—

16.1.26 0x40/0x5F MACData()

This is the data block for *AltManufacturerAccess()* or *AltManufacturerAccess()* commands.

I2C Cmd	Name	Access			Proto-col	Type	Min	Max	Default	Unit
		SE	US	FA						
0x40/5F	*MACData ()*	R	R	R	Block	—	—	—	—	—

16.1.27 0x60 MACDataChecksum()

This is the checksum of the *AltManufacturerAccess()* and *MACData()* bytes.

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x60	*MACDataChecksum()*	R	R	R	Byte	—	—	—	—	—

The checksum is the 8-bit sum of the MSB and LSB of the command + the (command length) bytes in the buffer. The final sum is the bitwise inversion of the result. Because the length is part of the checksum, the verification cannot take place until the length is written. The checksum and length must be written together as a word to be valid.

16.1.28 0x61 MACDataLength()

This is the length for *AltManufacturerAccess()* and *MACData()*.

I²C Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x61	*MACDataLength()*	R	R	R	Byte	—	—	—	—	—

The length byte for all MAC commands includes the 2-byte command, the 1-byte checksum, the 1-byte length, and 1 to 32 bytes of data. This means the minimum length value is 5 for a valid block (no length or checksum is used for command only writes, so a block of 0 size is not necessary). For proper write command validation, the checksum and length must be written in order (word access triggered).

16.2 0x00, 0x01 ManufacturerAccess() and 0x3E, 0x3F AltManufacturerAccess()

AltManufacturerAccess() provides a method of reading and writing data in the Manufacturer Access System (MAC). The MAC command is sent via *AltManufacturerAccess()* by a block protocol. The result is returned on *AltManufacturerAccess()* via a block read.

Commands are sent by writing to registers 0x00/0x01 or 0x3E/0x3F. 0x3E and 0x3F work the same as 0x00 and 0x01, but are primarily intended for block writes and reads.

Example: Send a MAC *Gauging()* to enable IT via *AltManufacturerAccess().*

1. With Impedance Track disabled, send *Gauging()* (0x0021) to *AltManufacturerAccess()*
   a. Command Write, start address = 0x3E (or 0x00). Data = 21 00 (data must be sent in little endian).
2. IT is enabled, *ManufacturingStatus()[GAUGE_EN]* = 1.

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

1. Send *Chemical ID()* to *AltManufacturerAccess().*
   a. Command Write, start address = 0x3E (or 0x00). Data sent = 06 00 (data must be sent in little endian).
2. Read the result from *AltManufacturerAccess()* and *MACData()*.
   a. Command Read, start address = 0x3E length = 36 bytes. The first 4 bytes of the response will be 06 00 10 12.
   b. The first two bytes "06 00" is the MAC command (for verification).
   c. The second two bytes "10 12" are the Chem ID in little endian. That is, 0x1210 for ChemID 1210.
   d. The last two bytes of the 36-byte block will be the checksum and length. The length in this case will be 6. The checksum is 0xFF – (sum of the first length – 2 bytes). The length and checksum are used to validate the block response.

It is recommended to send “command only” operations to 0x00 and 0x01, and to set the command for a read back in the same way. The reason for this is that it can always reset any legacy support options that may be in effect; whereas, some legacy support options use 0x3E and 0x3F for other purposes. However, 0x3E and 0x3F can always safely be used for block reads. For backward compatibility, a request of the device number or version reports a value for a read on 0x00/0x01. The response word for the MAC commands DEV and VERSION

(0x0001 and 0x0002) should report 0xFFA5 as the legacy response. This is meant as a token to indicate to the host that the real response is on the extended block. “Command only” operations take place immediately after the word write.

Table 16-2. 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	Instruction Flash Signature	R	Block	Yes	—	Yes	Hex	—
0x0005	StaticDFSignature	R	Block	Yes	—	Yes	Hex	—
0x0006	Chemical ID	R	Block	Yes	—	Yes	Hex	—
0x0008	StaticChemDFSignature	R	Block	Yes	—	Yes	Hex	—
0x0009	AllDFSignature	R	Block	Yes	—	Yes	Hex	—
0x000A	StorageMode	W	—	—	—	Yes	Hex	—
0x0010	ShutdownMode	W	—	—	—	Yes	Hex	—
0x0011	SleepMode	W	—	—	—	—	Hex	—
0x001D	FuseToggle	W	—	—	—	—	Hex	—
0x001F	CHGFETToggle	W	—	—	—	—	Hex	—
0x0020	DSGFETToggle	W	—	—	—	—	Hex	—
0x0021	Gauging	W	—	—	—	—	Hex	—
0x0022	FETControl	W	—	—	—	—	Hex	—
0x0023	LifetimeDataCollection	W	—	—	—	—	Hex	—
0x0024	PermanentFailure	W	—	—	—	—	Hex	—
0x0025	BlackBoxRecorder	W	—	—	—	—	Hex	—
0x0028	LifetimeDataReset	W	—	—	—	—	Hex	—
0x0029	PermanentFailData Reset	W	—	—	—	—	Hex	—
0x002A	BlackBoxRecorderReset	W	—	—	—	—	Hex	—
0x002D	CalibrationMode	W	—	—	—	—	Hex	—
0x002E	LifetimeDataFlush	W	—	—	—	—	Hex	—
0x002F	LifetimeDataSpeedUp Mode	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	—
0x005A	NoLoadRemCap	R	Block	Yes	—	Yes	Mixed	Mixed
0x005E	ChargingStatusEXT	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
0x0063	LifetimeDataBlock4	R	Block	Yes	—	Yes	Mixed	Mixed
0x0064	LifetimeDataBlock5	R	Block	Yes	—	Yes	Mixed	Mixed

Table 16-2. ManufacturerAccess() Command List (continued)

Command	Function	Access	Format	Data Read on 0x44 or 0x23	Data Read on 0x2F	Available in SEALED Mode	Type	Unit
0x0065	LifetimeDataBlock6	R	Block	Yes	—	Yes	Mixed	Mixed
0x0066	LifetimeDataBlock7	R	Block	Yes	—	Yes	Mixed	Mixed
0x0067	LifetimeDataBlock8	R	Block	Yes	—	Yes	Mixed	Mixed
0x0068	LifetimeDataBlock9	R	Block	Yes	—	Yes	Mixed	Mixed
0x0069	LifetimeDataBlock10	R	Block	Yes	—	Yes	Mixed	Mixed
0x006A	LifetimeDataBlock11	R	Block	Yes	—	Yes	Mixed	Mixed
0x006B	LifetimeDataBlock12	R	Block	Yes	—	Yes	Mixed	Mixed
0x006C	LifetimeDataBlock13	R	Block	Yes	—	Yes	Mixed	Mixed
0x006D	LifetimeDataBlock14	R	Block	Yes	—	Yes	Mixed	Mixed
0x006E	LifetimeDataBlock15	R	Block	Yes	—	Yes	Mixed	Mixed
0x006F	PowerEvents	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
0x0073	GaugeStatus1	R	Block	Yes	—	Yes	Mixed	Mixed
0x0074	GaugeStatus2	R	Block	Yes	—	Yes	Mixed	Mixed
0x0075	GaugeStatus3	R	Block	Yes	—	Yes	Mixed	Mixed
0x0076	CBStatus	R	Block	Yes	—	Yes	Mixed	Mixed
0x0077	StateofHealth	R	Block	Yes	—	Yes	Mixed	Mixed
0x0078	FilterCapacity	R	Block	Yes	—	Yes	Mixed	Mixed
0x0079	RSOCWrite	W	—	—	—	—	Hex	—
0x007A	ManufacturerInfoB	R	Block	Yes	—	Yes	Hex	Hex
0x007B	ManufacturerInfoC	R/W	Block	Yes	—	Yes	Hex	Hex
0x007E	LifetimeDataBlock16	R	Block	Yes	—	Yes	Mixed	Mixed
0x0098	AccumulationChargeEnable	W	—	—	—	No	—	—
0x0099	AccumulationDischarge Enable	W	—	—	—	No	—	—
0x009A	AccumulationReset	W	—	—	—	Yes	—	—
0x009B	AccumulationStop	W	—	—	—	Yes	—	—
0x009C	AccumulationStart	W	—	—	—	Yes	Signed Int	mAh
0x009D	AccumulationCharge Threshold	RW	Block	Yes	—	Yes	Signed Int	mAh
0x009E	AccumulationDischarge Threshold	RW	Block	Yes	—	Yes	Signed Int	mAh
0x009F	AccumulatedTimeCharge	R	Block	Yes	—	Yes	Mixed	Mixed
0x00B0	ChargingVoltageOverride	R/W	Block	Yes	—	Yes	Signed Int	mV
0x00B2	ChargingCurrentOverride	R/W	Block	Yes	—	Yes	Signed Int	mA
0x00F0	IATAShutdown	W	—	—	—	—	Hex	—
0x00F1	IATARm	W	—	—	—	—	Hex	—
0x00F2	IATAFcc	W	—	—	—	—	Hex	—
0x0F00	ROMMode	W	—	—	—	—	Hex	—
0x3008	WriteTemp	W	Block	Yes	—	Yes	Signed Int	0.1 K
0xF080	ExitCalibrationOutput	R/W	Block	Yes	—	—	Hex	—
0xF081	OutputCCADCCal	R/W	Block	Yes	—	—	Hex	—
0xF082	OutputShortedCCADCCal	R/W	Block	Yes	—	—	Hex	—

16.2.1 ManufacturerAccess() 0x0000

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

16.2.2 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

16.2.3 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	Dynamic Z Track™ Version
RR	Reserved
EE	Reserved

16.2.4 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()*.

16.2.5 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()*.

16.2.6 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.

16.2.7 ManufacturerAccess() 0x0006 Chemical ID

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

16.2.8 ManufacturerAccess() 0x0008 Static Chem DF Signature

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

16.2.9 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 expected that this signature will change due to updates of lifetime, gauging, and other information.

16.2.10 ManufacturerAccess() 0x000A STORAGE Mode

This command activates STORAGE mode.

16.2.11 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, and the CHG and DSG FETs will be turned off when the counter reaches ***Ship FET Off Time*** . The counter will continue to count up after the FETs are turned off. When the counter reaches ***Ship Delay*** time, the device will enter SHUTDOWN mode if the voltage at PACK pin is < ***Shutdown Voltage*** and no charger present is detected and the ENAB pin is high.

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 or the ENAB pin pulled low. The device will power up and a full reset is applied.

16.2.12 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	|*Current()*| < ***Power:Sleep Current***	Turn off PCHG FET Turn off CHG FET if ***FET Options[SLEEPCHG]*** = 0 The device goes to sleep. The device wakes up every Power ***:Sleep:Measure Time*** period to measure voltage and temperature. The device wakes up every Power ***:Sleep Current Time*** period to measure current.
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

16.2.13 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.

16.2.14 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.

16.2.15 ManufacturerAccess() 0x0021 Gauging

This command enables/disables the gauging function to ease testing during manufacturing. The initial setting is loaded from ***Mfg Status Init[GAUGE_EN]*** . If the *ManufacturingStatus()[GAUGE_EN]* = 0, sending this command enables gauging and the *ManufacturingStatus()[GAUGE_EN]* = 1 and vice versa.

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

16.2.16 ManufacturerAccess() 0x0022 FET Control

This command enables/disables control of the CHG, DSG, and PCHG FETs 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.

16.2.17 ManufacturerAccess() 0x0023 Lifetime Data Collection

This command enables/disables ***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.

16.2.18 ManufacturerAccess() 0x0024 Permanent Failure

This command enables/disables ***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.

16.2.19 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.

16.2.20 ManufacturerAccess() 0x0028 Lifetime Data Reset

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

16.2.21 ManufacturerAccess() 0x0029 Permanent Fail Data Reset

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

16.2.22 ManufacturerAccess() 0x002A Black Box Recorder Reset

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

16.2.23 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 Calibration is not allowed to take place.
Enable	*ManufacturingStatus()[CAL_EN]* = 0 AND 0x002D to *ManufacturerAccess()*	*ManufacturingStatus()[CAL_EN]* = 1 Calibration is allowed to take place, min voltage checkes for saving data flash is bypassed, shutdown is prevented, *OperationStatus()[CAL]* entry is blocked.

16.2.24 ManufacturerAccess() 0x002E Lifetime Data Flush

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

16.2.25 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 1 hour in firmware 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.

16.2.26 ManufacturerAccess() 0x0030 Seal Device

This command seals the device for the field, disabling certain SBS commands and access to data flash. See *SBS Commands* for details.

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

16.2.27 ManufacturerAccess() 0x0035 Security Keys

This is a read/write command for two-word UNSEAL, FULL ACCESS, DF Read Only, Manual PF, Lifetimes Reset, Override, and MfgInfoC Write keys.

When reading the keys, data can be read from *ManufacturerData()* or *ManufacturerBlockAccess()*. The keys are returned in the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNN, 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
EEee	First word of the DF Read Only key
FFff	Second word of the DF Read Only key
GGgg	First word of the Manual PF key
HHhh	Second word of the Manual PF key
IIii	First word of the Lifetimes Reset key
JJjj	Second word of the Lifetimes Reset key
KKkk	First word of the Override key
LLll	Second word of the Override key
MMmm	First word of the MfgInfoC Write key
NNnn	Second word of the MfgInfoC Write key

The default UNSEAL key is 0x0414 and 0x3672. The default FULL ACCESS key is 0xFFFF and 0xFFFF. The default DF Read Only key is 0x7632 and 0x1712. The default Manual PF key is 0x2857 and 0x2A98. The default Lifetimes Reset key is 0x2B14 and 0x2C8A. The default Override key is 0x2D18 and 0x2E9B. The default MfgInfoC Write key is 0x3C45 and 0x5D89.

It is highly recommended to change the UNSEAL, FULL ACCESS, DF Read Only, Manual PF, Lifetimes Reset and Override keys from default.

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

Example: Change UNSEAL key to 0x1234, 0x5678, and leave the other security keys at their default values.

Send an SMBus block write with Command = 0x0035.

Data	= MAC command + UNSEAL key + FULL ACCESS KEY + DF Read Only key + PF key + Lifetimes Reset key + Override key + MfgInfoC Write key
	= 35 00 34 12 78 56 FF FF FF FF 32 76 12 17 57 28 98 2A 14 2B 8A 2C 18 2D 9B 2E 45 3C 89 5D

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.

16.2.28 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 256-bit authentication key to *ManufacturerBlockAccess()* OR
- Send the *AuthenticationKey()* to *ManufacturerAccess()*, then send the 256-bit authentication key to *Authenticate()*.

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 *Authenticate()* after updating the new authentication key.

The device also includes the capability to store the authentication key in secure memory. This is controlled using the ***SHA1_SECURE*** data flash bit; however, the authentication key cannot be written into the device using *AuthenticationKey()* as described above. It must be programmed using a separate method. Also, when using secure memory, the authentication key can only be written once and cannot be changed after it is written.

Note: The device uses SHA-256 for authentication. The authentication key is 256 bits (32 bytes). When *Settings:Configuration:Auth Config[SPLIT_RESPONSE]* is set, the 60-byte authentication response is split into two 30-byte fields.

16.2.29 ManufacturerAccess() 0x0041 Device Reset

This command resets the device.

Note

Command 0x0012 also resets the device (for backwards compatibility with the bq30zxy device).

16.2.30 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	OCDL	COVL	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	AOCCL	RSVD	AOCDL	RSVD	OCD2	OCD1	OCC2	OCC1	COV	CUV

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

OCDL (Bit 29): Overcurrent in discharge

1 = Detected

0 = Not detected

COVL (Bit 28): Cell overvoltage latch

1 = Detected

0 = Not detected

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.

1 = Detected

0 = Not detected

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.

AOCCL (Bit 9): Short-circuit during charge latch

1 = Detected

0 = Not detected

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

AOCDL (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

16.2.31 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
ACOV	ACUV	OCDL	COVL	UTD	UTC	PCHG C	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	ASC DL	ASCD	ASC CL	AOCC	AOCD L	AOCD	OCD2	OCD1	OCC2	OCC1	COV	CUV

ACOV (Bit 31): Cell Over Voltage

1 = Detected

0 = Not detected

ACUV (Bit 31): Cell Under Voltage

1 = Detected

0 = Not detected

OCDL (Bit 29): Overcurrent in discharge

1 = Detected
0 = Not detected

COVL (Bit 28): Cell overvoltage latch
1 = Detected
0 = Not detected

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

HWDF (Bit 17): SBS Host watchdog timeout
1 = Detected
0 = Not detected

OTF (Bit 16): Overtemperature FET
1 = Detected
0 = Not detected

RSVD (Bit 15): RSVD. 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

AOCCL (Bit 9): Short-circuit during charge latch

1 = Detected

0 = Not detected

AOCC (Bit 8): Short-circuit during charge

1 = Detected

0 = Not detected

AOCDL (Bit 7): Overload during discharge latch

1 = Detected

0 = Not detected

AOCD (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

16.2.32 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
ISD HI	ISD LO	RSVD	TS	RSVD	DFW	PF FORC E	BSD	NTC	2LVL	AFEC	AFER	FUSE	OCDL	DFE TF	CFE TF

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ASCDL	AOCCL	AOCDL	VIMA	VIMR	CD	IMP	CB	QIM	SOTF	COVL	SOT	SOCD	SOCC	SOV	SUV

ISD_HI (Bit 31): Internal short detection high failure

1 = Detected

0 = Not detected

ISD_LO (Bit 30): Internal short detection low failure

1 = Detected

0 = Not detected

RSVD (Bit 29): Reserved. Do not use.

TS (Bit 28): Open thermistor – TS1 failure. Triggered when the TS1 temperature reading falls significantly below the internal thermistor temperature for the configured time, indicating a disconnected or open thermistor.

1 = Detected

0 = Not detected

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

DFW (Bit 26): Data flash write failure

1 = Detected

0 = Not detected

PFFORCE (Bit 25): Permanent failure forced by command

1 = Detected

0 = Not detected

BSD (Bit 24): Battery swelling detection failure

1 = Detected

0 = Not detected

NTC (Bit 23): AFE NTC error

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

OCDL (Bit 18): Overcurrent in discharge latch

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

ASCDL (Bit 15): AFE short circuit in discharge latch

1 = Detected

0 = Not detected

AOCCL (Bit 14): AFE overcurrent in charge latch

1 = Detected

0 = Not detected

AOCDL (Bit 13): AFE overcurrent in discharge latch

1 = Detected

0 = Not detected

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

CD (Bit 10): Capacity degradation failure

1 = Detected

0 = Not detected

IMP (Bit 9): Impedance failure

1 = Detected

0 = Not detected

CB (Bit 8): Cell balancing failure

1 = Detected

0 = Not detected

QIM (Bit 7): QMax imbalance failure

1 = Detected

0 = Not detected

SOTF (Bit 6): Safety overtemperature FET failure

1 = Detected

0 = Not detected

COVL (Bit 5): Cell overvoltage latch

1 = Detected

0 = Not detected

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

16.2.33 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
ISD HI	ISD LO	RSVD	TS	RSVD	DFW	PF FORCE	BSD	NTC	2LVL	AFEC	AFER	FUSE	OCDL	DFE TF	CFE TF

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ASCDL	AOCCL	AOCDL	VIMA	VIMR	CD	IMP	CB	QIM	SOTF	COVL	SOT	SOCD	SOCC	SOV	SUV

ISD_HI (Bit 31): Internal short detection high failure

1 = Detected

0 = Not detected

ISD_LO (Bit 30): Internal short detection low failure

1 = Detected

0 = Not detected

RSVD (Bit 29): Reserved. Do not use.

TS (Bit 28): Open thermistor – TS1 failure. Triggered when the TS1 temperature reading falls significantly below the internal thermistor temperature for the configured time, indicating a disconnected or open thermistor.

1 = Detected

0 = Not detected

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

DFW (Bit 26): Data flash wearout failure

1 = Detected

0 = Not detected

PFFORCE (Bit 25): Permanent failure forced by command

1 = Detected

0 = Not detected

BSD (Bit 24): Battery swelling detection failure

1 = Detected

0 = Not detected

NTC (Bit 23): AFE NTC error

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

OCDL (Bit 18): Overcurrent in discharge latch
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

ASCDL (Bit 15): AFE short circuit in discharge latch
1 = Detected
0 = Not detected

AOCCL (Bit 14): AFE overcurrent in charge latch
1 = Detected
0 = Not detected

AOCDL (Bit 13): AFE overcurrent in discharge latch
1 = Detected
0 = Not detected

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

CD (Bit 10): Capacity degradation failure
1 = Detected
0 = Not detected

IMP (Bit 9): Impedance failure
1 = Detected
0 = Not detected

CB (Bit 8): Cell balancing failure
1 = Detected
0 = Not detected

QIM (Bit 7): QMax imbalance failure
1 = Detected
0 = Not detected

SOTF (Bit 6): Safety overtemperature FET failure

1 = Detected
0 = Not detected

COVL (Bit 5): Cell overvoltage latch
1 = Detected
0 = Not detected

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

16.2.34 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
IOSHUT	PSSHUT	DISCONN	RSVD	RSVD	-STORAGEM	SMBLCAL	INIT	SLEEPM	XL	CAL_OFFSET	CAL	AUTOCALM	AUTH	RSVD	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	EMSHUT	MINSYS	ACTHR	RSVD	CHG	DSG	PRES

IOSHUT (Bit 31): IO-based shutdown
1 = Active
0 = Inactive

PSSHUT (Bit 30): Power saving shutdown
1 = Active
0 = Inactive

DISCONN (Bit 29): System disconnect
1 = Active
0 = Inactive

RSVD (Bit 27-28): Reserved. Not use.

STORAGEM (Bit 26): Storage Mode is triggered via command
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): ***CC Auto Offset*** Calibration by MAC *AutoCCOffset()*

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

0 = Clear when the calibration is completed.

AUTH (Bit 18): Authentication in progress

1 = Active

0 = Inactive

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

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 status. This is the ORd value of all the Safety Status bits.

1 = Active

0 = Inactive

SDV (Bit 10): Shutdown triggered via low battery stack 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 *Battery Trip Point (BTP)* for details.

EMSHUT (Bit 6): Emergency FET Shutdown

1 = Active

0 = Inactive

MINSYS (Bit 5): MINSYS operation status

1 = Active

0 = Inactive

ACTHR (Bit 4): Accumulated charge threshold

1 = Active

0 = Inactive

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

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

16.2.35 ManufacturerAccess() 0x0055 ChargingStatus

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

39	38	37	36	35	34	33	32
SOC_VCT	SOC_MCHG	SOC_SU	SOC_IN	SOC_HV	SOC_MV	SOC_LV	SOC_PV

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
V_VCT	V_MCHG	V_SU	V_IN	V_HV	V_MV	V_LV	V_PV	DEG1	DEG0	ERETM	ERM	NCT	CCC	CVR	CCR

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
VCT	MCHG	SU	IN	HV	MV	LV	PV	RSVD	OT	HT	STH	RT	STL	LT	UT

SOC_VCT (Bit 39): Charge Termination Status based on SOC

1 = Active

0 = Inactive

SOC_MCHG (Bit 38): Maintenance Charge Status based on SOC

1 = Active

0 = Inactive

SOC_SU (Bit 37): Suspend Charge Status based on SOC

1 = Active

0 = Inactive

SOC_IN (Bit 36): Charge Inhibit Status based on SOC

1 = Active

0 = Inactive

SOC_HV (Bit 35): High Voltage Region Status based on SOC

1 = Active

0 = Inactive

SOC_MV (Bit 34): Mid Voltage Region Status based on SOC

1 = Active

0 = Inactive

SOC_ LV (Bit 33): Low Voltage Region Status based on SOC

1 = Active

0 = Inactive

SOC_PV (Bit 32): Precharge Voltage Region Status based on SOC

1 = Active

0 = Inactive

V_VCT (Bit 31): Charge Termination Status based on voltage

1 = Active

0 = Inactive

V_MCHG (Bit 30): Maintenance Charge Status based on voltage

1 = Active

0 = Inactive

V_SU (Bit 29): Suspend Charge Status based on voltage

1 = Active

0 = Inactive

V_IN (Bit 28): Charge Inhibit Status based on voltage

1 = Active

0 = Inactive

V_HV (Bit 27): High Voltage Region Status based on voltage

1 = Active

0 = Inactive

V_MV (Bit 26): Mid Voltage Region Status based on voltage

1 = Active

0 = Inactive

V_ LV (Bit 25): Low Voltage Region Status based on voltage

1 = Active

0 = Inactive

V_PV (Bit 24): Precharge Voltage Region Status based on voltage

1 = Active

0 = Inactive

DEG1, DEG0 (Bits 23–22): Degradation mode

0, 0 = No degradation

0, 1 = Cycle Count based degradation of *ChargingCurrent()* and *ChargingVoltage()* active

1, 0 = SOH based degradation of *ChargingCurrent()* and *ChargingVoltage()* active

1, 1 = Runtime based degradation of *ChargingCurrent()* and *ChargingVoltage()* active

ERETM (Bit 21): ELEVATED RSOC and TEMPERATURE modes

1 = Active

0 = Inactive

ERM (Bit 20): ELEVATED RSOC mode

1 = Active

0 = Inactive

NCT (Bit 19): Near Charge Termination. This flag indicates the pack may be within 40 seconds of charge termination. When smoothing is enabled and while NCT is high, *RemainingCapacity()* will be smoothed to 100% over the next 40 seconds.

1 = Active

0 = Inactive

CCC (Bit 18): Charging Loss Compensation

1 = Active

0 = Inactive

CVR (Bit 17): Charging Voltage Rate of Change

1 = Active

0 = Inactive

CCR (Bit 16): Charging Current Rate of Change

1 = Active

0 = Inactive

VCT (Bit 15): Charge Termination.

1 = Active

0 = Inactive

MCHG (Bit 14): Maintenance Charge

1 = Active

0 = Inactive

SU (Bit 13): Suspend Charge

1 = Active

0 = Inactive

IN (Bit 12): Charge Inhibit

1 = Active

0 = Inactive

HV (Bit 11): High Voltage Region

1 = Active

0 = Inactive

MV (Bit 10): Mid Voltage Region

1 = Active

0 = Inactive

LV (Bit 9): Low Voltage Region

1 = Active

0 = Inactive

PV (Bit 8): Precharge Voltage Region

1 = Active
0 = Inactive

Temperature Range Flags (Bits 7–0):

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

OT (Bit 6): Overtemperature Region
1 = Active
0 = Inactive

HT (Bit 5): High Temperature Region
1 = Active
0 = Inactive

STH (Bit 4): Standard Temperature High Region
1 = Active
0 = Inactive

RT (Bit 3): Recommended Temperature Region
1 = Active
0 = Inactive

STL (Bit 2): Standard Temperature Low Region
1 = Active
0 = Inactive

LT (Bit 1): Low Temperature Region
1 = Active
0 = Inactive

UT (Bit 0): Undertemperature Region
1 = Active
0 = Inactive

Note

Bit 24-31 is the Charging Status based on voltage (**ChargingStatus_V**), Bit 32-39 is the Charging Status based on SOC (**ChargingStatus_SOC**), Bit 8-15 is the ChargingStatus based on both voltage and SOC (**ChargingStatus**), its status depends on the settings of **V_SOC_CHARGE** and **SOC_CHARGE**.

- If **V_SOC_CHARGE** = 0 and **SOC_CHARGE** = 0, **ChargingStatus** equals to **ChargingStatus_V**;
- If **V_SOC_CHARGE** = 0 and **SOC_CHARGE** = 1, **ChargingStatus** equals to **ChargingStatus_SOC**;
- If **V_SOC_CHARGE** = 1 and no matter the status of **SOC_CHARGE**, **ChargingStatus** equals to MAX(**ChargingStatus_V**, **ChargingStatus_SOC**).

16.2.36 ManufacturerAccess() 0x0056 GaugingStatus

This command returns the *GaugingStatus()* flags on *ManufacturerBlockAccess()* or *ManufacturerData()*. The 6-byte response consists of three 16-bit sub-registers: Gauging Status (bytes 0–1, bits 15–0), IT Status (bytes 2–3, bits 31–16), and DZT Status (bytes 4–5, bits 47–32).

47	46	45	44	43	42	41	40
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD

39	38	37	36	35	34	33	32
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	DZT

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
RSVD	EDVC ONV	RSVD	OCV FR	LDMD	RX	QMax	VDQ	NSFM	OCV PRED	SLP QMax	QEN	VOK	R_DIS	RSVD	REST

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	VLB	CF	DSG	EDV	RSVD	TC	TD	FC	FD

DZT Status (Bits 47–32)

RSVD (Bits 47–33): Reserved. Do not use.

DZT (Bit 32): Dynamic Impedance Track active

1 = Active when ***DZT Gauging Configuration[PERF_MODE]*** is set

0 = Not active

IT Status (Bits 31–16)

RSVD (Bit 31): Reserved. Do not use.

EDVCONV (Bit 30): EDV convergence

1 = Converged

0 = Not converged

RSVD (Bit 29): Reserved. Do not use.

OCVFR (Bit 28): Open circuit voltage in flat region (during RELAX)

1 = Detected

0 = Not detected

LDMD (Bit 27): LOAD mode

1 = Constant Power

0 = Constant Current

RX (Bit 26): Resistance Update (toggles after every resistance update)

QMax (Bit 25): QMax Update (toggles after every QMax update)

VDQ (Bit 24): Discharge Qualified for Learning (opposite of the R_DIS flag)

1 = Detected

0 = Not detected

NSFM (Bit 23): Negative Scale Factor Mode

1 = Negative Ra Scaling Factor Detected

0 = Negative Ra Scaling Factor Not Detected

OCVPRED (Bit 22): Open-circuit-voltage predicted

1 = Fast OCV prediction is performed in RELAX mode.

0 = Fast OCV prediction is not performed or not in RELAX mode

SLPQMax (Bit 21): OCV update in SLEEP mode

1 = Active. OCV reading in process

0 = Inactive. Completed OCV reading

QEN (Bit 20): Impedance Track™ gauging (Ra and QMax updates are enabled.)

1 = Enabled

0 = Disabled

VOK (Bit 19): Voltages are OK for QMax update. This flag is updated at exit of the RELAX mode.

1 = A DOD is saved for next QMax update.

0 = No DOD saved and QMax update is not possible.

R_DIS (Bit 18): Resistance updates

1 = Disabled

0 = Enabled

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

REST (Bit 16): Rest

1 = OCV reading taken

0 = OCV reading not taken or not in RELAX

Gauging Status (Bits 15–0)

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

VLB (Bit 8): Very low battery warning

1 = Detected

0 = Not detected

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

EDV (Bit 5): End-of-discharge termination voltage

1 = Termination voltage reached during discharge

0 = Termination voltage not reached, or not in DISCHARGE mode

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

TC (Bit 3): Terminate charge

1 = Detected

0 = Not detected

TD (Bit 2): Terminate discharge

1 = Detected

0 = Not detected

FC (Bit 1): Fully charged

1 = Detected

0 = Not detected

FD (Bit 0): Fully discharged

1 = Detected

0 = Not detected

16.2.37 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		FUSE_EN
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
BBR_EN	PF_EN	LF_EN	FET_EN	GAUGE_EN	DSG_EN	CHG_EN	PCHG_EN

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.

FUSE_EN (Bit 8): Fuse action

1 = Enabled

0 = Disabled

BBR_EN (Bit 7): 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

GAUGE_EN (Bit 3): Gas gauging

1 = Enabled

0 = Disabled

DSG_EN (Bit 2): Discharge FET test

1 = Discharge FET test activated

0 = Disabled

CHG_EN (Bit 1): Charge FET test

1 = Charge FET test activated

0 = Disabled

PCHG_EN (Bit 0): Precharge FET test

1 = Precharge FET test activated

0 = Disabled

16.2.38 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

Value	Description
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

16.2.39 ManufacturerAccess() 0x005C VCT Voltage

This read block returns cell-based charging voltage used for charge termination detection. The output format is: aaAA.

Value	Description	Unit
AAaa	Charging voltage used for charge termination detection	mA

16.2.40 ManufacturerAccess() 0x005E ChargingStatusExt

This command returns the *ChargingStatusExt()* 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	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	EVHTM TTH5	EVHTM TTH4	EVHTM TTH3	EVHTM TTH2	EVHTM TTH1	EVMTM TTH5	EVMTM TTH4	EVMTM TTH3	EVMTM TTH2	EVMTM TTH1	EVLTM TTH5	EVLTM TTH4	EVLTM TTH3	EVLTM TTH2	EVLTM TTH1

RSVD (Bits 31–15): Reserved. Do not use.

EVHTM_TTH5 (Bit 14): Elevated voltage extended charge degradation activation in EVHTM temperature range for time duration ≥ EVHTM TTH5

1 = Active

0 = Inactive

EVHTM_TTH4 (Bit 13): Elevated voltage extended charge degradation activation in EVHTM temperature range for time duration ≥ EVHTM TTH4

1 = Active

0 = Inactive

EVHTM_TTH3 (Bit 12): Elevated voltage extended charge degradation activation in EVHTM temperature range for time duration ≥ EVHTM TTH3

1 = Active

0 = Inactive

EVHTM_TTH2 (Bit 11): Elevated voltage extended charge degradation activation in EVHTM temperature range for time duration ≥ EVHTM TTH2

1 = Active

0 = Inactive

EVHTM_TTH1 (Bit 10): Elevated voltage extended charge degradation activation in EVHTM temperature range for time duration ≥ EVHTM TTH1

1 = Active

0 = Inactive

EVMTM_TTH5 (Bit 9): Elevated voltage extended charge degradation activation in EVMTM temperature range for time duration ≥ EVMTM TTH5

1 = Active

0 = Inactive

EVMTM_TTH4 (Bit 8): Elevated voltage extended charge degradation activation in EVMTM temperature range for time duration ≥ EVMTM TTH4

1 = Active

0 = Inactive

EVMTM_TTH3 (Bit 7): Elevated voltage extended charge degradation activation in EVMTM temperature range for time duration ≥ EVMTM TTH3

1 = Active

0 = Inactive

EVMTM_TTH2 (Bit 6): Elevated voltage extended charge degradation activation in EVMTM temperature range for time duration ≥ EVMTM TTH2

1 = Active

0 = Inactive

EVMTM_TTH1 (Bit 5): Elevated voltage extended charge degradation activation in EVMTM temperature range for time duration ≥ EVMTM TTH1

1 = Active

0 = Inactive

EVLTM_TTH5 (Bit 4): Elevated voltage extended charge degradation activation in EVLTM temperature range for time duration ≥ EVLTM TTH5

1 = Active

0 = Inactive

EVLTM_TTH4 (Bit 3): Elevated voltage extended charge degradation activation in EVLTM temperature range for time duration ≥ EVLTM TTH4

1 = Active

0 = Inactive

EVLTM_TTH3 (Bit 2): Elevated voltage extended charge degradation activation in EVLTM temperature range for time duration ≥ EVLTM TTH3

1 = Active

0 = Inactive

EVLTM_TTH2 (Bit 1): Elevated voltage extended charge degradation activation in EVLTM temperature range for time duration ≥ EVLTM TTH2

1 = Active

0 = Inactive

EVLTM_TTH1 (Bit 0): Elevated voltage extended charge degradation activation in EVLTM temperature range for time duration ≥ EVLTM TTH1

1 = Active

0 = Inactive

16.2.41 ManufacturerAccess() 0x0060 Lifetime Data Block 1

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMM.

Value	Description
AAaa	Cell 1 Max Voltage
BBbb	RSVD - Do not use
CCcc	RSVD - Do not use
DDdd	RSVD - Do not use
EEee	Cell 1 Min Voltage
FFff	RSVD - Do not use
GGgg	RSVD - Do not use
HHhh	RSVD - Do not use
IIii	RSVD - Do not use
JJjj	Max Charge Current
KKkk	Max Discharge Current
LLll	Max Avg Dsg Current
MMmm	Max Avg Dsg Power

16.2.42 ManufacturerAccess() 0x0061 Lifetime Data Block 2

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJ.

Value	Description
AAaa	Min FCC-SOH mAh
BBbb	Min FCC-SOH cWh
DDddCCcc	CB Time Cell 1
FFffEEee	RSVD - Do not use
iHHhhGGgg	RSVD - Do not use
JJjjIIii	RSVD - Do not use

16.2.43 ManufacturerAccess() 0x0062 Lifetime Data Block 3

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBB.

Value	Description
BBbbAAaa	Total FW Runtime

16.2.44 ManufacturerAccess() 0x0063 Lifetime Data Block 4

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

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
IIii	No. of OCC1 Events
JJjj	Last OCC1 Event
KKkk	No. of OCC2 Events
LLll	Last OCC2 Event
MMmm	No. of AOCD Events
NNnn	Last AOCD Event

Value	Description
OOoo	No. of ASCD Events
PPpp	Last ASCD Event

16.2.45 ManufacturerAccess() 0x0064 Lifetime Data Block 5

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
AAaa	No. of AOCC Events
BBbb	Last AOCC 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
KKkk	No. of Qmax Updates
LLll	Last Qmax Update
MMmm	No. of Ra Updates
NNnn	Last Ra Update
OOoo	No. of Ra Disable
PPpp	Last Ra Disable

16.2.46 ManufacturerAccess() 0x0065 Lifetime Data Block 6

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_UT RSOC A
DDddCCcc	Time Spent In LFT_UT RSOC B
FFffEEee	Time Spent In LFT_UT RSOC C
HHhhGGgg	Time Spent In LFT_UT RSOC D
JJjjIIii	Time Spent In LFT_UT RSOC E
LLllKKkk	Time Spent In LFT_UT RSOC F
NNnnMMmm	Time Spent In LFT_UT RSOC G
PPppOOoo	Time Spent In LFT_UT RSOC H

16.2.47 ManufacturerAccess() 0x0066 Lifetime Data Block 7

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_LT RSOC A
DDddCCcc	Time Spent In LFT_LT RSOC B
FFffEEee	Time Spent In LFT_LT RSOC C
HHhhGGgg	Time Spent In LFT_LT RSOC D
JJjjIIii	Time Spent In LFT_LT RSOC E
LLllKKkk	Time Spent In LFT_LT RSOC F
NNnnMMmm	Time Spent In LFT_LT RSOC G

Value	Description
PPppOOoo	Time Spent In LFT_LT RSOC H

16.2.48 ManufacturerAccess() 0x0067 Lifetime Data Block 8

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_STL RSOC A
DDddCCcc	Time Spent In LFT_STL RSOC B
FFffEEee	Time Spent In LFT_STL RSOC C
HHhhGGgg	Time Spent In LFT_STL RSOC D
JJjjIIii	Time Spent In LFT_STL RSOC E
LLllKKkk	Time Spent In LFT_STL RSOC F
NNnnMMmm	Time Spent In LFT_STL RSOC G
PPppOOoo	Time Spent In LFT_STL RSOC H

16.2.49 ManufacturerAccess() 0x0068 Lifetime Data Block 9

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_RT RSOC A
DDddCCcc	Time Spent In LFT_RT RSOC B
FFffEEee	Time Spent In LFT_RT RSOC C
HHhhGGgg	Time Spent In LFT_RT RSOC D
JJjjIIii	Time Spent In LFT_RT RSOC E
LLllKKkk	Time Spent In LFT_RT RSOC F
NNnnMMmm	Time Spent In LFT_RT RSOC G
PPppOOoo	Time Spent In LFT_RT RSOC H

16.2.50 ManufacturerAccess() 0x0069 Lifetime Data Block 10

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_STH RSOC A
DDddCCcc	Time Spent In LFT_STH RSOC B
FFffEEee	Time Spent In LFT_STH RSOC C
HHhhGGgg	Time Spent In LFT_STH RSOC D
JJjjIIii	Time Spent In LFT_STH RSOC E
LLllKKkk	Time Spent In LFT_STH RSOC F
NNnnMMmm	Time Spent In LFT_STH RSOC G
PPppOOoo	Time Spent In LFT_STH RSOC H

16.2.51 ManufacturerAccess() 0x006A Lifetime Data Block 11

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_HT RSOC A
DDddCCcc	Time Spent In LFT_HT RSOC B

Value	Description
FFffEEee	Time Spent In LFT_HT RSOC C
HHhhGGgg	Time Spent In LFT_HT RSOC D
JJjjIIii	Time Spent In LFT_HT RSOC E
LLllKKkk	Time Spent In LFT_HT RSOC F
NNnnMMmm	Time Spent In LFT_HT RSOC G
PPppOOoo	Time Spent In LFT_HT RSOC H

16.2.52 ManufacturerAccess() 0x006B Lifetime Data Block 12

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_OT RSOC A
DDddCCcc	Time Spent In LFT_OT RSOC B
FFffEEee	Time Spent In LFT_OT RSOC C
HHhhGGgg	Time Spent In LFT_OT RSOC D
JJjjIIii	Time Spent In LFT_OT RSOC E
LLllKKkk	Time Spent In LFT_OT RSOC F
NNnnMMmm	Time Spent In LFT_OT RSOC G
PPppOOoo	Time Spent In LFT_OT RSOC H

16.2.53 ManufacturerAccess() 0x006C Lifetime Data Block 13

This command returns the ***Lifetime Data*** with the following format:

AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVXXYYZZ1122334455.

Value	Description
AA	Max Temp Cell in RELAX mode
BB	Min Temp Cell in RELAX mode
CC	Max Delta Cell Temperature in RELAX mode
DD	Max Temp Int Sensor in RELAX mode
EE	Min Temp Int Sensor in RELAX mode
FF	Max Temp FET in RELAX mode
GG	Max Temp TS1 in RELAX mode
HH	RSVD - Dot not use
II	RSVD - Dot not use
JJ	RSVD - Dot not use
KK	Min Temp TS1 in RELAX mode
LL	RSVD - Dot not use
MM	RSVD - Dot not use
NN	RSVD - Dot not use

16.2.54 ManufacturerAccess() 0x006D Lifetime Data Block 14

This command returns the ***Lifetime Data*** with the following format:

AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVXXYYZZ1122334455.

Value	Description
AA	Max Temp Cell in CHARGE mode
BB	Min Temp Cell in CHARGE mode
CC	Max Delta Cell Temperature in CHARGE mode
DD	Max Temp Int Sensor in CHARGE mode
EE	Min Temp Int Sensor in CHARGE mode
FF	Max Temp FET in CHARGE mode

Value	Description
GG	Max Temp TS1 in CHARGE mode
HH	RSVD - Dot not use
II	RSVD - Dot not use
JJ	RSVD - Dot not use
KK	Min Temp TS1 in CHARGE mode
LL	RSVD - Dot not use
MM	RSVD - Dot not use
NN	RSVD - Dot not use

16.2.55 ManufacturerAccess() 0x006E Lifetime Data Block 15

This command returns the ***Lifetime Data*** with the following format:

AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVXXYYZZ1122334455.

Value	Description
AA	Max Temp Cell in DISCHARGE mode
BB	Min Temp Cell in DISCHARGE mode
CC	Max Delta Cell Temperature in DISCHARGE mode
DD	Max Temp Int Sensor in DISCHARGE mode
EE	Min Temp Int Sensor in DISCHARGE mode
FF	Max Temp FET in DISCHARGE mode
GG	Max Temp TS1 in DISCHARGE mode
HH	RSVD - Do not use
II	RSVD - Do not use
JJ	RSVD - Do not use
KK	Min Temp TS1 in DISCHARGE mode
LL	RSVD - Do not use
MM	RSVD - Do not use
NN	RSVD - Do not use

16.2.56 ManufacturerAccess() 0x006F Power Events

This command returns the ***Power Events*** with the following format:

AABBCCDD.

Value	Description
AA	No. of Shutdowns
BB	No. of Partial Resets
CC	No. of Full Resets
DD	No. of WDT Resets

16.2.57 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: AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVWWXXYYZZ112233445566

16.2.58 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	RSVD - Do not use	mV
CCcc	RSVD - Do not use	mV
DDdd	RSVD - Do not use	mV
EEee	RSVD - Do not use	mV
FFff	PACK voltage. Voltage at the PACK+ pin.	mV
GGgg	Cell Current 1. Simultaneous current measured during Cell Voltage 1 measurement	mA
HHhh	RSVD - Do not use	mA
IIii	RSVD - Do not use	mA
JJjj	RSVD - Do not use	mA
KKkk	Cell Power 1. Calculated using Cell Voltage1 and Cell Current 1 data	cW
LLll	RSVD - Do not use	cW
MMmm	RSVD - Do not use	cW
NNnn	RSVD - Do not use	cW
OOoo	Power calculated by *Voltage()* × *Current()*	cW
PPpp	Average Power	cW

16.2.59 ManufacturerAccess() 0x0072 DAStatus2

This command returns the internal temperature sensor, TS1, cell temp, FET temp, gauging temperature, user temperature, and cell voltages without IR loss compensation on *ManufacturerBlockAccess()* or *ManufacturerData()*.

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

Action: Output 24 bytes of temperature data values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMM where:

Value	Description	Unit
AAaa	Int Temperature	0.1 K
BBbb	TS1 Temperature	0.1 K
CCcc	RSVD - Do not use.	0.1 K
DDdd	RSVD - Do not use.	0.1 K
EEee	RSVD - Do not use.	0.1 K
FFff	Cell Temperature	0.1 K
GGgg	FET Temperature	0.1 K
HHhh	Gauging Temperature	0.1 K
IIii	User Temperature (written by *ManufacturerAccess() 0x3008 WriteTemp()*)	0.1 K
JJjj	Uncompensated Cell Voltage 1	mV
KKkk	RSVD - Do not use.	mV
LLll	RSVD - Do not use.	mV
MMmm	RSVD - Do not use.	mV

16.2.60 ManufacturerAccess() 0x0073 GaugeStatus1

This command instructs the device to return Impedance Track™ related gauging information on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition
Activate	0x0073 to *ManufacturerBlockAccess()* or *ManufacturerAccess()*

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

Value	Description	Unit
AAaa	True Rem Q. True remaining capacity in mAh from IT simulation before any filtering or smoothing function. This value can be negative or higher than FCC.	mAh
BBbb	True Rem E. True remaining energy in cWh from IT simulation before any filtering or smoothing function. This value can be negative or higher than FCC.	cWh
CCcc	Initial Q. Initial capacity calculated from IT simulation	mAh
DDdd	Initial E. Initial energy calculated from IT simulation	cWh
EEee	True FCC Q. True full charge capacity from IT simulation without the effects of any smoothing function	mAh
FFff	True FCC E. True full charge energy from IT simulation without the effects of any smoothing function	cWh
GGgg	T_sim. Temperature during the last simulation run.	0.1 K
HHhh	T_ambient. Current assumed ambient temperature used by the IT algorithm for thermal modeling	0.1 K
IIii	RaScale 0. Ra table scaling factor of Cell 1	—
JJjj	RSVD - Do not use	—
KKkk	RSVD - Do not use	—
LLll	RSVD - Do not use	—
MMmm	CompRes 0. Last temperature compensated Resistance of Cell 1	2^{-10} Ω
NNnn	RSVD - Do not use	2^{-10} Ω
OOoo	RSVD - Do not use	2^{-10} Ω
PPpp	RSVD - Do not use	2^{-10} Ω

16.2.61 *ManufacturerAccess() 0x0074 GaugeStatus2*

This command instructs the device to return Impedance Track™ related gauging information on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition
Activate	0x0074 to *ManufacturerBlockAccess()* or *ManufacturerAccess()*

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

Value	Description	Unit
AA	Pack Grid. Active pack impedance grid point (minimum of Cell Grid 0 to Cell Grid 3). This data is only valid during DISCHARGE mode when *[R_DIS]* = 0. If *[R_DIS]* = 1 or not discharging, this value is not updated.	—
BB	BB: LStatus—Learned status of resistance table Bit 3 | Bit 2 | Bit 1| Bit 0 QMax | ITEN | CF1 | CF0 CF1, CF0: QMax Status 0,0 = Battery OK 0,1 = QMax is first updated in learning cycle. 1,0 = QMax and resistance table updated in learning cycle ITEN: IT enable 0 = IT disabled 1 = IT enabled QMax: QMax update in field 0 = QMax has not been updated in the field. 1= QMax updated in the field.	—
CC	Cell Grid 0. Active grid point of Cell 1. This data is only valid during DISCHARGE mode when *[R_DIS]* = 0. If *[R_DIS]* = 1 or not discharging, this value is not updated.	—
DD	Cell Grid 1. Active grid point of Cell 2. This data is only valid during DISCHARGE mode when *[R_DIS]* = 0. If *[R_DIS]* = 1 or not discharging, this value is not updated.	—
EE	Cell Grid 2. Active grid point of Cell 3. This data is only valid during DISCHARGE mode when *[R_DIS]* = 0. If *[R_DIS]* = 1 or not discharging, this value is not updated.	—
FF	Cell Grid 3. Active grid point of Cell 4. This data is only valid during DISCHARGE mode when *[R_DIS]* = 0. If *[R_DIS]* = 1 or not discharging, this value is not updated.	—

Value	Description	Unit
HHhhGGgg	State Time. Time passed since the last state change (DISCHARGE, CHARGE, REST)	s
IIii	DOD0_0. Depth of discharge for Cell 1	—
JJjj	RSVD - Do not use	—
KKkk	RSVD - Do not use	—
LLll	RSVD - Do not use	—
MMmm	DOD0 Passed Q. Passed capacity since the last DOD0 update	mAh
NNnn	DOD0 Passed E. Passed energy since last DOD0 update	cWh
OOoo	DOD0 Time. Time passed since the last DOD0 update	hr/16
PPpp	DODEOC 0. Depth of discharge at end of charge of Cell 1	—
QQqq	RSVD - Do not use	—
RRrr	RSVD - Do not use	—
SSss	RSVD - Do not use	—

16.2.62 ManufacturerAccess() 0x0075 GaugeStatus3

This command instructs the device to return Impedance Track™ related gauging information on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition
Activate	0x0075 to *ManufacturerBlockAccess()* or *ManufacturerAccess()*

Action: Output 24 bytes of IT data values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLL where:

Value	Description	Unit
AAaa	QMax 0. QMax of Cell 1	mAh
BBbb	RSVD - Do not use	mAh
CCcc	RSVD - Do not use	mAh
DDdd	RSVD - Do not use	mAh
EEee	QMax DOD0_0. DOD0 saved to be used for next QMax update of Cell 1. The value is only valid when *[VOK]* = 1.	—
FFff	RSVD - Do not use	—
GGgg	RSVD - Do not use	—
HHhh	RSVD - Do not use	—
IIii	QMax Passed Q. Pass capacity since last QMax DOD value is saved.	mAh
JJjj	QMax Time. Time passed since last QMax DOD value is saved.	hr/16
KKkk	Temp k. Thermal Model temperature factor	—
LLll	Temp a. Thermal Model temperature	—

16.2.63 ManufacturerAccess() 0x0076 CBStatus

This command instructs the device to return cell balance time information on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition
Activate	0x0076 to *ManufacturerBlockAccess()* or *ManufacturerAccess()*

Action: Output 19 bytes of IT data values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjj where:

Value	Description	Unit
AAaa	Cell balance time 0. Calculated cell balancing time of Cell 1	s
BBbb	RSVD - Do not use	s
CCcc	RSVD - Do not use	s
DDdd	RSVD - Do not use	s
EEee	Cell 1 balance DOD	—

Value	Description	Unit
FFff	RSVD - Do not use	—
GGgg	RSVD - Do not use	—
HHhh	RSVD - Do not use	—
IIii	Total DOD Charge	—
jj	Cell Balance Status Bit 3 | Bit 2 | Bit 1 | Bit 0 CELL4 | CELL3 | CELL2 | CELL1 CELL1: Cell 1 balance circuit 0 = Inactive 1 = Active CELL2: Cell 2 balance circuit 0 = Inactive 1 = Active CELL3: Cell 3 balance circuit 0 = Inactive 1 = Active CELL4: Cell 4 balance circuit 0 = Inactive 1 = Active	—

16.2.64 ManufacturerAccess() 0x0077 StateofHealth

This command returns the state-of-health FCC in mAh and energy in cWh with the following format:

aaAAbbBB.

Value	Description	Unit
AAaa	State-of-Health FCC	mAh
BBbb	State-of-Health energy	cWh

16.2.65 ManufacturerAccess() 0x0078 FilterCapacity

This command instructs the device to return the filtered remaining capacity and full charge capacity even if ***[SMOOTH]*** = 0 on *ManufacturerBlockAccess()* or *ManufacturerData()*.

Status	Condition
Activate	0x0078 to *ManufacturerBlockAccess()* or *ManufacturerAccess()*

Action: Output 8 bytes of IT data values on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: aaAAbbBBccCCddDD where:

Value	Description	Unit
AAaa	Filtered remaining capacity	mAh
BBbb	Filtered remaining energy	cWh
CCcc	Filtered full charge capacity	mAh
DDdd	Filtered full charge energy	cWh

16.2.66 ManufacturerAccess() 0x0079 RSOCWrite

This command is typically used for testing purposes and will allow a specific value to be loaded into RSOC. However, subsequent IT simulation can overwrite this value. This command works only in UNSEALED mode. Additionally, this command will work with or without smoothing enabled.

16.2.67 ManufacturerAccess() 0x007A ManufacturerInfoB

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

Status	Condition	Action
Activate	0x007A to *ManufacturerAccess()*	Output 32 bytes of ManufacturerInfoB on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVWWXXYYZZ112233445566

16.2.68 ManufacturerAccess() 0x007B ManufacturerInfoC

This command enables ***ManufacturerInfoC*** read/write on *ManufacturerBlockAccess()* and *ManufacturerData()* in SEALED, UNSEALED, and FULL ACCESS modes.

Status	Condition	Action
Activate	0x007B to *ManufacturerAccess()*	Output 32 bytes of ManufacturerInfoC on *ManufacturerBlockAccess()* or *ManufacturerData()* in the following format: AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVWWXXYYZZ112233445566 A two-word MfgInfoC Write MAC sequence, which is programmable using *ManufacturerAccess()* 0x0035 Security Keys, is required to enable writing these registers during SEALED mode. Refer to the description in Manufacturer Info C for further details.

16.2.69 ManufacturerAccess() 0x007E Lifetime Data Block 16

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
BBbbAAaa	Time Spent In LFT_UUT RSOC A
DDddCCcc	Time Spent In LFT_UUT RSOC B
FFffEEee	Time Spent In LFT_UUT RSOC C
HHhhGGgg	Time Spent In LFT_UUT RSOC D
JJjjIIii	Time Spent In LFT_UUT RSOC E
LLllKKkk	Time Spent In LFT_UUT RSOC F
NNnnMMmm	Time Spent In LFT_UUT RSOC G
PPppOOoo	Time Spent In LFT_UUT RSOC H

16.2.70 ManufacturerAccess() 0x0098 AccumulationChargeEnable

This command enables accumulated charge measurement in the CHARGE direction by setting ***[ACCHG_EN]*** .

16.2.71 ManufacturerAccess() 0x0099 AccumulationDischargeEnable

This command enables accumulated charge measurement in the DISCHARGE direction by setting ***[ACDSG_EN]*** .

16.2.72 ManufacturerAccess() 0x009A AccumulationReset

This command resets the accumulated charge and time values, and clears *[ACTHR]* if previously triggered.

16.2.73 ManufacturerAccess() 0x009B AccumulationStop

This command stops the accumulated charge and time accumulation.

16.2.74 ManufacturerAccess() 0x009C AccumulationStart

This command starts the accumulated charge and time accumulation.

16.2.75 ManufacturerAccess() 0x009D AccumulationChargeThreshold

This command can be used to set ***Accum Charge Threshold*** with the following format: aaAA.

Value	Description	Unit
AAAaa	Accum Charge Threshold	mAh

16.2.76 ManufacturerAccess() 0x009E AccumulationDischargeThreshold

This command can be used to set ***Accum Discharge Threshold*** with the following format: aaAA.

Value	Description	Unit
AAAaa	Accum Discharge Threshold	mAh

16.2.77 ManufacturerAccess() 0x009F AccumulatedChargeTime

This command returns the accumulated charge and time values in the following format: aaAAbbBBccCC.

Value	Description	Unit
BBbbAAaa	Accumulated Time	s
CCcc	Accumulated Charge	mAh

16.2.78 ManufacturerAccess() 0x00B0 ChargingVoltageOverride

Note

Before writing this command, the Override Key unlock sequence must be sent to register 0x00. The Override Key values can be read using ManufacturerAccess() 0x0035 Security Keys. The default Override Key is 0x2D18 (first word) and 0x2E9B (second word). Send the first word to register 0x00 (LSB first), then send the second word to register 0x01 to unlock. The unlock window is 4 seconds; the write must complete within this time.

Note

After completing a write to this command, allow at least 100 ms before initiating the next write sequence. This ensures the device has time to complete internal flash operations.

This command enables writing the five advanced charge algorithm charging voltage values in SEALED mode. The data written will take immediate effect. However, to prevent over-usage of this command from causing severe data flash wear, ***Sealed Write.Hold Off*** sets the delay time before the new charging voltage valueis written to data flash. ***Sealed Write.Lockout*** sets the period of time after the value is written to data flash when 0x00B0 command is ignored. The maximum limit on values allowed to write is ***CHGV Override Max*** , and the minimum limit on values allowed to write is ***CHGV Override Min*** . The format is asfollows: aaAAbbBBccCCddDDeeEE, where:

Value	Description	Unit
AAaa	Low Temperature Charging Voltage	mV
BBbb	Standard Temperature Low Charging Voltage	mV
CCcc	Standard Temperature High Charging Voltage	mV
DDdd	High Temperature Charging Voltage	mV
EEee	Recommended Temperature Charging Voltage	mV

16.2.79 ManufacturerAccess() 0x00B2 ChargingCurrentOverride

Note

Before writing this command, the Override Key unlock sequence must be sent to register 0x00. The Override Key values can be read using ManufacturerAccess() 0x0035 Security Keys. The default Override Key is 0x2D18 (first word) and 0x2E9B (second word). Send the first word to register 0x00 (LSB first), then send the second word to register 0x01 to unlock. The unlock window is 4 seconds; the write must complete within this time.

Note

After completing a write to this command, allow at least 100 ms before initiating the next write sequence. This ensures the device has time to complete internal flash operations.

This command enables writing the thirty advanced charge algorithm charging current values in SEALED mode. The data written will take immediate effect. However, to prevent over-usage of this command from causing severe data flash wear, ***Sealed Write.Hold Off*** sets the delay time before the new charging current value is written to data flash. ***Sealed Write.Lockout*** sets the period of time after the value is written to data flash when 0x00B2 command is ignored. The maximum limit on values allowed to write is ***CHGI Override Max*** and minimum limit on values allowed to write is ***CHGI Override Min*** . The format is as following: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOO where:

Value	Description	Unit
AAaa	Low Temperature Charging Current Low	mA
BBbb	Low Temperature Charging Current Med	mA
CCcc	Low Temperature Charging Current High	mA
DDdd	Standard Temperature Low Charging Current Low	mA
EEee	Standard Temperature Low Charging Current Med	mA
FFff	Standard Temperature Low Charging Current High	mA
GGgg	Standard Temperature High Charging Current Low	mA
HHhh	Standard Temperature High Charging Current Med	mA
IIii	Standard Temperature High Charging Current High	mA
JJii	High Temperature Charging Voltage Charging Current Low	mA
KKkk	High Temperature Charging Charging Current Med	mA
LLll	High Temperature Charging Charging Current High	mA
MMmm	Recommended Temperature Charging Current Low	mA
NNnn	Recommended Temperature Charging Current Med	mA
OOoo	Recommended Temperature Charging Current High	mA

16.2.80 ManufacturerAccess() 0x00B4 RTC Access

The command is to read/write RTC data. It can work under SEALED, UNSEALED, and FULL ACCESS mode.

The RTC begins incrementing once the Timer/Date/Counter registers are programmed and will continue incrementing through all non-POR resets. If the Timer/Date/Counter registers are being written just as a non-POR reset occurs, the value being written will be corrupted and set to 0.

RTC information is read/written in the format of aaAABBbbCCccDDdd.

Value	Description
AAaa	Year
BB	Month
bb	Day of month
CC	Day of week
cc	Hour
DD	Minute
dd	second

Note

- The range of AAaa (Year) is from 0 to 4096
- The range of BB (Month) is from 1 to 12
- The range of bb (Day of month) is from 1 to 31
- The range of CC (Day of week) is from 0 to 6
- The range of cc (Hour) is from 0 to 23
- The range of DD (Minute) is from 0 to 59
- The range of dd (Second) is from 0 to 60

16.2.81 ManufacturerAccess() 0x00B5 ChargerStatus

This command returns the *ChargerStatus()* register indicating the current state of the linear charger and charger detection.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	LIN OFFT	LIN SUPP	IDOFF	IDON	LIN	CHGR _DET	LIN CHGR

RSVD (Bits 15–7): Reserved. Do not use.

LINOFFT (Bit 6): Device in Linear charger off-timer state.

1 = Device currently in Linear charger off-timer state

0 = Device currently not in Linear charger off-timer state

LINSUPP (Bit 5): Device in Linear charger Supplement state.

1 = Device currently in Linear charger Supplement state

0 = Device currently not in Linear charger Supplement state

IDOFF (Bit 4): Device in Ideal Diode OFF state.

1 = Device currently in Ideal Diode OFF state

0 = Device currently not in Ideal Diode OFF state

IDON (Bit 3): Device in Ideal Diode ON state.

1 = Device currently in Ideal Diode ON state

0 = Device currently not in Ideal Diode ON state

LIN (Bit 2): Device in Linear Mode status

1 = Device currently in Linear Mode

0 = Device currently not in Linear Mode

CHGR_DET (Bit 1): Charger Detect status. This bit indicates whether an upstream charger is detected based on the voltage difference between PACK and BAT. The bit is set when (VPACK - VBAT) >= ***CHGR_DET On Voltage*** (default 0 mV) and cleared when (VBAT - VPACK) >= ***CHGR_DET Off Voltage*** (default 10 mV). The separate On and Off thresholds provide hysteresis to prevent noise-induced toggling.

1 = Upstream charger attached/present

0 = Upstream charger removed/not present

LINCHGR (Bit 0): Linear charger enabled status. Reflects the state of the ***Charging Configuration Ext[LINCHGR]*** setting.

1 = Linear charger hardware and firmware enabled

0 = Linear charger hardware and firmware disabled

16.2.82 ManufacturerAccess() 0x00D2 ISI Current State

The ISI_CURR_STATE command is used to retrieve the current state of the ISI algorithm. It indicates the current state of the ISI algorithm based on the internal short current.

The CurrStateFine field is a 2-bit field that indicates the current state of the ISI algorithm. The field is updated based on the value of the internal short current as follows:

CURR_STATE_HIGH (0x3): The internal short current is above 200mA.

CURR_STATE_MEDIUM (0x2): The internal short current is between 100mA and 200mA (inclusive).

CURR_STATE_LOW (0x1): The internal short current is between 10mA and 100mA (inclusive).

CURR_STATE_OFF (0x0): The internal short current is below 10mA.

The ISI_CURR_STATE command returns the current value of the CurrStateFine field, which can be used to determine the current state of the ISI algorithm.

16.2.83 ManufacturerAccess() 0x00F0 IATAShutdown

This command, when used in conjunction with the *[IATA_SHUT]* bit in the *IATA Flag* register, enables the gauge to enter IATA shutdown (provided certain other requirements are met).

16.2.84 ManufacturerAccess() 0x00F1 IATARm

This command is used in relation to IATA to read out the stored ***IATARm*** value.

16.2.85 ManufacturerAccess() 0x00F2 IATAFcc

This command is used in relation to IATA to read out the stored ***IATAFcc*** value.

16.2.86 ManufacturerAccess() 0x0F00 ROM Mode

This command sends the device into ROM mode in preparation for firmware reprogramming. 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).

16.2.87 ManufacturerAccess() 0x3008 WriteTemp

This command, available in SEALED and UNSEALED modes, is used to write the temperature register when enabled by setting ***Settings:Temperature Enable[USER_TS]*** = 1 . In this case, the gauge's cell temperature inputs (TS1 through TS3) are ignored.

Note

When this feature is used, the temperature must be written in 0.1 K.

16.2.88 ManufacturerAccess() 0x4000–0x5FFF DataFlashAccess

Accessing data flash (DF) is only supported by the *ManufacturerBlockAccess()* by addressing the physical address. Numeric data items in DF are in little endian byte order.

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 numeric data items must be sent in little endian byte order.

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; items are in little endian byte order.

Read from DF example:

Assuming: data1 locates at address 0x4000 and data2 locates at address 0x4002.

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

b. Send SMBus read block with command 0x44

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

= 0x00 + 0x40 + data1_LowByte + data1_HighByte + data2_LowByte + data2_HighByte.... data31_Byte + data32_Byte

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.

16.2.89 ManufacturerAccess() 0xF080 and 0xF081 Output CCADCCal Control

These commands control 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	RSVD - Do not use
DDdd	RSVD - Do not use
EEee	RSVD - Do not use
FFff	PACK Voltage
GGgg	RSVD - Do not use (use Cell Voltage 1 as BAT Voltage)
HHhh	Cell Current 1
IIii	RSVD - Do not use
JJjj	RSVD - Do not use
KKkk	RSVD - Do not use

16.2.90 ManufacturerAccess() 0xF082 OutputShortedCCADCCal

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 its 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	0xF082 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	RSVD - Do not use
DDdd	RSVD - Do not use
EEee	RSVD - Do not use
FFff	PACK Voltage
GGgg	RSVD - Do not use
HHhh	Cell Current 1
IIii	RSVD - Do not use
JJjj	RSVD - Do not use
KKkk	RSVD - Do not use

17 Data Flash Values

17.1 Settings

17.1.1 Configuration

17.1.1.1 Charging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Charging Configuration	H2	0x0000	0xFFFF	0x0000	Hex

15	14	13	12	11	10	9	8
V_SOC_CHARGE	CC_SEALED_EN	CV_SEALED_EN	HT_INIHIB_DIS	HIBAT_CHG	TAPER_VOLT	RTORFCC	RUNTIME_DEGRADE

7	6	5	4	3	2	1	0
CYCLE_DEGRADE	SOH_DEGRADE	DEGRADE_CC	COMP_IR	CS_CV	SOC_CHARGE	CCC	CRATE

V_SOC_CHARGE (Bit 15): Enables both Voltage or SoC level to determine the thresholds in Advanced Charging Algorith,

1 = Enables voltage or SOC levels to determine the charging state in Advanced Charging Algorithm

0 = **SOC_CHARGE** (bit 2) determines the charging state in Advanced Charging Algorithm

CC_SEALED_EN (Bit 14): Enables writing the Advanced Charging Algorithm charging current values in SEALED mode to data flash by the *ManufacturerAccess() 0x00B2 ChargingCurrentOverride* command mode to data flash

1 = Enabled

0 = Disabled

CV_SEALED_EN (Bit 13): Enables writing the Advanced Charging Algorithm charging voltage values in SEALED mode to data flash by the *ManufacturerAccess() 0x00B0 ChargingVoltageOverride* command

1 = Enabled

0 = Disabled

HT_INHIB_DIS (Bit 12): High Temperature Disable

0 = HT inhibit enabled

HIBAT_CHG (Bit 11): See the *Charging Voltage* sections below.

1 = Enabled

0 = Disabled

TAPER_VOLT (Bit 10): Uses fixed ***Charge Term Charging Voltage***

1 = Uses fixed ***Charge Term Charging Voltage*** for Charge Termination

0 = Uses *ChargingVoltage()* for Charge Termination

RTORCC (Bit 9): Uses the first of runtime or cycle count degrade when also enabled

1 = Enabled

0 = Disabled

RUNTIME_DEGRADE (Bit 8): Runtime-based charging voltage or charging current degradation

1 = Degrade CC/CV based on runtime

0 = No degradation of CC/CV based on runtime

CYCLE_DEGRADE (Bit 7): ***Cycle Count*** based charging voltage or charging current degradation

1 = Degrade CC/CV based on ***Cycle Count***

0 = No degradation of CC/CV based on ***Cycle Count***

SOH_DEGRADE (Bit 6): SOH-based charging voltage or charging current degradation

1 = Degrade CC/CV based on SOH

0 = No degradation of CC/CV based on SOH

DEGRADE_CC (Bit 5): Enables charging current degradation based on ***Cycle Count*** or SOH.

1 = Enables Charging Current degradation

0 = Disables Charging Current degradation

COMP_IR (Bit 4): Enables IR compensation at the system level to ensure the correct voltage level required for a specific charging voltage at the battery terminals

1 = Enables system level IR compensation

0 = Disables system level IR compensation

CS_CV (Bit 3): This enables the cell swelling control under specific cell voltage and cell temperature thresholds by reducing the charging voltage.

1 = Enables cell swelling control

0 = Disables cell swelling control

SOC_CHARGE (Bit 2)

1 = Enables SOC threshold to replace voltage thresholds (CLV, CMV, and CHV) in ***Advanced Charging Algorithm***

0 = Uses voltage thresholds (CLV, CMV, and CHV) in ***Advanced Charging Algorithm***

CCC (Bit 1)

1 = Enables Charging Loss Compensation feature

0 = Disables Charging Loss Compensation (default)

CRATE (Bit 0): Charge Current rate

1 = *ChargingCurrent()* adjusted based on *FullChargeCapacity()* / *DesignCapacity()*

0 = No adjustment to *ChargingCurrent()* (default)

17.1.1.2 Charging Configuration Ext

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Charging Configuration Ext	H1	0x00	0x07	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	LINCHGR	SLOW_CRATE	CELL_VAL1	CELL_VAL0

RSVD (Bit 7–4): Reserved. Do not use.

LINCHGR (Bit 3): Enable device linear charger HW and FW options

1 = Device linear charger HW and FW enabled (default)

0 = Device linear charger HW and FW disabled

SLOW_CRATE (Bit 2): Enables the slows-down of the ***Current Rate*** current transition time

1 = The 1-second per step ***Current Rate*** is multiplied by 5 to arrive at the next *ChargingCurrent()* setting

0 = ***Current Rate*** remains unchanged

CELL_VAL1, CELL_VAL0 (Bit 1–0): JEITA charging voltage is determined based on either max cell, min cell, or average cell voltage. Leave as default for single cell devices.

1, 1 = Reserved

1, 0 = JEITA charging voltage determined based on average cell voltage

0, 1 = JEITA charging voltage determined based on min cell voltage

0, 0 = JEITA charging voltage determined based on max cell voltage (default)

17.1.1.3 FET Options

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	FET Options	H2	0x0	0x00FF	0x0020	Hex

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

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

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 1-0): Reserved. Do not use.

17.1.1.4 SBS Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SBS Gauging Configuration	H2	0x0	0x003F	0x0004	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	VLB	1PERCENT_HOLD	RSOC_RND_OFF	LOCK0	RSOC_HOLD	RSOCL

RSVD (Bits 7–6): Reserved. Do not use.

VLB (Bit 5): Enables very low battery warning option

1 = Enabled

0 = Disabled

1PERCENT_HOLD (Bit 4): Setting this bit prevents RSOC from going below 1% until ***Terminate Voltage*** is detected.

1 = Enabled

0 = Disabled

RSOC_RND_OFF (Bit 3): Enables a round-off option of RSOC (instead of a ceiling function available by default)

1 = Enables RSOC round-off

0 = Disables RSOC round-off (A ceiling function is used instead.)

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

1 = Enabled (default)

0 = Disabled

RSOC_HOLD (Bit 1): Prevent RSOC from increasing during discharge

1 = RSOC not allowed to increase during discharge

0 = RSOC not limited (default)

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

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

0 = Actual value shown (default)

17.1.1.5 SBS Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SBS Configuration	H2	0x0	0x00FF	0x0020	Hex

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

FLASH_BUSY_WAIT (Bit 7): This enables clock stretching during a flash program or erase operation.

1 = The device will clock stretch (up to the timeout for I2C devices) during flash operations.

0 = The device will NACK any I2C engine interrupt that occurs during a flash operation (program or erase).

RSVD(Bit 6): Reserved. Do no use.

BLT1 (Bit 5): Bus low timeout

1,1 = 3-s SBS bus low timeout

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

0,1 = 1-s SBS bus low timeout

0,0 = No SBS bus low timeout

BLT0 (Bit 4): Bus low timeout

1,1 = 3-s SBS bus low timeout

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

0,1 = 1-s SBS bus low timeout

0,0 = No SBS bus low timeout

XL (Bit 3): Enables 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)

Note: When PEC = 1, it enables the PEC calculation when communicating with the host. PEC is a CRC calculation that is included in the I2C protocol. It is used to verify the integrity of the data being transmitted. When enabled, the gauge will calculate the PEC and transmit it along with the data. The host will then calculate the PEC and verify it against the one received * from the gauge.

CPE (Bit 1): PEC on charger broadcast

1 = Enabled

0 = Disabled (default)

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

1 = Enabled

0 = Disabled (default)

17.1.1.6 Auth Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Auth Config	H1	0x0	0x0E	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	DF_READ_EN	SHA1_SECURE	SPLIT_RESPONSE	RSVD

RSVD (Bits 7–4): Reserved. Do not use.

DF_READ_EN (Bit 3): Enables data flash read in SEALED mode

1 = Enables data flash read in SEALED mode. The host can read data flash parameters without unsealing the device. This is useful for applications that need to verify configuration without compromising security.

0 = Data flash read in SEALED mode not allowed (default). The device must be unsealed to read data flash parameters.

SHA1_SECURE (Bit 2): Enables secure memory usage for encryption key storage

1 = Enables secure memory usage. When enabled, the authentication key is stored in secure (OTP) memory. The key can only be written once and cannot be changed after programming. This provides maximum security for production devices.

0 = Disables secure memory usage (default). The authentication key is stored in standard data flash and can be updated using *AuthenticationKey()* command while in FULL ACCESS mode.

SPLIT_RESPONSE (Bit 1): Enables splitting of the authentication response into two 30-byte fields

1 = Enables split response mode. The 60-byte authentication response (32-byte HMAC + 32-byte challenge echo, minus 4 bytes overhead) is divided into two 30-byte fields. The host must read twice to retrieve the complete response. This mode is useful for hosts with limited I2C buffer sizes.

0 = Disables split response mode (default). The authentication response is returned as a single 60-byte field in one read operation.

RSVD (Bit 0): Reserved. Do not use.

17.1.1.7 Power Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Power Config	H2	0x0	0x7FBF	0x0000	Hex

15	14	13	12	11	10	9	8
RSVD	SHIPM_ON_RST	IO_TIMEOUT	IO_PUL_DIS	IO_POL	IO_SHUT	RSVD	SLP_ACCUM

7	6	5	4	3	2	1	0
RSVD	RSOC_SD	CHECK_WAKE_FET	CHECK_WAKE	EMSHUT_EXIT_COMM	EMSHUT_EXIT_VPACK	PWR_SAVE_VSHUT	AUTO_SHIP_EN

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

SHIPM_ON_RST (Bit 14): Save and restore SHIP mode MAC status on reset

1 = Enabled: Retains MAC status and SHIPM flag through power-on reset (POR) when gauge is in SHIP mode

0 = Disabled: SHIPM flag clears on reset

IO_TIMEOUT (Bit 13): IO-Based Shutdown Timeout enable

1 = IO Shutdown timeout count-down is enabled

0 = IO Shutdown timeout count-down is disabled

IO_PUL_DIS (Bit 12): IO-Based Shutdown Pullup Disable

1 = Pullup disabled

0 = Pullup enabled (active only during read)

IO_POL (Bit 11): IO Based Shutdown Polarity

1 = Active high

0 = Active low

IO_SHUT (Bit 10): Enables the IO Based Shutdown feature

1 = Enabled

0 = Disabled

RSVD (Bit 9): Reserved. Do not use.

SLP_ACCUM (Bit 8): Enables charge accumulation while in SLEEP mode

1 = Enables charge accumulation in SLEEP mode

0 = Disables charge accumulation in SLEEP mode

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

RSOC_SD (Bit 6): Enables low RSOC time-based shutdown feature

1 = Enables auto shutdown after the RSOC ≤ ***Low RSOC SD Threhold*** for more than the time interval specified in ***Low RSOC SD Time*** without charge current detection

0 = Disables the low RSOC time-based shutdown feature

CHECK_WAKE_FET (Bit 5): Enables the CHG and DSG FETs not to be forced off during the ***Delay*** timer period

1 = FETs are not to be forced off during the ***Delay*** timer period.

0 = FETs are forced off during the ***Delay*** timer period.

CHECK_WAKE (Bit 4): Enables option to manage unintended wakeup from SHUTDOWN.

1 = Enables this option for unintended wakeup

0 = Disables this option for unintended wakeup

EMSHUT_EXIT_COMM (Bit 3): Enables exit from Emergency FET Shutdown if valid SMBus communication is received. Valid SMBus communication means a valid gauge address and any command is received (that is, an invalid command with a valid address is acceptable).

1 = Enables valid communication reception based exit from EMSHUT

0 = Disables valid communication reception based exit from EMSHUT

EMSHUT_EXIT_VPACK (Bit 2): This bit enables exit from an emergency FET shutdown if the voltage at the PACK pin > ***Charger Present Threshold*** for two samples (~2 s).

1 = Enables PACK voltage based exit from EMSHUT

0 = Disables PACK voltage based exit from EMSHUT

PWR_SAVE_VSHUT (Bit 1): Enables POWER SAVE SHUTDOWN when specific thresholds have been reached.

1 = Enables POWER SAVE SHUTDOWN

0 = Disables POWER SAVE SHUTDOWN

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

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

0 = Disables the auto shutdown feature

17.1.1.8 IO Config

The ***IO Config*** data flash parameter configures three independent GPIO-related features: Battery Trip Point (BTP) interrupt output (***BTP_EN*** , bit 0), BTP threshold source selection (***BTP_MODE*** , bit 2), general-purpose GPIO output mode for Flag Map Setup (***GPIO_EN*** , bit 3), and Permanent Failure (PF) indication output (***GPIO_PF*** , bit 4). Each feature uses a separately configured package pin.

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	IO Config	H2	0x0000	0x001D	0x0000	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	GPIO_PF	GPIO_EN	BTP_MODE	RSVD	BTP_EN

RSVD (Bits 7–5): Reserved. Do not use.

GPIO_PF (Bit 4): Enables a GPIO output pin to indicate a Permanent Failure (PF) condition. When set, the pin assigned to the GPIO_PF function in the GPIO configuration data flash is driven high after a PF event is detected. The pin remains asserted for the duration configured by ***GPIO Timeout*** ; if ***GPIO Timeout*** is 0, the pin is held asserted indefinitely. This bit is independent of ***GPIO_EN*** .

1 = Enabled

0 = Disabled (default)

GPIO_EN (Bit 3): Enables general-purpose GPIO output mode. When set, two functions become active:

- The *Flag Map Setup* entries are activated. This allows the device to assert a pin in response to conditions such as over-temperature, full charge, or a safety event. When ***GPIO_EN*** = 0, all Flag Map outputs are inactive regardless of the Flag Map Setup configuration.
- The *GPIORead()* and *GPIOWrite()* SBS commands become accessible for the configured GPIO pins.

1 = Enabled

0 = Disabled (default)

BTP_MODE (Bit 2): Selects the threshold source for the Battery Trip Point (BTP) comparison.

1 = BTP threshold compared against *RelativeSoC()* in %

0 = BTP threshold compared against *RemainingCapacity()* in mAh (default)

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

BTP_EN (Bit 0): Enables assertion of the BTP pin

1 = Enables assertion of the BTP pin when BTP is triggered.

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

17.1.1.9 Temperature Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Temperature Enable	H1	0	0xFF	0x03	hex

Description: Enables temperature sensor inputs. Bit 0: Internal temp, Bit 1: External temp 1. Default 0x03 enables internal and first external sensor.

Default value updated per FW v0.03 Build 4 (previous TRM value: 0xFF).

17.1.1.10 Temperature Mode

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Temperature Mode	H1	0	0xFF	0x01	hex

Description: Temperature measurement mode configuration. Controls which temperature source is used for gauging calculations.

Default value updated per FW v0.03 Build 4 (previous TRM value: 0x04).

17.1.1.11 DA Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	DA Configuration	H2	0x0	0xFFFF	0x001c	Hex

15	14	13	12	11	10	9	8
CTEMP1	CTEMP0	RSVD	RSVD	RSVD	ISI ACCUM	RSVD	EMSHUT_ PEXIT_DIS

7	6	5	4	3	2	1	0
FTEMP	DISCONN_EN	EMSHUT_EN	SLEEP	IN_SYSTEM _SLEEP	NR	RSVD	RSVD

CTEMP (Bits 15–14): Defines which temperature sensor's output is displayed by the SBS *Temperature()* command

1, 1 = Smart temperature

1, 0 = Minimum temperature

0, 1 = Average temperature

0, 0 = Maximum temperature (default)

RSVD (Bits 13–11): Reserved. Do not use.

ISI_ACCUM (Bit 10): Internal short indication accumulation enable

1 = Enabled

0 = Disabled

RSVD (Bit 9): Reserved. Do not use.

EMSHUT_PEXIT_DIS (Bit 8): Disables the SHUTDN pin exit option of the Emergency FET Shutdown feature (when a high-to-low transition on the SHUTDN pin is detected).

1 = Prevents usage of SHUTDN pin as exit option

0 = Allows usage of SHUTDN pin as an exit option (default)

FTEMP (Bit 7): FET temperature protection source

1 = Average

0 = MAX (default)

DISCONN_EN (Bit 6): System Disconnect

1 = Enabled

0 = Disabled

EMSHUT_EN (Bit 5): Emergency FET Shutdown Enable

1 = Enabled

0 = Disabled

SLEEP (Bit 4): SLEEP mode

1 = Enables SLEEP mode (default)

0 = Disables SLEEP mode

IN_SYSTEM_SLEEP (Bit 3): In-system SLEEP mode

1 = Enables (default)

0 = Disables

NR (Bit 2): Use $\overline{PRES}$ in system detection

1 = NON-REMOVABLE mode (default)

0 = Use $\overline{PRES}$, REMOVABLE mode

RSVD (Bits 1–0): Reserved. Do not use.

17.1.1.12 SOC Flag Config A

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SOC Flag Config A	H2	0x0	0x0FFF	0x0C8C	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 (Bits 15–12): Reserved. Do not use.

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

1 = Enabled (default)

0 = Disabled

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

1 = Enabled (default)

0 = Disabled

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

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

1 = Enabled (default)

0 = Disabled

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

1 = Enabled

0 = Disabled (default)

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

1 = Enabled

0 = Disabled (default)

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

1 = Enabled

0 = Disabled (default)

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

1 = Enabled (default)

0 = Disabled

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

1 = Enabled (default)

0 = Disabled

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

1 = Enabled

0 = Disabled (default)

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

1 = Enabled

0 = Disabled (default)

17.1.1.13 SOC Flag Config B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	SOC Flag Config B	H2	0x0	0x00FF	0x008C	Hex

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

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

1 = Enabled (default)

0 = Disabled

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

1 = Enabled

0 = Disabled (default)

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

1 = Enabled

0 = Disabled (default)

FCSETV (Bit 4): Enables the FC flag set by cell voltage threshold

1 = Enabled

0 = Disabled (default)

FDCLEARRSOC (Bit 3): Enables the FD flag clear by RSOC threshold

1 = Enabled (default)

0 = Disabled

FDSETRSOC Bit 2: Enables the FD flag set by RSOC threshold

1 = Enabled (default)

0 = Disabled

FDCLEARV (Bit 1): Enables the FD flag clear by cell voltage threshold

1 = Enabled

0 = Disabled (default)

FDSETV (Bit 0): Enables the FD flag set by cell voltage threshold

1 = Enabled

0 = Disabled (default)

17.1.1.14 IT Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	IT Gauging Configuration	H2	0x0000	0xFDFF	0xD0FE	Hex

15	14	13	12	11	10	9	8
DOD_RSCALE_EN	RELAX_SMOOTH_OK	TDELTAV	SMOOTH	RELAX_JUMP_OK	DELAY_DROP_TO_0	RSVD	FAST_QMAX_FLD

7	6	5	4	3	2	1	0
FAST_QMAX_LRN	RSOC_CONV	LFP_RELAX	DOD0EW	OCVFR	RFACTSTEP	CSYNC	CCT

DOD_RSCALE_EN (Bit 15): Configures which DOD the new RScale is to be applied.

1 = The RScale is only applied to DODs higher than the DOD where the RScale was calculated.

0 = The RScale is applied to all DODs during IT simulations.

RELAX_SMOOTH_OK (Bit 14): Smooth RSOC during RELAX mode

1 = Enabled (default)

0 = Disabled

TDELTAV (Bit 13): TURBO Mode Delta Voltage

1 = Must set this flag to 1 to support TURBO mode.

0 = Use of ***DeltaVoltage*** learned as the maximal difference between instantaneous and average voltage (default).

SMOOTH (Bit 12): Smooth RSOC

1 = Smoothed *FullChargeCapacity()* and *RemainingCapacity()* is used (default).

0 = True *FullChargeCapacity()* and *RemainingCapacity()* is used.

RELAX_JUMP_OK (Bit 11): Allows RSOC jump during RELAX mode

1 = Enabled

0 = Disabled (default)

DELAY_DROP_TO_0 (Bit 10): Delay

1 = Enabled

0 = Disabled (default)

RSVD (Bit 9): Reserved. Do not use.

FAST_QMAX_FLD (Bit 8): Fast Qmax Update in Field

1 = Enabled

0 = Disabled (default)

FAST_QMAX_LRN (Bit 7): Fast Qmax Update in Learning

1 = Enabled (default)

0 = Disabled

RSOC_CONV (Bit 6): RSOC Convergence (Fast Scaling)

1 = Enabled (default)

0 = Disabled

LFP_RELAX (Bit 5): Lithium Iron Phosphate Relax

1 = Enabled (default)

0 = Disabled

DOD0EW (Bit 4): DOD0 Error Weighting

1 = Enabled (default)

0 = Disabled

OCVFR (Bit 3): Open Circuit Voltage Flat Region

1 = Enabled (default)

0 = Disabled

RFACTSTEP (Bit 2): Ra Factor Step

1 = Enabled (default).

0 = Disabled

CSYNC (Bit 1): Sync *RemainingCapacity()* with *FullChargeCapacity()* at valid charge termination

1 = Synchronized (default)

0 = Not synchronized

CCT (Bit 0): Cycle Count Threshold

1 = Use CC % of *FullChargeCapacity()*

0 = Use CC % of *DesignCapacity()* (default)

17.1.1.15 IT Gauging Ext

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	IT Gauging Ext	H2	0x0000	0x03FF	0x005A	Hex

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	EDV_CONV	FOCV_EN

7	6	5	4	3	2	1	0
SOH_LEARN_EN	TS1	TS0	THERM_SAT	THERM_IV	AMB_PRED	CHG_100_SMOOTH_OK	DSG_0_SMOOTH_OK

RSVD (Bits 15–10): Reserved. Do not use.

EDV_CONV (Bit 9): Enables the EVCS feature

1= Enabled

0 = Disabled (default)

FOCV_EN (Bit 8): Enables fast OCV feature

1= Enabled

0 = Disabled (default)

SOH_LEARN_EN (Bit 7): Enables SOH FCC learning

1 = Enabled

0 = Disabled (default)

TS1 (Bit 6), TS0 (Bit 5): These two bits select how the IT algorithm aggregates the enabled cell temperature sources (internal thermistor and any thermistor pins configured via IO Config).

1,1 = Not used

1,0 = Min Temperature is used (IT uses the lowest temperature among all enabled cell temperature sources). (Default)

0,1 = Avg Temperature is used (IT uses the average of all enabled cell temperature sources)

0,0 = Max Temperature is used (IT uses the highest temperature among all enabled cell temperature sources)

THERM_SAT (Bit 4): Thermal saturation enables adjustment of the IT thermal model

1 = Enables adjustment of the IT thermal model

0 = Disables adjustment of the IT thermal model

THERM_IV (Bit 3): Enables freeze of the temperature model at certain points in IT to prevent overestimation by the thermal model

1 = Enables Freeze of the temperature model

0 = Disables Freeze of the temperature model

AMB_PRED (Bit 2): Enables ambient temperature prediction in modes other than RELAX

1 = Enables ambient temperature prediction

0 = Disables ambient temperature prediction

CHG_100_SMOOTH_OK (Bit 1): Enables smoothing in the charge direction when there is a jump to 100%

1 = Enables smoothing to 100%

0 = Disables smoothing to 100%

DSG_0_SMOOTH_OK (Bit 0): Enables smoothing in the discharge direction when there is a jump to 0%. When enabled, this smoothing option must be used in conjunction with ***Term Smooth Start Cell V Delta*** , ***Term Smooth Time*** , and ***Term Smooth Final Cell V Delta*** . If not configured properly, this smoothing option can cause remaining capacity to report 0 too early.

1 = Enables smoothing to 0%

0 = Disables smoothing to 0%

17.1.1.16 Elevated Degrade Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Elevated Degrade Configuration	H1	0x00	0xFF	0x15	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	EVTM_EXT_MODE	ERETM_MAX_T	ERETM_MODE	ERETM_TIME	ERM_MODE	ERM_TIME

RSVD (Bits 7–6): Reserved. Do not use.

EVTM_EXT_MODE (Bit 5):

1 = Enables ***Elevated Voltage Extended Charge Degradation*** when ERETM is activated

0 = Disables ***Elevated Voltage Extended Charge Degradation***

ERETM_MAX_T (Bit 4):

1 = Enables ***ERETM Temperature Max Threshold*** for immediate *[ERETM]* mode

0 = Disables ***ERETM Temperature Max Threshold*** for immediate *[ERETM]* mode

ERETM_MODE (Bit 3):

1 = Uses voltage thresholds for ERETM

0 = Uses RSOC thresholds for ERETM

ERETM_TIME (Bit 2):

1 = Enables ERETM

0 = Disables ERETM

ERM_MODE (Bit 1):

1 = Uses voltage thresholds for ERM

0 = Uses RSOC thresholds for ERM

ERM_TIME (Bit 0):

1 = Enables ERM

0 = Disables ERM

17.1.1.17 DZT Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	DZT Gauging Configuration	H2	0x0000	0x0001	0x0001	Hex

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

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

RSVD (Bits 15–1): Reserved. Do not use.

PERF_MODE (Bit 0): Performance mode enable. The bit allows the gauge enters performance mode to fit the dynamic load profile.

1 = Enables performance mode

0 = Disables performance mode

17.1.2 Flag Map

17.1.2.1 Set Up 1 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 1 Configuration	H2	0x0000	0xFFFF	0x0000	Hex

15	14	13	12	11	10	9	8
FLAG_EN	RSVD	FLAG_OD	FLAG_OR	RSVD	RSVD	RSVD	FLAG_POL

7	6	5	4	3	2	1	0
FLAG_BIT3	FLAG_BIT2	FLAG_BIT1	FLAG_BIT0	FLAG_REG3	FLAG_REG2	FLAG_REG1	FLAG_REG0

FLAG_EN (Bit 15): Enable/disable the control

1 = Enable

0 = Disable

RSVD (Bit 14): Reserved. Do not use.

FLAG_OD (Bit 13): Determines whether the GPIO pin is driven between two levels as hi-Z/driven-low (that is, open drain) or as driven-high/driven-low (that is, active high).
Note: The *[FLAG_OD]* bit cannot be set differently by separate controls when mapped to the same GPIO pin.

1 = Hi-Z/driven-low

0 = Driven-high/driven-low

FLAG_OR (Bit 12): The flag OR'ed vs AND'ed with other flags mapped to the same GPIO pin. This OR/AND operation takes place after the polarity from *FLAG_POL* is evaluated.

1 = OR Operation

0 = AND Operation

RSVD (Bit 11, 10, 9): Reserved. Do not use.

FLAG_POL (Bit 8): Polarity of the flag when mapped to a GPIO pin

1 = Invert flag polarity

0 = No change to flag polarity

FLAG_BIT3, FLAG_BIT2, FLAG_BIT1, FLAG_BIT0 (Bit 7, Bit 6, Bit 5, Bit 4): Bit position within the 16-bit register of the flag

0, 0, 0, 0 = Bit 0

0, 0, 0, 1 = Bit 1

0, 0, 1, 0 = Bit 2

0, 0, 1, 1 = Bit 3

0, 1, 0, 0 = Bit 4

0, 1, 0, 1 = Bit 5

0, 1, 1, 0 = Bit 6

0, 1, 1, 1 = Bit 7

1, 0, 0, 0 = Bit 8

1, 0, 0, 1 = Bit 9

1, 0, 1, 0 = Bit 10

1, 0, 1, 1 = Bit 11

1, 1, 0, 0 = Bit 12

1, 1, 0, 1 = Bit 13

1, 1, 1, 0 = Bit 14

1, 1, 1, 1 = Bit 15

FLAG_REG3, FLAG_REG2, FLAG_REG1, FLAG_REG0 (Bit 3, Bit 2, Bit 1, Bit 0): Address of the register that contains the flag

0, 0, 0, 0 = *BatteryMode()*

0, 0, 0, 1 = *BatteryStatus()*

0, 0, 1, 0 = *OperationStatusA()*, lower 16 bits of *OperationStatus()*

0, 0, 1, 1 = *OperationStatusB()*, higher 16 bits of *OperationStatus()*

0, 1, 0, 0 = *ChargingStatus()*

0, 1, 0, 1 = *TempStatus()*

0, 1, 1, 0 = *GaugingStatus()*

0, 1, 1, 1 = *ITStatus()*

1, 0, 0, 0 = *SafetyStatusAB()*, lower 16 bits of *SafetyStatus()*

1, 0, 0, 1 = *SafetyStatusCD()*, higher 16 bits of *SafetyStatus()*

1, 0, 1, 0 = Any Safety Status bit in *SafetyStatus()*

1, 0, 1, 1 = *PFStatusAB()*, lower 16 bits of *PFStatus()*

1, 1, 0, 0 = *PFStatusCD()*, higher 16 bits of *PFStatus()*

1, 1, 0, 1 = Any PF Status bit in *PFStatus()*

1, 1, 1, 0 = Unused

1, 1, 1, 1 = Unused

17.1.2.2 Set Up 1 Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 1 Pin Number	U1	0x00	0xFF	0x00	—

Value	Pin Assignment
0x00 =	Disabled (No pin assigned)
0xC2 =	Pad C2 (INT pin)

Description: Package pin assigned as the GPIO output for this flag map entry. Pad C2 (INT pin) is the only pin available for flag map output assignment. The remaining GPIO-capable pads are reserved for dedicated battery and communication functions: pad C1 (TS/thermistor), pad C3 (CP_BOOT), pad D3 (SDA), and pad E3 (SCL).

17.1.2.3 Set Up 2 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 2 Configuration	H2	0x0000	0xFFFF	0x0000	Hex

15	14	13	12	11	10	9	8
FLAG_EN	RSVD	FLAG_OD	FLAG_OR	RSVD	RSVD	RSVD	FLAG_POL

7	6	5	4	3	2	1	0
FLAG_BIT3	FLAG_BIT2	FLAG_BIT1	FLAG_BIT0	FLAG_REG3	FLAG_REG2	FLAG_REG1	FLAG_REG0

FLAG_EN (Bit 15): Enable/disable the control

1 = Enable

0 = Disable

RSVD (Bit 14): Reserved. Do not use.

FLAG_OD (Bit 13): This bit determines whether the GPIO pin is driven between two levels as hi-Z/driven-low (that is, open drain) or as driven-high/driven-low (that is, active high).
Note: The *[FLAG_OD]* bit cannot be set differently by separate controls when mapped to the same GPIO pin.

1 = Hi-Z/driven-low

0 = Driven-high/driven-low

FLAG_OR (Bit 12): The flag OR'ed vs AND'ed with other flags mapped to the same GPIO pin. This OR/AND operation takes place after the polarity from FLAG_POL is evaluated.

1 = OR Operation

0 = AND Operation

RSVD (Bit 11, 10, 9): Reserved. Do not use.

FLAG_POL (Bit 8): Polarity of the flag when mapped to a GPIO pin

1 = Invert flag polarity

0 = No change to flag polarity

FLAG_BIT3, FLAG_BIT2, FLAG_BIT1, FLAG_BIT0 (Bit 7, Bit 6, Bit 5, Bit 4): Bit position within the 16-bit register of the flag

0, 0, 0, 0 = Bit 0

0, 0, 0, 1 = Bit 1

0, 0, 1, 0 = Bit 2

0, 0, 1, 1 = Bit 3

0, 1, 0, 0 = Bit 4

0, 1, 0, 1 = Bit 5

0, 1, 1, 0 = Bit 6

0, 1, 1, 1 = Bit 7

1, 0, 0, 0 = Bit 8

1, 0, 0, 1 = Bit 9

1, 0, 1, 0 = Bit 10

1, 0, 1, 1 = Bit 11

1, 1, 0, 0 = Bit 12

1, 1, 0, 1 = Bit 13

1, 1, 1, 0 = Bit 14

1, 1, 1, 1 = Bit 15

FLAG_REG3, FLAG_REG2, FLAG_REG1, FLAG_REG0 (Bit 3, Bit 2, Bit 1, Bit 0): Address of the register that contains the flag

0, 0, 0, 0 = *BatteryMode()*

0, 0, 0, 1 = *BatteryStatus()*

0, 0, 1, 0 = *OperationStatusA()*, lower 16 bits of *OperationStatus()*

0, 0, 1, 1 = *OperationStatusB()*, higher 16 bits of *OperationStatus()*

0, 1, 0, 0 = *ChargingStatus()*

0, 1, 0, 1 = *TempStatus()*

0, 1, 1, 0 = *GaugingStatus()*

0, 1, 1, 1 = *ITStatus()*

1, 0, 0, 0 = *SafetyStatusAB()*, lower 16 bits of *SafetyStatus()*

1, 0, 0, 1 = *SafetyStatusCD()*, higher 16 bits of *SafetyStatus()*

1, 0, 1, 0 = Any Safety Status bit in *SafetyStatus()*

1, 0, 1, 1 = *PFStatusAB()*, lower 16 bits of *PFStatus()*

1, 1, 0, 0 = *PFStatusCD()*, higher 16 bits of *PFStatus()*

1, 1, 0, 1 = Any PF Status bit in *PFStatus()*

1, 1, 1, 0 = Unused

1, 1, 1, 1 = Unused

17.1.2.4 Set Up 2 Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 2 Pin Number	U1	0x00	0x0A	0x00	#

Value	Pin Assignment
0 =	Disabled (No pin assigned)
1 =	INT (Pad C2) - Programmable interrupt/GPIO output

Note: The device is a 15-pad BGA package. The INT pin (pad C2) is the only GPIO-capable pin that can be used for flag mapping. The INT pin can be configured as a programmable output interrupt or GPIO via device firmware.

17.1.2.5 Set Up 3 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 3 Configuration	H2	0x0000	0xFFFF	0x0000	Hex

15	14	13	12	11	10	9	8
FLAG_EN	RSVD	FLAG_OD	FLAG_OR	RSVD	RSVD	RSVD	FLAG_POL

7	6	5	4	3	2	1	0
FLAG_BIT3	FLAG_BIT2	FLAG_BIT1	FLAG_BIT0	FLAG_REG3	FLAG_REG2	FLAG_REG1	FLAG_REG0

FLAG_EN (Bit 15): Enable/disable the control

1 = Enable

0 = Disable

RSVD (Bit 14): Reserved. Do not use.

FLAG_OD (Bit 13): This bit determines whether the GPIO pin is driven between two levels as hi-Z/driven-low (that is, open drain) or as driven-high/driven-low (that is, active high).
Note: The *[FLAG_OD]* bit cannot be set differently by separate controls when mapped to the same GPIO pin.

1 = Hi-Z/driven-low

0 = Driven-high/driven-low

FLAG_OR (Bit 12): The flag OR'ed vs AND'ed with other flags mapped to the same GPIO pin. This OR/AND operation takes place after the polarity from *[FLAG_POL]* is evaluated.

1 = OR Operation

0 = AND Operation

RSVD (Bit 11, 10, 9): Reserved. Do not use.

FLAG_POL (Bit 8): Polarity of the flag when mapped to a GPIO pin

1 = Invert flag polarity

0 = No change to flag polarity

FLAG_BIT3, FLAG_BIT2, FLAG_BIT1, FLAG_BIT0 (Bit 7, Bit 6, Bit 5, Bit 4): Bit position within the 16-bit register of the flag

0, 0, 0, 0 = Bit 0

0, 0, 0, 1 = Bit 1

0, 0, 1, 0 = Bit 2

0, 0, 1, 1 = Bit 3

0, 1, 0, 0 = Bit 4

0, 1, 0, 1 = Bit 5

0, 1, 1, 0 = Bit 6

0, 1, 1, 1 = Bit 7

1, 0, 0, 0 = Bit 8

1, 0, 0, 1 = Bit 9

1, 0, 1, 0 = Bit 10

1, 0, 1, 1 = Bit 11

1, 1, 0, 0 = Bit 12

1, 1, 0, 1 = Bit 13

1, 1, 1, 0 = Bit 14

1, 1, 1, 1 = Bit 15

FLAG_REG3, FLAG_REG2, FLAG_REG1, FLAG_REG0 (Bit 3, Bit 2, Bit 1, Bit 0): Address of the register containing the flag

0, 0, 0, 0 = *BatteryMode()*

0, 0, 0, 1 = *BatteryStatus()*

0, 0, 1, 0 = *OperationStatusA()*, lower 16 bits of *OperationStatus()*

0, 0, 1, 1 = *OperationStatusB()*, higher 16 bits of *OperationStatus()*

0, 1, 0, 0 = *ChargingStatus()*

0, 1, 0, 1 = *TempStatus()*

0, 1, 1, 0 = *GaugingStatus()*

0, 1, 1, 1 = *ITStatus()*

1, 0, 0, 0 = *SafetyStatusAB()*, lower 16 bits of *SafetyStatus()*

1, 0, 0, 1 = *SafetyStatusCD()*, higher 16 bits of *SafetyStatus()*

1, 0, 1, 0 = Any Safety Status bit in *SafetyStatus()*

1, 0, 1, 1 = *PFStatusAB()*, lower 16 bits of *PFStatus()*

1, 1, 0, 0 = *PFStatusCD()*, higher 16 bits of *PFStatus()*

1, 1, 0, 1 = Any PF Status bit in *PFStatus()*

1, 1, 1, 0 = Unused

1, 1, 1, 1 = Unused

17.1.2.6 Set Up 3 Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 3 Pin Number	U1	0x00	0x0A	0x00	#

Value	Pin Assignment
0 =	Disabled (No pin assigned)
1 =	INT (Pad C2) - Programmable interrupt/GPIO output

Note: The device is a 15-pad BGA package. The INT pin (pad C2) is the only GPIO-capable pin that can be used for flag mapping. The INT pin can be configured as a programmable output interrupt or GPIO via device firmware.

17.1.2.7 Set Up 4 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 4 Configuration	H2	0x0000	0xFFFF	0x0000	Hex

15	14	13	12	11	10	9	8
FLAG_EN	RSVD	FLAG_OD	FLAG_OR	RSVD	RSVD	RSVD	FLAG_POL

7	6	5	4	3	2	1	0
FLAG_BIT3	FLAG_BIT2	FLAG_BIT1	FLAG_BIT0	FLAG_REG3	FLAG_REG2	FLAG_REG1	FLAG_REG0

FLAG_EN (Bit 15): Enable/disable the control

1 = Enable

0 = Disable

RSVD (Bit 14): Reserved. Do not use.

FLAG_OD (Bit 13): This bit determines whether the GPIO pin is driven between two levels as hi-Z/driven-low (that is, open drain) or as driven-high/driven-low (that is, active high).
Note: The *[FLAG_OD]* bit cannot be set differently by separate controls when mapped to the same GPIO pin.

1 = Hi-Z/driven-low

0 = Driven-high/driven-low

FLAG_OR (Bit 12): Flag OR'ed vs AND'ed with other flags mapped to the same GPIO pin. This OR/AND operation takes place after the polarity from *[FLAG_POL]* is evaluated.

1 = OR Operation

0 = AND Operation

RSVD (Bit 11, 10, 9): Reserved. Do not use.

FLAG_POL (Bit 8): Polarity of the flag when mapped to a GPIO pin

1 = Invert flag polarity

0 = No change to flag polarity

FLAG_BIT3, FLAG_BIT2, FLAG_BIT1, FLAG_BIT0 (Bit 7, Bit 6, Bit 5, Bit 4): Bit position within the 16-bit register of the flag

0, 0, 0, 0 = Bit 0

0, 0, 0, 1 = Bit 1

0, 0, 1, 0 = Bit 2

0, 0, 1, 1 = Bit 3

0, 1, 0, 0 = Bit 4

0, 1, 0, 1 = Bit 5

0, 1, 1, 0 = Bit 6

0, 1, 1, 1 = Bit 7

1, 0, 0, 0 = Bit 8

1, 0, 0, 1 = Bit 9

1, 0, 1, 0 = Bit 10

1, 0, 1, 1 = Bit 11

1, 1, 0, 0 = Bit 12

1, 1, 0, 1 = Bit 13

1, 1, 1, 0 = Bit 14

1, 1, 1, 1 = Bit 15

FLAG_REG3, FLAG_REG2, FLAG_REG1, FLAG_REG0 (Bit 3, Bit 2, Bit 1, Bit 0): Address of the register that contains the flag

0, 0, 0, 0 = *BatteryMode()*

0, 0, 0, 1 = *BatteryStatus()*

0, 0, 1, 0 = *OperationStatusA()*, lower 16 bits of *OperationStatus()*

0, 0, 1, 1 = *OperationStatusB()*, higher 16 bits of *OperationStatus()*

0, 1, 0, 0 = *ChargingStatus()*

0, 1, 0, 1 = *TempStatus()*

0, 1, 1, 0 = *GaugingStatus()*

0, 1, 1, 1 = *ITStatus()*

1, 0, 0, 0 = *SafetyStatusAB()*, lower 16 bits of *SafetyStatus()*

1, 0, 0, 1 = *SafetyStatusCD()*, higher 16 bits of *SafetyStatus()*

1, 0, 1, 0 = Any Safety Status bit in *SafetyStatus()*

1, 0, 1, 1 = *PFStatusAB()*, lower 16 bits of *PFStatus()*

1, 1, 0, 0 = *PFStatusCD()*, higher 16 bits of *PFStatus()*

1, 1, 0, 1 = Any PF Status bit in *PFStatus()*

1, 1, 1, 0 = Unused

1, 1, 1, 1 = Unused

17.1.2.8 Set Up 4 Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 4 Pin Number	U1	0x00	0x0A	0x00	#

Value	Pin Assignment
0 =	Disabled (No pin assigned)
1 =	INT (Pad C2) - Programmable interrupt/GPIO output

Note: The device is a 15-pad BGA package. The INT pin (pad C2) is the only GPIO-capable pin that can be used for flag mapping. The INT pin can be configured as a programmable output interrupt or GPIO via device firmware.

17.1.3 GPIO

17.1.3.1 Pres Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Pres Pin Number	U1	0x00	0xFF	0xC3	—

Description: Package pin number assigned to the system presence detection input. When the ***NR*** flag is cleared, the firmware samples this pin as an active-low input to detect whether the device is installed in a system. Setting this parameter to 0x00 disables the system presence function.

17.1.3.2 Disconnect Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Disconnect Pin Number	U1	0	0xFF	0	—

Description: Package pin number used for disconnect pin.

17.1.3.3 Emergency Shutdown Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Emergency Shutdown Pin Number	U1	0	0xFF	0	—

Description: Package pin number used for ESHUT pin.

17.1.3.4 IO Shutdown Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	IO Shutdown Pin Number	U1	0	0xFF	0	—

Description: Package pin number used for IO Shutdown pin.

17.1.3.5 BTP Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	BTP Pin Number	U1	0	0xFF	0	—

Description: Package pin number used for BTP interrupts.

17.1.3.6 BTP Pin Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	BTP Pin Config	H1	0x0	0x02	2	Hex

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

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

ACTIVE_HI (Bit 1): Assert Polarity

1 = Active high (default)

0 = Active low

RSVD (Bit 0): Reserved. Do not use.

17.1.3.7 GPIO_PF Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_PF Pin Number	U1	0	0xFF	0	—

Description: Package pin number used for indicating PF on GPIO.

17.1.3.8 GPIO_INT Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_INT Enable	H1	0x00	0x73	0x40	Hex

7	6	5	4	3	2	1	0
RSVD	RC2_PIN_C3	RC1_PIN_C1	RC0_PIN_C2	RSVD	RSVD	RA1_PIN_E3	RA0_PIN_D3

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

RC2_PIN_C3 (Bit 6): Enable RC2 (package pin C3) for GPIO

1 = Enabled (default)

0 = Disabled

RC1_PIN_C1 (Bit 5): Enable RC1 (package pin C1) for GPIO

1 = Enabled

0 = Disabled (default)

RC0_PIN_C2 (Bit 4): Enable RC0 (package pin C2) for GPIO

1 = Enabled

0 = Disabled (default)

RSVD (Bits 3–2): Reserved. Do not use.

RA1_PIN_E3 (Bit 1): Enable RA1 (package pin E3) for GPIO

1 = Enabled

0 = Disabled (default)

RA0_PIN_D3 (Bit 0): Enable RA0 (package pin D3) for GPIO

1 = Enabled

0 = Disabled (default)

17.1.3.9 GPIO_INT Output Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_INT Output Enable	H1	0x00	0x73	0x40	Hex

7	6	5	4	3	2	1	0
RSVD	RC2_PIN_C3	RC1_PIN_C1	RC0_PIN_C2	RSVD	RSVD	RA1_PIN_E3	RA0_PIN_D3

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

RC2_PIN_C3 (Bit 6): Initial direction of RC2 (package pin C3)

1 = Enabled for output (default)

0 = Disabled for output. The pin is read as input using pulsed pull-up.

RC1_PIN_C1 (Bit 5): Initial direction of RC1 (package pin C1)

1 = Enabled for output

0 = Disabled for output. The pin is read as input using pulsed pull-up. (default)

RC0_PIN_C2 (Bit 4): Initial direction of RC0 (package pin C2)

1 = Enabled for output

0 = Disabled for output. The pin is read as input using pulsed pull-up. (default)

RSVD (Bits 3–2): Reserved. Do not use.

RA1_PIN_E3 (Bit 1): Initial direction of RA1 (package pin E3)

1 = Enabled for output

0 = Disabled for output. The pin is read as input using pulsed pull-up. (default)

RA0_PIN_D3 (Bit 0): Initial direction of RA0 (package pin D3)

1 = Enabled for output

0 = Disabled for output. The pin is read as input using pulsed pull-up. (default)

17.1.3.10 GPIO_INT Default Out

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_INT Default Out	H1	0x00	0x73	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	RC2_PIN_C3	RC1_PIN_C1	RC0_PIN_C2	RSVD	RSVD	RA1_PIN_E3	RA0_PIN_D3

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

RC2_PIN_C3 (Bit 6): Initial output value of RC2 (package pin C3), if enabled as output by ***GPIO_INT Output Enable***

1 = Initial output is high

0 = Initial output is low (default)

RC1_PIN_C1 (Bit 5): Initial output value of RC1 (package pin C1), if enabled as output by ***GPIO_INT Output Enable***

1 = Initial output is high

0 = Initial output is low (default)

RC0_PIN_C2 (Bit 4): Initial output value of RC0 (package pin C2), if enabled as output by ***GPIO_INT Output Enable***

1 = Initial output is high

0 = Initial output is low (default)

RSVD (Bits 3–2): Reserved. Do not use.

RA1_PIN_E3 (Bit 1): Initial output value of RA1 (package pin E3), if enabled as output by ***GPIO_INT Output Enable***

1 = Initial output is high

0 = Initial output is low (default)

RA0_PIN_D3 (Bit 0): Initial output value of RA0 (package pin D3), if enabled as output by ***GPIO_INT Output Enable***

1 = Initial output is high

0 = Initial output is low (default)

17.1.3.11 Sealed Access Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Sealed Access Config	H1	0x00	0x73	0x40	Hex

7	6	5	4	3	2	1	0
RSVD	RC2_PIN_C3	RC1_PIN_C1	RC0_PIN_C2	RSVD	RSVD	RA1_PIN_E3	RA0_PIN_D3

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

RC2_PIN_C3 (Bit 6): RC2_PIN_C3 SEALED mode access

1 = Enabled (default)

0 = Disabled

RC1_PIN_C1 (Bit 5): RC1_PIN_C1 SEALED mode access

1 = Enabled

0 = Disabled (default)

RC0_PIN_C2 (Bit 4): RC0_PIN_C2 SEALED mode access

1 = Enabled

0 = Disabled (default)

RSVD (Bits 3–2): Reserved. Do not use.

RA1_PIN_E3 (Bit 1): RA1_PIN_E3 SEALED mode access

1 = Enabled

0 = Disabled (default)

RA0_PIN_D3 (Bit 0): RA0_PIN_D3 SEALED mode access

1 = Enabled

0 = Disabled (default)

17.1.4 BTP

17.1.4.1 Init Discharge Set

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	BTP	Init Discharge Set	U2	0	32767	150	mAh

Description: Initial value for *BTPDischargeSet()* if *Settings.Configuration.IO Config[BTP_MODE]* is set to 0.

17.1.4.2 Init Charge Set

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	BTP	Init Charge Set	U2	0	32767	175	mAh

Description: Initial value for *BTPChargeSet()* if *Settings.Configuration.IO Config[BTP_MODE]* is set to 0.

17.1.4.3 Init Charge SOC Set

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	BTP	Init Charge SOC Set	U1	0	100	10	0%

Description: Initial value for *BTPChargeSet()* if *Settings.Configuration.IO Config[BTP_MODE]* is set to 1.

17.1.4.4 Init Discharge SOC Set

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	BTP	Init Discharge SOC Set	U1	0	100	5	%

Description: Initial value for *BTPDischargeSet()* if *Settings.Configuration.IO Config[BTP_MODE]* is set to 1.

17.1.5 Sealed Access

17.1.5.1 DF Only Read Timeout

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Sealed Access	DF Read Only Timeout	U1	0	255	10	s

Description: Time limit on data flash read in DF Read Only mode when gauge is SEALED

17.1.5.2 MfgInfoC Write Timeout

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Sealed Access	MfgInfoC Write Timeout	U1	0	255	10	s

Description: Time limit for *ManufacturerInfoC()* data flash update after MfgInfoC Write MAC sequence is issued while the gauge is SEALED.

Note

Please be aware that this timer will stop if the device enters SLEEP mode within the programmed time limit while ***[AUTO_CAL_EN]*** = 1, and will resume after the auto CC calibration completes.

17.1.6 Lifetimes

17.1.6.1 Lifetimes Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Lifetimes Configuration	H2	0x0000	0xFFFF	0x0000	Hex

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

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

RSVD (Bits 15–1): Reserved. Do not use.

SEALED_RESET (Bit 0): Enables reset of ***Lifetime Data***

1 = Enabled

0 = Disabled

17.1.6.2 Time RSOC Thresholds

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Lifetimes	Time RSOC Threshold A	U1	0	100	95	%
Settings	Lifetimes	Time RSOC Threshold B	U1	0	100	90	%
Settings	Lifetimes	Time RSOC Threshold C	U1	0	100	80	%
Settings	Lifetimes	Time RSOC Threshold D	U1	0	100	50	%
Settings	Lifetimes	Time RSOC Threshold E	U1	0	100	20	%
Settings	Lifetimes	Time RSOC Threshold F	U1	0	100	10	%
Settings	Lifetimes	Time RSOC Threshold G	U1	0	100	5	%

Description: Configure RSOC slots to record Total firmware runtime spent according to running RSOC for a temperature range

17.1.6.3 Temperature Hold-off Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Lifetimes	Temperature Hold-off Time	U1	0	255	5	s

Description: Minimum time required to be in CHARGE, DISCHARGE or RELAX mode to start collecting lifetime temeprature data

17.1.6.4 Time Temperature Limits

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Lifetimes	LFT_T0 Temp	I2	2332	3932	2632	0.1 K
Settings	Lifetimes	Hysteresis Temp LFT_T0	I2	0	150	10	0.1 K
Settings	Lifetimes	LFT_T1 Temp	I2	2332	3932	2732	0.1 K
Settings	Lifetimes	Hysteresis Temp LFT_T1	I2	0	150	10	0.1 K
Settings	Lifetimes	LFT_T2 Temp	I2	2332	3932	2852	0.1 K
Settings	Lifetimes	Hysteresis Temp LFT_T2	I2	0	150	10	0.1 K
Settings	Lifetimes	LFT_T5 Temp	I2	2332	3932	2932	0.1 K
Settings	Lifetimes	Hysteresis Temp LFT_T5	I2	0	150	10	0.1 K
Settings	Lifetimes	LFT_T6 Temp	I2	2332	3932	2982	0.1 K
Settings	Lifetimes	Hysteresis Temp LFT_T6	I2	0	150	10	0.1 K
Settings	Lifetimes	LFT_T3 Temp	I2	2332	3932	3032	0.1 K
Settings	Lifetimes	Hysteresis Temp LFT_T3	I2	0	150	10	0.1 K
Settings	Lifetimes	LFT_T4 Temp	I2	2332	3932	3282	0.1 K
Settings	Lifetimes	Hysteresis Temp LFT_T4	I2	0	150	10	0.1 K

Description: Temperature limits used for Lifetime Temperature-RSOC recording. Settings must follow the ***LFT_T0*** ≤ ***LFT_T1*** ≤ ***LFT_T2*** ≤ ***LFT_T5*** ≤ ***LFT_T6*** ≤ ***LFT_T3*** ≤ ***LFT_T4*** order.

17.1.7 Protection

17.1.7.1 Protection Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Protection Configuration	H2	0x0000	0x000F	0x0000	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	CHECK_FAULT_WAKE	CUDEP_REQ_CHG	CUV_RECOV_CHG	SUV_MODE

RSVD (Bits 7–4): Reserved. Do not use.

CHECK_FAULT_WAKE (Bit 3) If any protection (ignoring the time delay) is active at POR, corresponding FETs are prevented from closing.

1 = Enabled

0= Disabled (default)

CUDEP_REQ_CHG (Bit 2): Requests*ChargingVoltage()* and *ChargingCurrent()* during the copper deposition check while the FETs are off when ***[SUV_MODE]*** is enabled to prevent the charger from turning off before the check is complete.

1 = Enabled

0 = Disabled (default)

CUV_RECOV_CHG (Bit 1): Requires PACK voltage > ***Charger Present Threshold*** to recover *SafetyStatus()[CUV]*

1 = Enabled

0 = Disabled (default)

SUV_MODE (Bit 0): Copper deposition check for *PFStatus()[CUV]*

1 = Enabled

0 = Disabled (default)

17.1.7.2 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
AOCDL	RSVD_ONE	OCD2	OCD1	OCC2	OCC1	COV	CUV

AOCDL (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

17.1.7.3 Enabled Protections B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Enabled Protections B	H1	0x00	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
RSVD	CUVC	OTD	OTC	ASCDL	RSVD_ONE	AOCCL	AOCC

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

CUVC (Bit 6): I*R compensated CUV

1 = Enabled (default)

0 = Disabled

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.

AOCCL (Bit 1): Short circuit in charge latch

1 = Enabled (default)

0 = Disabled

AOCC (Bit 0): Short circuit in charge

1 = Enabled (default)

0 =

17.1.7.4 Enabled Protections C

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Enabled Protections C	H1	0x00	0xFF	0xD5	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): Precharging timeout
1 = Enabled (default)
0 = Disabled

HWDF (Bit 1): SBS Host watchdog timeout
1 = Enabled
0 = Disabled (default)

OTF (Bit 0): FET overtemperature
1 = Enabled (default)
0 = Disabled

17.1.7.5 Enabled Protections D

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Protection	Enabled Protections D	H1	0x00	0xFF	0x0F	Hex

7	6	5	4	3	2	1	0
ACOV	ACUV	OCDL	COVL	UTD	UTC	PCHGC	CHGV

(Bit 7): Over Voltage Hardware based protection
1 = Enabled
0 = Disabled (Default)

(Bit 6): Under Voltage Hardware based protection
1 = Enabled
0 = Disabled (Default)

OCDL (Bit 5): Overcurrent in Discharge related PF
1 = Enabled
0 = Disabled (default)

COVL (Bit 4): Cell Overvoltage Latch related PF
1 = Enabled)
0 = Disabled (default)

UTD (Bit 3): Undertemperature While Not Charging
1 = Enabled (default)
0 = Disabled

UTC (Bit 2): Undertemperature While Charging
1 = Enabled (default)
0 = Disabled

PCHGC (Bit 1): *ChargingCurrent()* higher than requested in precharge

1 = Enabled (default)

0 = Disabled

CHGV (Bit 0): *ChargingVoltage()* higher than requested

1 = Enabled (default)

0 = Disabled

17.1.8 Permanent Failure

17.1.8.1 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
QIM	SOTF	COVL	SOT	SOCD	SOCC	SOV	SUV

QIM (Bit 7): QMax Imbalance

1 = Enabled

0 = Disabled (default)

OTF (Bit 6): Overtemperature FET

1 = Enabled

0 = Disabled (default)

COVL (Bit 5): Cell Overvoltage Latch

1 = Enabled

0 = Disabled (default)

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)

17.1.8.2 Enabled PF B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Permanent Failure	Enabled PF B	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0

ASCDL	AOCCL	AOCDL	VIMA	VIMR	CD	IMP	CB

ASCDL (Bit 7): Short Circuit in Discharge—PF Enable

1 = Enabled

0 = Disabled (default)

AOCCL (Bit 6): Short Circuit in Charge—PF Enable

1 = Enabled

0 = Disabled (default)

AOCDL (Bit 5): Overload in Discharge—PF Enable

1 = Enabled

0 = Disabled (default)

VIMA (Bit 4): Voltage Imbalance Active

1 = Enabled

0 = Disabled (default)

VIMR (Bit 3): Voltage Imbalance At Rest

1 = Enabled

0 = Disabled (default)

CD (Bit 2): Capacity Degradation

1 = Enabled

0 = Disabled (default)

IMP (Bit 1): Cell impedance

1 = Enabled

0 = Disabled (default)

CB (Bit 0): Cell balancing

1 = Enabled

0 = Disabled (default)

17.1.8.3 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
NTC	2LVL	AFEC	AFER	RSVD	OCDL	DFETF	CFETF

NTC (Bit 7): Permanent Fail Flag Display

1 = Enables ***PFStatus[NTC]*** = 1 when NTC fault is triggered.

0 = Disables the ***PFStatus[NTC]*** = 1 when NTC fault is triggered.

2LVL (Bit 6): FUSE input indicating a fuse trigger by an 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 = n/a (default)

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

OCDL (Bit 2): Overcurrent in Discharge—PF Enable

1 = Enabled

0 = Disabled (default)

DFETF (Bit 1): Discharge FET

1 = Enabled

0 = Disabled (default)

CFETF (Bit 0): Charge FET

1 = Enabled

0 = Disabled (default)

17.1.8.4 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
ISD HI	ISD LO	RSVD	TS	RSVD	RSVD	PF FORCE	BSD

ISD_HI (Bit 7): Internal short detection high failure enable

1 = Enabled

0 = Disabled

ISD_LO (Bit 6): Internal short detection low failure enable

1 = Enabled

0 = Disabled

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

TS (Bit 4): Open thermistor – TS1 failure enable

1 = Enabled

0 = Disabled

RSVD (Bits 3–2): Reserved. Do not use.

PFFORCE (Bit 1): Permanent failure forced by command enable. See *Manual Permanent Failure* for more information.

1 = Enabled

0 = Disabled

BSD (Bit 0): Battery swelling detection failure enable

1 = Enabled

0 = Disabled

17.1.9 AFE

17.1.9.1 OCC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCC	U1	0x0	0x7F	0x06	Hex

7	6	5	4	3	2	1	0
RSVD	SC_OCC_SEL						

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

SC_OCC_SEL (Bits 6-0): Voltage threshold for overcurrent in charge. The threshold should be based on V_{SRP}-V_{SRN} and equal to 1mV * SC_OCC_SEL.

17.1.9.2 OCD

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD1	U1	0x0	0x7F	0x06	Hex

7	6	5	4	3	2	1	0
RSVD	SC_OCD1_SEL						

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

SC_OCD1_SEL (Bits 6-0): Voltage threshold for overcurrent in discharge. AOCD Voltage Threshold is -1mV * SC_OCD1_SEL.

17.1.9.3 Short Circuit Discharge

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Short Circuit Discharge	U1	0x0	0x7F	0x7F	Hex

7	6	5	4	3	2	1	0
RSVD	SC_SCD_SEL						

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

SC_SCD_SEL (Bits 6-0): Voltage threshold for short circuit in discharge. ASCD VoltageThreshold is -1mV * SC_SCD_SEL.

17.1.9.4 Under Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Under Voltage	H1	0x0	0x7F	0x28	Hex

7	6	5	4	3	2	1	0
RSVD	SC_BATUV_SEL						

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

SC_BATUV_SEL (Bits 6-0): Voltage threshold for under voltage protection. The threshold should be based on V_{BAT} and equal to 50mV * SC_BATUV_SEL.

17.1.9.5 Over Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Over Voltage	U1	0x0	0x7F	0x64	Hex

7	6	5	4	3	2	1	0
RSVD	SC_BATOV_SEL						

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

SC_BATOV_SEL (Bits 6-0): Voltage threshold for hardware over voltage protection. The threshold should be based on V_{BAT} and equal to 50mV * SC_BATOV_SEL.

17.1.9.6 Current Charge Wake

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Current Charge Wake	U1	0x70	0x7F	0x74	Hex

7	6	5	4	3	2	1	0
RSVD				SC_CC_WAKE_SEL (3-0)			

RSVD (Bits 7-4): Reserved. Do not use.

SC_CC_WAKE_SEL_LSB (Bits 3-0): These bits are used to set voltage threshold of current charge wake. With 0.5mV * SC_CC_WAKE_SEL[3-0].

17.1.9.7 Current Discharge Wake

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Current Discharge Wake	U1	0x70	0x7F	0x74	Hex

7	6	5	4	3	2	1	0
RSVD				SC_CD_WAKE_SEL (Bits 3-0)			

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

SC_CD_WAKE_SEL_LSB (Bits 3-0): These bits are used to set voltage threshold of current discharge wake. With -0.5mV * SC_CD_WAKE_SEL[3-0)]

17.1.9.8 OCC Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCC Delay	U1	0x00	0x7F	0x07	Hex

7	6	5	4	3	2	1	0
RSVD (Bit 7)				SC_OCC_FAULT_DLY (Bits 6-0)			

RSVD: Reserved. Do not use.

SC_OCC_FAULT_DLY (Bits 6-0): SC_OCC_FAULT_DLY * 0.854ms. Note a value of 0 disables the OCC hardware protection.

17.1.9.9 OCD Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD Delay	U1	0x0	0x7F	0x07	Hex

7	6	5	4	3	2	1	0
RSVD (Bit 7)				SC_OCD_FAULT_DLY (Bits 6-0)			

RSVD (Bit 7): Reserved. Do Not Use.

SC_OCD_FAULT_DLY (Bits 6-0): SC_OCD_FAULT_DLY * 0.854ms. Note a value of 0 disables the OCD hardware protection.

17.1.9.10 Short Circuit Discharge Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Short Circuit Discharge Delay	H1	0x0	0x07	0x07	Hex

7	6	5	4	3	2	1	0
RSVD (Bits 7-3)	SC_SCD_FAULT_DLY (Bits 2-0)						

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

SC_SC_SCD_FAULT_DLY (Bits 2-0): For (SC_SCD_FAULT_DLY = 1): Minimum t_{SCD} = 91.5μs and Maximum t_{SCD} = 274.5μs. For (SC_SCD_FAULT_DLY > 1): t_{SCD} = (SC_SCD_FAULT_DLY = 1 Time) + 8μs + ((SC_SCD_FAULT_DLY - 2)) × 122μs).

17.1.9.11 Under Voltage Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Under Voltage Delay	U1	0x0	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
SC_BATUV_FAULT_DLY							

SC_BATUV_FAULT_DLY (Bits 7-0): SC_BATUV_FAULT_DLY * 0.854ms. A value of 0 disables Under Voltage hardware protection.

17.1.9.12 Over Voltage Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Over Voltage Delay	U1	0x0	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
SC_BATOV_FAULT_DLY							

SC_BATOV_FAULT_DLY (Bits 7-0): SC_BATOV_FAULT_DLY * 0.854ms. A value of 0 disables Over Voltage hardware protection.

17.1.9.13 Over Voltage Delay Hi

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Over Voltage Delay Hi	U1	0x0	0x1F	0x1F	Hex

15	14	13	12	11	10	9	8
RSVD (Bits 15-13)	SC_BATOV_FAULT_DLY (Bits 12-8)						

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

SC_BATOV_FAULT_DLY (Bits 12-8): Upper bits for Over Voltage Delay hardware protection. SC_BATOV_FAULT_DLY * 0.854ms. A value of 0 disables Over Voltage hardware protection.

17.1.9.14 CD Wake Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	CD Wake Delay	U1	0x0	0x1F	0x1F	Hex

7	6	5	4	3	2	1	0
RSVD (Bits 7-5)				SC_CD_WAKE_DLY (Bits 4-0)			

RSVD: Reserved. Do not use.

SC_CD_WAKE_DLY (Bits 4-0): SC_CD_WAKE_DLY * 0.854ms. A value of 0 disables CD Wake detection.

17.1.9.15 CC Wake Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	CC Wake Delay	U1	0x0	0x1F	0x1F	Hex

7	6	5	4	3	2	1	0
RSVD (Bits 7-5)			SC_CC_WAKE_DLY (Bits 4-0)				

RSVD (Bits 7-5): Reserved. Do not use.

SC_CC_WAKE_DLY (Bits 4-0): SC_CC_WAKE_DLY * 0.854ms. A value of 0 disables CC Wake detection.

17.1.9.16 ZVCHG Exit Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Configuration	AFE	ZVCHG Exit Threshold	I2	0	80000	2400	mV

Description: *Voltage()* threshold where the gauge will exit ZVCHG mode when CFET is used for precharging.

17.1.10 Smart Temperature

17.1.10.1 Mid Point Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Smart Temperature	Mid Point Temp	I2	–400	1200	250	0.1°C

Description: Mid point to calculate cell temeprature for smart temperature sensor scheme.

17.1.11 Manufacturing

17.1.11.1 Manufacturing Status Init

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Manufacturing	Manufacturing Status Init	H2	0x0000	0xFFFF	0x0000	Hex

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	RSVD	ACCHG_EN	ACDSG_EN	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 15–12): Reserved. Do not use.

ACCCG_EN (Bit 11): Accumulated Charge Measurement in CHARGE direction

1 = Enabled

0 = Disabled

ACDSG_EN (Bit 10): Accumulated Charge Measurement in DISCHARGE direction

1 = Enabled

0 = Disabled

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.

17.1.12 Accumulated Charge Measurement

17.1.12.1 Accum Discharge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Accumulated Charge	Discharge Threshold	I2	–32767	0	-1000	mAh

17.1.12.2 Accum Charge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Accumulated Charge	Charge Threshold	I2	0	32767	1000	mAh

17.2 Advanced Charging Algorithm

17.2.1 Minimum System Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Charger	Minimum System Voltage	I	0	32767	3000	mV

Description: Charger Minimum System Voltage (default 3000mV) to enter Minsys operation

17.2.2 CHGR_DET Off Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charger	CHGR_DET Off Voltage	I2	-32768	32767	10	mV

Description: This parameter sets the voltage threshold for charger detection exit (hysteresis). When the voltage on the charger detection pin falls below this threshold, the device recognizes the charger has been disconnected.

Default Value: 10mV provides a small hysteresis band below CHGR_DET On Voltage.

Related Parameter: CHGR_DET On Voltage (recommended 150mV) - sets the entry threshold for charger detection.

The difference between CHGR_DET On Voltage and CHGR_DET Off Voltage creates the hysteresis band that prevents chattering when the charger voltage is near the detection threshold.

17.2.3 CHGR_DET On Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charger	CHGR_DET On Voltage	I2	-32768	32767	0	mV

Description: This parameter sets the voltage threshold for charger detection entry. When the voltage on the charger detection pin exceeds this threshold relative to the CHGR_DET Off Voltage, the device recognizes a charger is connected.

Recommended Value: 150mV. The default value of 0mV may result in false charger detection in some applications.

Related Parameter: CHGR_DET Off Voltage (default 10mV) - sets the hysteresis for charger detection exit.

For reliable charger detection, set CHGR_DET On Voltage higher than CHGR_DET Off Voltage to create proper hysteresis and avoid chattering.

17.2.4 Temperature Ranges

17.2.4.1 T1 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	T1 Temp	I2	2332	3932	2732	0.1°K

Description: T1 low temperature range lower limit

17.2.4.2 Hysteresis Temp T1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	Hysteresis Temp T1	I2	0	150	10	0.1°K

Description: This is the temperature hysteresis applied when temperature is increasing from under temperature to TI low temperaure range.

17.2.4.3 T2 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	T2 Temp	I2	2332	3932	2852	0.1 K

Description: T2 low temperature range to standard temperature range

17.2.4.4 Hysteresis Temp T2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	Hysteresis Temp T2	I2	0	150	10	0.1 K

Description: This is the temperature hysteresis applied when temperature is increasing from low temperature to T2 standard low temperaure range .

17.2.4.5 T5 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	T5 Temp	I2	2332	3932	2932	0.1 K

Description: T5 recommended temperature range lower limit

17.2.4.6 Hysteresis Temp T5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	Hysteresis Temp T5	I2	0	150	10	0.1 K

Description: This is the temperature hysteresis applied when temperature is increasing from standard low temperature to T5 recommended temperaure range .

17.2.4.7 T6 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	T6 Temp	I2	2332	3932	2982	0.1 K

Description: T6 recommended temperature range upper limit

17.2.4.8 Hysteresis Temp T6

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	Hysteresis Temp T6	I2	0	150	10	0.1 K

Description: This is the temperature hysteresis applied when temperature is decreasing from standard high temperature to T5 recommended temperaure range .

17.2.4.9 T3 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	T3 Temp	I2	2332	3932	3032	0.1 K

Description: T3 standard temperature range to high temperature range

17.2.4.10 Hysteresis Temp T3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	Hysteresis Temp T3	I2	0	150	10	0.1 K

Description: This is the temperature hysteresis applied when temperature is decreasing from high temperature to T3 standard high temperaure range .

17.2.4.11 T4 Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	T4 Temp	I2	2332	3932	3282	0.1 K

Description: T4 high temperature range upper limit

17.2.4.12 Hysteresis Temp T4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Temperature Ranges	Hysteresis Temp T4	I2	0	150	10	0.1 K

Description: This is the temperature hysteresis applied when temperature is decreasing from over temperature to T4 high temperaure range .

17.2.5 PreCharging

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	PCHG	Current	I2	0	32767	88	mA

Description: Precharge *ChargingCurrent()*

Important: The actual precharge current delivered depends on the ***Current Gain*** parameter in data flash, which must be configured based on the external sense resistor value. If the ***Current Gain*** is not properly configured for the application's sense resistor, the actual precharge current will differ from the configured value. See the *Linear Charger Current Gain* section for configuration details.

17.2.6 Maintenance Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	MCHG	Current	I2	0	32767	44	mA

Description: Maintenance *ChargingCurrent()*

17.2.7 Voltage Range

17.2.7.1 Precharge Start Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Voltage Range	Precharge Start Voltage	I2	0	32767	2500	mV

Description: Min cell voltage to enter PRECHARGE mode

17.2.7.2 Charging Voltage Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Voltage Range	Charging Voltage Low	I2	0	32767	2900	mV

Description: Precharge Voltage range to ***Charging Voltage Low*** range

17.2.7.3 Charging Voltage Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Voltage Range	Charging Voltage Med	I2	0	32767	3600	mV

Description: ***Charging Voltage Low*** range to ***Charging Voltage Med*** range

17.2.7.4 Charging Voltage High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Voltage Range	Charging Voltage High	I2	0	32767	4000	mV

Description: ***Charging Voltage Med*** to ***Charging Voltage High*** range

17.2.7.5 Charging Voltage Hysteresis

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Voltage Range	Charging Voltage Hysteresis	U1	0	255	0	mV

Description: ***Charging Voltage Hysteresis*** applied when voltage is decreasing.

17.2.8 Degrade Mode 1

17.2.8.1 Cycle Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 1	Cycle Threshold	U2	0	65535	50	—

Description: This sets the cycle count related threshold at/above which the first Level (Mode 1) CV and CC degradations can begin if *[CYCLE_DEGRADE]* is set.

17.2.8.2 SOH Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 1	SOH Threshold	U1	0	100	95	%

Description: This sets the SOH-related threshold at/above which the first Level (Mode 1) CV and CC degradations can begin if *[SOH_DEGRADE]* is set.

17.2.8.3 Runtime Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 1	Runtime Threshold	U2	0	65535	8760	hrs

Description: This sets the runtime-related threshold at/above which the first level (Mode 1) CV and CC degradations can begin if *[RUNTIME_DEGRADE]* is set.

17.2.8.4 Voltage Degradation

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 1	Voltage Degradation	I2	0	32767	10	mV

Description: This sets the amount of voltage degradation from the charging voltage that will occur at the Mode 1 level if this feature is enabled.

17.2.8.5 Current Degradation

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 1	Current Degradation	U2	0	100	10	%

Description: This sets the percentage of current degradation from the charging current that will occur at the Mode 1 level if this feature is enabled.

17.2.9 Degrade Mode 2

17.2.9.1 Cycle Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 2	Cycle Threshold	U2	0	65535	150	—

Description: This sets the cycle count related threshold at/above which the first level (Mode 2) CV and CC degradations can begin if CYCLE_DEGRADE is set.

17.2.9.2 SOH Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 2	SOH Threshold	U1	0	100	80	%

Description: This sets the SOH related threshold at/above which the first level (Mode 2) CV and CC degradations can begin if SOH_DEGRADE is set.

17.2.9.3 Runtime Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 2	Runtime Threshold	U2	0	65535	17520	hrs

Description: This sets the runtime-related threshold at/above which the first level (Mode 2) CV and CC degradations can begin if RUNTIME_DEGRADE is set.

17.2.9.4 Voltage Degradation

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 2	Voltage Degradation	I2	0	32767	40	mV

Description: This sets the amount of voltage degradation from the charging voltage that will occur at the Mode 2 level if this feature is enabled.

17.2.9.5 Current Degradation

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 2	Current Degradation	U2	0	100	20	%

Description: This sets the percentage of current degradation from the charging current that will occur at the Mode 2 level if this feature is enabled.

17.2.10 Degrade Mode 3

17.2.10.1 Cycle Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 3	Cycle Threshold	U2	0	65535	350	—

Description: This sets the cycle count related threshold at/above which the first Level (Mode 3) CV and CC degradations can begin if CYCLE_DEGRADE is set.

17.2.10.2 SOH Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 3	SOH Threshold	U1	0	100	60	%

Description: This sets the SOH related threshold at/above which the first Level (Mode 3) CV and CC degradations can begin if SOH_DEGRADE is set.

17.2.10.3 Runtime Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 3	Runtime Threshold	U2	0	65535	26280	hrs

Description: This sets the runtime-related threshold at/above which the first Level (Mode 3) CV and CC degradations can begin if RUNTIME_DEGRADE is set.

17.2.10.4 Voltage Degradation

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 3	Voltage Degradation	I2	0	32767	70	mV

Description: This sets the amount of voltage degradation from the charging voltage that will occur at the Mode 3 level if this feature is enabled.

17.2.10.5 Current Degradation

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode 3	Current Degradation	U2	0	100	40	%

Description: This sets the percentage of current degradation from the charging current that will occur at the Mode 3 level if this feature is enabled.

17.2.11 Degrade Mode

17.2.11.1 Runtime Degrade

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode	Runtime Degrade	U2	0	65535	0	hrs

Description: This is the accumulated runtime for runtime degradation.

17.2.11.2 Runtime Update Interval

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode	Runtime Update Interval	U2	0	65535	0	hrs

Description: Runtime Degrade is updated periodically every Runtime Update Interval.

17.2.11.3 Cycle Count Start Runtime

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Degrade Mode	Cycle Count Start Runtime	U1	0	255	1	-

Description: This sets the cycle count threshold above which runtime begins to accumulate for runtime degradation.

17.2.12 CS Degrade

17.2.12.1 Temperature Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	CS Degrade	Temperature Threshold	I2	0	32767	3232	0.1 K

Description: This sets the temperature threshold that the cell temperature is compared to in the cell swelling control feature.

17.2.12.2 Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	CS Degrade	Voltage Threshold	I2	0	32767	4200	mV

Description: This sets the voltage threshold that the cell voltage is compared to in the cell swelling control feature.

17.2.12.3 Time Interval

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	CS Degrade	Time Interval	U2	0	14400	300	s

Description: This sets the time period that the cell swelling control feature compares with how long the max cell voltage and cell temperature have been above their thresholds. After which the charging voltage is stepped down.

17.2.12.4 Delta Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	CS Degrade	Delta Voltage	I2	0	32767	25	mV

Description: This sets the voltage level that the charging voltage will be stepped down as part of the swelling control feature.

17.2.12.5 Min CV

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	CS Degrade	Min CV	I2	0	32767	3000	mV

Description: This sets the lowest level that the charging voltage will be allowed to step down to as part of the swelling control feature.

17.2.13 Charge Voltage Override

17.2.13.1 CHGV Override Max

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charge Voltage Override	CHGV Override Max	I2	0	32767	4500	mV

Description: This sets the maximum value allowed to write in for advanced charge algorithm charging voltage in data flash by ManufacturerAccess() 0x00B0 ChargingVoltageOverride.

17.2.13.2 CHGV Override Min

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charge Voltage Override	CHGV Override Min	I2	0	32767	2000	mV

Description: This sets the minimum value allowed to write in for advanced charge algorithm charging voltage in data flash by *ManufacturerAccess()* 0x00B0 *ChargingVoltageOverride()*.

17.2.14 Charge Current Override

17.2.14.1 CHGI Override Max

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charge Current Override	CHGI Override Max	I2	0	32767	4500	mA

Description: This sets the maximum value allowed to write in for advanced charge algorithm charging current in data flash by *ManufacturerAccess() 0x00B2 ChargingCurrentOverride*.

17.2.14.2 CHGI Override Min

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Charge Current Override	CHGI Override Min	I2	0	32767	100	mA

Description: This sets the minimum value allowed to write in for advanced charge algorithm charging current in data flash by *ManufacturerAccess() 0x00B2 ChargingCurrentOverride*.

17.2.15 Termination Config

17.2.15.1 Charge Term Taper Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Termination Config	Charge Term Taper Current	I2	0	32767	250	mA

Description: Valid charge termination taper current qualifier threshold

17.2.15.2 Charge Term Voltage Offset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Termination Config	Charge Term Voltage Offset	I2	0	32767	75	mV

Description: Valid charge termination delta voltage qualifier, max cell-based

17.2.15.3 Charge Term Charging Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Termination Config	Charge Term Charging Voltage	I2	0	32767	4200	mV

Description: If ***[TAPER_VOLT]*** = 1, ***Charge Term Charging Voltage*** will be used for a valid charge termination condition.

17.2.16 Charging Rate of Change

17.2.16.1 Current Rate

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Charging Rate of Change	Current Rate	U2	1	1000	1	steps

Description: Number of 1-second steps to add between any two *ChargingCurrent()* settings. When ***[SLOW_CRATE]*** = 1, ***Current Rate*** is multiplied by 5 to transition over 5x the period.

17.2.16.2 Voltage Rate

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Charging Rate of Change	Voltage Rate	U1	1	255	1	steps/s

Description: Number of steps to add between any two *ChargingVoltage()* settings

17.2.17 Charge Loss Compensation

17.2.17.1 CCC Current Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Charge Loss Compensation	CCC Current Threshold	I2	0	32767	3520	mA

Description: CONSTANT CURRENT CHARGE mode *ChargingCurrent()* threshold to activate Charge Loss Compensation

17.2.17.2 CCC Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Charge Loss Compensation	CCC Voltage Threshold	I2	0	32767	4200	mV

Description: CONSTANT CURRENT CHARGE mode max *ChargingVoltage()* increase limit

17.2.18 IR Correction

17.2.18.1 Averaging Interval

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	IR Correction	Averaging Interval	U1	1	255	12	s

Description: To prevent overcharging by the IR compensation scheme (in case the ***System Resistance*** is set too high) the IT algorithm runs an averaging calculation to reduce the charging voltage if needed. This averaging calculation is averaged over the averaging interval defined in this register.

17.2.19 Sealed Write

17.2.19.1 Hold Off

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Sealed Write	Hold Off	U2	0	65535	2	s

Description: This sets the delay time for changing the JEITA charging voltage or current settings in data flash after receiving the last 0x00B0 ChargingVoltageOverride or 0x00B2 ChargingCurrentOverride commands.

17.2.19.2 Lockout

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Sealed Write	Lockout	U2	0	65535	7200	s

Description: This sets the delay time before MAC 0x00B0 ChargingVoltageOverride command or 0x00B2 ChargingCurrentOverride command can take effect again after the JEITA charging voltage or current setting is updated in the data flash. Writes to 0x00B0 and 0x00B2 are ignore during this delay time.

17.2.20 Low Temp Charging

17.2.20.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Low Temp Charging	Voltage	I2	0	32767	4000	mV

Description: Sets the *ChargingVoltage()* for the low temperature range

17.2.20.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Low Temp Charging	Current Low	I2	0	32767	132	mA

Description: Sets the *ChargingCurrent()* for the low temperature range, low voltage range

17.2.20.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Low Temp Charging	Current Med	I2	0	32767	352	mA

Description: Sets the *ChargingCurrent()* for the low temperature range, medium voltage range

17.2.20.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Low Temp Charging	Current High	I2	0	32767	264	mA

Description: Sets the *ChargingCurrent()* for the low temperature range, high voltage range

17.2.21 Standard Temp Low Charging

17.2.21.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp Low Charging	Voltage	I2	0	32767	4200	mV

Description: Sets the *ChargingVoltage()* for the standard temperature range

17.2.21.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp Low Charging	Current Low	I2	0	32767	1980	mA

Description: Sets the *ChargingCurrent()* for the standard temperature range, low voltage range

17.2.21.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp Low Charging	Current Med	I2	0	32767	4004	mA

Description: Sets the *ChargingCurrent()* for the standard temperature range, medium voltage range

17.2.21.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp Low Charging	Current High	I2	0	32767	2992	mA

Description: Sets the *ChargingCurrent(* for the standard temperature range, high voltage range

17.2.22 Standard Temp High Charging

17.2.22.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp High Charging	Voltage	I2	0	32767	4200	mV

Description: Sets the *ChargingVoltage()* for the standard temperature range

17.2.22.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp High Charging	Current Low	I2	0	32767	1980	mA

Description: Sets the *ChargingCurrent()* for the standard temperature range, low voltage range

17.2.22.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp High Charging	Current Med	I2	0	32767	4004	mA

Description: Sets the *ChargingCurrent()* for the standard temperature range, medium voltage range

17.2.22.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Standard Temp High Charging	Current High	I2	0	32767	2992	mA

Description: Sets the *ChargingCurrent(* for the standard temperature range, high voltage range

17.2.23 High Temp Charging

17.2.23.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	High Temp Charging	Voltage	I2	0	32767	4000	mV

Description: Sets the *ChargingVoltage()* for the high temperature range

17.2.23.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	High Temp Charging	Current Low	I2	0	32767	1012	mA

Description: Sets the *ChargingCurrent()* for the high temperature range, low voltage range

17.2.23.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	High Temp Charging	Current Med	I2	0	32767	1980	mA

Description: Sets the *ChargingCurrent()* for the high temperature range, medium voltage range

17.2.23.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	High Temp Charging	Current High	I2	0	32767	1496	mA

Description: Sets the *ChargingCurrent()* for the high temperature range, high voltage range

17.2.24 Rec Temp Charging

17.2.24.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Rec Temp Charging	Voltage	I2	0	32767	4100	mV

Description: Sets the *ChargingVoltage()* for the recommended temperature range

17.2.24.2 Current Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Rec Temp Charging	Current Low	I2	0	32767	2508	mA

Description: Sets the *ChargingCurrent()* for the recommended temperature range, low voltage range

17.2.24.3 Current Med

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Rec Temp Charging	Current Med	I2	0	32767	4488	mA

Description: Sets the *ChargingCurrent()* for the recommended temperature range, medium voltage range

17.2.24.4 Current High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Rec Temp Charging	Current High	I2	0	32767	3520	mA

Description: Sets the *ChargingCurrent()* for the recommended temperature range, high voltage range

17.2.25 Elevated Degrade

17.2.25.1 Accumulated ERM Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	Accumulated ERM Time	U2	0	65535	0	h

Description: This is the accumulated ERM time counted by the device.

17.2.25.2 Accumulated ERETM Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	Accumulated ERETM Time	U2	0	65535	0	h

Description: This is the accumulated ERETM time counted by the device.

17.2.25.3 Accumulated EVLTM Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	Accumulated EVLTM Time	U2	0	65535	0	h

Description: This is the accumulated EVLTM time counted by the device.

17.2.25.4 Accumulated EVMTM Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	Accumulated EVMTM Time	U2	0	65535	0	h

Description: This is the accumulated EVMTM time counted by the device.

17.2.25.5 Accumulated EVHTM Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	Accumulated EVHTM Time	U2	0	65535	0	h

Description: This is the accumulated EVHTM time counted by the device.

17.2.25.6 ERETM Status

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERETM Status	H1	0x00	0xFF	0x00	-

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RVSD	ERETM_DEGRADE	ERETM_ACTIVE

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

ERETM_DEGRADE (Bit 1): This is the ERETM active flag the gauge sets when ERETM is active and beginning the next CHARGE cycle.

1 = ERETM degrade active

0 = ERETM degrade not active

ERETM_ACTIVE (Bit 0): ERETM conditions have been met and *ChargingVoltage()* will be degraded starting with next charge cycle

1 = ERETM conditions met

0 = ERETM conditions not met

17.2.25.7 EVTM Degrade

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVTM Degrade	H2	0x0	0xFFFF	0x0	-

15	14	13	12	11	10	9	8
RSVD	EVHTM_TTH5	EVHTM_TTH4	EVHTM_TTH3	EVHTM_TTH2	EVHTM_TTH1	EVMTM_TTH5	EVMTM_TTH4

7	6	5	4	3	2	1	0
EVMTM_TTH3	EVMTM_TTH2	EVMTM_TTH1	EVLTM_TTH5	EVLTM_TTH4	EVLTM_TTH3	EVLTM_TTH2	EVLTM_TTH1

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

EVHTM_TTH5 (Bits 14): Status of EVHTM_TTH5 degradataion

1 = ***EVHTM CV Delta5*** degradation has been applied

0 = ***EVHTM CV Delta5*** degradition has not been applied

EVHTM_TTH4 (Bits 13): Status of EVHTM_TTH4 degradataion

1 = ***EVHTM CV Delta4*** degradation has been applied

0 = ***EVHTM CV Delta4*** degradition has not been applied

EVHTM_TTH3 (Bits 12): Status of EVHTM_TTH3 degradataion

1 = ***EVHTM CV Delta3*** degradation has been applied

0 = ***EVHTM CV Delta3*** degradation has not been applied

EVHTM_TTH2 (Bits 11): Status of EVHTM_TTH2 degradataion

1 = ***EVHTM CV Delta2*** degradation has been applied

0 = ***EVHTM CV Delta2*** degradation has not been applied

EVHTM_TTH1 (Bits 10): Status of EVHTM_TTH1 degradataion

1 = ***EVHTM CV Delta1*** degradation has been applied

0 = ***EVHTM CV Delta1*** degradation has not been applied

EVMTM_TTH5 (Bits 9): Status of EVMTM_TTH5 degradataion

1 = ***EVMTM CV Delta5*** degradation has been applied

0 = ***EVMTM CV Delta5*** degradition has not been applied

EVMTM_TTH4 (Bits 8): Status of EVMTM_TTH4 degradataion

1 = ***EVMTM CV Delta4*** degradation has been applied

0 = ***EVMTM CV Delta4*** degradition has not been applied

EVMTM_TTH3 (Bits 7): Status of EVMTM_TTH3 degradataion

1 = ***EVMTM CV Delta3*** degradation has been applied

0 = ***EVMTM CV Delta3*** degradation has not been applied

EVMTM_TTH2 (Bits 6): Status of EVMTM_TTH2 degradataion

1 = ***EVMTM CV Delta2*** degradation has been applied

0 = ***EVMTM CV Delta2*** degradation has not been applied

EVMTM_TTH1 (Bits 5): Status of EVMTM_TTH1 degradataion

1 = ***EVMTM CV Delta1*** degradation has been applied

0 = ***EVMTM CV Delta1*** degradation has not been applied

EVLTM_TTH5 (Bits 4): Status of EVLTM_TTH5 degradataion

1 = ***EVLTM CV Delta5*** degradation has been applied

0 = ***EVLTM CV Delta5*** degradition has not been applied

EVLTM_TTH4 (Bits 3): Status of EVLTM_TTH4 degradataion

1 = ***EVLTM CV Delta4*** degradation has been applied

0 = ***EVLTM CV Delta4*** degradition has not been applied

EVLTM_TTH3 (Bits 2): Status of EVLTM_TTH3 degradataion

1 = ***EVLTM CV Delta3*** degradation has been applied

0 = ***EVLTM CV Delta3*** degradation has been not applied

EVLTM_TTH2 (Bits 1): Status of EVLTM_TTH2 degradataion

1 = ***EVLTM CV Delta2*** degradation has been applied

0 = ***EVLTM CV Delta2*** degradation has been not applied

EVLTM_TTH1 (Bits 0): Status of EVLTM_TTH1 degradataion

1 = ***EVLTM CV Delta1*** degradation has been applied

0 = ***EVLTM CV Delta1*** degradation has not been applied

17.2.25.8 EVTM Active

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVTM Active	H2	0x0	0xFFFF	0x0	-

15	14	13	12	11	10	9	8
RSVD	EVHTM_TTH5	EVHTM_TTH4	EVHTM_TTH3	EVHTM_TTH2	EVHTM_TTH1	EVMTM_TTH5	EVMTM_TTH4

7	6	5	4	3	2	1	0
EVMTM_TTH3	EVMTM_TTH2	EVMTM_TTH1	EVLTM_TTH5	EVLTM_TTH4	EVLTM_TTH3	EVLTM_TTH2	EVLTM_TTH1

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

EVHTM_TTH5 (Bits 14): Status of EVHTM_TTH5 activation

1 = EVHTM_TTH5 conditions are met, and ***EVHTM CV Delta5*** degradation will be applied when device enters CHARGE mode

0 = EVHTM_TTH5 conditions are not met

EVHTM_TTH4 (Bits 13): Status of EVHTM_TTH4 activation

1 = EVHTM_TTH4 conditions are met, and ***EVHTM CV Delta4*** degradation will be applied when device enters CHARGE mode

0 = EVHTM_TTH4 conditions are not met

EVHTM_TTH3 (Bits 12): Status of EVHTM_TTH3 activation

1 = EVHTM_TTH3 conditions are met, and ***EVHTM CV Delta3*** degradation will be applied when device enters CHARGE mode

0 = EVHTM_TTH3 conditions are not met

EVHTM_TTH2 (Bits 11): Status of EVHTM_TTH2 activation

1 = EVHTM_TTH2 conditions are met, and ***EVHTM CV Delta2*** degradation will be applied when device enters CHARGE mode

0 = EVHTM_TTH2 conditions are not met

EVHTM_TTH1 (Bits 10): Status of EVHTM_TTH1 activation

1 = EVHTM_TTH1 conditions are met, and ***EVHTM CV Delta1*** degradation will be applied when device enters CHARGE mode

0 = EVHTM_TTH1 conditions are not met

EVMTM_TTH5 (Bits 9): Status of EVMTM_TTH5 activation

1 = EVMTM_TTH5 conditions are met, and ***EVMTM CV Delta5*** degradation will be applied when device enters CHARGE mode

0 = EVMTM_TTH5 conditions are not met

EVMTM_TTH4 (Bits 8): Status of EVMTM_TTH4 activation

1 = EVMTM_TTH4 conditions are met, and ***EVMTM CV Delta4*** degradation will be applied when device enters CHARGE mode

0 = EVMTM_TTH4 conditions are not met

EVMTM_TTH3 (Bits 7): Status of EVMTM_TTH3 activation

1 = EVMTM_TTH3 conditions are met, and ***EVMTM CV Delta3*** degradation will be applied when device enters CHARGE mode

0 = EVMTM_TTH3 conditions are not met

EVMTM_TTH2 (Bits 6): Status of EVMTM_TTH2 activation

1 = EVMTM_TTH2 conditions are met, and ***EVMTM CV Delta2*** degradation will be applied when device enters CHARGE mode

0 = EVMTM_TTH2 conditions are not met

EVMTM_TTH1 (Bits 5): Status of EVMTM_TTH1 activation

1 = EVMTM_TTH1 conditions are met, and ***EVMTM CV Delta1*** degradation will be applied when device enters CHARGE mode

0 = EVMTM_TTH1 conditions are not met

EVLTM_TTH5 (Bits 4): Status of EVLTM_TTH5 activation

1 = EVLTM_TTH5 conditions are met, and ***EVLTM CV Delta5*** degradation will be applied when device enters CHARGE mode

0 = EVLTM_TTH5 conditions are not met

EVLTM_TTH4 (Bits 3): Status of EVLTM_TTH4 activation

1 = EVLTM_TTH4 conditions are met, and ***EVLTM CV Delta4*** degradation will be applied when device enters CHARGE mode

0 = EVLTM_TTH4 conditions are not met

EVLTM_TTH3 (Bits 2): Status of EVLTM_TTH3 activation

1 = EVLTM_TTH3 conditions are met, and ***EVLTM CV Delta3*** degradation will be applied when device enters CHARGE mode

0 = EVLTM_TTH3 conditions are not met

EVLTM_TTH2 (Bits 1): Status of EVLTM_TTH2 activation

1 = EVLTM_TTH2 conditions are met, and ***EVLTM CV Delta2*** degradation will be applied when device enters CHARGE mode

0 = EVLTM_TTH2 conditions are not met

EVLTM_TTH1 (Bits 0): Status of EVLTM_TTH1 activation

1 = EVLTM_TTH1 conditions are met, and ***EVLTM CV Delta1*** degradation will be applied when device enters CHARGE mode

0 = EVLTM_TTH1 conditions are not met

17.2.25.9 ERM Reset RSoC Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERM Reset RSoC Threshold	U1	0	100	85	%

Description: This sets the RSOC value by which ***Elevated Degrade*** will reset when ***[ERM_MODE]*** is cleared.

17.2.25.10 ERM Reset Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERM Reset Voltage Threshold	I2	0	32767	3700	mV

Description: This sets the RSOC value by which ***Elevated Degrade*** will reset when ***[ERM_MODE]*** is set.

17.2.25.11 ERM RSoC Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERM RSoC Threshold	U1	0	100	90	%

Description: This sets the RSOC threshold above which ***Accumulated ERM Time*** will count when ***[ERM_MODE]*** is cleared.

17.2.25.12 ERM Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERM Voltage Threshold	I2	0	32767	4000	mV

Description: This sets the voltage threshold above which ***Accumulated ERM Time*** will count when ***[ERM_MODE]*** is set.

17.2.25.13 ERM Time Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERM Time Threshold	U2	0	65535	10000	hrs

Description: This sets the time threshold above which *[ERM]* is set.

17.2.25.14 ERETM RSoC Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERETM RSoC Threshold	U1	0	100	90	%

Description: This sets the RSOC threshold above which ***Accumulated ERETM Time*** will count when ***[ERETM_MODE]*** is cleared.

17.2.25.15 ERETM Voltage Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERETM Voltage Threshold	I2	0	32767	4200	mV

Description: This sets the voltage threshold above which ***Accumulated ERETM Time*** will count when the temperature condition is met and ***[ERETM_MODE]*** is set.

17.2.25.16 ERETM Temperature Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERETM Temperature Threshold	I2	2332	3932	3123	0.1 K
Advanced Charge Algorithm	Elevated Degrade	ERETM Temperature Max Threshold	I2	2332	3932	3223	0.1 K

Description: This sets the temperature threshold above which ***Accumulated ERETM Time*** will count when RSOC or voltage condition is met, and the lower temperature threshold which ***Accumulated EVLTM Time*** will count when the voltage condition is met.

17.2.25.17 ERETM Time Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERETM Time Threshold	U2	0	65535	10000	h

Description: This sets the time threshold above which *[ERM]* is set and *ChargingVoltage()* is set to ***ERETM Charging Voltage*** upon the next CHARGE cycle.

17.2.25.18 ERETM Charging Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	ERETM Charging Voltage	I2	0	32767	3900	mV

Description: This sets the *ChargingVoltage()* for all temperature ranges when the device enters ***Elevated RSOC and Temperature Mode*** .

17.2.25.19 EVTM Voltage Thresholds

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVTM Voltage Low Threshold	I2	0	32767	4300	mV
Advanced Charge Algorithm	Elevated Degrade	EVTM Voltage Mid Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	Elevated Degrade	EVTM Voltage High Threshold	I2	0	32767	4100	mV

Description: These parameters set the 3 levels of voltage thresholds which ***Accumulated EVLTM/EVMTM/EVHTM Time*** will count, when the temperature condition is met.

17.2.25.20 EVTM Temperature Thresholds

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVTM Temperature Low Threshold	I2	2332	3932	3123	0.1 K
Advanced Charge Algorithm	Elevated Degrade	EVTM Temperature Mid Threshold	I2	2332	3932	3173	0.1 K
Advanced Charge Algorithm	Elevated Degrade	EVTM Temperature High Threshold	I2	2332	3932	3223	0.1 K

Description: These parameters set the 3 levels of temperature thresholds and hysteresis which ***Accumulated EVLTM/EVMTM/EVHTM Time*** will count, when the voltage condition is met.

17.2.25.21 EVLTM Time Thresholds

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVLTM TTH1	U2	0	65535	480	h
Advanced Charge Algorithm	Elevated Degrade	EVLTM TTH2	U2	0	65535	720	h
Advanced Charge Algorithm	Elevated Degrade	EVLTM TTH3	U2	0	65535	1680	h
Advanced Charge Algorithm	Elevated Degrade	EVLTM TTH4	U2	0	65535	2880	h
Advanced Charge Algorithm	Elevated Degrade	EVLTM TTH5	U2	0	65535	5760	h

Description: These parameters set the 5 levels of time thresholds for elevated voltage extended charge degradation under EVLTM temperature range.

17.2.25.22 EVLTM Delta Charging Voltages

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVLTM CV Delta1	I2	0	32767	50	mV
Advanced Charge Algorithm	Elevated Degrade	EVLTM CV Delta2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	EVLTM CV Delta3	I2	0	32767	150	mV
Advanced Charge Algorithm	Elevated Degrade	EVLTM CV Delta4	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	EVLTM CV Delta5	I2	0	32767	300	mV

Description: These parameters set the 5 levels of stepdown voltaged to be reduced from *ChargingVoltage()* for elevated voltage extended charge degradation under EVLTM temperature range.

17.2.25.23 EVMTM Time Thresholds

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVMTM TTH1	U2	0	65535	240	h
Advanced Charge Algorithm	Elevated Degrade	EVMTM TTH2	U2	0	65535	480	h
Advanced Charge Algorithm	Elevated Degrade	EVMTM TTH3	U2	0	65535	1440	h
Advanced Charge Algorithm	Elevated Degrade	EVMTM TTH4	U2	0	65535	2160	h
Advanced Charge Algorithm	Elevated Degrade	EVMTM TTH5	U2	0	65535	2400	h

Description: These parameters set the 5 levels of time thresholds for elevated voltage extended charge degradation under EVMTM temperature range.

17.2.25.24 EVMTM Delta Charging Voltages

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVMTM CV Delta1	I2	0	32767	50	mV
Advanced Charge Algorithm	Elevated Degrade	EVMTM CV Delta2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	EVMTM CV Delta3	I2	0	32767	150	mV
Advanced Charge Algorithm	Elevated Degrade	EVMTM CV Delta4	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	EVMTM CV Delta5	I2	0	32767	300	mV

Description: These parameters set the 5 levels of stepdown voltaged to be reduced from *ChargingVoltage()* for elevated voltage extended charge degradation under EVMTM temperature range.

17.2.25.25 EVHTM Time Thresholds

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVHTM TTH1	U2	0	65535	24	h
Advanced Charge Algorithm	Elevated Degrade	EVHTM TTH2	U2	0	65535	120	h
Advanced Charge Algorithm	Elevated Degrade	EVHTM TTH3	U2	0	65535	336	h

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVHTM TTH4	U2	0	65535	480	h
Advanced Charge Algorithm	Elevated Degrade	EVHTM TTH5	U2	0	65535	720	h

Description: These parameters set the 5 levels of time thresholds for elevated voltage extended charge degradation under EVHTM temperature range.

17.2.25.26 EVHTM Delta Charging Voltages

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Elevated Degrade	EVHTM CV Delta1	I2	0	32767	50	mV
Advanced Charge Algorithm	Elevated Degrade	EVHTM CV Delta2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	EVHTM CV Delta3	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	EVHTM CV Delta4	I2	0	32767	250	mV
Advanced Charge Algorithm	Elevated Degrade	EVHTM CV Delta5	I2	0	32767	300	mV

Description: These parameters set the 5 levels of stepdown voltaged to be reduced from *ChargingVoltage()* for elevated voltage extended charge degradation under EVHTM temperature range.

17.3 Power

17.3.1 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

17.3.2 Shutdown

17.3.2.1 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

17.3.2.2 Shutdown Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	Shutdown Time	U1	0	255	10	s

Description: Cell-based shutdown voltage trip delay

17.3.2.3 IO Shutdown Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	IO Shutdown Delay	U1	0	255	1	250ms

Description: IO shutdown input debounce time

17.3.2.4 IO Shutdown Timeout

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	IO Shutdown Timeout	U1	0	255	8	250ms

Description: This is the IO shutdown activation timeout when ***[IO_TIMEOUT]*** is set and PACK voltage > ***Charger Present Threshold*** .

17.3.2.5 Low RSoC Shutdown Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	Low RSoC Shutdown Threshold	U1	0	100	2	%

Description: When ***Power Config[RSOC_SD]*** is enabled, this parameter sets the RSOC threshold below which a timer will start to count down from ***[Low RSOC SD Time]*** before auto shutdown if no charge current is detected during the count down.

17.3.2.6 Low RSoC Shutdown Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	Low RSoC Shutdown Time	U1	0	255	24	hours

Description: Time limit for Low RSOC auto shutdown

17.3.2.7 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 for shutdown hardware. This value should not be greater than 3 V, unless the charger output is less than 3 V.

17.3.3 Sleep

17.3.3.1 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 below the ***deadband*** will set the *Current()* = 0 mA.

17.3.3.2 Low Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Low Current	I2	0	32767	5	mA

Description: If gauge is not in sleep mode and *Current()* < Low Current, current is measured every Low Current Period.

17.3.3.3 Low Current Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Low Current Period	H2	0x0008	0x0040	0x0010	Hex

Description: Low Current Period determines the current measurement period. 0x0040 is 8s, 0x0020 is 4s, 0x0010 is 2s, 0x0008 is 1s.

17.3.3.4 Measure Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Measure Time	U2	8	8	8	s

Description: Voltage measurement time in sleep mode.

17.3.3.5 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

17.3.3.6 Current Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Current Time	U1	1	64	16	s

Description: *Current()* sampling period in SLEEP mode

Note

A valid ***Current Time*** must be the multiple of 8s. It means that ***Current Time*** can only be configured as 8, 16, 24, 32, 40, 48, 56, 64s.

17.3.4 Ship

17.3.4.1 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.

17.3.4.2 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.

17.3.4.3 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.

17.3.5 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 FET Shutdown condition

17.3.6 Manual FET Control

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Manual FET Control	MFC Delay	U1	0	255	60	0.25 s

Description: Delay time to turn off FETs through MFC

17.3.7 System Present

17.3.7.1 SysPres Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	System Present	SYS_PRES Delay	U1	1	8	1	Count

Description: Number of consecutive pin samples required to determine the state of a configured function. This parameter is used for debouncing the $\overline{\text{SHUTDN}}$ and $\overline{\text{PRES}}$ functions when assigned to a GPIO pin via IO Config settings. Samples are taken at 250-ms intervals.

17.3.8 Storage

17.3.8.1 Storage Delay

Class	Subclass	Name	Type	Min	Max	Default	Units
Power	Storage	Storage Delay	U1	0	255	10	s

Description: Sets the time after which the CHG and DSG FETs are turned off for STORAGE mode.

17.3.8.2 Storage Ignore SMB Delay

Class	Subclass	Name	Type	Min	Max	Default	Units
Power	Storage	Storage Ignore SMB Delay	U1	0	255	30	s

Description: This sets the time after which the CHG and DSG FETs are turned back on if the device is not in SLEEP mode.

17.3.9 Power Events

17.3.9.1 Power Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Power Events	No of Shutdowns	U1	0	255	0	events
Lifetimes	Power Events	No of Partial Resets	U1	0	255	0	events
Lifetimes	Power Events	No of Full Resets	U1	0	255	0	events
Lifetimes	Power Events	No of Wdt Resets	U1	0	255	0	events

Description: Total number of shutdown events, partial resets, full resets and watchdog resets.

17.3.10 IATA

17.3.10.1 IATA Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA Config	H1	0x00	0xFF	0x03	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	ISTORE_RM	ISTORE_FCC

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

ISTORE_RM (Bit 1): This bit defines whether the stored value of RM (***IATA RM***) or the true value is displayed during the ***IATA Delay Time*** period.

1 = Stored value of RM (IATA RM) is displayed during the ***IATA Delay Time*** period. (default)

0 = True (present) value of RM is displayed.

ISTORE_FCC (Bit 0): This bit defines whether the stored value of FCC (***IATA FCC***) or the true value is displayed during the ***IATA Delay Time*** period.

1 = Stored value of FCC (***IATA FCC***) is displayed during the ***IATA Delay Time*** period. (default)

0 = True (present) value of FCC is displayed.

17.3.10.2 IATA Delay Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA Delay Time	U2	0	65535	10	s

Description: ***IATA Delay Time*** holds the time that the stored RM and FCC values are displayed initially on wake up from IATA shutdown.

17.3.10.3 IATA RSOC Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA RSOC Threshold	U1	0	100	30	%

Description: ***IATA RSOC Threshold*** holds the RSOC threshold above which IATA shutdown will not be allowed.

17.3.10.4 IATA Wake AbsRSOC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA Wake AbsRSOC	U1	0	100	10	%

Description: On wake up from ***IATA*** shutdown, if ***IATA Delay Time*** = 0, and if true RSOC is ≤ ***IATA Wake AbsRSOC*** , then the true value of remaining capacity and FCC will be immediately displayed on wake up.

17.3.10.5 IATA MIN Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA MIN Temperature	I2	2332	3932	2832	0.1 K

Description: ***IATA MIN Temperature*** holds the min temperature below which, on wake up from IATA, only the true (present) value of FCC and RM is displayed.

17.3.10.6 IATA MAX Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA MAX Temperature	I2	2332	3932	3132	0.1 K

Description: ***IATA MAX Temperature*** holds the max temperature above which, on wake up from IATA, only the true (present) value of FCC and RM is displayed.

17.3.10.7 IATA MIN Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA MIN Voltage	I2	0	32767	3000	mV

Description: ***IATA MIN Voltage*** holds the min voltage below which, on wake up from IATA, only the true (present) value of FCC and RM is displayed.

17.3.10.8 IATA MAX Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA MAX Voltage	I2	0	32767	3600	mV

Description: ***IATA MAX Voltage*** holds the max voltage above which, on wake up from IATA, only the true (present) value of FCC and RM is displayed.

17.3.11 IATA STORE

17.3.11.1 IATA RM mAH

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA STORE	IATA RM mAH	I2	0	32767	0	mAh

Description: ***IATA RM mAH*** stores the remaining capacity (in mAh) at the time an IATA shutdown occurs.

17.3.11.2 IATA RM cWH

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA STORE	IATA RM cWH	I2	0	32767	0	cWh

Description: ***IATA RM cWH*** stores the remaining capacity (in cWh) at the time an IATA shutdown occurs.

17.3.11.3 IATA FCC mAH

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA STORE	IATA FCC mAH	I2	0	32767	0	mAh

Description: ***IATA FCC mAH*** stores the value of FCC (in mAh) at the time an IATA shutdown occurs.

17.3.11.4 IATA FCC cWH

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA STORE	IATA FCC cWH	I2	0	32767	0	cWh

Description: ***IATA FCC cWH*** stores the value of FCC (in cWh) at the time an IATA shutdown occurs.

17.3.11.5 IATA Flag

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA STORE	IATA Flag	H1	0x00	0xFF	0x0	Hex

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

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

IATA_SHUT (Bit 0): Enables the IATA shutdown to proceed. This bit is automatically set if the *IATA_SHUTDOWN()* MAC command is used. This bit needs to be manually set if the normal *ShutdownMode()* MAC command is expected to do an IATA shutdown.

1 = IATA shutdown is enabled.

0 = IATA shutdown is disabled.

17.3.12 Unintended Wakeup

17.3.12.1 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Unintended Wakeup	Delay	U1	0	240	2	s

Description: This sets the time in which communication is checked. If during this ***Delay*** timer period there is no valid communication with the device, then the device goes back into shutdown (with FETs turned off). If there is valid communication within the ***Delay*** timer period, then the device stays in wake and continues like a normal wakeup.

17.3.12.2 Count

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Unintended Wakeup	Count	U1	0	255	3	—

Description: The number of times the gauge wakes up from shutdown unintentionally is recorded. This "unintentional wakeup" counter is reset when the gauge wakes up and sees valid communication. If this count exceeds the threshold set by this register (***Count*** with the default of 3), then the next time the gauge wakes up from shutdown, it will execute a normal wakeup without looking for valid communication (and the counter recording wakeup will be reset). If ***Count*** is set to 0, then no threshold exists and the gauge will only wake up with valid communications.

17.4 System Data

17.4.1 Manufacturer Info

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Manufacturer Data	ManufacturerInfo	S33	—	—	abcdefghijklmnopqrstuvw zxy012345	—

Description: *ManufacturerInfo()* value

17.4.2 Manufacturer Info B

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Manufacturer Info B	Manufacturer Info B Length	U1	1	32	32	—
System Data	Manufacturer Info B	Manufacturer Info B01	H1	0x0	0xFF	01	Hex
System Data	Manufacturer Info B	Manufacturer Info B02	H1	0x0	0xFF	23	Hex
System Data	Manufacturer Info B	Manufacturer Info B03	H1	0x0	0xFF	45	Hex
System Data	Manufacturer Info B	Manufacturer Info B04	H1	0x0	0xFF	67	Hex
System Data	Manufacturer Info B	Manufacturer Info B05	H1	0x0	0xFF	89	Hex
System Data	Manufacturer Info B	Manufacturer Info B06	H1	0x0	0xFF	AB	Hex
System Data	Manufacturer Info B	Manufacturer Info B07	H1	0x0	0xFF	CD	Hex
System Data	Manufacturer Info B	Manufacturer Info B08	H1	0x0	0xFF	EF	Hex
System Data	Manufacturer Info B	Manufacturer Info B09	H1	0x0	0xFF	10	Hex
System Data	Manufacturer Info B	Manufacturer Info B10	H1	0x0	0xFF	11	Hex
System Data	Manufacturer Info B	Manufacturer Info B11	H1	0x0	0xFF	12	Hex
System Data	Manufacturer Info B	Manufacturer Info B12	H1	0x0	0xFF	13	Hex
System Data	Manufacturer Info B	Manufacturer Info B13	H1	0x0	0xFF	14	Hex
System Data	Manufacturer Info B	Manufacturer Info B14	H1	0x0	0xFF	15	Hex
System Data	Manufacturer Info B	Manufacturer Info B15	H1	0x0	0xFF	16	Hex
System Data	Manufacturer Info B	Manufacturer Info B16	H1	0x0	0xFF	17	Hex
System Data	Manufacturer Info B	Manufacturer Info B17	H1	0x0	0xFF	18	Hex
System Data	Manufacturer Info B	Manufacturer Info B18	H1	0x0	0xFF	19	Hex
System Data	Manufacturer Info B	Manufacturer Info B19	H1	0x0	0xFF	1A	Hex
System Data	Manufacturer Info B	Manufacturer Info B20	H1	0x0	0xFF	1B	Hex
System Data	Manufacturer Info B	Manufacturer Info B21	H1	0x0	0xFF	1C	Hex
System Data	Manufacturer Info B	Manufacturer Info B22	H1	0x0	0xFF	1C	Hex
System Data	Manufacturer Info B	Manufacturer Info B23	H1	0x0	0xFF	1D	Hex
System Data	Manufacturer Info B	Manufacturer Info B24	H1	0x0	0xFF	1E	Hex
System Data	Manufacturer Info B	Manufacturer Info B25	H1	0x0	0xFF	1F	Hex
System Data	Manufacturer Info B	Manufacturer Info B26	H1	0x0	0xFF	20	Hex
System Data	Manufacturer Info B	Manufacturer Info B27	H1	0x0	0xFF	21	Hex
System Data	Manufacturer Info B	Manufacturer Info B28	H1	0x0	0xFF	22	Hex
System Data	Manufacturer Info B	Manufacturer Info B29	H1	0x0	0xFF	23	Hex
System Data	Manufacturer Info B	Manufacturer Info B30	H1	0x0	0xFF	24	Hex

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Manufacturer Info B	Manufacturer Info B31	H1	0x0	0xFF	25	Hex
System Data	Manufacturer Info B	Manufacturer Info B32	H1	0x0	0xFF	26	Hex

Description: *ManufacturerInfoB()* value

17.4.3 Manufacturer Info C

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Manufacturer Info C	Manufacturer Info C Length	U1	1	32	32	—
System Data	Manufacturer Info C	Manufacturer Info C01	H1	0x0	0xFF	01	Hex
System Data	Manufacturer Info C	Manufacturer Info C02	H1	0x0	0xFF	23	Hex
System Data	Manufacturer Info C	Manufacturer Info C03	H1	0x0	0xFF	45	Hex
System Data	Manufacturer Info C	Manufacturer Info C04	H1	0x0	0xFF	67	Hex
System Data	Manufacturer Info C	Manufacturer Info C05	H1	0x0	0xFF	89	Hex
System Data	Manufacturer Info C	Manufacturer Info C06	H1	0x0	0xFF	AB	Hex
System Data	Manufacturer Info C	Manufacturer Info C07	H1	0x0	0xFF	CD	Hex
System Data	Manufacturer Info C	Manufacturer Info C08	H1	0x0	0xFF	EF	Hex
System Data	Manufacturer Info C	Manufacturer Info C09	H1	0x0	0xFF	10	Hex
System Data	Manufacturer Info C	Manufacturer Info C10	H1	0x0	0xFF	11	Hex
System Data	Manufacturer Info C	Manufacturer Info C11	H1	0x0	0xFF	12	Hex
System Data	Manufacturer Info C	Manufacturer Info C12	H1	0x0	0xFF	13	Hex
System Data	Manufacturer Info C	Manufacturer Info C13	H1	0x0	0xFF	14	Hex
System Data	Manufacturer Info C	Manufacturer Info C14	H1	0x0	0xFF	15	Hex
System Data	Manufacturer Info C	Manufacturer Info C15	H1	0x0	0xFF	16	Hex
System Data	Manufacturer Info C	Manufacturer Info C16	H1	0x0	0xFF	17	Hex
System Data	Manufacturer Info C	Manufacturer Info C17	H1	0x0	0xFF	18	Hex
System Data	Manufacturer Info C	Manufacturer Info C18	H1	0x0	0xFF	19	Hex
System Data	Manufacturer Info C	Manufacturer Info C19	H1	0x0	0xFF	1A	Hex
System Data	Manufacturer Info C	Manufacturer Info C20	H1	0x0	0xFF	1B	Hex
System Data	Manufacturer Info C	Manufacturer Info C21	H1	0x0	0xFF	1C	Hex
System Data	Manufacturer Info C	Manufacturer Info C22	H1	0x0	0xFF	1C	Hex
System Data	Manufacturer Info C	Manufacturer Info C23	H1	0x0	0xFF	1D	Hex
System Data	Manufacturer Info C	Manufacturer Info C24	H1	0x0	0xFF	1E	Hex
System Data	Manufacturer Info C	Manufacturer Info C25	H1	0x0	0xFF	1F	Hex
System Data	Manufacturer Info C	Manufacturer Info C26	H1	0x0	0xFF	20	Hex
System Data	Manufacturer Info C	Manufacturer Info C27	H1	0x0	0xFF	21	Hex
System Data	Manufacturer Info C	Manufacturer Info C28	H1	0x0	0xFF	22	Hex
System Data	Manufacturer Info C	Manufacturer Info C29	H1	0x0	0xFF	23	Hex
System Data	Manufacturer Info C	Manufacturer Info C30	H1	0x0	0xFF	24	Hex
System Data	Manufacturer Info C	Manufacturer Info C31	H1	0x0	0xFF	25	Hex
System Data	Manufacturer Info C	Manufacturer Info C32	H1	0x0	0xFF	26	Hex

Description: *ManufacturerInfoC()* values. To enable writing these registers during SEALED mode, a two-word MfgInfoC Write MAC sequence is required. The two-word key is programmable using ManufacturerAccess() 0x0035 Security Keys. Both keys must be sent within 4 seconds of each other. Once the correct two-word MAC sequence is received, host can update *ManufacturerInfoC()* values in SEALED mode for the time period specified in ***MfgInfoC Write Timeout*** . After this period runs out, *ManufacturerInfoC()* will automatically be sealed again and updates will no longer be allowed.

17.4.4 Integrity

17.4.4.1 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.

17.4.4.2 Static Chem DF

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Integrity	Static Chem DF Signature	H2	0x0	0x7FFF	0x73B5	Hex

Description: Static chemistry data signature. Use MAC *StaticChemDFSignature()* (with MSB set to 0) to initialize this value.

17.4.4.3 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.

17.5 SBS Configuration

17.5.1 Data

17.5.1.1 Manufacturer Date

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Manufacturer Date	U2	0	65535	0	Date

Description: *ManufacturerDate()* value in the following format: Day + Month×32 + (Year–1980) × 512

17.5.1.2 Serial Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Serial Number	H2	0x0000	0xFFFF	0x0001	Hex

Description: *SerialNumber()* value

17.5.1.3 Manufacturer Name

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Manufacturer Name	S20+1	—	—	Texas Instruments	ASCII

Description: *ManufacturerName()* value

17.5.1.4 Device Name

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Device Name	S20+1	—	—	BQDEVICE	ASCII

Description: *DeviceName()* value

17.5.1.5 Device Chemistry

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Device Chemistry	S4+1	—	—	LION	ASCII

Description: *DeviceChemistry()* value

17.5.1.6 Remaining Capacity Alarm

17.5.1.6.1 Remaining Ah Capacity Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Remaining Ah Capacity Alarm	U2	0	32767	300	mAh

Description: *RemainingCapacityAlarm()* value in mAh

17.5.1.6.2 Remaining Wh Capacity Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Remaining Wh Capacity Alarm	U2	0	32767	432	cWh

Description: *RemainingCapacityAlarm()* value in cWh

17.5.1.7 RemainingTimeAlarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Remaining Time Alarm	U2	0	65535	10	min

Description: *RemainingTimeAlarm()* value

17.5.1.8 Initial Battery Mode

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Initial Battery Mode	H2	0x0000	0xFFFF	0x0081	Hex

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 cW or cWh

0 = Report in mA or mAh (default)

CHGM (Bit 14): Charger_Mode (R/W)

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

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

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

1 = Disables *AlarmWarning()* broadcasts to the host and smart battery charger

0 = Enables *AlarmWarning()* broadcasts to the 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 is okay.

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

PBS (Bit 1): Primary_Battery_Support (R)

1 = Primary or secondary battery support

0 = Function is not supported. (default)

ICC (Bit 0): Internal_Charge_Controller (R)

1 = Function is supported.

0 = Function is not supported. (default)

17.5.1.9 Specification Information

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Specification Information	H2	0x0000	0xFFFF	0x0031	Hex

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)

17.5.1.10 VLB Remaining Capacity

17.5.1.10.1 VLB Remaining Cap mAh

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	VLB Remaining Cap mAh	I2	0	32767	176	mAh

Description: Very low battery warning hold capacity in mAh.

17.5.1.10.2 VLB Remaining Cap in cWh

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	VLB Remaining Cap cWh	I2	0	32767	254	cWh

Description: Very low battery warning hold capacity in cWh.

17.5.1.11 VLB Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	VLB Voltage	I2	0	5000	2850	mV

Description: Very low battery warning voltage.

17.5.1.12 VLB Hold Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	VLB Hold Time	U1	0	255	2	s

Description: Very low battery warning hold time.

17.5.1.13 VLB Timeout

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	VLB Timeout	U1	0	255	120	s

Description: *RemainingCapacity()* is hold to ***VLB Remaning Cap*** .for ***VLB Timeout*** .

17.6 Lifetimes

17.6.1 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

17.6.2 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

17.6.3 Current

17.6.3.1 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

17.6.3.2 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

17.6.3.3 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

17.6.3.4 Max Avg Dsg Power

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Avg Dsg Power	I2	–32768	0	0	cW

Description: Maximum reported average power in the discharge direction

17.6.4 Temperature-Relax

17.6.4.1 Max Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp Cell	U1	0	255	0	°C

Description: Maximum reported cell temperature in RELAX mode

17.6.4.2 Min Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp Cell	I1	–128	127	127	°C

Description: Minimum reported cell temperature in RELAX mode

17.6.4.3 Min Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp Int Sensor	I1	–128	127	127	°C

Description: Minimum reported internal temperature sensor temperature in RELAX mode

17.6.4.4 Max Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp Int Sensor	U1	0	255	0	°C

Description: Maximum reported internal temperature sensor temperature in RELAX mode

17.6.4.5 Max Temp Fet

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp Fet	U1	0	255	0	°C

Description: Maximum reported FET temperature in RELAX mode

17.6.4.6 Max Temp TS1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TS1	U1	0	255	0	°C

Description: Maximum reported TS1 in RELAX mode

17.6.4.7 Min Temp TS1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TS1	I1	–128	127	127	°C

Description: Minimum reported TS1 in RELAX mode

17.6.5 Max Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp Cell	U1	0	255	0	°C

Description: Maximum reported cell temperature in CHARGE mode

17.6.6 Min Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp Cell	I1	–128	127	127	°C

Description: Minimum reported cell temperature in CHARGE mode

17.6.7 Max Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp Int Sensor	U1	0	255	0	°C

Description: Maximum reported internal temperature sensor temperature in CHARGE mode

17.6.8 Min Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp Int Sensor	I1	–128	127	127	°C

Description: Minimum reported internal temperature sensor temperature in CHARGE mode

17.6.9 Max Temp Fet

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp Fet	U1	0	255	0	°C

Description: Maximum reported FET temperature in CHARGE mode

17.6.10 Max Temp TS1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TS1	U1	0	255	0	°C

Description: Maximum reported TS1 in CHARGE mode

17.6.11 Min Temp TS1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TS1	I1	–128	127	127	°C

Description: Minimum reported TS1 in CHARGE mode

17.6.12 Max Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp Cell	U1	0	255	0	°C

Description: Maximum reported cell temperature in DISCHARGE mode

17.6.13 Min Temp Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp Cell	I1	–128	127	127	°C

Description: Minimum reported cell temperature in DISCHARGE mode

17.6.14 Max Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp Int Sensor	U1	0	255	0	°C

Description: Maximum reported internal temperature sensor temperature in DISCHARGE mode

17.6.15 Min Temp Int Sensor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp Int Sensor	I1	–128	127	127	°C

Description: Minimum reported internal temperature sensor temperature in DISCHARGE mode

17.6.16 Max Temp Fet

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp Fet	U1	0	255	0	°C

Description: Maximum reported FET temperature in DISCHARGE mode

17.6.17 Max Temp TS1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TS1	U1	0	255	0	°C

Description: Maximum reported TS1 in DISCHARGE mode

17.6.18 Min Temp TS1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TS1	I1	–128	127	127	°C

Description: Minimum reported TS1 in DISCHARGE mode

17.6.19 Safety Events

17.6.19.1 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

17.6.19.2 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

17.6.19.3 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

17.6.19.4 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

17.6.19.5 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

17.6.19.6 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

17.6.19.7 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

17.6.19.8 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

17.6.19.9 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

17.6.19.10 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

17.6.19.11 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

17.6.19.12 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

17.6.19.13 No Of AOCD Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of AOCD Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[AOCD]* events

17.6.19.14 Last AOCD Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last AOCD Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[AOCD]* event in *CycleCount()* cycles

17.6.19.15 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()[ASCD]* events

17.6.19.16 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()[ASCD]* event in *CycleCount()* cycles

17.6.19.17 No Of AOCC Events

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	No Of AOCC Events	U2	0	32767	0	events

Description: Total number of *SafetyStatus()[AOCC]* events

17.6.19.18 Last AOCC Event

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Safety Events	Last AOCC Event	U2	0	32767	0	cycles

Description: Last *SafetyStatus()[AOCC]* event in *CycleCount()* cycles

17.6.19.19 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

17.6.19.20 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

17.6.19.21 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

17.6.19.22 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

17.6.19.23 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

17.6.19.24 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

17.6.20 Charging Events

17.6.20.1 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

17.6.20.2 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

17.6.21 Gauging Events

17.6.21.1 No Of Qmax Updates

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Gauging Events	No Of Qmax Updates	U2	0	32767	0	events

Description: Total number of *GaugingStatus()[QMax]* toggles

17.6.21.2 Last Qmax Update

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Gauging Events	Last Qmax Update	U2	0	32767	0	cycles

Description: The *CycleCount()* cycles made at the last event of *GaugingStatus()[QMax]* update

17.6.21.3 No Of Ra Updates

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Gauging Events	No Of Ra Updates	U2	0	32767	0	events

Description: Total number of *GaugingStatus()[RX]* toggles

17.6.21.4 Last Ra Update

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Gauging Events	Last Ra Update	U2	0	32767	0	cycles

Description: Last *GaugingStatus()[RX]* toggle in *CycleCount()* cycles

17.6.21.5 No Of Ra Disable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Gauging Events	No Of Ra Disable	U2	0	32767	0	events

Description: Total number of *GaugingStatus()[R_DIS]* = 1 event

17.6.21.6 Last Ra Disable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Gauging Events	Last Ra Disable	U2	0	32767	0	cycles

Description: The *CycleCount()* cycles of the last update event of *GaugingStatus()[R_DIS]* = 1

17.6.22 Time

17.6.22.1 Total Firmware Runtime

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Total Firmware Runtime	U4	0	4294967295	0	s

Description: Total firmware runtime between resets

17.6.22.2 Time Spent in LFT_UUT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_UUT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UUT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UUT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UUT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UUT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UUT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UUT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UUT RSOC H	U4	0	4294967295	0	s

Description: Firmware runtime spent below LFT_T0 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.6.22.3 Time Spent in LFT_UT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_UT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_UT RSOC H	U4	0	4294967295	0	s

Description: Firmware runtime spent between LFT_T0 andLFT_T1 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.6.22.4 Time Spent in LFT_LT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_LT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_LT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_LT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_LT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_LT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_LT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_LT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_LT RSOC H	U4	0	4294967295	0	s

Description: Total firmware runtime spent between LFT_T1 and LFT_T2 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.6.22.5 Time Spent in LFT_STL

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_STL RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STL RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STL RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STL RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STL RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STL RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STL RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STL RSOC H	U4	0	4294967295	0	s

Description: Total firmware runtime spent between LFT_T2 and LFT_T5 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.6.22.6 Time Spent in LFT_RT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_RT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_RT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_RT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_RT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_RT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_RT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_RT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_RT RSOC H	U4	0	4294967295	0	s

Description: Total firmware runtime spent between LFT_T5 and LFT_T6 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.6.22.7 Time Spent in LFT_STH

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_STH RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STH RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STH RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STH RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in STH RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STH RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STH RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_STH RSOC H	U4	0	4294967295	0	s

Description: Total firmware runtime spent between LFT_T6 and LFT_T3 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.6.22.8 Time Spent in LFT_HT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_HT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_HT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_HT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_HT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_HT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_HT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_HT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_HT RSOC H	U4	0	4294967295	0	s

Description: Total firmware runtime spent between LFT_T3 and LFT_T4 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.6.22.9 Time Spent in LFT_OT

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Time	Time Spent in LFT_OT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_OT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_OT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_OT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_OT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_OT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_OT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	Time Spent in LFT_OT RSOC H	U4	0	4294967295	0	s

Description: Total firmware runtime spent above LFT_T4 broken up according to running RSOC:

The RSOC A slot defines the range greater than or equal to ***Time RSOC Threshold A*** .

RSOC B is the range greater than or equal to ***Time RSOC Threshold B*** and less than ***Time RSOC Threshold A*** .

RSOC C is the range greater than or equal to ***Time RSOC Threshold C*** and less than ***Time RSOC Threshold B*** .

RSOC D is the range greater than or equal to ***Time RSOC Threshold D*** and less than ***Time RSOC Threshold C*** .

RSOC E is the range greater than or equal to ***Time RSOC Threshold E*** and less than ***Time RSOC Threshold D*** .

RSOC F is the range greater than or equal to ***Time RSOC Threshold F*** and less than ***Time RSOC Threshold E*** .

RSOC G is the range greater than or equal to ***Time RSOC Threshold G*** and less than ***Time RSOC Threshold F*** .

RSOC H is the range less than ***Time RSOC Threshold G*** .

17.7 Protections

17.7.1 CUV—Cell Undervoltage

17.7.1.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Threshold	I2	0	32767	2500	mV

Description: Cell undervoltage trip threshold

17.7.1.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Delay	U1	0	255	2	s

Description: Cell undervoltage trip delay

17.7.1.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Recovery	I2	0	32767	3000	mV

Description: Cell undervoltage recovery threshold

17.7.1.4 Recovery Charger Present Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Recovery Charger Present Time	U1	0	255	2	s

Description: Time required for PACK voltage > ***Charger Present Threshold*** to recover from Cell undervoltage protection if ***Protection Configuration[CUV_RECOV_CHG]*** = 1.

17.7.2 CUVC—Cell Undervoltage

17.7.2.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUVC	Threshold	I2	0	32767	2400	mV

Description: Cell undervoltage trip threshold

17.7.2.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUVC	Delay	U1	0	255	2	s

Description: Cell undervoltage trip delay

17.7.2.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUVC	Recovery	I2	0	32767	3000	mV

Description: Cell undervoltage recovery threshold

17.7.3 ACUV—Cell Under Voltage hardware based

17.7.3.1 Recovery (ACUV)

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ACUV	Recovery	I2	0	32767	3000	mV

Description: ***ACUV*** recovery voltage threshold for AFE cell undervoltage hardware protection. The ACUV SafetyStatus flag clears immediately (no time delay) when the minimum cell voltage rises to or above this threshold. Upon recovery, the AFE hardware BATUV latch is also cleared.

17.7.4 ACOV—Cell Over Voltage hardware based

17.7.4.1 Recovery (ACOV)

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ACOV	Recovery	I2	0	32767	3900	mV

Description: ***ACOV*** recovery voltage threshold for AFE cell overvoltage hardware protection. The ACOV SafetyStatus flag clears immediately (no time delay) when the maximum cell voltage falls to or below this threshold. Upon recovery, the AFE hardware BATOV latch is also cleared.

17.7.5 COV—Cell Overvoltage

17.7.5.1 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

17.7.5.2 Threshold Standard Temp Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Threshold Standard Temp Low	I2	0	32767	4300	mV

Description: Cell overvoltage standard temperature low range trip threshold

17.7.5.3 Threshold Standard Temp High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Threshold Standard Temp High	I2	0	32767	4300	mV

Description: Cell overvoltage standard temperature high range trip threshold

17.7.5.4 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

17.7.5.5 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

17.7.5.6 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Delay	U1	0	255	2	s

Description: Cell overvoltage trip delay

17.7.5.7 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

17.7.5.8 Recovery Standard Temp Low

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Recovery Standard Temp Low	I2	0	32767	3900	mV

Description: Cell overvoltage standard temperature low recovery range threshold

17.7.5.9 Recovery Standard Temp High

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Recovery Standard Temp High	I2	0	32767	3900	mV

Description: Cell overvoltage standard temperature high recovery range threshold

17.7.5.10 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

17.7.5.11 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

17.7.5.12 Cell Overvoltage Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Latch Limit	I2	0	255	0	counts

Description: Cell overvoltage latch counter trip threshold

17.7.5.13 Cell Overvoltage Counter Decrement Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Counter Dec Delay	I2	0	255	10	s

Description: Cell overvoltage counter decrement delay

17.7.5.14 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Reset	I2	0	255	15	s

Description: Cell overvoltage latch reset time

17.7.6 OCC1—Overcurrent In Charge 1

17.7.6.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC1	Threshold	I2	–32768	32767	6000	mA

Description: Overcurrent in Charge 1 trip threshold

17.7.6.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC1	Delay	U1	0	255	6	s

Description: Overcurrent in Charge 1 trip delay

17.7.7 OCC2—Overcurrent In Charge 2

17.7.7.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC2	Threshold	I2	–32768	32767	8000	mA

Description: Overcurrent in Charge 2 trip threshold

17.7.7.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC2	Delay	U1	0	255	3	s

Description: Overcurrent in Charge 2 trip delay

17.7.8 OCC—Overcurrent In Charge Recovery

17.7.8.1 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

17.7.8.2 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

17.7.9 OCD1—Overcurrent In Discharge 1

17.7.9.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD1	Threshold	I2	–32768	32767	–6000	mA

Description: Overcurrent in Discharge 1 trip threshold

17.7.9.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD1	Delay	U1	0	255	6	s

Description: Overcurrent in Discharge 1 trip delay

17.7.10 OCD2—Overcurrent In Discharge 2

17.7.10.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD2	Threshold	I2	–32768	32767	–8000	mA

Description: Overcurrent in Discharge 2 trip threshold

17.7.10.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD2	Delay	U1	0	255	3	s

Description: Overcurrent in Discharge 2 trip delay

17.7.11 OCD—Overcurrent In Discharge Recovery

17.7.11.1 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

17.7.11.2 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

17.7.11.3 Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD	Latch Limit	U1	0	255	0	counts

Description: Overcurrent in Discharge (OCD) latch counter trip threshold

17.7.11.4 Counter Dec Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD	Counter Dec Delay	U1	0	255	10	s

Description: Overcurrent in Discharge (OCD) counter decrement delay

17.7.11.5 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD	Reset	U1	0	255	15	s

Description: Overcurrent in Discharge (OCD) latch reset time

17.7.12 AOCD—Overload in Discharge

17.7.12.1 Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCD	Latch Limit	U1	0	255	0	counts

Description: Overload latch counter trip threshold

17.7.12.2 Counter Dec Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCD	Counter Dec Delay	U1	0	255	10	s

Description: Overload latch counter decrement delay

17.7.12.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCD	Recovery	U1	0	255	5	s

Description: Overload recovery time

17.7.12.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCD	Reset	U1	0	255	15	s

Description: Overload latch reset time

17.7.13 AOCC—Overcurrent In Charge

17.7.13.1 Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCC	Latch Limit	U1	0	255	0	counts

Description: Short Circuit in Charge Latch counter trip threshold

17.7.13.2 Counter Dec Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCC	Counter Dec Delay	U1	0	255	10	s

Description: Short Circuit in Charge counter decrement delay

17.7.13.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCC	Recovery	U1	0	255	5	s

Description: Short Circuit in Charge recovery time

17.7.13.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCC	Reset	U1	0	255	15	s

Description: Short Circuit in Charge latch reset time

17.7.14 ASCD—Short Circuit in Discharge

17.7.14.1 Latch Limit

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Latch Limit	U1	0	255	0	counts

Description: Short Circuit in Discharge Latch counter trip threshold

17.7.14.2 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

17.7.14.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Recovery	U1	0	255	5	s

Description: Short Circuit in Discharge recovery time

17.7.14.4 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

17.7.15 OTC—Overtemperature in Charge

17.7.15.1 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

17.7.15.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTC	Delay	U1	0	255	2	s

Description: Overtemperature in Charge Cell trip delay

17.7.15.3 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

17.7.16 OTD—Overtemperature in Discharge

17.7.16.1 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

17.7.16.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTD	Delay	U1	0	255	2	s

Description: Overtemperature in Discharge trip delay

17.7.16.3 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

17.7.17 OTF—Overtemperature FET

17.7.17.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Threshold	I2	–400	1500	800	0.1°C

Description: Overtemperature FET trip threshold

17.7.17.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Delay	U1	0	255	2	s

Description: Overtemperature FET trip delay

17.7.17.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Recovery	I2	–400	1500	650	0.1°C

Description: Overtemperature FET recovery threshold

17.7.18 UTC—Undertemperature in Charge

17.7.18.1 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

17.7.18.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTC	Delay	U1	0	255	2	s

Description: Undertemperature in Charge Cell trip delay

17.7.18.3 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

17.7.19 UTD—Undertemperature in Discharge

17.7.19.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Threshold	I2	–400	1500	0	0.1°C

Description: Undertemperature in Discharge trip threshold

17.7.19.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Delay	U1	0	255	2	s

Description: Undertemperature in Discharge trip delay

17.7.19.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Recovery	I2	–400	1500	50	0.1°C

Description: Undertemperature in Discharge recovery threshold

17.7.20 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

17.7.21 PTO—PRECHARGE Mode Time Out

17.7.21.1 Charge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Charge Threshold	I2	–32768	32767	2000	mA

Description: Precharge Timeout Current Threshold

17.7.21.2 Suspend Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Suspend Threshold	I2	–32768	32767	1800	mA

Description: Precharge Timeout Suspend Threshold

17.7.21.3 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Delay	U2	0	65535	1800	s

Description: Precharge Timeout Trip Delay

17.7.21.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Reset	I2	0	32767	2	mAh

Description: Precharge Timeout Reset Threshold

17.7.22 CTO—Fast Charge Mode Time Out

17.7.22.1 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

17.7.22.2 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

17.7.22.3 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Delay	U2	0	65535	54000	s

Description: Fast-Charge Timeout Trip Delay

17.7.22.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Reset	I2	0	32767	2	mAh

Description: Fast-Charge Timeout Reset Threshold

17.7.23 OC—Overcharge

17.7.23.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	Threshold	I2	–32768	32767	300	mAh

Description: Overcharge trip threshold

17.7.23.2 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	Recovery	I2	–32768	32767	2	mAh

Description: Overcharge recovery threshold

17.7.23.3 RSOC Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	RSOC Recovery	U1	0	100	90	%

Description: Overcharge *RelativeStateOfCharge()* recovery threshold

17.7.24 CHGV—ChargingVoltage

17.7.24.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Threshold	I2	–32768	32767	500	mV

Description: *ChargingVoltage()* delta trip threshold

17.7.24.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Delay	U1	0	255	30	s

Description: *ChargingVoltage()* delta trip delay

17.7.24.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Recovery	I2	–32768	32767	–500	mV

Description: *ChargingVoltage()* delta recovery threshold

17.7.25 CHGC—ChargingCurrent

17.7.25.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Threshold	I2	–32768	32767	500	mA

Description: *ChargingCurrent()* delta trip threshold

17.7.25.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Delay	U1	0	255	2	s

Description: *ChargingCurrent()* delta trip delay

17.7.25.3 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Recovery Threshold	I2	–32768	32767	100	mA

Description: *ChargingCurrent()* delta recovery threshold

17.7.25.4 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Recovery Delay	U1	0	255	2	s

Description: *ChargingCurrent()* delta recovery delay

17.7.26 PCHGC—Pre-ChargingCurrent

17.7.26.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Threshold	I2	–32768	32767	50	mA

Description: *Pre-ChargingCurrent()* trip threshold

17.7.26.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Delay	U1	0	255	2	s

Description: *Pre-ChargingCurrent()* trip delay

17.7.26.3 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Recovery Threshold	I2	–32768	32767	10	mA

Description: *Pre-ChargingCurrent()* recovery threshold

17.7.26.4 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Recovery Delay	U1	0	255	2	s

Description: *Pre-ChargingCurrent()* recovery delay

17.8 Permanent Fail

17.8.1 SUV—Safety Cell Undervoltage

17.8.1.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SUV	Threshold	I2	0	32767	2200	mV

Description: Safety Cell Undervoltage trip threshold

17.8.1.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SUV	Delay	U1	0	255	5	s

Description: Safety Cell Undervoltage trip delay

17.8.2 SOV—Safety Cell Overvoltage

17.8.2.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOV	Threshold	I2	0	32767	4500	mV

Description: Safety Cell Overvoltage trip threshold

17.8.2.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOV	Delay	U1	0	255	5	s

Description: Safety Cell Overvoltage trip delay

17.8.3 SOCC—Safety Overcurrent in Charge

17.8.3.1 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

17.8.3.2 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

17.8.4 SOCD—Safety Overcurrent in Discharge

17.8.4.1 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

17.8.4.2 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

17.8.5 SOT—Overtemperature Cell

17.8.5.1 SOTC Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOT	SOTC Threshold	I2	–400	1500	650	0.1°C

Description: Overtemperature Cell trip threshold in CHARGE mode

17.8.5.2 SOTC Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOT	SOTC Delay	U1	0	255	5	s

Description: Overtemperature cell trip delay in CHARGE mode

17.8.5.3 SOTD Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOT	SOTD Threshold	I2	–400	1500	700	0.1°C

Description: Overtemperature Cell trip threshold in DISCHARGE and RELAX mode

17.8.5.4 SOTD Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOT	SOTD Delay	U1	0	255	5	s

Description: Overtemperature Cell trip delay in DISCHARGE and RELAX mode

17.8.6 SOTF—Overtemperature FET

17.8.6.1 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

17.8.6.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOTF	Delay	U1	0	255	5	s

Description: Overtemperature FET trip delay

17.8.7 CD—Capacity Degradation

17.8.7.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CD	Threshold	I2	0	32767	0	mAh

Description: Capacity Degradation Threshold

17.8.7.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CD	Delay	U1	0	255	2	cycles

Description: Capacity Degradation Trip Delay

17.8.8 CFET—CHG FET Failure

17.8.8.1 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

17.8.8.2 OFF Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CFET	OFF Delay	U1	0	255	5	s

Description: CHG FET OFF trip delay

17.8.9 DFET—DFET Failure

17.8.9.1 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

17.8.9.2 OFF Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	DFET	OFF Delay	U1	0	255	5	s

Description: DSG FET OFF trip delay

17.8.10 AFER—AFE Register

17.8.10.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFER	Threshold	U1	0	255	100	—

Description: AFE Register comparison fail trip threshold

17.8.10.2 Delay Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFER	Delay Period	U1	0	255	2	s

Description: AFE Register comparison counter decrement period

17.8.10.3 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

17.8.11 AFEC—AFE Communication

17.8.11.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFEC	Threshold	U1	0	255	100	—

Description: AFE Communication fail trip threshold

17.8.11.2 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

17.9 PF Status

The data in this class is saved at the time of the PF event.

17.9.1 Device Status Data

17.9.1.1 Safety Alert A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert A	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.2 Safety Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status A	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.3 Safety Alert B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert B	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.4 Safety Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status B	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.5 Safety Alert C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert C	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.6 Safety Status C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status C	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.7 Safety Alert D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Alert D	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.8 Safety Status D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Safety Status D	H1	0x00	0xFF	0x00	Hex

Description: Accumulated safety flags since PF event

17.9.1.9 PF Alert A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert A	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.10 PF Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status A	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.11 PF Alert B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert B	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.12 PF Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status B	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.13 PF Alert C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert C	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.14 PF Status C

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status C	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.15 PF Alert D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Alert D	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.16 PF Status D

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	PF Status D	H1	0x00	0xFF	0x00	Hex

Description: Accumulated PF flags since PF event

17.9.1.17 Fuse Flag

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Fuse Flag	H2	0x0000	0xFFFF	0x0000	Hex

Description: Flag set to indicate fuse blow

17.9.1.18 Operation Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Operation Status A	H2	0x0000	0xFFFF	0x0000	Hex

Description: *OperationStatus()* data at the time of the PF event

17.9.1.19 Operation Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Operation Status B	H2	0x0000	0xFFFF	0x0000	Hex

Description: *OperationStatus()* data at the time of the PF event

17.9.1.20 Temp Range

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Temp Range	H1	0x00	0xFF	0x00	Hex

Description: Temperature range status at the time of the PF event. The temperature range information returned by *ChargingStatus()*

17.9.1.21 Charging Status A

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Charging Status A	H1	0x00	0xFF	0x00	Hex

Description: The charging status at the time of the PF event. See *Section 16.2.35* for the bit definitions.

7	6	5	4	3	2	1	0
VCT	MCHG	SU	IN	HV	MV	LV	PV

17.9.1.22 Charging Status B

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Charging Status B	H1	0x00	0xFF	0x00	Hex

Description: The charging status at the time of the PF event. See *Section 16.2.35*for the bit definitions.

7	6	5	4	3	2	1	0
VCT	RSVD	RSVD	RSVD	RSVD	CCC	CVR	CCR

17.9.1.23 Gauging Status

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	Gauging Status	H2	0x0000	0xFFFF	0x0000	Hex

Description: The gauging status at the time of the PF event. See *ManufacturerAccess() 0x0056 GaugingStatus* for bit definitions.

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	VLB

7	6	5	4	3	2	1	0
CF	DSG	EDV	RSVD	TC	TD	FC	FD

17.9.1.24 IT Status

Class	Subclass	Name	Type	Min	Max	Default	Units
PF Status	Device Status Data	IT Status	H2	0x0000	0xFFFF	0x0000	Hex

Description: The Impedance Track™ status at the time of the PF event. See *ManufacturerAccess() 0x0056 GaugingStatus* for the bit definitions.

15	14	13	12	11	10	9	8
RSVD	EDVCONV	RSVD	OCVFR	LDMD	RX	QMAX	VDQ

7	6	5	4	3	2	1	0
NSFM	OCVPRED	SLPQ MAX	QEN	VOK	RDIS	RSVD	REST

17.9.2 Device Voltage Data (at the Time of PF Event)

17.9.2.1 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

17.9.2.2 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

17.9.2.3 Pack Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Pack Voltage	I2	–32768	32767	0	mV

Description: PACK voltage

17.9.3 Device Current Data

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Current Data	Current	I2	–32768	32767	0	mV

Description: *Current()*

17.9.4 Device Gauging Data (at the Time of PF Event)

17.9.4.1 Cell 1DOD0

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Gauging Data	Cell 1 DOD0	I2	–32768	32767	0	—

Description: Cell 1 depth of discharge

17.9.4.2 Passed Charge

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Gauging Data	Passed Charge	I2	–32768	32767	0	mAh

Description: Passed charge since last QMax update

17.9.5 AFE Regs

The ***AFE Regs*** data is intended for Texas Instruments' use to help with internal firmware diagnostics. They are not settings. They are the snapshot of the corresponding registers under ***Settings:AFE*** when permanent failur occurs.

17.9.5.1 OCC

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCC	H1	0x0	0x7F	0x03	Hex

Description: AFE OCC Register Contents

17.9.5.2 OCD1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD1	H1	0x0	0x7F	0x03	Hex

Description: AFE OCD1 Register Contents

17.9.5.3 OCD2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD2	H1	0x0	0x7F	0x04	Hex

Description: AFE OCD2 Register Contents

17.9.5.4 Short Circuit Discharge

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	Short Circuit Discharge	H1	0x0	0x7F	0x64	Hex

Description: AFE Short Circuit Discharge Register Contents

17.9.5.5 Current Discharge Wake

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	Current Discharge Wake	H1	0x70	0x7F	0x79	Hex

Description: AFE Current Discharge Wake Register Contents

17.9.5.6 Current Charge Wake

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	Current Charge Wake	H1	0x70	0x7F	0x79	Hex

Description: AFE Current Charge Wake Register Contents

17.9.5.7 OCC 1 Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCC 1 Delay 2	H1	0x0	0x07	0x07	Hex

Description: AFE OCC 1 Delay2 Register Contents

17.9.5.8 OCC 1 Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCC 1 Delay 1	H1	0x0	0xFF	0xFF	Hex

Description: AFE OCC 1 Delay 1 Register Contents

17.9.5.9 OCD 1 Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD 1 Delay 2	H1	0x0	0x07	0x07	Hex

Description: AFE OCD 1 Delay 2 Register Contents

17.9.5.10 OCD 1 Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD 1 Delay 1	H1	0x0	0xFF	0xFF	Hex

Description: AFE OCD 1 Delay 1 Register Contents

17.9.5.11 OCD 2 Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD 2 Delay 2	H1	0x0	0x07	0x07	Hex

Description: AFE OCD 2 Delay 2 Register Contents

17.9.5.12 OCD 2 Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD 2 Delay 1	H1	0x0	0xFF	0xFF	Hex

Description: AFE OCD 2 Delay 1 Register Contents

17.9.5.13 Short Circuit Discharge Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	Short Circuit Discharge Delay	H1	0x0	0x3F	0x14	Hex

Description: AFE Short Circuit Discharge Delay Register Contents

17.9.5.14 Over Temperature Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	Over Temperature Delay	H1	0x0	0x1F	0x14	Hex

Description: AFE Over Temperature Delay Register Contents

17.9.5.15 OCD Wake Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD Wake Delay 2	H1	0x0	0x01	0x01	Hex

Description: AFE OCD Wake Delay 2 Register Contents

17.9.5.16 OCD Wake Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD Wake Delay 1	H1	0x0	0xFF	0xFF	Hex

Description: AFE OCD Wake Delay 1 Register Contents

17.9.5.17 OCC Wake Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCC Wake Delay 2	H1	0x0	0x01	0x01	Hex

Description: AFE OCC Wake Delay 2 Register Contents

17.9.5.18 OCC Wake Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCC Wake Delay 1	H1	0x0	0xFF	0xFF	Hex

Description: AFE OCC Wake Delay 1 Register Contents

17.10 Black Box

17.10.1 Safety Status

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Black Box	Safety Status	1st Safety Status A	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Safety Status B	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Safety Status C	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Safety Status D	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	1st Time to Next Event	U2	0	65535	0	s	Time from 1st event to 2nd event
Black Box	Safety Status	1st Cycle Count	U2	0	65535	0	—	Cycle Count of 1st event
Black Box	Safety Status	2nd Safety Status A	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	2nd Safety Status B	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	2nd Safety Status C	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	2nd Safety Status D	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	2nd Time to Next Event	U2	0	65535	0	s	Time from 2nd event to 3rd event
Black Box	Safety Status	2nd Cycle Count	U2	0	65535	0	—	Cycle Count of 2nd event
Black Box	Safety Status	3rd Safety Status A	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Safety Status B	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Safety Status C	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Safety Status D	H1	0x00	0xFF	0x00	Hex	*SafetyStatus()* data
Black Box	Safety Status	3rd Time to Next Event	U2	0	65535	0	s	Time since 3rd event
Black Box	Safety Status	3rd Cycle Count	U2	0	65535	0	—	Cycle Count of 3rd event

17.10.2 PF Status

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Black Box	PF Status	1st PF Status A	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	1st PF Status B	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Black Box	PF Status	1st PF Status C	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	1st PF Status D	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	1st Time to Next Event	U2	0	65535	0	s	Time from 1st event to 2nd event
Black Box	PF Status	1st Cycle Count	U2	0	65535	0	—	Cycle Count of 1st event
Black Box	PF Status	2nd PF Status A	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	2nd PF Status B	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	2nd PF Status C	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	2nd PF Status D	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	2nd Time to Next Event	U2	0	65535	0	s	Time from 2nd event to 3rd event
Black Box	PF Status	2nd Cycle Count	U2	0	65535	0	—	Cycle Count of 2nd event
Black Box	PF Status	3rd PF Status A	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	3rd PF Status B	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	3rd PF Status C	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	3rd PF Status D	H1	0x00	0xFF	0x00	Hex	*PFStatus()* data
Black Box	PF Status	3rd Cycle Count	U2	0	65535	0	—	Cycle Count of 3rd event

17.11 Gas Gauging

17.11.1 Current Thresholds

17.11.1.1 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

17.11.1.2 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

17.11.1.3 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

17.11.1.4 Dsg Relax Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Dsg Relax Time	U1	0	255	1	s

Description: Discharge to relax timeout. When discharge is stopped, the device will exit the DISCHARGE mode after this time is passed.

17.11.1.5 Chg Relax Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Current Thresholds	Chg Relax Time	U1	0	255	60	s

Description: Charge to relax timeout. When charging is stopped, the device will exit the CHARGE mode after this time is passed.

17.11.2 Design

17.11.2.1 Design Capacity mAh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Design	Design Capacity mAh	I2	100	32767	4400	mAh

Description: ***Design Capacity*** in mAh. This is reported by *DesignCapacity()* if ***[CAPM]*** = 0.

17.11.2.2 Design Capacity 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.

17.11.2.3 Design Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Design	Design Voltage	I2	0	32767	3600	mV

Description: Nominal design voltage of the battery cell. Default 3600mV for single-cell Li-ion application.

17.11.3 Cycle

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Cycle	Cycle Count Percentage	U1	0	100	90	%

Description: This threshold increments the cycle count if the accumulated discharge is more than this set percentage of *FullChargeCapacity()* (if ***[CCT]*** = 1) or *DesignCapacity()* (if ***[CCT]*** = 0).

Note

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()*.

17.11.4 FD

17.11.4.1 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

17.11.4.2 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

17.11.4.3 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

17.11.4.4 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

17.11.5 FC

17.11.5.1 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

17.11.5.2 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

17.11.5.3 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

17.11.5.4 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

17.11.6 TD

GaugingStatus()[TD] sets *BatteryStatus()[TDA]* when in DISCHARGE mode.

17.11.6.1 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

17.11.6.2 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

17.11.6.3 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

17.11.6.4 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

17.11.7 TC

GaugingStatus()[TC] sets *BatteryStatus()[TCA]* when in CHARGE mode

17.11.7.1 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

17.11.7.2 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

17.11.7.3 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

17.11.7.4 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

17.11.8 State

17.11.8.1 QMax

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	State	QMax Cell	I2	0	32767	4400	mAh	QMax Cell
Gas Gauging	State	Qmax Cycle Count	U2	0	65535	0	—	The *CycleCount()* when Qmax updated

17.11.8.2 Update Status

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Update Status	H1	0x00	0x0E	0x00	Hex

7	6	5	4	3	2	1	0

RSVD	RSVD	RSVD	RSVD	QMax	Enable	Update1	Update0

RSVD (Bits 7–4): Reserved. Do not use.

QMax update in the field (Bit 3)

1 = Updated

0 = Not updated

Enable (Bit 2): Impedance Track™ gauging and lifetime updating enable

1 = Enabled

0 = Disabled

Update1, Update0 (Bits 1–0): Update Status

0,0 = Impedance Track™ gauging and lifetime updating is disabled.

0,1 = QMax updated

1,0 = QMax and Ra table have been updated.

17.11.8.3 Cell 1 Chg Voltage at EoC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Cell 1 Chg Voltage at EoC	I2	0	32767	4200	mV

Description: Cell 1 voltage value at end of charge

17.11.8.4 Current at EoC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Current at EoC	I2	0	32767	250	mA

Description: Current at end of charge

17.11.8.5 Average Last Run

17.11.8.5.1 Avg I Last Run

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Avg I Last Run	I2	–32768	32767	–2000	mA

Description: Average current last discharge cycle

17.11.8.5.2 Avg P Last Run

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Avg P Last Run	I2	–32768	32767	–3022	10 mW

Description: Average power last discharge cycle

17.11.8.6 Delta Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Delta Voltage	I2	–32768	32767	0	mV

Description: *Voltage()* delta between normal and short load spikes to optimize run time calculation

17.11.8.7 Temp

17.11.8.7.1 Temp k

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Temp k	I2	0	32767	100	0.1°C/ 2560 mW

Description: Initial thermal model temperature factor

17.11.8.7.2 Temp a

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Temp a	I2	0	32767	1000	s

Description: Initial thermal model temperature

17.11.8.8 Max Avg Last Run

17.11.8.8.1 Max Avg I Last Run

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Max Avg I Last Run	I2	–32768	32767	–2000	mA

Description: Max current last discharge cycle

17.11.8.8.2 Max Avg P Last Run

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Max Avg P Last Run	I2	–32768	32767	–3022	cW

Description: Max power last discharge cycle

17.11.8.9 SOH FCC Max

17.11.8.9.1 SOH FCC Max mAh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	SOH FCC Max mAh	I2	100	32767	4400	mAh

Description: Learned ***SOH FCC Max*** in mAh. This is used in *StateOfHealth()* calcualtion if ***[CAPM]*** = 0, ***Settings:IT Gauging Ext[SOH_LEARN_EN]*** = 1 and ***SOH FCC Max mAh*** > ***Design Capacity mAh*** ..

17.11.8.9.2 SOH FCC Max cWh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	SOH FCC Max cWh	I2	0	32767	6336	cWh

Description: Learned ***SOH FCC Max*** in cWh. This is used in *StateOfHealth()* calcualtion if ***[CAPM]*** = 1, ***Settings:IT Gauging Ext[SOH_LEARN_EN]*** = 1 and ***SOH FCC Max cWh*** > ***Design Capacity cWh*** .

17.11.8.10 SOH Temp

17.11.8.10.1 SOH Temp k

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	SOH Temp k	I2	0	32767	100	0.1°C/ 2560 mW

Description: Initial thermal model temperature factor for SOH simulation

17.11.8.10.2 SOH Temp a

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	SOH Temp a	I2	0	32767	1000	s

Description: Initial thermal model temperature for SOH simulation

17.11.8.11 Cycle Count

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	State	Cycle Count	U2	0	65535	0	—	Cycle Count

Description: Value reported by *CycleCount()*. The gauge updates this automatically when accumulated discharge exceeds the threshold set by ***Cycle Count Percentage*** .

17.11.9 Turbo Cfg

17.11.9.1 Min System Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Turbo Cfg	Min System Voltage	I2	0	32767	3000	mV

Description: This is the minimum required system voltage on the battery pack terminals to be used for TURBO mode.

17.11.9.2 Ten Second Max C-Rate

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Turbo Cfg	Ten Second Max C-Rate	I2	–32768	0	–200	0.01 C rate

Description: This value specifies the maximal discharge current for 10 s. The native unit for this parameter is 0.01C-rate

17.11.9.3 Ten Millisecond Max C-Rate

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Turbo Cfg	Ten Millisecond Max C-Rate	I2	–32768	0	–400	0.01 C rate

Description: This value specifies the maximal discharge current for 10 ms. The native unit for this parameter is 0.01C-rate

17.11.9.4 High Frequency Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Turbo Cfg	High Frequency Resistance	I2	0	32767	36	mΩ

Description: This is the high-frequency resistance related to the specific cell chemistry and pack configuration.

17.11.9.5 Reserve Energy %

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Turbo Cfg	Reserve Energy %	I1	0	100	0	%

Description: This is the remaining energy at present average discharge rate (as defined in ***Load Select***) until the maximal peak power reaches the value reported by *MaxPeakPower()*.

17.11.9.6 Turbo Adjustment Factor

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Turbo Cfg	Turbo Adjustment Factor	U1	0	255	100	%

Description: This is a resistance correction factor that, if used, would be a one-time adjustment the user computes from a 10-s pulse test.

17.11.10 IT-DZT Config

17.11.10.1 Design Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Design Resistance	I2	1	32767	96	mΩ

Description: Averaged cell resistance at ***Reference Grid*** point.

17.11.10.2 Pack Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Pack Resistance	I2	0	32767	0	mΩ

Description: Pack-side resistance value accessed using *TURBO_PACK_R()*

17.11.10.3 System Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	System Resistance	I2	0	32767	0	mΩ

Description: System side resistance value accessed using *TURBO_SYS_R()*

17.11.10.4 Predict Ambient Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Predict Ambient Time	U2	0	65535	2000	s

Description: The time interval to predict true ambient temperature using the thermal model during charge and discharge.

17.11.10.5 Ra Filter

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Ra Filter	U2	0	999	800	0.1%

Description: Filter value used in Ra Updates and specifies what percentage or Ra update is from the new value (100% setting) versus the old value (setting). The recommended setting is 80% if the ***[RSOC_CONV]*** feature is enabled. Otherwise, the setting should be 50% as default.

17.11.10.6 Ra Max Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Ra Max Delta	U1	0	255	15	%

Description: Maximum value of allowed Ra change

17.11.10.7 Reference Grid

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Reference Grid	U1	0	14	4	—

Description: ***Reference Grid*** point used by ***Design Resistance*** . The default setting should be used if the ***[RSOC_CONV]*** feature is enabled. Otherwise, grid point 11 should be used to ensure resistance updates fast enough at the grid where discharge termination occurs.

17.11.10.8 Resistance Parameter Filter

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Resistance Parameter Filter	U2	1	65535	65142	—

Description: This is one of the filters used for a resistance update. Reducing this filter setting can improve low temperature performance at high rates. The default setting is 41 s.

It is recommended to keep this filter within the range of 4 s (DF setting = 61680) up to the default 41 s (DF setting = 65142). Examining the ***Term Voltage Delta*** setting and ***Fast Scale Start SOC*** should be done prior to adjusting this parameter when trying to improve the RSOC performance.

The following is the formula to convert the DF setting into the actual filter time constant in units of seconds:

Filter time constant = [0.25 / (1 – (DF_Value / 65536))] – 0.25.

17.11.10.9 Near EDV Ra Param Filter

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Near EDV Ra Param Filter	U2	1	65535	59220	—

Description: Ra filter used in the fast scaling region if ***[FF_NEAR_EDV]*** = 1. Default value should be used. Near EDV Ra Param Filter = 65142 for use with Turbo Mode 3.0.

17.11.10.10 Max Current Change %

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Max Current Change %	U1	0	100	10	%

Description: Close to the end of discharge, if the change in current exceeds this threshold, the resistance update and Ra scale update are not allowed to prevent incorrect FCC drops.

17.11.10.11 Resistance Update Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Resistance Update Voltage	I2	0	32767	50	mV

Description: The difference between the voltage based on DoD and the measured voltage is estimated as the IR drop. If this IR drop is less than the value in this register, then the resistance calculation is not done and the resistance table is not updated.

17.11.10.12 Qmax Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Qmax Delta	U1	3	100	5	%

Description: Maximum allowed Qmax change from its previous value. The Qmax change will be capped by this setting if the delta from the previous Qmax is larger than ***Qmax Delta*** . ***Qmax Delta*** is a percentage of ***Design Capacity*** .

17.11.10.13 Qmax Upper Bound

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Qmax Upper Bound	U1	100	255	130	%

Description: Maximum Qmax value over the lifetime of the pack. If the updated Qmax value is larger than this setting, the updated Qmax will be capped to ***Qmax Upper Bound*** . ***Qmax Upper Bound*** is a percentage of ***Design Capacity*** .

17.11.10.14 Term Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Term Voltage	I2	0	32767	9000	mV

Description: Min stack voltage to be used for capacity calculation

17.11.10.15 Res Relax Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Res Relax Time	U2	0	65535	200	s

Description: The time constant associated with resistance at the start of discharge.

17.11.10.16 Term Voltage Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Term Voltage Delta	I2	0	32767	300	mV

Description: Controls when the ***[RSOC_CONV]*** feature becomes active. The recommended setting is 3.3 – ***Term Voltage*** /Number Cells.

The default setting is 300 mV, which is assuming a typical 3-V termination voltage per cell. If a different termination voltage is used, this parameter should be adjusted accordingly.

17.11.10.17 Max Simulation Iterations

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Max Simulation Iterations	U1	20	50	30	—

Description: ***Max Simulation Iterations*** enables the user to set the max number of simulation iterations IT is allowed to do. If the user finds that the watchdog is tripping, this number can be lowered. The default is set at the optimal setting of 30. For 4-series cell applications, a setting of 50 is not recommended.

17.11.10.18 Simulation Near Term Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Simulation Near Term Delta	I2	0	32767	250	mV

Description: Voltage delta from ***Term Voltage*** , which defines "near EDV" for IT simulations. If ***Term Voltage*** is increased, ***Simulation Near Term Delta*** should be decreased to keep ***Term Voltage*** + ***Simulation Near Term Delta*** around 3.2 V–3.5 V, the knee of the discharge curve.

17.11.10.19 Fast Scale Start SOC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Fast Scale Start SOC	U1	0	100	10	%

Description: Controls the start of convergence when ***[RSOC_CONV]*** = 1 based on RSOC %. Raising this setting can improve the RSOC drop at the end of discharge. However, the RSOC % chosen for this setting must be kept after the sharp drop of the discharge curve (the knee of the discharge curve).

17.11.10.20 DeltaV Max Voltage Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	DeltaV Max Voltage Delta	I2	–32768	32767	10	mV

Description: This sets the maximum bound of how much DeltaV can change.

17.11.10.21 Load Select

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Load Select	U1	0	7	7	—

Description: Defines load compensation mode used by the gauging algorithm. Load Select = 1 for use with Turbo Mode 3.0.

17.11.10.22 Fast Scale Load Select

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Fast Scale Load Select	U1	0	7	3	—

Description: Defines load compensation mode used by the gauging algorithm in the fast scaling region

17.11.10.23 Load Mode

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Load Mode	U1	0	1	0	—

Description: Defines unit used by the gauging algorithm:

1 =	Constant Power
0 =	Constant Current

17.11.10.24 User Rate-mA

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	User Rate-mA	I2	–9000	0	0	mA

Description: Discharge rate used for capacity calculation selected by ***Load Select*** = 6

17.11.10.25 User Rate-cW

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	User Rate-cW	I2	–32768	0	0	cW

Description: Discharge rate used for capacity calculation selected by ***Load Select*** = 6

17.11.10.26 Reserve Cap-mAh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Reserve Cap-mAh	I2	0	9000	0	mAh

Description: Capacity reserved available when the gauging algorithm reports 0% *RelativeStateOfCharge()*. The gauge predicts to report a capacity of 0 when approximately ***Reserve Cap-mAh*** remains. This parameter is used when Load Mode = 0 and predictions are made assuming a constant current load.

17.11.10.27 Reserve Cap-cWh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Reserve Cap-cWh	I2	0	32000	0	cWh

Description: Capacity reserved available when the gauging algorithm reports 0% RelativeStateOfCharge(). The gauge predicts to report a capacity of 0 when approximately ***Reserve Cap-cWh*** remains. This parameter is used when Load Mode = 1 and predictions are made using a constant power load.

17.11.11 Smoothing

17.11.11.1 Smooth Relax Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Smoothing	Smooth Relax Time	U2	1	32767	1000	s

Description: If ***[RELAX_SMOOTH_OK]*** = 1, the delta remaining capacity and full charge capacity are smoothed over this set period of time. It is recommended to use the default setting.

17.11.11.2 Term Smooth Start Cell V Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Smoothing	Term Smooth Start Cell V Delta	I2	0	32767	150	mV

Description: If the config bit ***[DSG_0_SMOOTH_OK]*** is set, then during discharge and once the pack voltage is below the threshold defined in this register, time-based smoothing is initiated. This will smooth RemCap to 0 mAh over the next ***Term Smooth Time*** seconds. ***Term Smooth Start Cell V Delta*** is a per cell voltage delta. This value is multiplied by the number of cells, added to ***Terminate Voltage*** , and checked against *Voltage()*. Smoothing will continue to 0% unless charging starts (even in RELAX mode).

17.11.11.3 Term Smooth Final Cell V Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Smoothing	Term Smooth Final Cell V Delta	I2	0	32767	100	mV

Description: If the config bit ***[DSG_0_SMOOTH_OK]*** is set, then during discharge and once the conditions for smoothing are reached, smoothing to 0 is initiated. To assure that the gauge reports 0% in low voltage situations, ***Term Smooth Final Cell V Delta*** is used. This value is multiplied by the number of cells, subtracted from ***Terminate Voltage*** , and checked against *Voltage()*. Once voltage passes this threshold, 0% will be forced even if smoothing has not completed.

Note

This DF can be disabled by setting it to 0, and is typically expected to be set low enough to enable the system to shut down properly (without brownout).

17.11.11.4 Term Smooth Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Smoothing	Term Smooth Time	U1	1	255	20	s

Description: If the config bit ***[DSG_0_SMOOTH_OK]*** is set, then during discharge and once the pack voltage is below the threshold defined in ***Term Smooth Start Cell V Delta*** , time-based smoothing is initiated. This will smooth RemCap to 0 mAh over the next ***Term Smooth Time*** seconds.

17.11.12 Condition Flag

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Condition Flag	Max Error Limit	U1	0	100	100	%

Description: Max Error Limit Percentage

17.11.13 Max Error

17.11.13.1 Time Cycle Equivalent

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Max Error	Time Cycle Equivalent	U1	1	255	12	2 h

Description: After valid QMax update, each passed time period of ***Time Cycle Equivalent*** will increment of *MaxError()* by ***Cycle Delta*** .

17.11.13.2 Cycle Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Max Error	Cycle Delta	U1	0	255	5	0.01%

Description: Each increment of *CycleCount()* after a valid QMax update will increment of *MaxError()* by ***Cycle Delta*** . Setting this parameter to 0 disables the *MaxError()* increment by time or cycle increment.

17.11.14 SOH

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	SOH	SOH Load Rate	U1	0	255	50	0.1 Hr rate

Description: Current rate used in SOH simulation specified in hour-rate (that is, current = C/ ***SOH Load Rate***)

17.12 RA Table

17.12.1 R_a0

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a0	Cell 0 R_A Flag	H2	0x0000	0xFFFF	0xFF55	Hex

Description:
This value indicates the validity of the cell impedance table for ***Cell 1*** . It is recommended not to change this value manually.

High Byte		Low Byte	
0x00	Cell impedance and QMax updated	0x00	The table is not used and QMax is updated.
0x05	RELAX mode and QMax update in progress	0x55	The table is used.
0x55	DISCHARGE mode and cell impedance updated	0xFF	The table is never used; no QMax or cell impedance update.
0xFF	Cell impedance never updated		

The gauge stores and updates the impedance profile for ***Cell 1*** , as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a0	Cell 0 R_A 0	I2	0	32767	67	mΩ	Cell 0 resistance at grid point 0
RA Table	R_a0	Cell 0 R_A 1	I2	0	32767	71	mΩ	Cell 0 resistance at grid point 1
RA Table	R_a0	Cell 0 R_A 2	I2	0	32767	83	mΩ	Cell 0 resistance at grid point 2
RA Table	R_a0	Cell 0 R_A 3	I2	0	32767	110	mΩ	Cell 0 resistance at grid point 3
RA Table	R_a0	Cell 0 R_A 4	I2	0	32767	96	mΩ	Cell 0 resistance at grid point 4
RA Table	R_a0	Cell 0 R_A 5	I2	0	32767	77	mΩ	Cell 0 resistance at grid point 5
RA Table	R_a0	Cell 0 R_A 6	I2	0	32767	96	mΩ	Cell 0 resistance at grid point 6
RA Table	R_a0	Cell 0 R_A 7	I2	0	32767	86	mΩ	Cell 0 resistance at grid point 7
RA Table	R_a0	Cell 0 R_A 8	I2	0	32767	84	mΩ	Cell 0 resistance at grid point 8
RA Table	R_a0	Cell 0 R_A 9	I2	0	32767	82	mΩ	Cell 0 resistance at grid point 9
RA Table	R_a0	Cell 0 R_A 10	I2	0	32767	81	mΩ	Cell 0 resistance at grid point 10
RA Table	R_a0	Cell 0 R_A 11	I2	0	32767	92	mΩ	Cell 0 resistance at grid point 11
RA Table	R_a0	Cell 0 R_A 12	I2	0	32767	103	mΩ	Cell 0 resistance at grid point 12
RA Table	R_a0	Cell 0 R_A 13	I2	0	32767	123	mΩ	Cell 0 resistance at grid point 13
RA Table	R_a0	Cell 0 R_A 14	I2	0	32767	658	mΩ	Cell 0 resistance at grid point 14

17.12.2 R_a0x

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a0x	xCell 0 R_A Flag	H2	0x0000	0xFFFF	0xFFFF	Hex

Description:
This value indicates the validity of the cell impedance table for ***Cell 1*** . It is recommended not to change this value manually.

Note

The Ra table serves as a backup during optimization cycles rather than alternating with RaX to manage flash wear as in previous generation devices. Flash wear management is handled through a file system approach instead.

High Byte		Low Byte	
0x00	Cell impedance and QMax updated	0x00	The table is not used and QMax is updated.
0x05	RELAX mode and QMax update in progress	0x55	The table is used.
0x55	DISCHARGE mode and cell impedance updated	0xFF	The table is never used; no QMax or cell impedance update.
0xFF	Cell impedance never updated		

The gauge stores and updates the impedance profile for ***Cell 1*** , as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a0x	xCell 0 R_A 0	I2	0	32768	67	mΩ	Cell 0 resistance at grid point 0
RA Table	R_a0x	xCell 0 R_A 1	I2	0	32768	71	mΩ	Cell 0 resistance at grid point 1
RA Table	R_a0x	xCell 0 R_A 2	I2	0	32768	83	mΩ	Cell 0 resistance at grid point 2
RA Table	R_a0x	xCell 0 R_A 3	I2	0	32768	110	mΩ	Cell 0 resistance at grid point 3
RA Table	R_a0x	xCell 0 R_A 4	I2	0	32768	96	mΩ	Cell 0 resistance at grid point 4
RA Table	R_a0x	xCell 0 R_A 5	I2	0	32768	77	mΩ	Cell 0 resistance at grid point 5
RA Table	R_a0x	xCell 0 R_A 6	I2	0	32768	96	mΩ	Cell 0 resistance at grid point 6
RA Table	R_a0x	xCell 0 R_A 7	I2	0	32768	86	mΩ	Cell 0 resistance at grid point 7
RA Table	R_a0x	xCell 0 R_A 8	I2	0	32768	84	mΩ	Cell 0 resistance at grid point 8
RA Table	R_a0x	xCell 0 R_A 9	I2	0	32768	82	mΩ	Cell 0 resistance at grid point 9
RA Table	R_a0x	xCell 0 R_A 10	I2	0	32768	81	mΩ	Cell 0 resistance at grid point 10
RA Table	R_a0x	xCell 0 R_A 11	I2	0	32768	92	mΩ	Cell 0 resistance at grid point 11
RA Table	R_a0x	xCell 0 R_A 12	I2	0	32768	103	mΩ	Cell 0 resistance at grid point 12
RA Table	R_a0x	xCell 0 R_A 13	I2	0	32768	123	mΩ	Cell 0 resistance at grid point 13
RA Table	R_a0x	xCell 0 R_A 14	I2	0	32768	658	mΩ	Cell 0 resistance at grid point 14

18 Data Flash Access and Format

18.1 Data Flash Access

18.1.1 Minimum Voltage

Data flash can only be updated when the measured cell voltage is above the ***Valid Update Voltage*** .

Note

ManufacturingStatus()[CAL_EN] = 1 overrides this voltage requirement so data flash can be updated prior to or during calibration of cell voltage. However, the voltage applied must exceed ***Valid Update Voltage*** for proper data flash update operation.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Power	Power	Valid Update Voltage	I2	0	32767	2100	mV	Min cell voltage threshold for the flash update

18.2 Data Formats

18.2.1 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

18.2.2 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

18.2.3 Floating Point

Floating point values are stored using the IEEE 754 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 special meaning.

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

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

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

18.2.4 Hex

Bit register definitions are stored in unsigned integer format.

18.2.5 String

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

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

19 Data Flash Summary

19.1 Data Flash Summary - Subject to Change upon FW build details

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Calibration	Voltage	0x4000	Cell Gain	I4	–2147483648	2147483647	12101	—
Calibration	Voltage	0x4004	Pack Gain	I4	–2147483648	2147483647	40253	—
Calibration	Current	0x400C	CC Gain	I4	–2147483648	2147483647	2507	—
Calibration	Current	0x45AB	Calibration Current Period	H1	0x08	0x40	0x08	Hex
Calibration	Current Offset	0x4014	CC Offset	I2	–32767	32767	0	—
Calibration	Current Offset	0x4016	Coulomb Counter Offset Samples	U2	0	65535	64	—
Calibration	Current Offset	0x4018	Board Offset	I2	–32768	32767	0	—
Calibration	Current Offset	0x5400	VG CC Offset	I2	–32768	32767	0	—
Calibration	Current Offset	0x5402	VG CC Offset Cal Point	I2	–32768	32767	0	—
Calibration	Temperature	0x401A	Internal Temp Offset	I2	–32768	32767	0	0.1°C
Calibration	Temperature	0x401C	External1 Temp Offset	I2	–32768	32767	0	0.1°C
Calibration	Internal Temp Model	0x4430	Int Gain	I4	–32768	32767	–20189	—
Calibration	Internal Temp Model	0x4434	Int base offset	I2	–32768	32767	6142	—
Calibration	Internal Temp Model	0x4436	Int Minimum AD	I2	–32768	32767	0	—
Calibration	Internal Temp Model	0x4438	Int Maximum Temp	I2	0	32767	5754	0.1°K
Calibration	Cell Temperature Model	0x443C	Coeff a1	I2	–32768	32767	–11130	—
Calibration	Cell Temperature Model	0x443E	Coeff a2	I2	–32768	32767	19142	—
Calibration	Cell Temperature Model	0x4440	Coeff a3	I2	–32768	32767	–19262	—
Calibration	Cell Temperature Model	0x4442	Coeff a4	I2	–32768	32767	28203	—
Calibration	Cell Temperature Model	0x4444	Coeff a5	I2	–32768	32767	892	—
Calibration	Cell Temperature Model	0x4446	Coeff b1	I2	–32768	32767	328	—
Calibration	Cell Temperature Model	0x4448	Coeff b2	I2	–32768	32767	–605	—
Calibration	Cell Temperature Model	0x444A	Coeff b3	I2	–32768	32767	–2443	—
Calibration	Cell Temperature Model	0x444C	Coeff b4	I2	–32768	32767	4696	—
Calibration	Cell Temperature Model	0x444E	Rc0	I2	–32768	32767	6999	—
Calibration	Cell Temperature Model	0x4450	Adc0	I2	–32768	32767	6999	—
Calibration	Cell Temperature Model	0x4452	Rpad	I2	–32768	32767	1	—

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Calibration	Cell Temperature Model	0x4454	Rint	I2	–32768	32767	18000	—
Calibration	Fet Temperature Model	0x4458	Coeff a1	I2	–32768	32767	–11130	—
Calibration	Fet Temperature Model	0x445A	Coeff a2	I2	–32768	32767	19142	—
Calibration	Fet Temperature Model	0x445C	Coeff a3	I2	–32768	32767	–19262	—
Calibration	Fet Temperature Model	0x445E	Coeff a4	I2	–32768	32767	28203	—
Calibration	Fet Temperature Model	0x4460	Coeff a5	I2	–32768	32767	892	—
Calibration	Fet Temperature Model	0x4462	Coeff b1	I2	–32768	32767	328	—
Calibration	Fet Temperature Model	0x4464	Coeff b2	I2	–32768	32767	–605	—
Calibration	Fet Temperature Model	0x4466	Coeff b3	I2	–32768	32767	–2443	—
Calibration	Fet Temperature Model	0x4468	Coeff b4	I2	–32768	32767	4696	—
Calibration	Fet Temperature Model	0x446A	Rc0	I2	–32768	32767	6999	—
Calibration	Fet Temperature Model	0x446C	Adc0	I2	–32768	32767	6999	—
Calibration	Fet Temperature Model	0x446E	Rpad	I2	–32768	32767	1	—
Calibration	Fet Temperature Model	0x4470	Rint	I2	–32768	32767	18000	—
Calibration	Current Deadband	0x4410	Deadband	U2	0	255	3	mA
Calibration	Current Deadband	0x4412	Coulomb Counter Deadband	U2	0	255	9	116 nV
Calibration	Interconnect Resistance	0x4720	Cell	I2	0	1000	0	mΩ
Settings	Configuration	0x4292	ZT SiAnode Gauging Configuration	H2	0x0	0x0001	0x0000	Hex
Settings	Configuration	0x4480	Charging Configuration	H2	0x0	0xFFFF	0x0	Hex
Settings	Configuration	0x4482	Charging Configuration Ext	H2	0x00	0x0007	0x00	Hex
Settings	Configuration	0x4510	Elevated Degrade Configuration	H2	0x0	0x00FF	0x0015	Hex
Settings	Configuration	0x4580	HMAC-SHA2 Challenge Size	U1	0	32	1	—
Settings	Configuration	0x45D2	FET Options	H2	0x0	0x00FF	0x0020	Hex
Settings	Configuration	0x45D4	Sbs Gauging Configuration	H2	0x0	0x003F	0x0004	Hex
Settings	Configuration	0x45D6	Sbs Configuration	H2	0x0	0x00FF	0x0020	Hex
Settings	Configuration	0x45D8	Auth Config	H2	0x0	0x001E	0x0000	Hex
Settings	Configuration	0x45DA	Power Config	H2	0x0	0x7D7F	0x0000	Hex
Settings	Configuration	0x45DE	IO Config	H2	0x0	0x001F	0x0000	Hex
Settings	Configuration	0x4610	Temperature Enable	H2	0x0	0x003F	0x0003	Hex
Settings	Configuration	0x4612	Ext TMP Temperature Enable	H2	0x0	0x00FF	0x00FF	Hex
Settings	Configuration	0x4614	Temperature Mode	H2	0x0	0x003F	0x0001	Hex
Settings	Configuration	0x4616	Ext TMP Temperature Mode	H2	0x0	0x00FF	0x0004	Hex
Settings	Configuration	0x4618	DA Configuration	H2	0x0	0xFFFF	0x001C	Hex
Settings	Configuration	0x4650	DZT Gauging Configuration	H2	0x0	0x0001	0x0000	Hex
Settings	Configuration	0x46F0	IT Gauging Configuration	H2	0x0	0xFFFF	0xD0FE	Hex
Settings	Configuration	0x46F4	IT Gauging Ext	H2	0x0000	0x03FF	0x005A	Hex
Settings	Configuration	0x524C	SOC Flag Config A	H2	0x0	0x0FFF	0x0C8C	Hex
Settings	Configuration	0x524E	SOC Flag Config B	H2	0x0	0x00FF	0x008C	Hex
Settings	GPIO	0x5220	Pres pin number	H1	0x0	0xFF	0xC3	—
Settings	GPIO	0x5222	Disconnect pin number	H1	0x0	0xFF	0x0	—

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Settings	GPIO	0x5224	Emergency Shutdown pin number	H1	0x0	0xFF	0x0	—
Settings	GPIO	0x5225	IO Shutdown pin number	H1	0x0	0xFF	0x0	—
Settings	GPIO	0x5226	BTP pin number	H1	0x0	0xFF	0x0	—
Settings	GPIO	0x5227	BTP pin config	H1	0x0	0x02	0x02	Hex
Settings	GPIO	0x5228	GPIO_PF pin number	H1	0x0	0xFF	0x0	—
Settings	GPIO	0x522A	GPIO_INT Enable	H1	0x0	0x73	0x40	Hex
Settings	GPIO	0x522B	GPIO_INT Output Enable	H1	0x0	0x73	0x40	Hex
Settings	GPIO	0x522C	GPIO_INT Default Out	H1	0x0	0x73	0x0	Hex
Settings	GPIO	0x522D	Sealed Access Config	H1	0x0	0x73	0x40	Hex
Settings	Fuse	0x45D0	GPIO Timeout	U2	0	65535	30	s
Settings	BTP	0x45E0	Init Discharge Set	I2	0	32767	150	mAh
Settings	BTP	0x45E2	Init Charge Set	I2	0	32767	175	mAh
Settings	BTP	0x45E4	Init Charge SoC Set	U2	0	100	10	%
Settings	BTP	0x45E6	Init Discharge SoC Set	U2	0	100	5	%
Settings	Flag Map	0x45EA	Set Up 1 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x45EC	Set Up 1 pin number	H1	0x0	0xFF	0x0	—
Settings	Flag Map	0x45EE	Set Up 2 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x45F0	Set Up 2 pin number	H1	0x0	0xFF	0x0	—
Settings	Flag Map	0x45F2	Set Up 3 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x45F4	Set Up 3 pin number	H1	0x0	0xFF	0x0	—
Settings	Flag Map	0x45F6	Set Up 4 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x45F8	Set Up 4 pin number	H1	0x0	0xFF	0x0	—
Settings	I2C	0x45FA	Address	H1	0x0	0xFF	0xAA	—
Settings	I2C	0x45FB	Address Check	H1	0x0	0xFF	0x56	—
Settings	Sealed Access	0x45FE	DF Read Only Timeout	U2	0	255	10	s
Settings	Sealed Access	0x4600	MfgInfoC Write Timeout	U1	0	255	10	s
Settings	Lifetimes	0x4680	Lifetimes Configuration	H2	0x0	0x00FF	0x0000	Hex
Settings	Lifetimes	0x4683	Time RSOC Threshold A	U1	0	100	95	%
Settings	Lifetimes	0x4684	Time RSOC Threshold B	U1	0	100	90	%
Settings	Lifetimes	0x4685	Time RSOC Threshold C	U1	0	100	80	%
Settings	Lifetimes	0x4686	Time RSOC Threshold D	U1	0	100	50	%
Settings	Lifetimes	0x4687	Time RSOC Threshold E	U1	0	100	20	%
Settings	Lifetimes	0x4688	Time RSOC Threshold F	U1	0	100	10	%
Settings	Lifetimes	0x4689	Time RSOC Threshold G	U1	0	100	5	%
Settings	Lifetimes	0x468A	Temperature Hold-off Time	U2	0	255	5	s
Settings	Lifetimes	0x468C	LFT_T0 Temp	I2	2332	3932	2632	0.1°K
Settings	Lifetimes	0x468E	Hysteresis Temp LFT_T0	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4690	LFT_T1 Temp	I2	2332	3932	2732	0.1°K
Settings	Lifetimes	0x4692	Hysteresis Temp LFT_T1	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4694	LFT_T2 Temp	I2	2332	3932	2852	0.1°K
Settings	Lifetimes	0x4696	Hysteresis Temp LFT_T2	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4698	LFT_T5 Temp	I2	2332	3932	2932	0.1°K
Settings	Lifetimes	0x469A	Hysteresis Temp LFT_T5	I2	0	150	10	0.1°K
Settings	Lifetimes	0x469C	LFT_T6 Temp	I2	2332	3932	2982	0.1°K
Settings	Lifetimes	0x469E	Hysteresis Temp LFT_T6	I2	0	150	10	0.1°K
Settings	Lifetimes	0x46A0	LFT_T3 Temp	I2	2332	3932	3032	0.1°K
Settings	Lifetimes	0x46A2	Hysteresis Temp LFT_T3	I2	0	150	10	0.1°K
Settings	Lifetimes	0x46A4	LFT_T4 Temp	I2	2332	3932	3282	0.1°K
Settings	Lifetimes	0x46A6	Hysteresis Temp LFT_T4	I2	0	150	10	0.1°K
Settings	Protection	0x5110	Enabled Protections A	H1	0x0	0xFF	0xFF	Hex

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Settings	Protection	0x5111	Enabled Protections B	H1	0x0	0xFF	0xFF	Hex
Settings	Protection	0x5112	Enabled Protections C	H1	0x0	0xFF	0xD5	Hex
Settings	Protection	0x5113	Enabled Protections D	H1	0x0	0xFF	0xCF	Hex
Settings	Protection	0x519C	Protection Configuration	H2	0x0	0x000F	0x0000	Hex
Settings	Permanent Failure	0x50A0	Enabled PF A	H1	0x0	0xFF	0x0	Hex
Settings	Permanent Failure	0x50A1	Enabled PF B	H1	0x0	0xFF	0x0	Hex
Settings	Permanent Failure	0x50A2	Enabled PF C	H1	0x0	0xFF	0x0	Hex
Settings	Permanent Failure	0x50A3	Enabled PF D	H1	0x0	0xFF	0x0	Hex
Settings	Smart Temperature	0x4628	Mid Point Temp	I2	2332	3932	2982	0.1°K
Settings	AFE	0x4630	OCC	H1	0x0	0x7F	0x3C	Hex
Settings	AFE	0x4631	OCD	H1	0x0	0x7F	0x3C	Hex
Settings	AFE	0x4632	Short Circuit Discharge	H1	0x0	0x7F	0x7F	Hex
Settings	AFE	0x4633	Under Voltage	H1	0x0	0x7F	0x28	Hex
Settings	AFE	0x4634	Over Voltage	H1	0x0	0x7F	0x64	Hex
Settings	AFE	0x4635	Current Charge Wake	H1	0x70	0x7F	0x74	Hex
Settings	AFE	0x4636	Current Discharge Wake	H1	0x70	0x7F	0x74	Hex
Settings	AFE	0x4637	OCC Delay	H1	0x0	0x7F	0x07	Hex
Settings	AFE	0x4638	OCD Delay	H1	0x0	0x7F	0x07	Hex
Settings	AFE	0x4639	Short Circuit Discharge Delay	H1	0x0	0x07	0x07	Hex
Settings	AFE	0x463A	Under Voltage Delay	H1	0x0	0xFF	0xFF	Hex
Settings	AFE	0x463B	Over Voltage Delay	H1	0x0	0xFF	0xFF	Hex
Settings	AFE	0x463C	Over Voltage Delay Hi	H1	0x0	0x1F	0x1F	Hex
Settings	AFE	0x463D	CD Wake Delay	H1	0x0	0x1F	0x1F	Hex
Settings	AFE	0x463E	CC Wake Delay	H1	0x0	0x1F	0x1F	Hex
Settings	Manufacturing	0x5518	Mfg Status init	H2	0x0	0xFFFF	0x0000	Hex
Settings	Accumulated Charge	0x46B0	Accum Discharge Threshold	I2	–32768	0	–1000	mAh
Settings	Accumulated Charge	0x46B2	Accum Charge Threshold	I2	0	32767	1000	mAh
Advanced Charge Algorithm	Temperature Ranges	0x4484	T1 Temp	I2	2332	3932	2732	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4486	Hysteresis Temp T1	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4488	T2 Temp	I2	2332	3932	2852	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x448A	Hysteresis Temp T2	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x448C	T5 Temp	I2	2332	3932	2932	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x448E	Hysteresis Temp T5	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4490	T6 Temp	I2	2332	3932	2982	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4492	Hysteresis Temp T6	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4494	T3 Temp	I2	2332	3932	3032	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4496	Hysteresis Temp T3	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4498	T4 Temp	I2	2332	3932	3282	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x449A	Hysteresis Temp T4	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Pre-Charging	0x449C	Current	I2	0	32767	88	mA
Advanced Charge Algorithm	Maintenance Charging	0x449E	Current	I2	0	32767	44	mA

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Voltage Range	0x44A0	Precharge Start Voltage	I2	0	32767	2500	mV
Advanced Charge Algorithm	Voltage Range	0x44A2	Charging Voltage Low	I2	0	32767	2900	mV
Advanced Charge Algorithm	Voltage Range	0x44A4	Charging Voltage Med	I2	0	32767	3600	mV
Advanced Charge Algorithm	Voltage Range	0x44A6	Charging Voltage High	I2	0	32767	4000	mV
Advanced Charge Algorithm	Voltage Range	0x44A8	Charging Voltage Hysteresis	U2	0	255	0	mV
Advanced Charge Algorithm	SoC Range	0x44AA	Charging SoC Med	U2	0	100	50	%
Advanced Charge Algorithm	SoC Range	0x44AC	Charging SoC High	U2	0	100	75	%
Advanced Charge Algorithm	SoC Range	0x44AE	Charging SoC Hysteresis	U2	0	100	1	%
Advanced Charge Algorithm	Degrade Mode 1	0x44B0	Cycle Threshold	U2	0	65535	50	—
Advanced Charge Algorithm	Degrade Mode 1	0x44B2	SOH Threshold	U2	0	100	95	%
Advanced Charge Algorithm	Degrade Mode 1	0x44B4	Runtime Threshold	U2	0	65535	8760	h
Advanced Charge Algorithm	Degrade Mode 1	0x44B6	Voltage Degradation	I2	0	32767	10	mV
Advanced Charge Algorithm	Degrade Mode 1	0x44B8	Current Degradation	U2	0	100	10	%
Advanced Charge Algorithm	Degrade Mode 2	0x44BC	Cycle Threshold	U2	0	65535	150	—
Advanced Charge Algorithm	Degrade Mode 2	0x44BE	SOH Threshold	U2	0	100	80	%
Advanced Charge Algorithm	Degrade Mode 2	0x44C0	Runtime Threshold	U2	0	65535	17520	h
Advanced Charge Algorithm	Degrade Mode 2	0x44C2	Voltage Degradation	I2	0	32767	40	mV
Advanced Charge Algorithm	Degrade Mode 2	0x44C4	Current Degradation	U2	0	100	20	%
Advanced Charge Algorithm	Degrade Mode 3	0x44C8	Cycle Threshold	U2	0	65535	350	—
Advanced Charge Algorithm	Degrade Mode 3	0x44CA	SOH Threshold	U2	0	100	60	%
Advanced Charge Algorithm	Degrade Mode 3	0x44CC	Runtime Threshold	U2	0	65535	26280	h
Advanced Charge Algorithm	Degrade Mode 3	0x44CE	Voltage Degradation	I2	0	32767	70	mV
Advanced Charge Algorithm	Degrade Mode 3	0x44D0	Current Degradation	U2	0	100	40	%
Advanced Charge Algorithm	Degrade Mode	0x44D4	Cycle Count Start Runtime	U2	0	255	1	—
Advanced Charge Algorithm	Degrade Mode	0x44D6	Runtime Update Interval	U2	0	18	10	h
Advanced Charge Algorithm	Degrade Mode	0x5200	Runtime Degrade	U2	0	65535	0	hours
Advanced Charge Algorithm	CS Degrade	0x44D8	Temperature Threshold	I2	0	32767	3232	0.1°K
Advanced Charge Algorithm	CS Degrade	0x44DA	Voltage Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	CS Degrade	0x44DC	Time Interval	U2	0	14400	300	s
Advanced Charge Algorithm	CS Degrade	0x44DE	Delta Voltage	I2	0	32767	25	mV
Advanced Charge Algorithm	CS Degrade	0x44E0	Min CV	I2	0	32767	3000	mV

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Charge Voltage Override	0x44E4	CHGV Override Max	I2	0	32767	4500	mV
Advanced Charge Algorithm	Charge Voltage Override	0x44E6	CHGV Override Min	I2	0	32767	2000	mV
Advanced Charge Algorithm	Charge Current Override	0x44E8	CHGI Override Max	I2	0	32767	4500	mA
Advanced Charge Algorithm	Charge Current Override	0x44EA	CHGI Override Min	I2	0	32767	100	mA
Advanced Charge Algorithm	Termination Config	0x44EC	Charge Term Taper Current	I2	0	32767	250	mA
Advanced Charge Algorithm	Termination Config	0x44F0	Charge Term Voltage Offset	I2	0	32767	75	mV
Advanced Charge Algorithm	Termination Config	0x44F2	Charge Term Charging Voltage	I2	0	32767	4200	mV
Advanced Charge Algorithm	Charging Rate of Change	0x44FC	Current Rate	I2	1	1000	1	steps
Advanced Charge Algorithm	Charging Rate of Change	0x44FE	Voltage Rate	I2	1	255	1	steps
Advanced Charge Algorithm	Charge Loss Compensation	0x4502	CCC Current Threshold	I2	0	32767	3520	mA
Advanced Charge Algorithm	Charge Loss Compensation	0x4504	CCC Voltage Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	IR Correction	0x4506	Averaging Interval	U2	1	255	12	s
Advanced Charge Algorithm	Sealed Write	0x4508	Hold Off	U2	0	65535	2	s
Advanced Charge Algorithm	Sealed Write	0x450A	Lockout	U2	0	65535	7200	s
Advanced Charge Algorithm	Low Temp Charging	0x51D0	Voltage	I2	0	32767	4000	mV
Advanced Charge Algorithm	Low Temp Charging	0x51DA	Current Low	I2	0	32767	132	mA
Advanced Charge Algorithm	Low Temp Charging	0x51DC	Current Med	I2	0	32767	352	mA
Advanced Charge Algorithm	Low Temp Charging	0x51DE	Current High	I2	0	32767	264	mA
Advanced Charge Algorithm	Standard Temp Low Charging	0x51D2	Voltage	I2	0	32767	4200	mV
Advanced Charge Algorithm	Standard Temp Low Charging	0x51E0	Current Low	I2	0	32767	441	mA
Advanced Charge Algorithm	Standard Temp Low Charging	0x51E2	Current Med	I2	0	32767	892	mA
Advanced Charge Algorithm	Standard Temp Low Charging	0x51E4	Current High	I2	0	32767	667	mA
Advanced Charge Algorithm	Standard Temp High Charging	0x51D4	Voltage	I2	0	32767	4200	mV
Advanced Charge Algorithm	Standard Temp High Charging	0x51E6	Current Low	I2	0	32767	441	mA
Advanced Charge Algorithm	Standard Temp High Charging	0x51E8	Current Med	I2	0	32767	892	mA
Advanced Charge Algorithm	Standard Temp High Charging	0x51EA	Current High	I2	0	32767	667	mA
Advanced Charge Algorithm	High Temp Charging	0x51D6	Voltage	I2	0	32767	4000	mV
Advanced Charge Algorithm	High Temp Charging	0x51EC	Current Low	I2	0	32767	225	mA
Advanced Charge Algorithm	High Temp Charging	0x51EE	Current Med	I2	0	32767	441	mA
Advanced Charge Algorithm	High Temp Charging	0x51F0	Current High	I2	0	32767	333	mA
Advanced Charge Algorithm	Rec Temp Charging	0x51D8	Voltage	I2	0	32767	4100	mV

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Rec Temp Charging	0x51F2	Current Low	I2	0	32767	559	mA
Advanced Charge Algorithm	Rec Temp Charging	0x51F4	Current Med	I2	0	32767	1000	mA
Advanced Charge Algorithm	Rec Temp Charging	0x51F6	Current High	I2	0	32767	784	mA
Advanced Charge Algorithm	Charger	0x4370	Minimum System Voltage	I2	0	32767	3000	mV
Advanced Charge Algorithm	Charger	0x437A	CHGR_DET On Voltage	I2	–32768	32767	0	mV
Advanced Charge Algorithm	Charger	0x437C	CHGR_DET Off Voltage	I2	–32768	32767	10	mV
Advanced Charge Algorithm	Charger	0x4404	Configuration	H2	0x00	0x0003	0x0001	Hex
Advanced Charge Algorithm	Elevated Degrade	0x4512	ERM Reset RSoC Threshold	U2	0	100	85	%
Advanced Charge Algorithm	Elevated Degrade	0x4514	ERM Reset Voltage Threshold	I2	0	32767	3700	mV
Advanced Charge Algorithm	Elevated Degrade	0x4516	ERM RSoC Threshold	U2	0	100	90	%
Advanced Charge Algorithm	Elevated Degrade	0x4518	ERM Voltage Threshold	I2	0	32767	4000	mV
Advanced Charge Algorithm	Elevated Degrade	0x451A	ERM Time Threshold	U2	0	65535	10000	hours
Advanced Charge Algorithm	Elevated Degrade	0x451C	ERETM RSoC Threshold	U2	0	100	90	%
Advanced Charge Algorithm	Elevated Degrade	0x451E	ERETM Voltage Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	Elevated Degrade	0x4520	ERETM Temperature Threshold	I2	2332	3932	3123	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x4522	EVTM Voltage Low Threshold	I2	0	32767	4300	mV
Advanced Charge Algorithm	Elevated Degrade	0x4524	EVTM Temperature Low Threshold	I2	2332	3932	3123	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x4526	EVLTM TTH1	U2	0	65535	480	hours
Advanced Charge Algorithm	Elevated Degrade	0x4528	EVLTM CV Delta 1	I2	0	32767	50	mV
Advanced Charge Algorithm	Elevated Degrade	0x452A	EVLTM TTH2	U2	0	65535	720	hours
Advanced Charge Algorithm	Elevated Degrade	0x452C	EVLTM CV Delta 2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	0x452E	EVLTM TTH3	U2	0	65535	1680	hours
Advanced Charge Algorithm	Elevated Degrade	0x4530	EVLTM CV Delta 3	I2	0	32767	150	mV
Advanced Charge Algorithm	Elevated Degrade	0x4532	EVLTM TTH4	U2	0	65535	2880	hours
Advanced Charge Algorithm	Elevated Degrade	0x4534	EVLTM CV Delta 4	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	0x4536	EVLTM TTH5	U2	0	65535	5760	hours
Advanced Charge Algorithm	Elevated Degrade	0x4538	EVLTM CV Delta 5	I2	0	32767	300	mV
Advanced Charge Algorithm	Elevated Degrade	0x453A	EVTM Voltage Mid Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	Elevated Degrade	0x453C	EVTM Temperature Mid Threshold	I2	2332	3932	3173	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x453E	EVMTM TTH1	U2	0	65535	240	hours
Advanced Charge Algorithm	Elevated Degrade	0x4540	EVMTM CV Delta 1	I2	0	32767	50	mV

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Elevated Degrade	0x4542	EVMTM TTH2	U2	0	65535	480	hours
Advanced Charge Algorithm	Elevated Degrade	0x4544	EVMTM CV Delta 2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	0x4546	EVMTM TTH3	U2	0	65535	1440	hours
Advanced Charge Algorithm	Elevated Degrade	0x4548	EVMTM CV Delta 3	I2	0	32767	150	mV
Advanced Charge Algorithm	Elevated Degrade	0x454A	EVMTM TTH4	U2	0	65535	2160	hours
Advanced Charge Algorithm	Elevated Degrade	0x454C	EVMTM CV Delta 4	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	0x454E	EVMTM TTH5	U2	0	65535	2400	hours
Advanced Charge Algorithm	Elevated Degrade	0x4550	EVMTM CV Delta 5	I2	0	32767	300	mV
Advanced Charge Algorithm	Elevated Degrade	0x4552	EVTM Voltage High Threshold	I2	0	32767	4100	mV
Advanced Charge Algorithm	Elevated Degrade	0x4554	EVTM Temperature High Threshold	I2	2332	3932	3223	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x4556	EVHTM TTH1	U2	0	65535	24	hours
Advanced Charge Algorithm	Elevated Degrade	0x4558	EVHTM CV Delta 1	I2	0	32767	50	mV
Advanced Charge Algorithm	Elevated Degrade	0x455A	EVHTM TTH2	U2	0	65535	120	hours
Advanced Charge Algorithm	Elevated Degrade	0x455C	EVHTM CV Delta 2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	0x455E	EVHTM TTH3	U2	0	65535	336	hours
Advanced Charge Algorithm	Elevated Degrade	0x4560	EVHTM CV Delta 3	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	0x4562	EVHTM TTH4	U2	0	65535	480	hours
Advanced Charge Algorithm	Elevated Degrade	0x4564	EVHTM CV Delta 4	I2	0	32767	250	mV
Advanced Charge Algorithm	Elevated Degrade	0x4566	EVHTM TTH5	U2	0	65535	720	hours
Advanced Charge Algorithm	Elevated Degrade	0x4568	EVHTM CV Delta 5	I2	0	32767	300	mV
Advanced Charge Algorithm	Elevated Degrade	0x456A	ERETM Temperature Max Threshold	I2	2332	3932	3223	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x456C	ERETM Time Threshold	U2	0	65535	10000	hours
Advanced Charge Algorithm	Elevated Degrade	0x456E	ERETM Charging Voltage	I2	0	32767	3900	mV
Advanced Charge Algorithm	Elevated Degrade	0x5210	Accumulated ERM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x5212	Accumulated ERETM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x5214	Accumulated EVLTM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x5216	Accumulated EVMTM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x5218	Accumulated EVHTM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x521A	ERETM Status	H2	0x0	0x00FF	0x0	—
Advanced Charge Algorithm	Elevated Degrade	0x521C	EVTM Degrade	H2	0x0	0xFFFF	0x0	—
Advanced Charge Algorithm	Elevated Degrade	0x521E	EVTM Active	H2	0x0	0xFFFF	0x0	—

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Power	Shutdown	0x4590	Shutdown Voltage	I2	0	32767	1750	mV
Power	Shutdown	0x4592	Shutdown Time	U2	0	255	10	s
Power	Shutdown	0x4594	IO Shutdown Delay	U2	0	255	1	250 ms
Power	Shutdown	0x4596	IO Shutdown Timeout	U2	0	255	8	250 ms
Power	Shutdown	0x4598	PF Shutdown Voltage	I2	0	32767	1750	mV
Power	Shutdown	0x459A	PF Shutdown Time	U2	0	255	10	s
Power	Shutdown	0x459C	PS Shutdown Voltage	I2	0	32767	2500	mV
Power	Shutdown	0x459E	PS NoLoadResCap Threshold	I2	0	32767	0	mAh
Power	Shutdown	0x45A2	Low RSoC Shutdown Threshold	U1	0	100	2	%
Power	Shutdown	0x45A3	Low RSoC Shutdown Time	U1	0	255	24	h
Power	Shutdown	0x45A4	Charger Present Threshold	I2	0	32767	3000	mV
Power	Power	0x45A0	Valid Update Voltage	I2	0	32767	2800	mV
Power	Sleep	0x45A6	Sleep Current	I2	0	32767	10	mA
Power	Sleep	0x45A8	Low Current	I2	0	32767	5	mA
Power	Sleep	0x45AA	Low Current Period	H1	0x08	0x40	0x08	Hex
Power	Sleep	0x45AC	Bus Timeout	U2	0	255	0	s
Power	Sleep	0x45B2	Measure Time	U2	8	8	8	s
Power	Sleep	0x45B4	Current Time	U2	8	64	16	s
Power	Ship	0x45B6	FET Off Time	U2	0	127	10	s
Power	Ship	0x45B8	Delay	U2	0	254	20	s
Power	Ship	0x45BA	Auto Ship Time	U2	0	65535	1440	min
Power	Power Off	0x45BC	Timeout	U2	0	65535	30	min
Power	Manual FET Control	0x45BE	MFC Delay	U1	0	255	60	0.25 s
Power	System Present	0x45BF	SYS_PRES Delay	U1	1	8	1	Counts
Power	ENAB	0x45C0	Startup ENAB Hold Time	U1	0	100	0	s
Power	Storage Mode	0x42C0	Storage Delay	U1	0	255	10	s
Power	Storage Mode	0x42C1	Storage Ignore SMB Delay	U1	0	255	30	s
Power	Power Events	0x5480	No Of Shutdowns	U1	0	255	0	events
Power	Power Events	0x5481	No Of Partial Resets	U1	0	255	0	events
Power	Power Events	0x5482	No Of Full Resets	U1	0	255	0	events
Power	Power Events	0x5483	No Of Wdt Resets	U1	0	255	0	events
Power	IATA	0x4660	IATA Config	H2	0x0	0x00FF	0x0003	—
Power	IATA	0x4662	IATA Delay Time	U2	0	65535	10	s
Power	IATA	0x4664	IATA RSOC Threshold	U2	0	100	30	%
Power	IATA	0x4666	IATA DeltaV Threshold	U2	0	255	50	mV
Power	IATA	0x4668	IATA Delta RSOC	U2	0	100	3	%
Power	IATA	0x466A	IATA Wake AbsRsoc	U2	0	100	10	%
Power	IATA	0x466C	IATA Min Temperature	I2	2332	3932	2832	0.1°K
Power	IATA	0x466E	IATA Max Temperature	I2	2332	3932	3132	0.1°K
Power	IATA	0x4670	IATA Min Voltage	I2	0	32767	3000	mV
Power	IATA	0x4672	IATA Max Voltage	I2	0	32767	3600	mV
Power	IATA STORE	0x5270	IATA RM mAh	I2	0	32767	0	mAh
Power	IATA STORE	0x5272	IATA RM cWh	I2	0	32767	0	cWh
Power	IATA STORE	0x5274	IATA FCC mAh	I2	0	32767	0	mAh
Power	IATA STORE	0x5276	IATA FCC cWh	I2	0	32767	0	cWh
Power	IATA STORE	0x5278	IATA Flag	H2	0x0	0x00FF	0x0	—
Power	Unintended Wakeup	0x46D0	Delay	U2	0	240	2	s
Power	Unintended Wakeup	0x46D2	Count	U2	0	255	3	—
Power	Ship Mode	0x42B0	Voltage Threshold	I2	0	32767	2300	mV

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Power	Ship Mode	0x42B2	Voltage Delay	U1	0	255	10	s
Power	Ship Mode	0x42B3	Command Delay	U1	0	255	0	s
Power	Ship Mode	0x42B4	Measure Time	U1	1	30	30	s
System Data	Manufacturer Data	0x4100	Manufacturer Info A Length	U1	1	32	32	—
System Data	Manufacturer Data	0x4101	Manufacturer Info Block A01	H1	0x0	0xFF	0x61	Hex
System Data	Manufacturer Data	0x4102	Manufacturer Info Block A02	H1	0x0	0xFF	0x62	Hex
System Data	Manufacturer Data	0x4103	Manufacturer Info Block A03	H1	0x0	0xFF	0x63	Hex
System Data	Manufacturer Data	0x4104	Manufacturer Info Block A04	H1	0x0	0xFF	0x64	Hex
System Data	Manufacturer Data	0x4105	Manufacturer Info Block A05	H1	0x0	0xFF	0x65	Hex
System Data	Manufacturer Data	0x4106	Manufacturer Info Block A06	H1	0x0	0xFF	0x66	Hex
System Data	Manufacturer Data	0x4107	Manufacturer Info Block A07	H1	0x0	0xFF	0x67	Hex
System Data	Manufacturer Data	0x4108	Manufacturer Info Block A08	H1	0x0	0xFF	0x68	Hex
System Data	Manufacturer Data	0x4109	Manufacturer Info Block A09	H1	0x0	0xFF	0x69	Hex
System Data	Manufacturer Data	0x410A	Manufacturer Info Block A10	H1	0x0	0xFF	0x6A	Hex
System Data	Manufacturer Data	0x410B	Manufacturer Info Block A11	H1	0x0	0xFF	0x6B	Hex
System Data	Manufacturer Data	0x410C	Manufacturer Info Block A12	H1	0x0	0xFF	0x6C	Hex
System Data	Manufacturer Data	0x410D	Manufacturer Info Block A13	H1	0x0	0xFF	0x6D	Hex
System Data	Manufacturer Data	0x410E	Manufacturer Info Block A14	H1	0x0	0xFF	0x6E	Hex
System Data	Manufacturer Data	0x410F	Manufacturer Info Block A15	H1	0x0	0xFF	0x6F	Hex
System Data	Manufacturer Data	0x4110	Manufacturer Info Block A16	H1	0x0	0xFF	0x70	Hex
System Data	Manufacturer Data	0x4111	Manufacturer Info Block A17	H1	0x0	0xFF	0x71	Hex
System Data	Manufacturer Data	0x4112	Manufacturer Info Block A18	H1	0x0	0xFF	0x72	Hex
System Data	Manufacturer Data	0x4113	Manufacturer Info Block A19	H1	0x0	0xFF	0x73	Hex
System Data	Manufacturer Data	0x4114	Manufacturer Info Block A20	H1	0x0	0xFF	0x74	Hex
System Data	Manufacturer Data	0x4115	Manufacturer Info Block A21	H1	0x0	0xFF	0x75	Hex
System Data	Manufacturer Data	0x4116	Manufacturer Info Block A22	H1	0x0	0xFF	0x76	Hex
System Data	Manufacturer Data	0x4117	Manufacturer Info Block A23	H1	0x0	0xFF	0x77	Hex
System Data	Manufacturer Data	0x4118	Manufacturer Info Block A24	H1	0x0	0xFF	0x7A	Hex
System Data	Manufacturer Data	0x4119	Manufacturer Info Block A25	H1	0x0	0xFF	0x78	Hex
System Data	Manufacturer Data	0x411A	Manufacturer Info Block A26	H1	0x0	0xFF	0x79	Hex
System Data	Manufacturer Data	0x411B	Manufacturer Info Block A27	H1	0x0	0xFF	0x30	Hex
System Data	Manufacturer Data	0x411C	Manufacturer Info Block A28	H1	0x0	0xFF	0x31	Hex
System Data	Manufacturer Data	0x411D	Manufacturer Info Block A29	H1	0x0	0xFF	0x32	Hex
System Data	Manufacturer Data	0x411E	Manufacturer Info Block A30	H1	0x0	0xFF	0x33	Hex
System Data	Manufacturer Data	0x411F	Manufacturer Info Block A31	H1	0x0	0xFF	0x34	Hex
System Data	Manufacturer Data	0x4120	Manufacturer Info Block A32	H1	0x0	0xFF	0x35	Hex
System Data	Manufacturer Info B	0x4121	Manufacturer Info B Length	U1	1	32	32	—
System Data	Manufacturer Info B	0x4122	Manufacturer Info Block B01	H1	0x0	0xFF	0x01	Hex
System Data	Manufacturer Info B	0x4123	Manufacturer Info Block B02	H1	0x0	0xFF	0x23	Hex
System Data	Manufacturer Info B	0x4124	Manufacturer Info Block B03	H1	0x0	0xFF	0x45	Hex
System Data	Manufacturer Info B	0x4125	Manufacturer Info Block B04	H1	0x0	0xFF	0x67	Hex
System Data	Manufacturer Info B	0x4126	Manufacturer Info Block B05	H1	0x0	0xFF	0x89	Hex
System Data	Manufacturer Info B	0x4127	Manufacturer Info Block B06	H1	0x0	0xFF	0xAB	Hex
System Data	Manufacturer Info B	0x4128	Manufacturer Info Block B07	H1	0x0	0xFF	0xCD	Hex
System Data	Manufacturer Info B	0x4129	Manufacturer Info Block B08	H1	0x0	0xFF	0xEF	Hex
System Data	Manufacturer Info B	0x412A	Manufacturer Info Block B09	H1	0x0	0xFF	0x10	Hex
System Data	Manufacturer Info B	0x412B	Manufacturer Info Block B10	H1	0x0	0xFF	0x11	Hex
System Data	Manufacturer Info B	0x412C	Manufacturer Info Block B11	H1	0x0	0xFF	0x12	Hex
System Data	Manufacturer Info B	0x412D	Manufacturer Info Block B12	H1	0x0	0xFF	0x13	Hex
System Data	Manufacturer Info B	0x412E	Manufacturer Info Block B13	H1	0x0	0xFF	0x14	Hex
System Data	Manufacturer Info B	0x412F	Manufacturer Info Block B14	H1	0x0	0xFF	0x15	Hex

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
System Data	Manufacturer Info B	0x4130	Manufacturer Info Block B15	H1	0x0	0xFF	0x16	Hex
System Data	Manufacturer Info B	0x4131	Manufacturer Info Block B16	H1	0x0	0xFF	0x17	Hex
System Data	Manufacturer Info B	0x4132	Manufacturer Info Block B17	H1	0x0	0xFF	0x18	Hex
System Data	Manufacturer Info B	0x4133	Manufacturer Info Block B18	H1	0x0	0xFF	0x19	Hex
System Data	Manufacturer Info B	0x4134	Manufacturer Info Block B19	H1	0x0	0xFF	0x1A	Hex
System Data	Manufacturer Info B	0x4135	Manufacturer Info Block B20	H1	0x0	0xFF	0x1B	Hex
System Data	Manufacturer Info B	0x4136	Manufacturer Info Block B21	H1	0x0	0xFF	0x1C	Hex
System Data	Manufacturer Info B	0x4137	Manufacturer Info Block B22	H1	0x0	0xFF	0x1C	Hex
System Data	Manufacturer Info B	0x4138	Manufacturer Info Block B23	H1	0x0	0xFF	0x1D	Hex
System Data	Manufacturer Info B	0x4139	Manufacturer Info Block B24	H1	0x0	0xFF	0x1E	Hex
System Data	Manufacturer Info B	0x413A	Manufacturer Info Block B25	H1	0x0	0xFF	0x1F	Hex
System Data	Manufacturer Info B	0x413B	Manufacturer Info Block B26	H1	0x0	0xFF	0x20	Hex
System Data	Manufacturer Info B	0x413C	Manufacturer Info Block B27	H1	0x0	0xFF	0x21	Hex
System Data	Manufacturer Info B	0x413D	Manufacturer Info Block B28	H1	0x0	0xFF	0x22	Hex
System Data	Manufacturer Info B	0x413E	Manufacturer Info Block B29	H1	0x0	0xFF	0x23	Hex
System Data	Manufacturer Info B	0x413F	Manufacturer Info Block B30	H1	0x0	0xFF	0x24	Hex
System Data	Manufacturer Info B	0x4140	Manufacturer Info Block B31	H1	0x0	0xFF	0x25	Hex
System Data	Manufacturer Info B	0x4141	Manufacturer Info Block B32	H1	0x0	0xFF	0x26	Hex
System Data	Manufacturer Info C	0x4142	Manufacturer Info C Length	U1	1	32	32	—
System Data	Manufacturer Info C	0x4143	Manufacturer Info Block C01	H1	0x0	0xFF	0x01	Hex
System Data	Manufacturer Info C	0x4144	Manufacturer Info Block C02	H1	0x0	0xFF	0x23	Hex
System Data	Manufacturer Info C	0x4145	Manufacturer Info Block C03	H1	0x0	0xFF	0x45	Hex
System Data	Manufacturer Info C	0x4146	Manufacturer Info Block C04	H1	0x0	0xFF	0x67	Hex
System Data	Manufacturer Info C	0x4147	Manufacturer Info Block C05	H1	0x0	0xFF	0x89	Hex
System Data	Manufacturer Info C	0x4148	Manufacturer Info Block C06	H1	0x0	0xFF	0xAB	Hex
System Data	Manufacturer Info C	0x4149	Manufacturer Info Block C07	H1	0x0	0xFF	0xCD	Hex
System Data	Manufacturer Info C	0x414A	Manufacturer Info Block C08	H1	0x0	0xFF	0xEF	Hex
System Data	Manufacturer Info C	0x414B	Manufacturer Info Block C09	H1	0x0	0xFF	0x10	Hex
System Data	Manufacturer Info C	0x414C	Manufacturer Info Block C10	H1	0x0	0xFF	0x11	Hex
System Data	Manufacturer Info C	0x414D	Manufacturer Info Block C11	H1	0x0	0xFF	0x12	Hex
System Data	Manufacturer Info C	0x414E	Manufacturer Info Block C12	H1	0x0	0xFF	0x13	Hex
System Data	Manufacturer Info C	0x414F	Manufacturer Info Block C13	H1	0x0	0xFF	0x14	Hex
System Data	Manufacturer Info C	0x4150	Manufacturer Info Block C14	H1	0x0	0xFF	0x15	Hex
System Data	Manufacturer Info C	0x4151	Manufacturer Info Block C15	H1	0x0	0xFF	0x16	Hex
System Data	Manufacturer Info C	0x4152	Manufacturer Info Block C16	H1	0x0	0xFF	0x17	Hex
System Data	Manufacturer Info C	0x4153	Manufacturer Info Block C17	H1	0x0	0xFF	0x18	Hex
System Data	Manufacturer Info C	0x4154	Manufacturer Info Block C18	H1	0x0	0xFF	0x19	Hex
System Data	Manufacturer Info C	0x4155	Manufacturer Info Block C19	H1	0x0	0xFF	0x1A	Hex
System Data	Manufacturer Info C	0x4156	Manufacturer Info Block C20	H1	0x0	0xFF	0x1B	Hex
System Data	Manufacturer Info C	0x4157	Manufacturer Info Block C21	H1	0x0	0xFF	0x1C	Hex
System Data	Manufacturer Info C	0x4158	Manufacturer Info Block C22	H1	0x0	0xFF	0x1C	Hex
System Data	Manufacturer Info C	0x4159	Manufacturer Info Block C23	H1	0x0	0xFF	0x1D	Hex
System Data	Manufacturer Info C	0x415A	Manufacturer Info Block C24	H1	0x0	0xFF	0x1E	Hex
System Data	Manufacturer Info C	0x415B	Manufacturer Info Block C25	H1	0x0	0xFF	0x1F	Hex
System Data	Manufacturer Info C	0x415C	Manufacturer Info Block C26	H1	0x0	0xFF	0x20	Hex
System Data	Manufacturer Info C	0x415D	Manufacturer Info Block C27	H1	0x0	0xFF	0x21	Hex
System Data	Manufacturer Info C	0x415E	Manufacturer Info Block C28	H1	0x0	0xFF	0x22	Hex
System Data	Manufacturer Info C	0x415F	Manufacturer Info Block C29	H1	0x0	0xFF	0x23	Hex
System Data	Manufacturer Info C	0x4160	Manufacturer Info Block C30	H1	0x0	0xFF	0x24	Hex
System Data	Manufacturer Info C	0x4161	Manufacturer Info Block C31	H1	0x0	0xFF	0x25	Hex
System Data	Manufacturer Info C	0x4162	Manufacturer Info Block C32	H1	0x0	0xFF	0x26	Hex

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
System Data	Integrity	0x4170	Static DF Signature	H2	0x0	0x7FFF	0x0	Hex
System Data	Integrity	0x4172	Static Chem DF Signature	H2	0x0	0x7FFF	0x73B5	Hex
System Data	Integrity	0x4174	All DF Signature	H2	0x0	0x7FFF	0x0	Hex
SBS Configuration	Data	0x40C0	Manufacture Date	U2	0	65535	0	date
SBS Configuration	Data	0x40C2	Serial Number	H2	0x0	0xFFFF	0x0001	Hex
SBS Configuration	Data	0x40C4	Manufacturer Name	S21	x	x	Texas Instruments	—
SBS Configuration	Data	0x40D9	Device Name	S21	x	x	bq27z855	—
SBS Configuration	Data	0x40EE	Device Chemistry	S5	x	x	LION	—
SBS Configuration	Data	0x46C0	Remaining AH Cap. Alarm	I2	0	32767	300	mAh
SBS Configuration	Data	0x46C2	Remaining WH Cap. Alarm	I2	0	32767	432	cWh
SBS Configuration	Data	0x46C4	Remaining Time Alarm	U2	0	65535	10	min
SBS Configuration	Data	0x46C6	Initial Battery Mode	H2	0x0	0xFFFF	0x0081	Hex
SBS Configuration	Data	0x46C8	Specification Information	H2	0x0	0xFFFF	0x0031	Hex
SBS Configuration	Data	0x46E0	VLB Remaining Cap. mAH	I2	0	32767	176	mAh
SBS Configuration	Data	0x46E2	VLB Remaining Cap. cWH	I2	0	32767	254	cWh
SBS Configuration	Data	0x46E4	VLB Voltage	I2	0	5000	2850	mV
SBS Configuration	Data	0x46E6	VLB Hold Time	U2	0	255	2	s
SBS Configuration	Data	0x46E8	VLB Timeout	U2	0	255	120	s
Lifetimes	Voltage	0x5280	Cell Max Voltage	I2	0	32767	0	mV
Lifetimes	Voltage	0x5282	Cell Min Voltage	I2	0	32767	32767	mV
Lifetimes	Current	0x5284	Max Charge Current	I2	0	32767	0	mA
Lifetimes	Current	0x5286	Max Discharge Current	I2	–32768	0	0	mA
Lifetimes	Current	0x5288	Max Avg Dsg Current	I2	–32768	0	0	mA
Lifetimes	Current	0x528C	Max Avg Dsg Power	I2	–32768	0	0	cW
Lifetimes	Temperature-Relax	0x5290	Max Temp Cell	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5291	Min Temp Cell	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x5292	Max Delta Cell Temp	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5293	Max Temp Int Sensor	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5294	Min Temp Int Sensor	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x5295	Max Temp Fet	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5296	Max Temp TS1	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5297	Min Temp TS1	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x5298	Max Temp Cell	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x5299	Min Temp Cell	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x529A	Max Delta Cell Temp	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x529B	Max Temp Int Sensor	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x529C	Min Temp Int Sensor	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x529D	Max Temp Fet	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x529E	Max Temp TS1	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x529F	Min Temp TS1	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x52A0	Max Temp Cell	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x52A1	Min Temp Cell	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x52A2	Max Delta Cell Temp	U1	0	255	0	°C

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Temperature-Discharge	0x52A3	Max Temp Int Sensor	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x52A4	Min Temp Int Sensor	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x52A5	Max Temp Fet	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x52A6	Max Temp TS1	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x52A7	Min Temp TS1	I1	–128	127	127	°C
Lifetimes	Safety Events	0x52A8	No Of COV Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52AA	Last COV Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52AC	No Of CUV Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52AE	Last CUV Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52B0	No Of OCD1 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52B2	Last OCD1 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52B4	No Of OCD2 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52B6	Last OCD2 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52B8	No Of OCC1 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52BA	Last OCC1 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52BC	No Of OCC2 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52BE	Last OCC2 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52C0	No Of AOCD Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52C2	Last AOCD Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52C4	No Of ASCD Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52C6	Last ASCD Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52C8	No Of AOCC Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52CA	Last AOCC Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52CC	No Of OTC Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52CE	Last OTC Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52D0	No Of OTD Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52D2	Last OTD Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x52D4	No Of OTF Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x52D6	Last OTF Event	U2	0	32767	0	cycles
Lifetimes	Charging Events	0x52D8	No Valid Charge Term	U2	0	32767	0	events
Lifetimes	Charging Events	0x52DA	Last Valid Charge Term	U2	0	32767	0	cycles
Lifetimes	Gauging Events	0x52DC	No Of Qmax Updates	U2	0	32767	0	events
Lifetimes	Gauging Events	0x52DE	Last Qmax Update	U2	0	32767	0	cycles
Lifetimes	Gauging Events	0x52E0	No Of Ra Updates	U2	0	32767	0	events
Lifetimes	Gauging Events	0x52E2	Last Ra Update	U2	0	32767	0	cycles
Lifetimes	Gauging Events	0x52E4	No Of Ra Disable	U2	0	32767	0	events
Lifetimes	Gauging Events	0x52E6	Last Ra Disable	U2	0	32767	0	cycles
Lifetimes	State of Health	0x52E8	Min FCC-SOH mAh	I2	0	32767	0	mAh
Lifetimes	State of Health	0x52EA	Min FCC-SOH cWh	I2	0	32767	0	cWh
Lifetimes	Time	0x52EC	Total Fw Runtime	U4	0	4294967295	0	s
Lifetimes	Time	0x52F0	Time Spent In UUT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x52F4	Time Spent In UUT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x52F8	Time Spent In UUT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x52FC	Time Spent In UUT RSOC D	U4	0	4294967295	0	s

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Time	0x5300	Time Spent In UUT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5304	Time Spent In UUT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x5308	Time Spent In UUT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x530C	Time Spent In UUT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5310	Time Spent In UT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5314	Time Spent In UT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x5318	Time Spent In UT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x531C	Time Spent In UT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5320	Time Spent In UT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5324	Time Spent In UT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x5328	Time Spent In UT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x532C	Time Spent In UT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5330	Time Spent In LT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5334	Time Spent In LT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x5338	Time Spent In LT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x533C	Time Spent In LT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5340	Time Spent In LT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5344	Time Spent In LT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x5348	Time Spent In LT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x534C	Time Spent In LT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5350	Time Spent In STL RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5354	Time Spent In STL RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x5358	Time Spent In STL RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x535C	Time Spent In STL RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5360	Time Spent In STL RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5364	Time Spent In STL RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x5368	Time Spent In STL RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x536C	Time Spent In STL RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5370	Time Spent In RT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5374	Time Spent In RT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x5378	Time Spent In RT RSOC C	U4	0	4294967295	0	s

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Time	0x537C	Time Spent In RT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5380	Time Spent In RT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5384	Time Spent In RT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x5388	Time Spent In RT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x538C	Time Spent In RT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5390	Time Spent In STH RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5394	Time Spent In STH RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x5398	Time Spent In STH RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x539C	Time Spent In STH RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x53A0	Time Spent In STH RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x53A4	Time Spent In STH RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x53A8	Time Spent In STH RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x53AC	Time Spent In STH RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x53B0	Time Spent In HT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x53B4	Time Spent In HT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x53B8	Time Spent In HT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x53BC	Time Spent In HT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x53C0	Time Spent In HT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x53C4	Time Spent In HT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x53C8	Time Spent In HT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x53CC	Time Spent In HT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x53D0	Time Spent In OT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x53D4	Time Spent In OT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x53D8	Time Spent In OT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x53DC	Time Spent In OT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x53E0	Time Spent In OT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x53E4	Time Spent In OT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x53E8	Time Spent In OT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x53EC	Time Spent In OT RSOC H	U4	0	4294967295	0	s
Protections	CUV	0x5114	Threshold	I2	0	32767	2500	mV
Protections	CUV	0x5116	Delay	U2	0	255	2	s
Protections	CUV	0x5118	Recovery	I2	0	32767	3000	mV

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Protections	CUV	0x513C	Recovery Charger Present Time	U2	0	255	2	s
Protections	CUVC	0x511A	Threshold	I2	0	32767	2400	mV
Protections	CUVC	0x511C	Delay	U2	0	255	2	s
Protections	CUVC	0x511E	Recovery	I2	0	32767	3000	mV
Protections	COV	0x5120	Threshold Low Temp	I2	0	32767	4300	mV
Protections	COV	0x5122	Threshold Standard Temp Low	I2	0	32767	4300	mV
Protections	COV	0x5124	Threshold Standard Temp High	I2	0	32767	4300	mV
Protections	COV	0x5126	Threshold High Temp	I2	0	32767	4300	mV
Protections	COV	0x5128	Threshold Rec Temp	I2	0	32767	4300	mV
Protections	COV	0x512A	Delay	U2	0	255	2	s
Protections	COV	0x512C	Recovery Low Temp	I2	0	32767	3900	mV
Protections	COV	0x512E	Recovery Standard Temp Low	I2	0	32767	3900	mV
Protections	COV	0x5130	Recovery Standard Temp High	I2	0	32767	3900	mV
Protections	COV	0x5132	Recovery High Temp	I2	0	32767	3900	mV
Protections	COV	0x5134	Recovery Rec Temp	I2	0	32767	3900	mV
Protections	COV	0x5138	Latch Limit	U2	0	255	0	—
Protections	COV	0x513A	Counter Dec Delay	U2	0	255	10	s
Protections	COV	0x513E	Reset	U2	0	255	15	s
Protections	ACUV	0x5140	Recovery	I2	0	32767	3000	mV
Protections	ACOV	0x5142	Recovery	I2	0	32767	3900	mV
Protections	OCC1	0x5144	Threshold	I2	–32768	32767	6000	mA
Protections	OCC1	0x5146	Delay	U2	0	255	6	s
Protections	OCC2	0x5148	Threshold	I2	–32768	32767	8000	mA
Protections	OCC2	0x514A	Delay	U2	0	255	3	s
Protections	OCC	0x514C	Recovery Threshold	I2	–32768	32767	–200	mA
Protections	OCC	0x514E	Recovery Delay	U2	0	255	5	s
Protections	OCD1	0x5150	Threshold	I2	–32768	32767	–6000	mA
Protections	OCD1	0x5152	Delay	U2	0	255	6	s
Protections	OCD2	0x5154	Threshold	I2	–32768	32767	–8000	mA
Protections	OCD2	0x5156	Delay	U2	0	255	3	s
Protections	OCD	0x5158	Recovery Threshold	I2	–32768	32767	200	mA
Protections	OCD	0x515A	Recovery Delay	U2	0	255	5	s
Protections	OCD	0x515C	Latch Limit	U2	0	255	0	—
Protections	OCD	0x515E	Counter Dec Delay	U2	0	255	10	s
Protections	OCD	0x5160	Reset	U2	0	255	15	s
Protections	AOCD	0x5164	Latch Limit	U2	0	255	0	—
Protections	AOCD	0x5166	Counter Dec Delay	U2	0	255	10	s
Protections	AOCD	0x5168	Recovery	U2	0	255	5	s
Protections	AOCD	0x516A	Reset	U2	0	255	15	s
Protections	AOCC	0x516C	Latch Limit	U2	0	255	0	—
Protections	AOCC	0x516E	Counter Dec Delay	U2	0	255	10	s
Protections	AOCC	0x5170	Recovery	U2	0	255	5	s
Protections	AOCC	0x5172	Reset	U2	0	255	15	s
Protections	ASCD	0x5174	Latch Limit	U2	0	255	0	—
Protections	ASCD	0x5176	Counter Dec Delay	U2	0	255	10	s
Protections	ASCD	0x5178	Recovery	U2	0	255	5	s
Protections	ASCD	0x517A	Reset	U2	0	255	15	s
Protections	OTC	0x517C	Threshold	I2	2332	3932	3282	0.1°K
Protections	OTC	0x517E	Delay	U2	0	255	2	s
Protections	OTC	0x5180	Recovery	I2	2332	3932	3232	0.1°K

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Protections	OTD	0x5182	Threshold	I2	2332	3932	3332	0.1°K
Protections	OTD	0x5184	Delay	U2	0	255	2	s
Protections	OTD	0x5186	Recovery	I2	2332	3932	3282	0.1°K
Protections	OTF	0x5188	Threshold	I2	2332	3932	3532	0.1°K
Protections	OTF	0x518A	Delay	U2	0	255	2	s
Protections	OTF	0x518C	Recovery	I2	2332	3932	3382	0.1°K
Protections	UTC	0x518E	Threshold	I2	2332	3932	2732	0.1°K
Protections	UTC	0x5190	Delay	U2	0	255	2	s
Protections	UTC	0x5192	Recovery	I2	2332	3932	2782	0.1°K
Protections	UTD	0x5194	Threshold	I2	2332	3932	2732	0.1°K
Protections	UTD	0x5196	Delay	U2	0	255	2	s
Protections	UTD	0x5198	Recovery	I2	2332	3932	2782	0.1°K
Protections	HWD	0x519A	Delay	U2	0	255	10	s
Protections	PTO	0x50E0	Charge Threshold	I2	–32768	32767	2000	mA
Protections	PTO	0x50E2	Suspend Threshold	I2	–32768	32767	1800	mA
Protections	PTO	0x50E4	Delay	U2	0	65535	1800	s
Protections	PTO	0x50E6	Reset	I2	0	32767	2	mAh
Protections	CTO	0x50E8	Charge Threshold	I2	–32768	32767	2500	mA
Protections	CTO	0x50EA	Suspend Threshold	I2	–32768	32767	2000	mA
Protections	CTO	0x50EC	Delay	U2	0	65535	54000	s
Protections	CTO	0x50EE	Reset	I2	0	32767	2	mAh
Protections	OC	0x50F0	Threshold	I2	–32768	32767	300	mAh
Protections	OC	0x50F2	Recovery	I2	–32768	32767	2	mAh
Protections	OC	0x50F4	RSOC Recovery	U2	0	100	90	%
Protections	CHGV	0x50F6	Threshold	I2	–32768	32767	1500	mV
Protections	CHGV	0x50F8	Delay	U2	0	255	30	s
Protections	CHGV	0x50FA	Recovery	I2	–32768	32767	–500	mV
Protections	CHGC	0x50FC	Threshold	I2	–32768	32767	500	mA
Protections	CHGC	0x50FE	Delay	U2	0	255	2	s
Protections	CHGC	0x5100	Recovery Threshold	I2	–32768	32767	100	mA
Protections	CHGC	0x5102	Recovery Delay	U2	0	255	2	s
Protections	PCHGC	0x5104	Threshold	I2	–32768	32767	50	mA
Protections	PCHGC	0x5106	Delay	U2	0	255	2	s
Protections	PCHGC	0x5108	Recovery Threshold	I2	–32768	32767	10	mA
Protections	PCHGC	0x510A	Recovery Delay	U2	0	255	2	s
Permanent Fail	SUV	0x50A4	Threshold	I2	0	32767	2200	mV
Permanent Fail	SUV	0x50A6	Delay	U2	0	255	5	s
Permanent Fail	SOV	0x50A8	Threshold	I2	0	32767	4500	mV
Permanent Fail	SOV	0x50AA	Delay	U2	0	255	5	s
Permanent Fail	SOCC	0x50AC	Threshold	I2	–32768	32767	10000	mA
Permanent Fail	SOCC	0x50AE	Delay	U2	0	255	5	s
Permanent Fail	SOCD	0x50B0	Threshold	I2	–32768	32767	–10000	mA
Permanent Fail	SOCD	0x50B2	Delay	U2	0	255	5	s
Permanent Fail	SOT	0x50B4	SOTC Threshold	I2	2332	4232	3382	0.1°K
Permanent Fail	SOT	0x50B6	SOTC Delay	U2	0	255	5	s
Permanent Fail	SOT	0x50B8	SOTD Threshold	I2	2332	4232	3432	0.1°K
Permanent Fail	SOT	0x50BA	SOTD Delay	U2	0	255	5	s
Permanent Fail	SOTF	0x50BC	Threshold	I2	2332	4232	3732	0.1°K
Permanent Fail	SOTF	0x50BE	Delay	U2	0	255	5	s
Permanent Fail	Open Thermistor	0x50C0	Threshold	I2	0	32767	2232	0.1°K
Permanent Fail	Open Thermistor	0x50C2	Delay	U2	0	255	5	s

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Permanent Fail	Open Thermistor	0x50C4	Fet Delta	I2	0	1500	200	0.1°K
Permanent Fail	Open Thermistor	0x50C6	Cell Delta	I2	0	1500	200	0.1°K
Permanent Fail	CD	0x50C8	Threshold	I2	0	32767	0	mAh
Permanent Fail	CD	0x50CA	Delay	U2	0	255	2	cycles
Permanent Fail	CFET	0x50CC	OFF Threshold	I2	0	500	5	mA
Permanent Fail	CFET	0x50CE	OFF Delay	U2	0	255	5	s
Permanent Fail	DFET	0x50D0	OFF Threshold	I2	–500	0	–5	mA
Permanent Fail	DFET	0x50D2	OFF Delay	U2	0	255	5	s
Permanent Fail	BSD	0x4282	Min R Threshold	I2	0	32767	200	mΩ
Permanent Fail	BSD	0x4284	Min Cycle Count Threshold	U2	0	65535	100	Cycle
Permanent Fail	BSD	0x4286	Max Slope	I2	0	32767	1000	mΩ/Cycle
Permanent Fail	BSD	0x4288	Slope Update Grid	U1	0	14	7	—
Permanent Fail	BSD	0x50D4	BSD Event Count	U2	0	255	5	Cycle
Permanent Fail	BSD	0x54BC	Cell 0 BSD Event Count	U1	0	255	0	—
Permanent Fail	ISI	0x50D6	Low Fault Count Threshold	U2	0	255	5	—
Permanent Fail	ISI	0x50D8	High Fault Count Threshold	U2	0	255	5	—
PF Status	Device Status Data	0x5430	Safety Alert A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5431	Safety Status A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5432	Safety Alert B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5433	Safety Status B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5434	Safety Alert C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5435	Safety Status C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5436	Safety Alert D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5437	Safety Status D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5438	PF Alert A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5439	PF Status A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x543A	PF Alert B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x543B	PF Status B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x543C	PF Alert C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x543D	PF Status C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x543E	PF Alert D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x543F	PF Status D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5440	Operation Status A	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Status Data	0x5442	Operation Status B	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Status Data	0x5444	Temp Range	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5445	Charging Status A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5446	Charging Status B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x544A	Gauging Status	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Status Data	0x544C	IT Status	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Voltage Data	0x544E	Cell Voltage	I2	–32768	32767	0	mV
PF Status	Device Voltage Data	0x5450	Pack Voltage	I2	–32768	32767	0	mV
PF Status	Device Current Data	0x5452	Current	I2	–32768	32767	0	mA
PF Status	Device Temperature Data	0x5454	Internal Temperature	I2	–1	32767	0	0.1°K
PF Status	Device Temperature Data	0x5456	External 1 Temperature	I2	–1	32767	0	0.1°K
PF Status	Device Gauging Data	0x5458	Cell Dod0	I2	–32768	32767	0	—
PF Status	Device Gauging Data	0x545A	Passed Charge	I2	–32768	32767	0	mAh

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
PF Status	Device ISI Data	0x545C	Coarse Max Internal Short	I2	–32768	32767	–32768	0.1 mA
PF Status	Device ISI Data	0x545E	Coarse Min Internal Short	I2	–32768	32767	32767	0.1 mA
PF Status	Device ISI Data	0x5460	Fine Max Internal Short	I2	–32768	32767	–32768	0.1 mA
PF Status	Device ISI Data	0x5462	Fine Min Internal Short	I2	–32768	32767	32767	0.1 mA
PF Status	Device ISI Data	0x5464	Low PF Time	U4	0	4294967295	0	s
PF Status	Device ISI Data	0x5468	Low First Fail	I2	–32768	32767	0	0.1 mA
PF Status	Device ISI Data	0x546A	Low Last Fail	I2	–32768	32767	0	0.1 mA
PF Status	Device ISI Data	0x546C	High PF Time	U4	0	4294967295	0	s
PF Status	Device ISI Data	0x5470	High First Fail	I2	–32768	32767	0	0.1 mA
PF Status	Device ISI Data	0x5472	High Last Fail	I2	–32768	32767	0	0.1 mA
PF Status	AFE Regs	0x5410	OCC	H1	0x0	0x7F	0x06	Hex
PF Status	AFE Regs	0x5411	OCD	H1	0x0	0x7F	0x06	Hex
PF Status	AFE Regs	0x5412	Short Circuit Discharge	H1	0x0	0x7F	0x7F	Hex
PF Status	AFE Regs	0x5413	Under Voltage	H1	0x0	0x7F	0x28	Hex
PF Status	AFE Regs	0x5414	Over Voltage	H1	0x0	0x7F	0x64	Hex
PF Status	AFE Regs	0x5415	Current Charge Wake	H1	0x70	0x7F	0x74	Hex
PF Status	AFE Regs	0x5416	Current Discharge Wake	H1	0x70	0x7F	0x74	Hex
PF Status	AFE Regs	0x5417	OCC Delay	H1	0x0	0x7F	0x07	Hex
PF Status	AFE Regs	0x5418	OCD Delay	H1	0x0	0x7F	0x07	Hex
PF Status	AFE Regs	0x5419	Short Circuit Discharge Delay	H1	0x0	0x07	0x07	Hex
PF Status	AFE Regs	0x541A	Under Voltage Delay	H1	0x0	0xFF	0xFF	Hex
PF Status	AFE Regs	0x541B	Over Voltage Delay	H1	0x0	0xFF	0xFF	Hex
PF Status	AFE Regs	0x541C	Over Voltage Delay Hi	H1	0x0	0x1F	0x1F	Hex
PF Status	AFE Regs	0x541D	CD Wake Delay	H1	0x0	0x1F	0x1F	Hex
PF Status	AFE Regs	0x541E	CC Wake Delay	H1	0x0	0x1F	0x1F	Hex
Black Box	Safety Status	0x51A0	1st Safety Status A	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51A1	1st Safety Status B	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51A2	1st Safety Status C	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51A3	1st Safety Status D	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51A4	1st Time to Next Event	U2	0	65535	0	s
Black Box	Safety Status	0x51A6	1st Cycle Count	U2	0	65535	0	—
Black Box	Safety Status	0x51A8	2nd Safety Status A	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51A9	2nd Safety Status B	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51AA	2nd Safety Status C	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51AB	2nd Safety Status D	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51AC	2nd Time to Next Event	U2	0	65535	0	s
Black Box	Safety Status	0x51AE	2nd Cycle Count	U2	0	65535	0	—
Black Box	Safety Status	0x51B0	3rd Safety Status A	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51B1	3rd Safety Status B	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51B2	3rd Safety Status C	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51B3	3rd Safety Status D	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x51B4	3rd Time to Next Event	U2	0	65535	0	s
Black Box	Safety Status	0x51B6	3rd Cycle Count	U2	0	65535	0	—
Black Box	PF Status	0x51B8	1st PF Status A	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51B9	1st PF Status B	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51BA	1st PF Status C	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51BB	1st PF Status D	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51BC	1st Time to Next Event	U2	0	65535	0	s
Black Box	PF Status	0x51BE	1st Cycle Count	U2	0	65535	0	—
Black Box	PF Status	0x51C0	2nd PF Status A	H1	0x0	0xFF	0x0	Hex

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Black Box	PF Status	0x51C1	2nd PF Status B	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51C2	2nd PF Status C	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51C3	2nd PF Status D	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51C4	2nd Time to Next Event	U2	0	65535	0	s
Black Box	PF Status	0x51C6	2nd Cycle Count	U2	0	65535	0	—
Black Box	PF Status	0x51C8	3rd PF Status A	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51C9	3rd PF Status B	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51CA	3rd PF Status C	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51CB	3rd PF Status D	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x51CE	3rd Cycle Count	U2	0	65535	0	—
Gas Gauging	Current Thresholds	0x461C	Dsg Current Threshold	I2	–32768	32767	100	mA
Gas Gauging	Current Thresholds	0x461E	Chg Current Threshold	I2	–32768	32767	50	mA
Gas Gauging	Current Thresholds	0x4620	Quit Current	I2	0	32767	10	mA
Gas Gauging	Current Thresholds	0x4622	Dsg Relax Time	U2	0	255	1	s
Gas Gauging	Current Thresholds	0x4624	Chg Relax Time	U2	0	255	60	s
Gas Gauging	Design	0x5240	Design Capacity mAh	I2	0	32767	4400	mAh
Gas Gauging	Design	0x5242	Design Capacity cWh	I2	0	32767	6336	cWh
Gas Gauging	Design	0x5244	Design Voltage	I2	0	32767	3600	mV
Gas Gauging	Cycle	0x5246	Cycle Count Percentage	U2	0	100	90	%
Gas Gauging	FD	0x5250	Set Voltage Threshold	I2	0	5000	3000	mV
Gas Gauging	FD	0x5252	Clear Voltage Threshold	I2	0	5000	3100	mV
Gas Gauging	FD	0x5254	Set % RSOC Threshold	U2	0	100	0	%
Gas Gauging	FD	0x5256	Clear % RSOC Threshold	U2	0	100	5	%
Gas Gauging	FC	0x5258	Set Voltage Threshold	I2	0	5000	4200	mV
Gas Gauging	FC	0x525A	Clear Voltage Threshold	I2	0	5000	4100	mV
Gas Gauging	FC	0x525C	Set % RSOC Threshold	U2	0	100	100	%
Gas Gauging	FC	0x525E	Clear % RSOC Threshold	U2	0	100	95	%
Gas Gauging	TD	0x5260	Set Voltage Threshold	I2	0	5000	3200	mV
Gas Gauging	TD	0x5262	Clear Voltage Threshold	I2	0	5000	3300	mV
Gas Gauging	TD	0x5264	Set % RSOC Threshold	U2	0	100	6	%
Gas Gauging	TD	0x5266	Clear % RSOC Threshold	U2	0	100	8	%
Gas Gauging	TC	0x5268	Set Voltage Threshold	I2	0	5000	4200	mV
Gas Gauging	TC	0x526A	Clear Voltage Threshold	I2	0	5000	4100	mV
Gas Gauging	TC	0x526C	Set % RSOC Threshold	U2	0	100	100	%
Gas Gauging	TC	0x526E	Clear % RSOC Threshold	U2	0	100	95	%
Gas Gauging	State	0x5230	Cycle Count	U2	0	65535	0	—
Gas Gauging	State	0x54C0	Qmax Cell	I2	0	32767	4400	mAh
Gas Gauging	State	0x54C2	Qmax Cycle Count	U2	0	65535	0	—
Gas Gauging	State	0x54C4	Update Status	H1	0x0	0x0E	0x0	—
Gas Gauging	State	0x54C8	Cell Chg Voltage at EoC	I2	0	32767	4200	mV
Gas Gauging	State	0x54CA	Current at EoC	I2	0	32767	250	mA
Gas Gauging	State	0x54CC	Avg I Last Run	I2	–32768	32767	–2000	mA
Gas Gauging	State	0x54CE	Avg P Last Run	I2	–32768	32767	–3022	cW
Gas Gauging	State	0x54D0	Temp k	I2	0	32767	100	0.1°C/256 cW
Gas Gauging	State	0x54D2	Temp a	I2	0	32767	1000	s
Gas Gauging	State	0x54D4	Max Avg I Last Run	I2	–32768	32767	–2000	mA
Gas Gauging	State	0x54D6	Max Avg P Last Run	I2	–32768	32767	–3022	cW
Gas Gauging	State	0x54D8	Delta Voltage	I2	–32768	32767	0	mV
Gas Gauging	State	0x54DA	SOH FCC Max mAh	I2	0	32767	4400	mAh
Gas Gauging	State	0x54DC	SOH FCC Max cWh	I2	0	32767	6336	cWh

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Gas Gauging	State	0x54DE	SOH Temp k	I2	0	32767	100	0.1°C/256 cW
Gas Gauging	State	0x54E0	SOH Temp a	I2	0	32767	1000	s
Gas Gauging	Turbo Cfg	0x5082	Min System Voltage	I2	0	32767	3000	mV
Gas Gauging	Turbo Cfg	0x5084	Ten Second Max C Rate	I2	–32768	0	–200	0.01°C-rate
Gas Gauging	Turbo Cfg	0x5086	Ten Millisecond Max C Rate	I2	–32768	0	–400	0.01°C-rate
Gas Gauging	Turbo Cfg	0x5088	High Frequency Resistance	I2	0	32767	36	mΩ
Gas Gauging	Turbo Cfg	0x508A	Reserve Energy %	U2	0	100	0	%
Gas Gauging	Turbo Cfg	0x508C	Turbo Adjustment Factor	U2	0	255	100	%
Gas Gauging	IT Cfg	0x4280	BSD Cfg	H2	0x0	0x0001	0x0001	—
Gas Gauging	IT Cfg	0x4294	Room Temp	I2	0	3372	2982	0.1°K
Gas Gauging	IT Cfg	0x4296	High Temp	I2	0	3372	3182	0.1°K
Gas Gauging	IT Cfg	0x4298	Time Count Max	U2	0	65535	1800	Days
Gas Gauging	IT Cfg	0x429A	Time Count Max High	U2	0	65535	720	Days
Gas Gauging	IT Cfg	0x429C	Cycle Count Max	U2	0	65535	1000	—
Gas Gauging	IT Cfg	0x429E	Cycle Count Max High	U2	0	65535	500	—
Gas Gauging	IT Cfg	0x42A0	End of Life Capacity	U1	0	100	20	%
Gas Gauging	IT Cfg	0x46F6	Load Select	U1	0	7	7	—
Gas Gauging	IT Cfg	0x46F7	Fast Scale Load Select	U1	0	7	3	—
Gas Gauging	IT Cfg	0x46F8	Load Mode	U1	0	1	0	—
Gas Gauging	IT Cfg	0x46FC	User Rate-mA	I2	–9000	0	0	mA
Gas Gauging	IT Cfg	0x46FE	User Rate-cW	I2	–32768	0	0	cW
Gas Gauging	IT Cfg	0x4700	Reserve Cap-mAh	I2	0	9000	0	mAh
Gas Gauging	IT Cfg	0x4702	Reserve Cap-cWh	I2	0	32000	0	cWh
Gas Gauging	IT Cfg	0x471E	Predict Ambient Time	U2	0	65535	2000	s
Gas Gauging	IT Cfg	0x4744	Ra Filter	U2	0	999	800	0.1%
Gas Gauging	IT Cfg	0x4748	Ra Max Delta	U2	0	255	15	%
Gas Gauging	IT Cfg	0x474C	Reference Grid	U2	0	14	4	—
Gas Gauging	IT Cfg	0x474E	Resistance Parameter Filter	U2	1	65535	65142	—
Gas Gauging	IT Cfg	0x4750	Near EDV Ra Param Filter	U2	1	65535	59220	—
Gas Gauging	IT Cfg	0x4752	Max Current Change %	U2	0	100	10	%
Gas Gauging	IT Cfg	0x4754	Resistance Update Voltage	I2	0	32767	50	mV
Gas Gauging	IT Cfg	0x478A	Qmax Delta	U2	3	100	5	%
Gas Gauging	IT Cfg	0x478C	Qmax Upper Bound	U2	100	255	130	%
Gas Gauging	IT Cfg	0x478E	OCV Pred Active T Limit	U2	100	65535	200	s
Gas Gauging	IT Cfg	0x4790	OCV Pred Transient T	U2	100	65535	300	s
Gas Gauging	IT Cfg	0x4792	OCV Pred Measure Time	U2	0	65535	200	s
Gas Gauging	IT Cfg	0x4794	Term Voltage	I2	0	32767	2800	mV
Gas Gauging	IT Cfg	0x4796	Term V Hold Time	U2	0	255	15	s
Gas Gauging	IT Cfg	0x4798	Term Voltage Delta	I2	0	32767	300	mV
Gas Gauging	IT Cfg	0x479C	Res Relax Time	U2	0	65535	200	s
Gas Gauging	IT Cfg	0x47A4	Max Simulation Iterations	U2	20	50	30	—
Gas Gauging	IT Cfg	0x47A8	Simulation Near Term Delta	I2	0	32767	250	mV
Gas Gauging	IT Cfg	0x47B8	Fast Scale Start SOC	U2	0	100	10	%
Gas Gauging	IT Cfg	0x47C6	Min Delta Voltage	I2	–32768	32767	0	mV
Gas Gauging	IT Cfg	0x47C8	Max Delta Voltage	I2	–32768	32767	200	mV
Gas Gauging	IT Cfg	0x47CA	DeltaV Max Voltage Delta	I2	–32768	32767	10	mV
Gas Gauging	IT Cfg	0x54F0	Design Qmax Status	H2	0x0	0x0001	0x00	—
Gas Gauging	IT Cfg	0x54F2	Design Qmax Cell 0	I2	0	32767	4400	mAh
Gas Gauging	IT Cfg	0x54F4	Design Resistance	I2	1	32767	96	mΩ

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Gas Gauging	IT Cfg	0x54F6	Pack Resistance	I2	0	32767	0	mΩ
Gas Gauging	IT Cfg	0x54F8	System Resistance	I2	0	32767	0	mΩ
Gas Gauging	IT Cfg	0x5500	Time Count	U2	0	65535	0	Days
Gas Gauging	IT Cfg	0x5502	Caploss Cell 0	I2	0	16383	0	—
Gas Gauging	Smoothing	0x4704	Smooth Relax Time	U2	1	32767	1000	s
Gas Gauging	Smoothing	0x4706	Term Smooth Start Cell V Delta	I2	0	32767	150	mV
Gas Gauging	Smoothing	0x4708	Term Smooth Final Cell V Delta	I2	0	32767	100	mV
Gas Gauging	Smoothing	0x470A	Term Smooth Time	U2	1	255	20	s
Gas Gauging	Max Error	0x4712	Time Cycle Equivalent	U2	1	255	12	2 h
Gas Gauging	Max Error	0x4714	Cycle Delta	U2	0	255	5	0.01%
Gas Gauging	Condition Flag	0x4718	Max Error Limit	U2	0	100	100	%
Gas Gauging	SoH	0x47D0	SoH Load Rate	U1	0	255	50	0.1 Hr rate
Ra Table	R_a0	0x5000	Cell0 R_a flag	H2	0x0	0xFFFF	0xFF55	—
Ra Table	R_a0	0x5002	Cell0 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a0	0x5004	Cell0 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a0	0x5006	Cell0 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a0	0x5008	Cell0 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a0	0x500A	Cell0 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a0	0x500C	Cell0 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a0	0x500E	Cell0 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a0	0x5010	Cell0 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a0	0x5012	Cell0 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a0	0x5014	Cell0 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a0	0x5016	Cell0 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a0	0x5018	Cell0 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a0	0x501A	Cell0 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a0	0x501C	Cell0 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a0	0x501E	Cell0 R_a 14	I2	0	32767	658	mΩ
Ra Table	R_a0x	0x5040	xCell0 R_a flag	H2	0x0	0xFFFF	0xFFFF	—
Ra Table	R_a0x	0x5042	xCell0 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a0x	0x5044	xCell0 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a0x	0x5046	xCell0 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a0x	0x5048	xCell0 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a0x	0x504A	xCell0 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a0x	0x504C	xCell0 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a0x	0x504E	xCell0 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a0x	0x5050	xCell0 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a0x	0x5052	xCell0 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a0x	0x5054	xCell0 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a0x	0x5056	xCell0 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a0x	0x5058	xCell0 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a0x	0x505A	xCell0 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a0x	0x505C	xCell0 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a0x	0x505E	xCell0 R_a 14	I2	0	32767	658	mΩ
ISI	Register	0x42D0	ISI Configuration	H2	0x0	0x0007	0x0003	Hex
ISI	Configuration	0x42DC	Manufacturing Completion Timeout	U1	0	255	1	hours
ISI	Configuration	0x42F2	Self-Discharge Current	I2	–32768	0	–6	0.1 mA
ISI	Configuration	0x42F6	Low Internal Short Threshold	I2	–32768	0	–40	0.1 mA
ISI	Configuration	0x42F8	High Internal Short Threshold	I2	–32768	0	–300	0.1 mA

Table 19-1. Data Flash Table for bq27z855 v0.05 build 6 (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
ISI	Configuration	0x42FA	Threshold Passes to Completion	U2	0	65535	3	—

20 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
April 2026	*	Initial Release

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