BQ41Z50

Technical Reference Manual

TEXAS INSTRUMENTS

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Preface
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About This Manual

This manual discusses the BQ41Z50 device's modules and peripherals, and how each is used to build a complete battery pack gas gauge and protection solution. See the *BQ41Z50 2-Series, 3-Series, and 4-Series Li-Ion Battery Pack Manager* data sheet (SLUSFB5) for BQ41Z50 electrical specifications.

Notational Conventions

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

- SBS commands: *italics* with parentheses and no breaking spaces; for example, *RemainingCapacity()*
- Data flash: *italics*, **bold**, and breaking spaces; for example, ***Design capacity***
- Register bits and flags: *italics* and brackets; for example, *[TDA]*
- Data flash bits: *italics* and **bold**; for example, ***[LED1]***
- Modes and states: ALL CAPITALS; for example, UNSEALED

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

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

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Chapter 1
Introduction

The BQ41Z50 device provides a feature-rich battery management solution for 2-series cell to 4-series cell battery-pack applications. The BQ41Z50 device has extended capabilities, including:

- Fully integrated 2-series, 3-series, and 4-series Li-ion, Li-polymer, or Li-ion-phosphate cell battery pack manager and protection
- Next-generation patented Dynamic Z Track™ technology accurately measures available charge in Li-ion, Li-polymer, and Li-ion-phosphate batteries
- High-side N-CH protection FET drive
- Integrated cell balancing while charging or at rest
- Low power modes
  - SLEEP
- Full array of programmable protection features
  - Voltage
  - Current
  - Temperature
  - Charge timeout
  - CHG/DSG FETs
  - Cell imbalance
- Sophisticated charge algorithms
  - JEITA
  - Advanced charging algorithm
  - Adaptive charging
  - Cell balancing
- Diagnostic lifetime data monitor
- Black box event recorder
- Supports two-wire SMBus v3.2 interface
- SHA-1, SHA-256, and ECC authentication
- Ultra-compact package: 32-lead QFN

Chapter 2

Protections

2.1 Introduction

The BQ41Z50 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 4.8 provides a summary of the various alarms flags' set conditions.

Note

Delay settings with 1-s granularity can have an average trigger delay equal to the delay setting plus 1.5 s.

2.2 Cell Undervoltage Protection

The BQ41Z50 device can detect cell undervoltage in batteries and protect cells from damage by preventing further discharge.

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

2.3 Cell Undervoltage Compensated Protection

The BQ41Z50 device can detect cell undervoltage in batteries and protect cells from damage by preventing further discharge. The protection is compensated by the *Current()* × cell resistance1..4.

Status	Condition	Action
Normal	Min cell voltage1..4 – *Current()* × cell resistance > ***CUVC: Threshold***	*SafetyAlert()[CUVC]* = 0 *BatteryStatus()[TDA]* = 0
Alert	Min cell voltage1..4 – *Current()* × cell resistance ≤ ***CUVC: Threshold***	*SafetyAlert()[CUVC]* = 1 *BatteryStatus()[TDA]* = 1
Trip	Min cell voltage1..4 – *Current()* × cell resistance ≤ ***CUVC: Threshold*** for ***CUVC:Delay*** duration	*SafetyAlert()[CUVC]* = 0 *SafetyStatus()[CUVC]* = 1 *BatteryStatus()[FD]* = 1, *[TDA]* = 0 *OperationStatus()[XDSG]* = 1
Recovery	Condition 1: *SafetyAlert()[CUVC]* = 1 AND Min cell voltage1..4 – *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: *SafetyAlert()[CUVC]* = 1 AND Min cell voltage1..4 – *Current()* × cell resistance > ***CUVC: Recovery*** AND ***Protection Configuration[CUV_RECOV_CHG]*** = 1 AND PACK voltage > ***Charger Present Threshold***	

2.4 Cell Overvoltage Protection

The BQ41Z50 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	Max cell voltage1..4 < ***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]* = 1	Max cell voltage1..4 < ***COV:Threshold Standard Temp Low***	
Normal, *ChargingStatus()[STH]* = 1	Max cell voltage1..4 < ***COV:Threshold Standard Temp High***	
Normal, *ChargingStatus()[RT]* = 1	Max cell voltage1..4 < ***COV:Threshold Rec Temp***	
Normal, *ChargingStatus()[HT] or [OT]* = 1	Max cell voltage1..4 < ***COV:Threshold High Temp***	
Alert, *ChargingStatus()[UT] or [LT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Low Temp***	*SafetyAlert()[COV]* = 1 *BatteryStatus()[TCA]* = 1
Alert, *ChargingStatus()[STL]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Standard Temp Low***	
Alert, *ChargingStatus()[STH]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Standard Temp High***	
Alert, *ChargingStatus()[RT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Rec Temp***	
Alert, *ChargingStatus()[HT] or [OT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold High Temp***	

Status	Condition	Action
Trip, *ChargingStatus()[UT] or [LT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Low Temp*** for ***COV:Delay*** duration	*SafetyAlert()[COV]* = 0 *SafetyStatus()[COV]* = 1 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 1 Increment COVL counter
Trip, *ChargingStatus()[STL]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Standard Temp Low*** for ***COV:Delay*** duration	
Trip, *ChargingStatus()[STH]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Standard Temp High*** for ***COV:Delay*** duration	
Trip, *ChargingStatus()[RT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold Rec Temp*** for ***COV:Delay*** duration	
Trip, *ChargingStatus()[HT] or [OT]* = 1	Max cell voltage1..4 ≥ ***COV:Threshold High Temp*** for ***COV:Delay*** duration	
Recovery, *ChargingStatus()[UT] or [LT]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery Low Temp***	*SafetyStatus()[COV]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0
Recovery, *ChargingStatus()[STL]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery Standard Temp Low***	
Recovery, *ChargingStatus()[STH]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery Standard Temp High***	
Recovery, *ChargingStatus()[RT]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery Rec Temp***	
Recovery, *ChargingStatus()[HT] or [OT]* = 1	*SafetyStatus()[COV]* = 1 AND Max cell voltage1..4 ≤ ***COV:Recovery High Temp***	
Latch Alert	COVL counter > 0	*SafetyAlert()[COVL]* = 1 if *EnabledProtections[COVL]* is set. *PFAlert()[COVL]* = 1 if *EnabledPF[COVL]* is set
Latch Trip	COVL counter ≥ COV:Latch limit	*SafetyStatus()[COVL]* = 1 if *EnabledProtections[COVL]* is set *PFStatus()[COVL]* = 1 if *EnabledPF[COVL]* is set. *PFAlert()[COVL]* = 0 *SafetyAlert()[COVL]* = 0 *OperationStatus()[XCHG]* = 1
Latch Reset(***[NR]*** =0)	*SafetyStatus()[COVL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	*SafetyStatus()[COVL]* = 0 Reset COVL counter. *OperationStatus[XCHG]* = 0 if *SafetyStatus()[COV]* = 0
Latch Reset(***[NR]*** =1)	(*SafetyStatus()[COVL]* = 1 AND ***DA Configuration[NR]*** =1 for COV:Reset time	*SafetyStatus()[COVL]* = 0 Reset COVL counter. *OperationStatus[XCHG]* = 0 if *SafetyStatus()[COV]* = 0

2.5 Overcurrent in Charge Protection

The BQ41Z50 device has two independent overcurrent in charge protections that can be set to different current and delay thresholds to accommodate different charging behaviors.

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

Status	Condition	Action
Recovery	*SafetyStatus()[OCC2]* = 1 AND *Current()* ≤ ***OCC:Recovery Threshold*** for ***OCC:Recovery Delay*** time	*SafetyStatus()[OCC2]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

2.6 Overcurrent in Discharge Protection

The BQ41Z50 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
Recovery	*SafetyStatus()[OCD2]* = 1 AND *Current()* ≥ ***OCD:Recovery Threshold*** for ***OCD:Recovery Delay*** time	*SafetyStatus()[OCD2]*=0 *OperationStatus()[XDSG]*=0 *BatteryStatus()[TDA]* = 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(***[NR]*** = 0)	*SafetyStatus()[OCDL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	*SafetyStatus()[OCDL]* = 0 Reset OCDL counter. OperationStatus[XDSG] = 0 if *SafetyStatus()[OCD1]* = 0 and *SafetyStatus()[OCD2]* = 0
Latch Reset(***[NR]*** = 1)	*SafetyStatus()[OCDL]* = 1 AND ***DA Configuration[NR]*** = 1 for ***OCD:Reset time***	*SafetyStatus()[OCDL]* = 0 Reset OCDL counter. *OperationStatus[XDSG]* = 0 if *SafetyStatus()[OCD1]* = 0 and *SafetyStatus()[OCD2]* = 0

2.7 Hardware-Based Protection

The BQ41Z50 device has three main hardware-based protections—AOCD1, AOCD2, AOCC, and ASCD —with adjustable current and delay time. 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 details on how to configure the AFE hardware protection, refer to the registers in AFE .

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

2.7.1 Overload in Discharge Protection

The BQ41Z50 device has two hardware-based overload in discharge protections (OCD1, 2) 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. The following table takes OCD1 as an example. OCD2 has the same registers for configuration.

Status	Condition	Action
Normal	*Current()* > (*AOCD Voltage Threshold* /R_{SENSE})	*SafetyAlert()[AOCDL]* = 0, if OLDL counter = 0 *PFAlert()[SAOCDL]* = 0 Decrement AOCDL counter by one after each ***AOCD:Counter Dec Delay*** period, if AOCDL counter > 0
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()[SAOCDL]* = 1, if *PFEnable()[SAOCDL]* 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 (***[NR]*** = 0)	*SafetyStatus()[AOCDL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	*SafetyStatus()[AOCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[AOCD]* = 0.
Latch Reset (***[NR]*** = 1)	*SafetyStatus()[AOCDL]* = 1 AND ***DA Configuration[NR]*** = 1 for ***AOCD:Reset*** time	*SafetyStatus()[AOCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[AOCD]* = 0.

2.7.2 Short Circuit in Charge Protection

The BQ41Z50 device has a hardware-based short circuit in charge protection 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

Status	Condition	Action
Trip	*Current()* ≥ (*AOCC Voltage Threshold* /R_{SENSE}) for *AOCC Delay* duration	*SafetyStatus()[AOCC]* = 1 *BatteryStatus()[TCA]* = 1 *OperationStatus()[XCHG]* = 1 increment AOCCL counter
Recovery	*SafetyStatus()[AOCC]* = 1 for ***AOCC:Recovery*** time	*SafetyStatus()[AOCC]* = 0 *BatteryStatus()[TCA]* = 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 (***[NR]*** = 0)	*SafetyStatus()[AOCCL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	*SafetyStatus()[AOCCL]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[AOCC]* = 0
Latch Reset (***[NR]*** = 1)	*SafetyStatus()[AOCCL]* = 1 AND ***DA Configuration[NR]*** = 1 for ***AOCC:Reset*** time	*SafetyStatus()[AOCCL]* = 0 *OperationStatus()[XCHG]* = 0 if *SafetyStatus()[AOCC]* = 0

2.7.3 Short Circuit in Discharge Protection

The BQ41Z50 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	SCD counter ≥ ***ASCD:Latch Limit***	*SafetyStatus()[ASCD]* = 0 *SafetyStatus()[ASCDL]* = 1 *OperationStatus()[XDSG]* = 1 *SafetyAlert()[ASCDL]* = 0 *PFAlert()[ASCDL]* = 0 *PFStatus()[ASCDL]* = 1, if *PFEnable()[ASCDL]* is set.
Latch Reset (***[NR]*** = 0)	*SafetyStatus()[ASCDL]* = 1 AND ***DA Configuration[NR]*** = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	*SafetyStatus()[ASCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[ASCD]* = 0
Latch Reset (***[NR]*** = 1)	*SafetyStatus()[AOCCL]* = 1 AND ***DA Configuration[NR]*** = 1 for ***ASCD:Reset*** time	*SafetyStatus()[ASCDL]* = 0 *OperationStatus()[XDSG]* = 0 if *SafetyStatus()[ASCD]* = 0

2.8 Temperature Protections

The BQ41Z50 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 four external thermistors 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][TS4][TS3][TS2][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][TS4 Mode][TS3 Mode][TS2 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 ***[TS4 Mode][TS3 Mode][TS2 Mode][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 6.3 for detailed descriptions of the gas gauge modes.

2.9 Overtemperature in Charge Protection

The BQ41Z50 device has an overtemperature protection for cells under charge.

Status	Condition	Action
Normal	Max Cell Temp TS1..4 < ***OTC:Threshold*** OR not charging	*SafetyAlert()[OTC]* = 0
Alert	Max Cell Temp TS1..4 ≥ ***OTC:Threshold*** AND charging	*SafetyAlert()[OTC]* = 1 *BatteryStatus()[TCA]* = 1
Trip	Max Cell Temp TS1..4 ≥ ***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 Max Cell Temp TS1..4 ≤ ***OTC:Recovery***	*SafetyStatus()[OTC]* = 0 *BatteryStatus()[OTA]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

2.10 Overtemperature in Discharge Protection

The BQ41Z50 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	Max Cell Temp TS1..4 < ***OTD:Threshold*** OR charging	*SafetyAlert()[OTD]* = 0
Alert	Max Cell Temp TS1..4 ≥ ***OTD:Threshold*** AND Not charging (that is, *BatteryStatus[DSG]* = 1)	*SafetyAlert()[OTD]* = 1 *BatteryStatus()[TDA]* = 1
Trip	Max Cell Temp TS1..4 ≥ ***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 Max Cell Temp TS1..4 ≤ ***OTD:Recovery***	*SafetyStatus()[OTD]* = 0 *BatteryStatus()[OTA]* = 0 *OperationStatus()[XDSG]* = 0 *BatteryStatus()[TDA]* = 0

2.11 Delta Cell Overtemperature Protection

The BQ41Z50 device has an overtemperature protection for temperature delta between cells. The protection is enabled when there are multiple cells and ***Enabled Protections B[DCOT]*** = 1.

Status	Condition	Action
Normal	Delta temperature between TS1..4 < ***DCOT:Threshold***	*SafetyAlert()[DCOT]* = 0
Alert	Delta temperature between TS1..4 ≥ ***DCOT:Threshold***	*SafetyAlert()[DCOT]* = 1 *BatteryStatus()[TDA]* = 1, *[TCA]* = 1
Trip	Delta temperature between TS1..4 ≥ ***DCOT:Threshold*** A for ***DCOT:Delay*** duration	*SafetyAlert()[DCOT]* = 0 *SafetyStatus()[DCOT]* = 1 *BatteryStatus()[OTA]* = 1 *BatteryStatus()[TDA]* = 0, *[TCA]* = 0 *OperationStatus()[XCHG][XDSG]* = 1,1 if ***FET Options[OTFET]*** = 1
Recovery	*SafetyStatus()[DCOT]* AND delta temperature between TS1..4 ≤ ***DCOT:Recovery***	*SafetyStatus()[DCOT]* = 0 *BatteryStatus()[OTA]* = 0 *BatteryStatus()[TDA]* = 0, *[TCA]* = 0 *OperationStatus()[XCHG][XDSG]* = 0,0

2.12 Overtemperature FET Protection

The BQ41Z50 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

2.13 Undertemperature in Charge Protection

The BQ41Z50 device has an undertemperature protection for cells in charge direction.

Status	Condition	Action
Normal	Min Cell Temp TS1..4 > ***UTC:Threshold*** OR not charging	*SafetyAlert()[UTC]* = 0
Alert	Min Cell Temp TS1..4 ≤ ***UTC:Threshold*** AND charging	*SafetyAlert()[UTC]* = 1 *BatteryStatus()[TCA]* = 1

Status	Condition	Action
Trip	Min Cell Temp TS1..4 ≤ ***UTC:Threshold*** AND Charging for ***UTC:Delay*** duration	*SafetyAlert()[UTC]* = 0 *SafetyStatus()[UTC]* = 1 *OperationStatus()[XCHG]* = 1 *BatteryStatus()[TCA]* = 0
Recovery	*SafetyStatus()[UTC]* AND Min Cell Temp TS1..4 ≥ ***UTC:Recovery***	*SafetyStatus()[UTC]* = 0 *OperationStatus()[XCHG]* = 0 *BatteryStatus()[TCA]* = 0

2.14 Undertemperature in Discharge Protection

The BQ41Z50 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	Min Cell Temp TS1..4 > ***UTD:Threshold*** OR charging	*SafetyAlert()[UTD]* = 0
Alert	Min Cell Temp TS1..4 ≤ ***UTD:Threshold*** AND Not charging (that is, *BatteryStatus[DSG]* = 1)	*SafetyAlert()[UTD]* = 1 *BatteryStatus()[TDA]* = 1
Trip	Min Cell Temp TS1..4 ≤ ***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 Min Cell Temp TS1..4 ≥ ***UTD:Recovery***	*SafetyStatus()[UTD]* = 0 *OperationStatus()[XDSG]* = 0 *BatteryStatus()[TDA]* = 0

2.15 SBS Host Watchdog Protection

The BQ41Z50 device can check periodic communication over SBS and prevent usage of the battery pack if no valid communication is detected.

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

2.16 Precharge Timeout Protection

The BQ41Z50 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 *BatteryStatus()[TCA]* = 1
Trip	PTO timer > ***PTO:Delay***	Stop PTO timer *SafetyStatus()[PTO]* = 1 *OperationStatus()[XCHG]* = 1
Reset	*SafetyStatus()[PTO]* = 1 AND ***DA Configuration[NR]*** = 0 AND (Discharge by an amount of ***PTO:Reset*** OR low-high-low transition on PRES)	Stop and reset PTO timer *SafetyAlert()[PTOS]* = 0 *SafetyStatus()[PTO]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0
Reset	*SafetyStatus()[PTO]* = 1 AND ***DA Configuration[NR]*** = 1 AND Discharge by an amount of ***PTO:Reset***	Stop and reset PTO timer *SafetyAlert()[PTOS]* = 0 *SafetyStatus()[PTO]* = 0 *BatteryStatus()[TCA]* = 0 *OperationStatus()[XCHG]* = 0

Note

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

2.17 Fast Charge Timeout Protection

The BQ41Z50 device can measure the charge time and stop charging if it exceeds the adjustable period.

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

Note

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

2.18 Overcharge Protection

The BQ41Z50 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 *BatteryStatus()[TCA]* = 1
Trip	*RelativeStateOfCharge()* ≥ 100% AND Internal charge counter ≥ ***OC:Threshold***	*SafetyAlert()[OC]* = 0 *SafetyStatus()[OC]* = 1 *BatteryStatus()[TCA]* = 0, *[OCA]* = 1 if the device is in the CHARGE state (that is, *BatteryStatus[DSG]* = 0). *OperationStatus()[XCHG]* = 1
Recovery, ***DA Configuration[NR]*** = 0	*SafetyStatus()[OC]* = 1 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	*SafetyStatus()[OC]* = 0 *BatteryStatus()[TCA]* = 0, *[OCA]* = 0 *OperationStatus()[XCHG]* = 0
Recovery ***DA Configuration[NR]*** = 1	Condition 1: *SafetyStatus()[OC]* = 1 AND discharge of ***Recovery*** OR Condition 2: *SafetyStatus()[OC]* = 1 AND ***DA Configuration[NR]*** = 1 AND *RelativeStateOfCharge()* < ***OC:RSOC Recovery***	*SafetyStatus()[OC]* = 0 *BatteryStatus()[TCA]* = 0, *[OCA]* = 0 *OperationStatus()[XCHG]* = 0

2.19 OverCharging Voltage Protection

The BQ41Z50 device can stop charging if it measures a difference between the requested *ChargingVoltage()* and the delivered voltage from the charger. This feature only operates when the device is in CHARGE mode.

Note

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

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

2.20 OverCharging Current Protection

The BQ41Z50 device can stop charging if it measures a difference between the requested *ChargingCurrent()* and the delivered current from the charger. This protection is designed to recover by a discharge event; therefore, ***CHGC:Recovery*** should be set to a negative value in data flash.

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

2.21 OverPrecharging Current Protection

The BQ41Z50 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

Chapter 3
Permanent Fail

3.1 Introduction

The BQ41Z50 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*** , ***OCD1*** , ***OCD2*** , ***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*** , ***OCD 2 Delay 2*** , ***OCD 2 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, TS1, TS2, TS3, and TS4 from *DAStatus2()*
   - Cell DOD0 and passed charge
7. Data flash writing is disabled (except to store subsequent *PFStatus()* flags).
8. The FUSE pin is driven high if configured for specific failures and *Voltage()* is above ***Min Blow Fuse Voltage*** or there is a CHG FET (CFETF) or DSG FET (DFETF) failure. The FUSE pin will remain asserted until the ***Fuse Blow Timeout*** expires.

Note

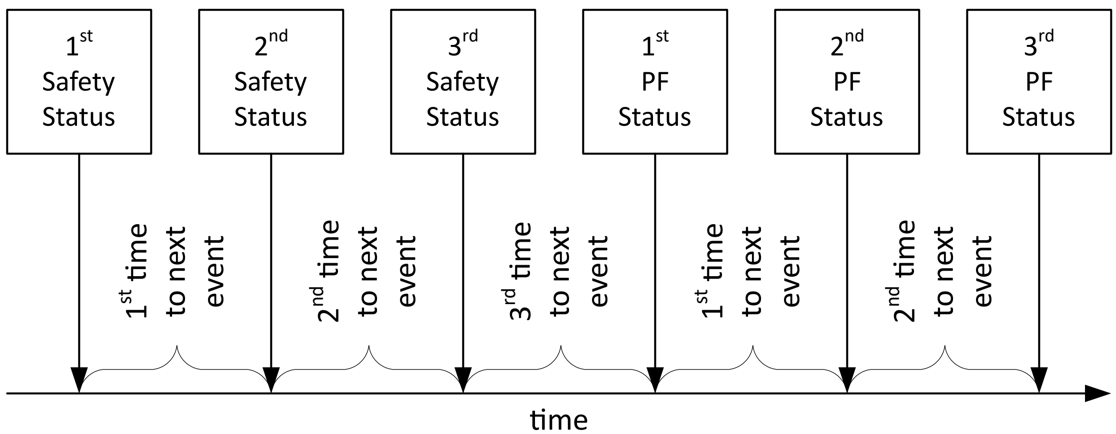
If ***[PACK_FUSE]*** = 0, *Voltage()* is used to check for ***Min Blow Fuse Voltage*** , indicating the fuse is connected to the BAT side.

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

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

3.1.1 Black Box Recorder

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



Note

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

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

3.1.2 GPIO Control During Permanent Failure

The device includes a feature to toggle a GPIO pin if the FUSE signal is asserted. It is enabled by setting ***[GPIO_PF]*** and clearing ***[LED_EN]*** . After the FUSE signal is asserted in PERMANENT FAILURE mode, the LEDCNTLC pin will be driven high for ***GPIO_Timeout*** seconds. If ***GPIO_Timeout*** = 0, the pin is held high indefinitely.

3.2 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	Min cell voltage1..4 > ***SUV:Threshold***	*PFAlert()[SUV]* = 0 *BatteryStatus()[TDA]* = 0
Alert	Min cell voltage1..4 ≤ ***SUV:Threshold***	*PFAlert()[SUV]* = 1 *BatteryStatus()[TDA]* = 1

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

3.2.1 SUV Check Option

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

3.3 Safety Cell Overvoltage Permanent Fail

The BQ41Z50 device can permanently disable the battery in the case of significant overvoltage in any of the cells.

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

3.4 Safety Overcurrent in Charge Permanent Fail

The BQ41Z50 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]* = 1 *PFStatus()[SOCC]* = 1

3.5 Safety Overcurrent in Discharge Permanent Fail

The BQ41Z50 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]* = 1 *PFStatus()[SOCD]* = 1

3.6 Safety Overtemperature Cell Permanent Fail

The BQ41Z50 device can permanently disable the battery pack in case of significant overtemperature of the cells detected using the external TS1..4 temperature sensor(s), 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

3.7 Safety Overtemperature FET Permanent Fail

The BQ41Z50 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

3.8 QMax Imbalance Permanent Fail

The BQ41Z50 device can permanently disable the battery pack in case the capacity of one of the cells is much lower than the others.

Status	Condition	Action
Normal	***[Max(QMax Cell 1..4) – Min(QMax1..4)]/Qmax Pack*** × 100 < ***QIM:Delta Threshold***	*PFAlert()[QIM]* = 0
Alert	***[Max(QMax Cell 1..4) – Min(QMax1..4)]/Qmax Pack*** × 100 > ***QIM:Delta Threshold***	*PFAlert()[QIM]* = 1
Trip	***[Max(QMax Cell 1..4) – Min(QMax1..4)]/Qmax Pack*** × 100 ≥ ***QIM:Delta Threshold*** for number of ***QIM:Delay*** (1) updates	*PFAlert()[QIM]* = 0 *PFStatus()[QIM]* = 1

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

3.9 Cell Balancing Permanent Fail

The BQ41Z50 device can permanently disable the battery pack in case one of the cells in the stack is cell-balanced much more than the others.

Status	Condition	Action
Normal	Δ(***CB Time Cell 1..4***) < ***CB:Delta Threshold***	*PFAlert()[CB]* = 0
Alert	Δ(***CB Time Cell 1..4***) ≥ ***CB:Delta Threshold***	*PFAlert()[CB]* = 1
Trip	Δ(***CB Time Cell 1..4***) ≥ ***CB:Delta Threshold*** for ***CB:Delay*** (1) cycles	*PFAlert()[CB]* = 0 *PFStatus()[CB]* = 1 *BatteryStatus()[TCA]* = 1 *BatteryStatus()[TDA]* = 1

Status	Condition	Action
Trip	Max (***CB Time Cell 1..4***) ≥ ***CB:Max Threshold***	*PFAlert()[CB]* = 0 *PFStatus()[CB]* = 1

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

3.10 Impedance Permanent Fail

The BQ41Z50 device can permanently disable the battery pack in case the impedance of one of the cells is much higher than the others.

Note

Reference Grid is configurable from 0 (resistance at fully charged cell) to 14 (resistance at fully discharged cell). The default setting of ***Reference Grid*** = 4 is a good typical value to use because it is close to the average in the range of 20% to 100% SOC. ***Design Resistance*** is automatically calculated and updated during the learning cycle and is part of the golden image).

This check is only performed when the gauge updates the ***Ra*** data for the ***Reference Grid*** directly. If a selected grid point is typically being scaled rather than directly updated by the gauge (for example, grid point 0 or grid point 14), this check is effectively disabled. It is recommended to use the default ***Design Resistance*** setting.

Status	Condition	Action
Normal	Δ(***Cell 1..4 R_a*** at ***IT Cfg:Reference Grid***) < (***IMP:Delta Threshold*** × ***IT Cfg:Design Resistance***)	*PFAlert()[IMP]* = 0
Alert	Δ(***Cell 1..4 R_a*** at ***IT Cfg:Reference Grid***) ≥ (***IMP:Delta Threshold*** × ***IT Cfg:Design Resistance***)	*PFAlert()[IMP]* = 1
Trip	Δ(***Cell 1..4 R_a*** at ***IT Cfg:Reference Grid***) ≥ (***IMP:Delta Threshold*** × ***IT Cfg:Design Resistance***) for ***IMP:Ra Update Counts***	*PFAlert()[IMP]* = 0 *PFStatus()[IMP]* = 1 *BatteryStatus()[TCA]* = 1 *BatteryStatus()[TDA]* = 1
Trip	Δ(***Cell 1..4 R_a*** at ***IT Cfg:Reference Grid***) ≥ (***IMP:Max Threshold*** × ***IT Cfg:Design Resistance***)	*PFAlert()[IMP]* = 0 *PFStatus()[IMP]* = 1

3.11 Capacity Degradation Permanent Fail

The BQ41Z50 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.

3.12 Voltage Imbalance At Rest Permanent Fail

The BQ41Z50 device can permanently disable the battery pack in case of a voltage difference between the cells in a stack while at rest.

Status	Condition	Action
Normal	Max cell voltage1..4 < ***VIMR:Check Voltage*** OR |*Current()*| > ***VIMR:Check Current*** OR Max cell voltage1..4 – Min cell voltage1..4 < ***VIMR:Delta Threshold***	*PFAlert()[VIMR]* = 0

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

3.13 Voltage Imbalance Active Permanent Fail

The BQ41Z50 device can permanently disable the battery pack in case of a voltage difference between the cells in a stack while active.

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

3.14 Charge FET Permanent Fail

The BQ41Z50 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

3.15 Discharge FET Permanent Fail

The BQ41Z50 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

3.16 Chemical Fuse Permanent Fail

The BQ41Z50 device can detect a non-working fuse. It cannot disable the battery pack permanently, but can record this event for analysis.

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

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

3.17 AFE Register Permanent Fail

The BQ41Z50 device compares the AFE hardware register periodically with a RAM backup and corrects any errors. If any errors are found during the check, the device increments the AFE register fail counter. If the comparison fails too many times, the device disables the pack permanently.

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

3.18 AFE Communication Permanent Fail

The BQ41Z50 device monitors the internal communication to the AFE hardware and increments the AFE read/write fail counter on any communication error. If the read or write fails exceed a limit within a configurable timeframe, the device disables the pack permanently.

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

3.19 NTC Permanent Fail

The BQ41Z50 device can detect overtemperature using a negative temperature coefficient (NTC) resistor connected to TS4 pin.

If the temperature from TS4 pin is over ***AFE:Over Temperature*** longer than ***AFE:Over Temperature Delay*** , the CHG and DSG FETs are turned off, and the pack is disabled permanently. For manufacturer testing, the fault state can be reset by a full power cycle of the device.

To enable this feature, the ***Settings.Permanent Failure.Enabled PF C.NTC*** should be set.

Status	Condition	Action
Normal	Temperature from TS4 pin lower than ***AFE:Over Temperature***	*PFStatus()[NTC]* = 0
Trip	Temperature from TS4 pin is over ***AFE:Over Temperature*** longer than ***AFE:Over Temperature Delay***	*PFStatus()[NTC]* = 1 FUSE = high *BatteryStatus()[TCA]* = 1 *BatteryStatus()[TDA]* = 1

3.20 Second Level Protection Permanent Fail

The BQ41Z50 device can detect an external trigger of the chemical fuse by an external protection circuit such as a 2nd-level protector by monitoring the FUSE pin state.

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

Clearing ***Enabled PF C[2LVL]*** does not prevent the second-level protector from triggering and blowing the fuse: Clearing ***Enabled PF C[2LVL]*** only prevents the gauge from detecting the FUSE state.

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

3.21 Data Flash (DF) Permanent Fail

The BQ41Z50 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

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

The BQ41Z50 device can permanently disable the battery if it detects an open thermistor on TS1, TS2, TS3, or TS4. The state of TS1..4 and the internal temperature sensor is available in *DAStatus2()*.

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

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

<table>
<tr><th>Status</th><th>Condition</th><th>Action</th></tr>
<tr><td rowspan="2">Trip,
TS3</td><td>Condition 1:
TS3 Temperature ≤ Open Thermistor:Threshold AND
Internal Temperature > TS3 Temperature + Cell Delta for Open Thermistor:Delay duration if
Temperature Mode[TS3 Mode] = 0</td><td rowspan="2">PFAlert()[TS3] = 0
PFStatus()[TS3] = 1</td></tr>
<tr><td>OR Condition 2:
TS3 Temperature ≤ Open Thermistor:Threshold AND
Internal Temperature > TS3 Temperature + FET Delta for
OpenThermistor:Delay duration if
Temperature Mode[TS3 Mode] = 1</td></tr>
<tr><td rowspan="2">Trip,
TS4</td><td>Condition 1:
TS4 Temperature ≤ Open Thermistor:Threshold AND
Internal Temperature > TS4 Temperature + Cell Delta for Open Thermistor:Delay duration if
Temperature Mode[TS4 Mode] = 0</td><td rowspan="2">PFAlert()[TS4] = 0
PFStatus()[TS4] = 1</td></tr>
<tr><td>OR Condition 2:
TS4 Temperature ≤ Open Thermistor:Threshold AND
Internal Temperature > TS4 Temperature + FET Delta for
OpenThermistor:Delay duration if
Temperature Mode[TS4 Mode] = 1</td></tr>
</table>

3.23 Cell Overvoltage Latch Permanent Failure

The BQ41Z50 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.

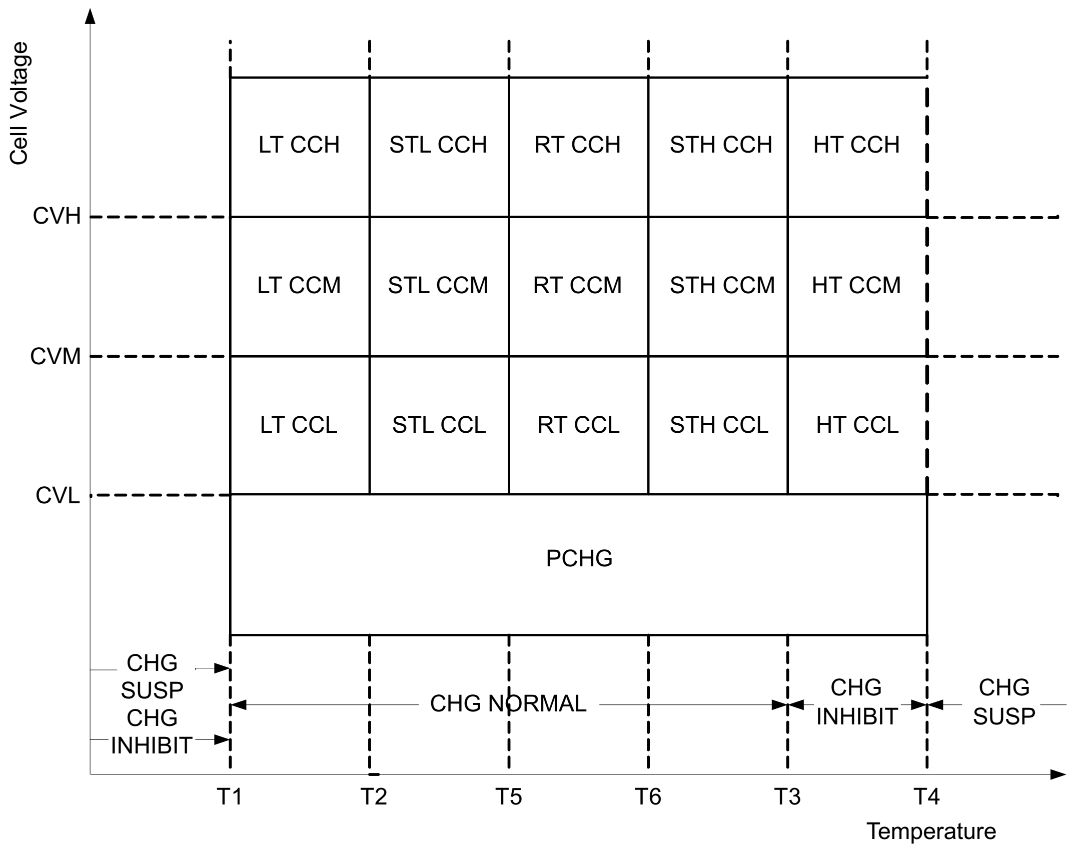
3.24 Manual Permanent Failure

The BQ41Z50 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.

Chapter 4
Advanced Charge Algorithm

4.1 Introduction

The BQ41Z50 device can change the values of *ChargingVoltage()* and *ChargingCurrent()* based on *Temperature()* and cell voltage1..4 or *RelativeStateofCharge()* . Its flexible charging algorithm is JEITA compatible and can also meet other specific cell manufacturer charge requirements. The *ChargingStatus()* register shows the state of the charging algorithm.



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

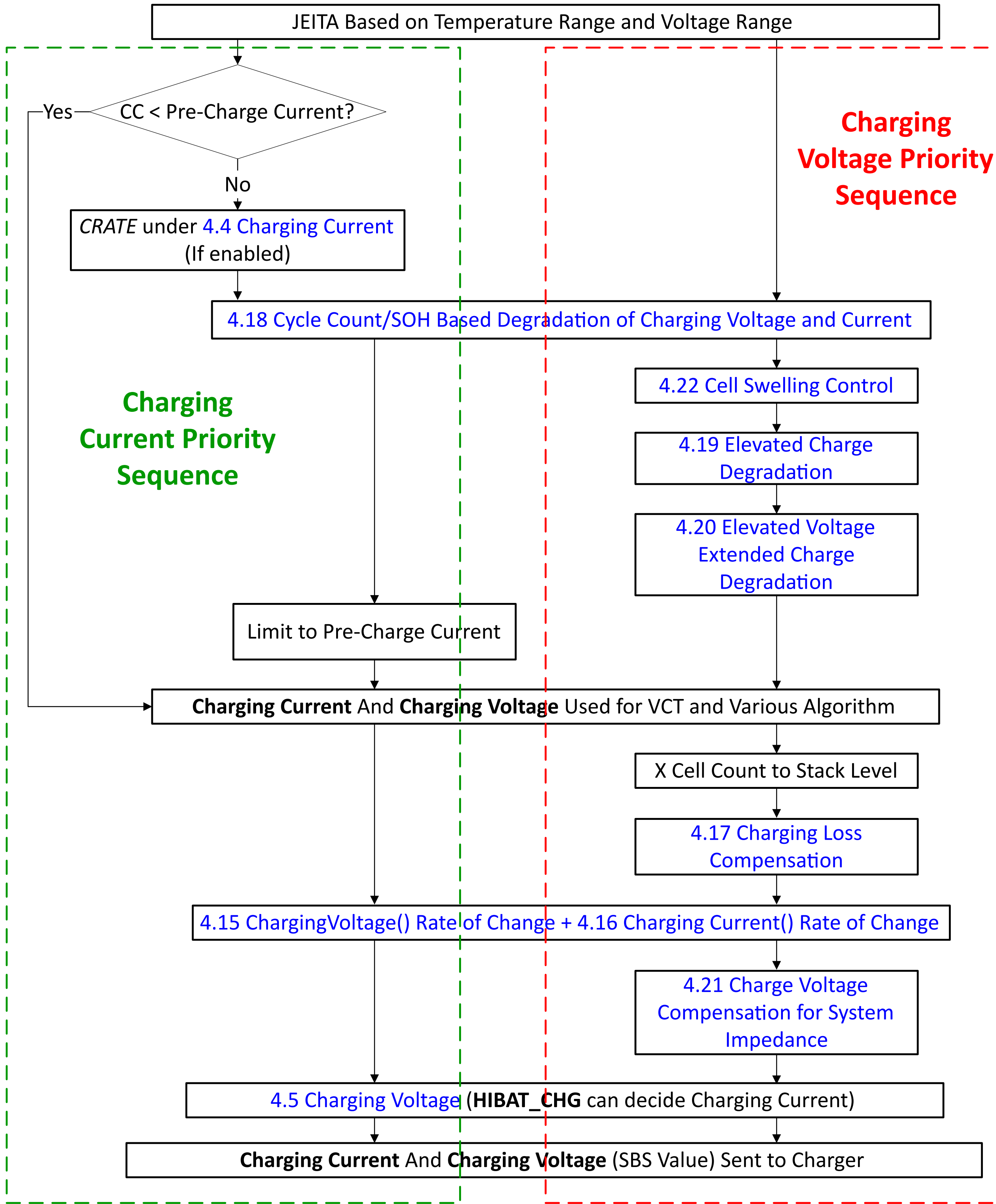
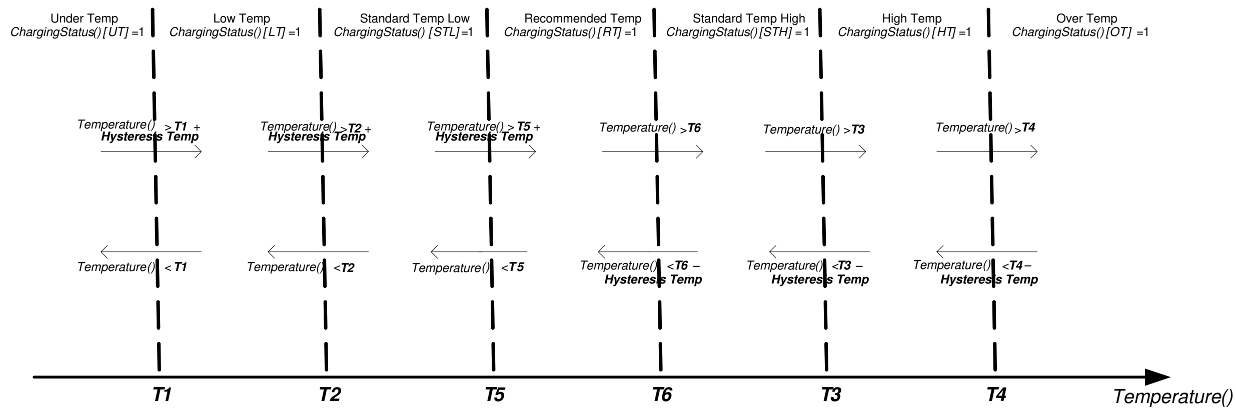


Figure 4-1. Charging Current and Charging Voltage Priority Sequence

4.2 Charge Temperature Ranges

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

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



4.3 Voltage Range

The measured cell voltage is segmented into several voltage ranges. The charging algorithm adjusts *ChargingCurrent()* according to the temperature 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. The voltage range below is determined based on either max cell voltage, min cell voltage, or average cell voltage by configuring ***Settings:Charging Configuration Ext[CELL_VAL1][CELL_VAL0]*** . Max Cell Voltage 1...4 below is used when ***Settings:Charging Configuration Ext[CELL_VAL1][CELL_VAL0]*** is set to 0, 0.

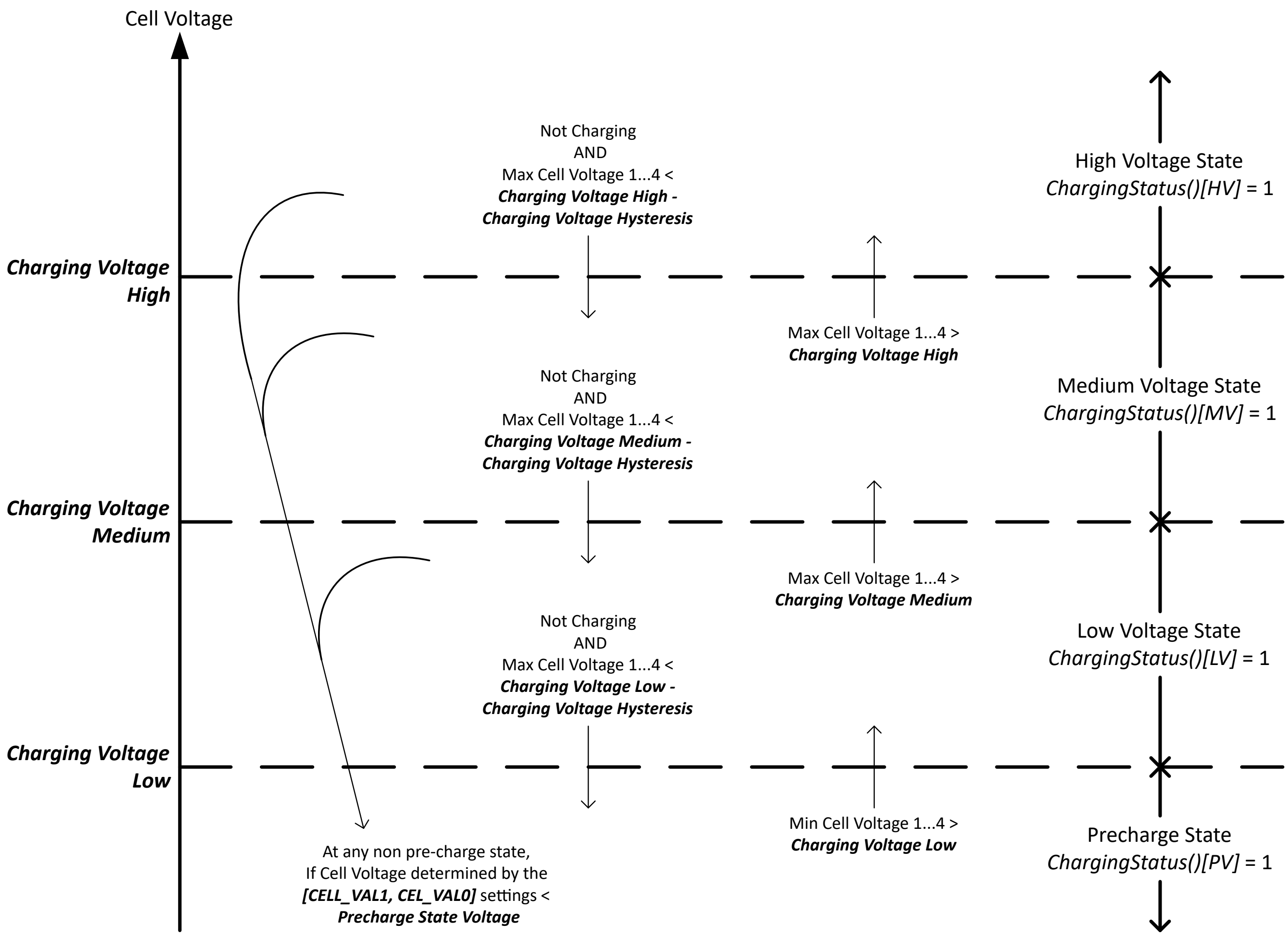


Figure 4-2. Cell Voltage Based Charging State Profile

4.3.1 RelativeStateofCharge() Range

If ***[SOC_CHARGE]*** in ***Charging Configuration*** is set while ***[V_SOC_CHARGE]*** remains 0, then the voltage threshold control, as described in Section 4.3, is replaced with the *RelativeStateOfCharge()* control.

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

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

Table 4-1. *RelativeStateofCharge()* Range

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

Note

If the ***[V_SOC_CHARGE]*** = 1, the Voltage or RSOC(0 Range feature will be used to determin the state of charging even if ***[SOC_CHARGE]*** = 1.

4.3.2 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 Figure 4-2:

- 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 Table 4-2.

Table 4-2. 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
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

Table 4-3 is the charging state matrix broken down by cell voltages and the RSOC ranges defined below:

When *[DSG]* = 0:

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

When *[DSG]* = 1:

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

Table 4-3. 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]

4.4 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***

Temp Range	Voltage Range	Condition	Action
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***

4.5 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
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

4.6 Valid Charge Termination

The charge termination condition must be met to enable valid charge termination. The BQ41Z50 device has the following actions at charge termination, based on the flags settings:

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

Status	Condition	Action
Charging	*GaugingStatus()[DSG]* = 0	Charge Algorithm active

Status	Condition	Action
Valid Charge Termination	All of the following conditions must occur for two consecutive 40-s periods: Charging (that is, *BatteryStatus[DSG]* = 0) AND *AverageCurrent()* < ***Charge Term Taper Current*** AND Max cell voltage1..4 + ***Charge Term Voltage*** ≥ *ChargingVoltage()* / number of cells in series AND ***[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 B[TCSETVCT]*** = 1

Note

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

4.7 Charge and Discharge Termination Flags

The *[TC]* and *[FC]* bits in *GaugingStatus()* can be set at charge termination, as well as based on RSOC or cell voltages. If multiple set and clear conditions are selected, then the corresponding flag will be set whenever a valid set or clear condition is met. If both set and clear conditions are true at the same time, the flag will clear. The same functionality is applied to the *[TD]* and *[FD]* bits in *GaugingStatus()*.

Note

GaugingStatus()[TC][TD][FC][FD] are the status flags based on the gauging conditions only. These flags are set and cleared based on ***SOC Flag Config A*** and ***SOC Flag Config B*** . 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 4.8.

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	Max cell voltage1..4 ≥ ***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	Max cell voltage1..4 ≥ ***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	Max cell voltage1..4 ≤ ***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	Max cell voltage1..4 ≤ ***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	Min cell voltage1..4 ≤ ***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	Min cell voltage1..4 ≤ ***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	Min cell voltage1..4 ≥ ***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	Min cell voltage1..4 ≥ ***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

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

[FC] = 1

- if *GaugingStatus()[FC]* = 1

[OCA] = 1 if

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

[TDA] = 1 if

- *SafetyAlert()[OCD1]*, *[OCD2]*, *[CUV]*, *[CUVC]*, *[OTD]*, *[DCOT]*, 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]*, *[DCOT]*, *[OTD]*, or *[OTF]* = 1 OR
- *PFStatus()[SOT]* or *[SOTF]* = 1

4.9 Precharge

The gauge enters PRECHARGE mode if,

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

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

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

The BQ41Z50 device also supports 0-V charging with a charging supply above the minimum operating voltage of the device using either an external precharge FET or CHG FET. If ***[PCHG_COMM]*** = 1, the gauge enables the hardware 0-V charging circuit automatically when the battery stack voltage is below the minimum operation voltage of the device (see the *BQ41Z50-R2 1-Series to 4-Series Li-Ion Battery Pack Manager* data sheet [SLUSCS4] for BQ41Z50 electrical specifications).

4.10 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()[TCA]* = 1	*ChargingStatus()[MCHG]* = 1 *ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm
Clear	*ChargingStatus()[IN]* = 1 OR *ChargingStatus()[SU]* = 1 OR *ChargingStatus()[PV]* = 1 OR *GaugingStatus()[TCA]* = 0	*ChargingStatus()[MCHG]* = 0 *ChargingVoltage()* = Charging Algorithm *ChargingCurrent()* = Charging Algorithm

4.11 Charge Control SMBus Broadcasts

If the ***[HPE]*** bit is enabled, MASTER mode broadcasts to the host address are PEC enabled. If the ***[CPE]*** bit is enabled, MASTER mode broadcasts to the smart-charger address are PEC enabled. The ***[BCAST]*** bit enables all broadcasts to a host or a smart charger. When the ***[BCAST]*** bit is enabled, the following broadcasts are sent:

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

4.12 Charge Disabled

The BQ41Z50 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 *SafetyStatus()[DCOT]* = 1 OR *SafetyStatus()[OTC]* = 1 if ***[OTFET]*** = 1 OR *ChargingStatus()[IN]* = 1 if ***[CHGIN]*** = 1 OR *ChargingStatus()[SU]* = 1 if ***[CHGSU]*** = 1 OR *OperationStatus()[SLEEP]* = 1 if ***[NR]*** = 1 AND ***[SLEEPCHG]*** = 0 OR *OperationStatus()[EMSHUT]* = 1 OR *OperationStatus()[PRES]* = 0 OR *GaugingStatus()[TCA]* = 1 if ***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***

4.13 Charge Inhibit

The BQ41Z50 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
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

4.14 Charge Suspend

The BQ41Z50 device can stop charging at high and low temperatures to prevent damage of the cells. The *ChargingStatus()[SU]* condition is only active in the CHARGING mode. Once CHARGE SUSPEND is triggered, the gauge will exit CHARGING mode after ***Chg Relax Time*** and the CHARGE SUSPEND will change to CHARGE INHIBIT.

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

4.15 ChargingVoltage() Rate of Change

The BQ41Z50 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.

4.16 ChargingCurrent() Rate of Change

The BQ41Z50 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()*.

4.17 Charging Loss Compensation

The BQ41Z50 device can modify *ChargingVoltage()* and *ChargingCurrent()* to compensate losses caused by the FETs, the fuse, and the sense resistor by measuring the cell voltages directly and adjusting *ChargingCurrent()* and *ChargingVoltage()* accordingly.

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

Note

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

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

4.18 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.

4.18.1 Degradation Modes

4.18.1.1 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.

4.18.1.2 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.

4.18.1.3 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.

4.18.2 Degradation Process

4.18.2.1 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).

4.18.2.2 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.

4.19 Elevated Charge Degradation

The BQ41Z50 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 ***ERETM Temperature Threshold*** < temperature < ***ERETM Temperature Max Threshold***. For periods where *RelativeStateOfCharge()* < ***ERETM RSoC Threshold*** or *RelativeStateOfCharge()* ≥ ***ERETM RSoC Threshold*** and 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]***).

4.20 Elevated Voltage Extended Charge Degradation

The BQ41Z50 device includes an extension of the elevated charge degradation function described in Section 4.19, 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 4-4, 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 4-4. 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 High Threshold***
Accumulated EVMTM Time	EVMTM	***EVTM Temperature Mid Threshold*** ≤ temperature < ***EVTM Temperature High Threshold*** and cell voltage ≥ ***EVTM Voltage Mid Threshold***

Table 4-4. Accumulated Time Spent in Elevated Voltage and Temperature Ranges (continued)

Lifetimes Counter	Temperature Range	Temperature Condition
Accumulated EVHTM Time	EVHTM	***EVTM Temperature High Threshold*** ≤ temperature and cell voltage ≥ ***EVTM Voltage Low 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 4-5. 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 4-5. 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***
3	***EVLTM TTH3*** ≤ ***Accumulated EVLTM Time*** < ***EVLTM TTH4***	*ChargingVoltage()* - ***EVLTM CV Delta3***	***EVMTM TTH1*** ≤ ***Accumulated EVMTM Time*** < ***EVMTM TTH2***	*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.

4.21 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.

4.22 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 4-3) when enabled by setting ***[CS_CV]*** (default is cleared) in the ***Charging Configuration*** register. When the max cell voltage1..4 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 max cell voltage1..4 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.

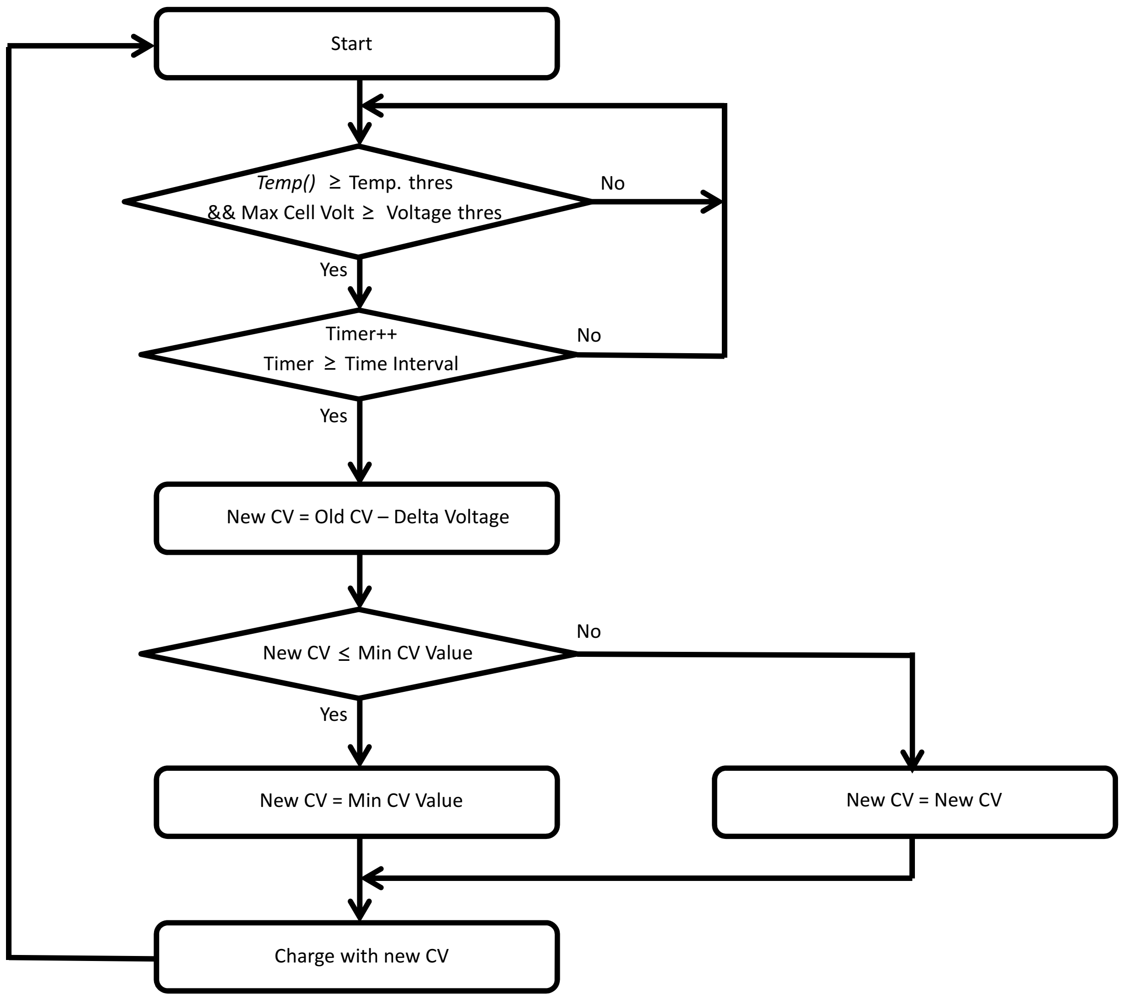
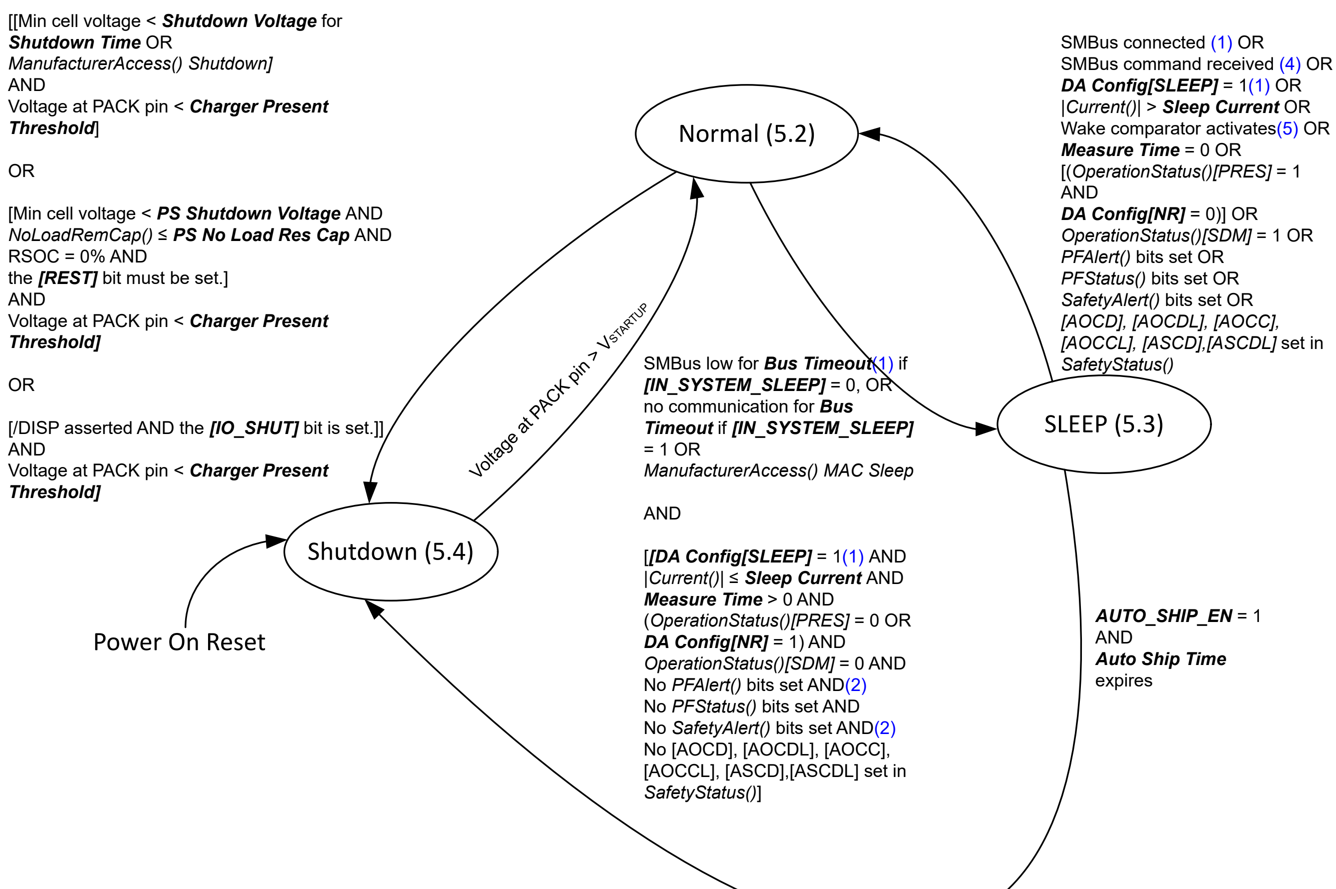


Figure 4-3. Cell Swelling Control

Chapter 5
Power Modes

5.1 Introduction

To enhance battery life, the BQ41Z50 device supports several power modes to minimize power consumption during operation. Figure 5-1 shows a summary of the power modes.



(1) ***DA Config[SLEEP]*** and SMBus low are not checked if the *ManufacturerAccess()* SLEEP mode command is used to enter SLEEP mode.
(2) *SafetyAlert()[PTO]*, *[PTOS]*, *[CTO]*, *[CTOS]*, or *PFAlert()[QIM]*, *[OC]*, *[IMP]*, *[CB]* will not prevent the gauge to enter SLEEP mode.
(3) For ***[NR]*** = 0, the CHG FET and PCHG FET remains on in SLEEP mode if ***[SLEEPCHG]*** = 1, but if the battery pack is removed from the system, the CHG FET is off because the system present takes higher priority than ***[SLEEPCHG]***.
(4) 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).
(5) The wake comparator threshold is set through ***AFE.Current Charge Wake[3:0]*** and ***AFE.Current Discharge Wake[3:0]***.

Figure 5-1. Power Modes Summary Diagram

5.2 NORMAL Mode

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

5.2.1 BATTERY PACK REMOVED Mode/System Present Detection

Pack removal and system present detection should be disabled for non-removable packs by setting the ***DA Configuration[NR]*** bit.

If the ***[NR]*** bit is set, the $\overline{\text{PRES}}$ input is not monitored. If ***[NR]*** is set and ***[EMSHUT_EN]*** is cleared, the $\overline{\text{PRES}}$ pin should be tied to VSS. If ***[NR]*** and ***[EMSHUT_EN]*** are set, then the $\overline{\text{PRES}}$ input must be configured correctly for that function.

5.2.1.1 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).

5.2.1.2 Battery Pack Removed

The BQ41Z50 device detects the BATTERY PACK REMOVED mode if the ***[NR]*** bit is cleared AND the $\overline{\text{PRES}}$ input is high (*[PRES]* = 0).

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

Polling of the $\overline{\text{PRES}}$ pin continues at a rate of once every 250 ms.

The BQ41Z50 exits the BATTERY PACK REMOVED state if the $\overline{\text{PRES}}$ input is low (*[PRES]* = 1). When this occurs, the *[TCA]* and *[TDA]* flags are reset.

5.3 SLEEP Mode

5.3.1 Device Sleep

When the sleep conditions are met, the BQ41Z50 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()[PRES]* = 0 OR ***DA Config[NR]*** = 1 or ***DA Configuration[IN_SYSTEM_SLEEP*** = 1]) 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.

Status	Condition	Action
Exit	SMBus connected OR SMBus command received OR |*Current()*| > ***Sleep Current*** OR Wake comparator activates OR (*OperationStatus()[PRES]* = 1 AND ***DA Config[NR]*** = 0 and ***DA Configuration[IN_SYSTEM_SLEEP]*** = 0) 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. For ***[NR]*** = 0, the CHG FET and PCHG FET remains on in SLEEP mode if ***[SLEEPCHG]*** = 1, but if the battery pack is removed from the system, the CHG FET is off because the system present takes higher priority than ***[SLEEPCHG]*** .
4. The wake comparator threshold is set through ***AFE:Current Charge Wake[3:0]*** and ***AFE:Current Discharge Wake[3:0]*** . Refers to Current Wake Detector.
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 5-1. CHG/DSG FETs in SLEEP mode

[NR]	*[SLEEPCHG]*	*[IN_SYSTEM_SLEEP]*	*[PRES]*	CHG FET1	DSG FET1
1	0	X	X	OFF	ON
1	1	X	X	ON	ON
0	0	X	0	OFF	OFF
0	1	X	0	OFF	OFF
0	0	1	1	OFF	ON
0	1	1	1	ON	ON

1. 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

5.3.2 IN SYSTEM SLEEP Mode

The BQ41Z50 device provides an option for removable packs (that is, ***DA Config[NR]*** = 0) to enter SLEEP mode in-system. When the ***DA Config[IN_SYSTEM_SLEEP]*** = 1, the device will turn off CHG FET and PCHG FET if ***FET Options[SLEEPCHG]*** = 0 and enter SLEEP mode even if the *OperationStatus()[PRES]* = 1. This option ignores the $\overline{\text{PRES}}$ pin status only. Additionally, 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_SYTEM_SLEEP]*** can be used for testing purposes, but it is not recommended to set the ***Bus Timeout*** = 0 in the field. If ***Bus Timeout*** = 0, the device's sleep and wake conditions are strictly controlled by current detection. If the host system performs a low load operation periodically (for example, wireless detection in a tablet application), this small load current may be missed, introducing an error into remaining capacity tracking. Having a non-zero ***Bus Timeout*** setting enables the gauge to wake up by a communication and capture the current measurement.

5.3.3 ManufacturerAccess() MAC Sleep

The SLEEP MAC command can override the requirement for bus low to enter sleep. In this case, the BQ41Z50 clock and data high condition is ignored for sleep to exit, though sleep will also exit if there is any further SMBus communication. The BQ41Z50 device can be sent to sleep with *ManufacturerAccess()* if specific sleep entry conditions are met.

5.3.4 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.

5.4 SHUTDOWN Mode

5.4.1 VOLTAGE BASED SHUTDOWN

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

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

Table 5-2. PF Shutdown Voltage

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

Table 5-3. PF Shutdown Time

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

Note

The BQ41Z50 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.

5.4.2 ManufacturerAccess() MAC Shutdown

In SHUTDOWN mode, the device turns off the FETs after ***FET Off Time*** , and then shuts down to minimize power consumption after ***Delay*** time. ***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 BQ41Z50 device returns to NORMAL mode when the voltage at the PACK pin > $V_{STARTUP}$. The BQ41Z50 device can be sent to this mode with the *ManufacturerAccess() Shutdown* command. Charger voltage must not be present for the device to enter SHIP SHUTDOWN mode.

Note

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

5.4.3 Time-Based Shutdown

The BQ41Z50 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 BQ41Z50 device returns to NORMAL mode when voltage at PACK pin > $V_{STARTUP}$.

5.4.4 Low RSOC Time-Based Shutdown

The BQ41Z50 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 BQ41Z50 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.

5.4.5 Power Save Shutdown

Power Save Shutdown is enabled when ***[PWR_SAVE_VSHUT]*** is set. The BQ41Z50 enters ***Power Save Shutdown*** when the lowest cell voltage is below ***PS Shutdown Voltage*** and:
NoLoadRemCap() < ***PS NoLoadResCapThreshold*** .

Status	Condition	Action
Enable	Min cell voltage < ***PS Shutdown Voltage***	*OperationStatus()[PSSHUT]* = 1
Trip	Min 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

Table 5-4. PS Shutdown Voltage

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Power	Shutdown	PS Shutdown Voltage	Int	2	0	32767	2500	mV

Table 5-5. PS No Load Res Cap

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Power	Shutdown	PS No Load Res Cap	Unsigned Int	2	0	32767	0	mAh

5.4.6 IO Based Shutdown

The BQ41Z50 device can shut down upon the assertion of the $\overline{\text{DISP}}$ pin when the configuration bits ***[IO_SHUT]*** = 1 and ***[LED_EN]*** = 0. This feature is disabled when the LED display is enabled. 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	$\overline{\text{DISP}}$ 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.

5.5 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.

5.6 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()*.

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.

5.6.1 Enter Emergency FET Shutdown Through $\overline{\text{SHUTDN}}$

When a high-to-low transition on the $\overline{\text{SHUTDN}}$ 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 only applies if ***[NR]*** = 1 and ***DA Configuration[EMSHUT]*** = 1. If ***[NR]*** = 0, the $\overline{\text{SHUTDN}}$ pin will restore to the regular system present detection.

5.6.2 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. This entry method applies to ***[NR]*** = 0 and ***[NR]*** = 1.

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*** .

5.6.3 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 $\overline{\text{SHUTDN}}$ pin is detected with a debounce delay of 1 s for the low level threshold. For example, a push button is pressed again. 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 addition to these exit conditions, if the gauge enters EMSHUT (via a push button, for example), it can exit the EMSHUT mode after a shutdown restore timeout defined by the ***Timeout*** parameter. When the timeout is equal to 0, it will not exit EMSHUT mode.

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

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

5.7 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.

5.8 System Disconnect

The system can signal the gas gauge via the $\overline{\text{PRES}}$ pin to open the CFET and DFET, disconnecting the battery power to the host. This feature is only enabled for an embedded pack configuration (that is, ***[NR]*** = 1). For a removable battery pack configuration (that is, ***[NR]*** = 0), the original $\overline{\text{PRES}}$ pin function remains as a system-present detection. The internal pullup of the $\overline{\text{PRES}}$ pin is enabled for this feature. Entry to the SYSTEM DISCONNECT mode occurs when the gas gauge detects a high-to-low transition of the $\overline{\text{PRES}}$ 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 $\overline{\text{PRES}}$ pin is high.

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

Chapter 6
Gauging

6.1 Introduction

The BQ41Z50 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 BQ41Z50 measures charge and discharge activity by monitoring the voltage across a small-value series sense resistor (1-mΩ typical) 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 BQ41Z50 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.

6.2 Impedance Track Configuration

Load Mode

During normal operation, the battery-impedance profile compensation of the Impedance 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 BQ41Z50 must be configured for the current (or power) that will flow in the future. While it cannot be exactly known, the BQ41Z50 can use load history, such as the average current of the present discharge, to make a sufficiently accurate prediction.

The BQ41Z50 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 BQ41Z50 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 6-1. 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 6-2. 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 BQ41Z50 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*** .

No Load Reserve Capacity

The ***PS No Load Res Cap*** threshold is programmed to a value in mAh based on how much capacity to reserve for powering the RTC for a period of time after RSOC is 0%.

Table 6-3. PS No Load Res Cap

Class	Subclass	Name	Format	Size in Bytes	Min	Max	Default	Unit
Power	Shutdown	PS No Load Res Cap	Unsigned Int	2	0	32767	0	mAh

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Note

There is no requirement to change ***Term Voltage*** , and this can remain set to the minimum system operation voltage.

Stack Based and Cell Based Termination

The BQ41Z50 forces *RemainingCapacity()* to 0 mAh when the battery stack voltage reaches the ***Term Voltage*** for a period of ***Term V Hold Time*** . If ***IT Gauging Configuration[CELL_TERM]*** = 1, the battery can terminate based on cell voltage or battery stack voltage. When the cell-based termination is used, the ***Term Min Cell V*** threshold is checked for the termination condition. The cell-based termination can provide an option to enable the gauge to reach 0% before the device triggers CUV for a pack imbalance.

Table 6-4. Term V Hold Time

Class	Subclass	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
Gas Gauging	IT-DZT Cfg	Term V Hold Time	Unsigned Int	1	0	255	15	s

6.3 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.

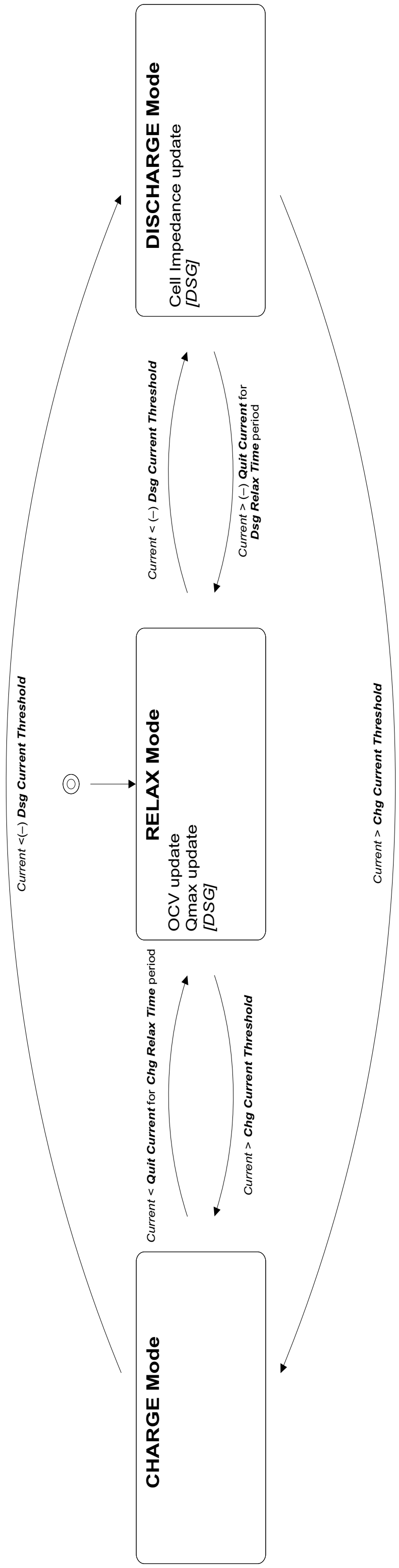


Figure 6-1. Gas Gauge Operating Modes

- 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*** .

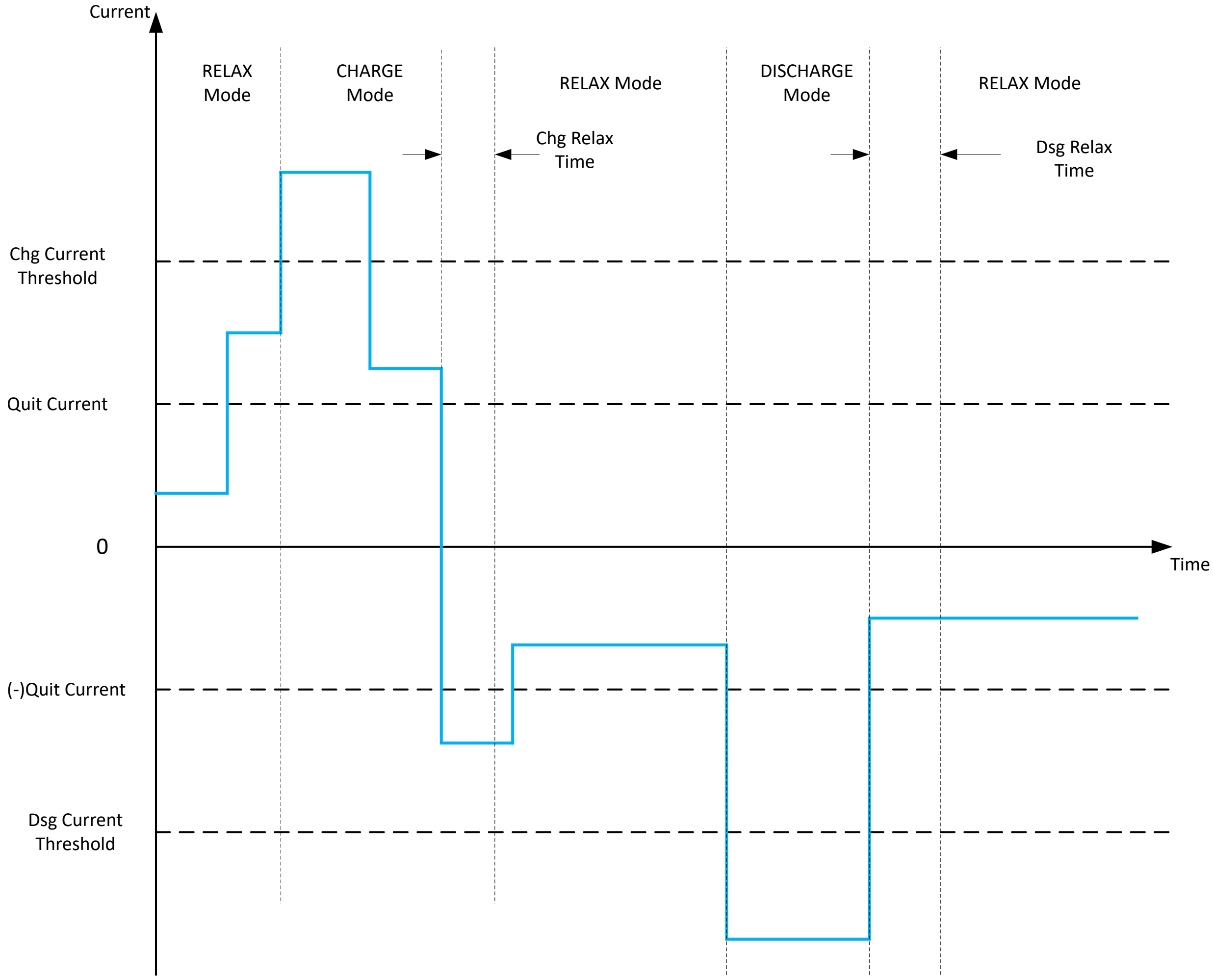


Figure 6-2. Gas Gauge Operating Mode Example

6.4 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 BQ41Z50 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*** .

6.4.1 QMax Initial Values

The initial ***QMax Pack*** , ***QMax Cell 0*** , ***QMax Cell 1*** , ***QMax Cell 2*** , and ***QMax Cell 3*** values should be taken from the cell manufacturers' data sheet multiplied by the number of parallel cells, and are used for the *DesignCapacity* function value in the ***Design Capacity*** data flash value.

6.4.2 QMax Update Conditions

A QMax update is enabled when gauging is enabled. This is indicated by the *GaugingStatus()[QEN]* flag. The BQ41Z50 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 *CellVoltage4..1()* is inside a flat voltage region. (See the *Support of Multiple Li-Ion Chemistries with Impedance 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.

6.4.3 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 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.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
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.

6.4.4 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.

6.4.5 QMax and Fast Qmax Update Boundary Check

The BQ41Z50 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 BQ41Z50 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.

6.4.6 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*** , ***Cell 1 R_a0...14*** , ***Cell 2 R_a0...14*** , ***Cell 3 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*** , ***Cell 1 R_a Flag*** , ***Cell 2 R_a Flag*** , ***Cell 3 R_a Flag*** indicate 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

High Byte		Low Byte	
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.

6.4.7 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.

6.4.8 Application of Resistance Scaling

As a part of the Impedance Track™ algorithm, the BQ41Z50 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.

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

The Impedance 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.

6.6 Impedance Track™ Configuration Options

The BQ41Z50 provides several Impedance Track™ (IT) 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. When the device exits reset and ***[RSOCL]*** = 1, then even if the battery is fully charged (***[FC]*** = 1), only a value of ≤ 99% is reported by *RelativeStateOfCharge()* until a valid charge termination is detected. See Section 4.6 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 BQ41Z50 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 BQ41Z50 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 6.4.4 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 6.2.

[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.

[TS1, TS0] : These two flags together provide an option to select which one of the individual temperature sensors (TS 1…4) is used by the IT algorithm.

[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.

[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).

6.7 State of Health (SOH)

The BQ41Z50 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 BQ41Z50 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.

6.8 TURBO Mode 3.0

A system with TURBO Mode 3.0 applies short high-power load pulses (for example, up to 4 C-rate for as long as 10 ms). In addition, 10-s load pulses of 2 C-rate can occur in some cases prior to 10-ms pulses, resulting in a combined effect during the turbo boost operation. The 10-s pulse support is new in TURBO Mode 3.0 (relative to TURBO Mode 1.0). Additionally, TURBO Mode 3.0 provides Rhf effective and Vload parameters for the host to use to make power-level decisions.

These high-power pulses may drop down battery voltage. If the battery voltage drops below the ***Shutdown Voltage*** , the system will shut down. To avoid shutting down the system during turbo boost operation, the system should never apply a pulse that would cause the system voltage to drop below the termination voltage (or exceed the recommended current threshold) that could result in a shutdown, reducing the total available run time.

The BQ41Z50 TURBO Mode 3.0 helps the system to adjust the power level by providing information about maximal power, depending on the battery state-of-charge, temperature, and present battery impedance. In particular, the gauge informs the system about the power level above which would cause the system voltage to drop below termination after the 10-s pulse, called the sustained peak power (SPP). In addition, the gauge also reports the maximum power for the combined 10-s and 10-ms pulses called the maximum peak power (MPP).

The SPP is computed using a 10-s effective resistance that is temperature- and DOD-dependent. The computation of MPP uses the high-frequency resistance along with the 10-s effective resistance. Both of these resistances are chemistry-specific. In addition, the ***Pack Resistance*** and ***System Resistance*** are important parameters used in the calculation of these two powers. The computed TURBO mode currents, the sustained peak current, and the maximum peak current are capped to their respective maximum discharge rates. Depending on how often the system polls the peak power data and how fast the system can switch to a lower power mode, it is possible to exceed the reported peak power levels during the present power consumption. To avoid any system shutdown, the gauge provides a *Reserve Energy %* setting that can serve as a buffer to ensure there is available energy at the present average discharge rate. These calculations occur on the cell level using ***Term Min Cell V*** , on the pack level using ***Term Voltage*** , and on the system level using ***Min System Voltage*** , ***Pack Resistance*** , and ***System Resistance*** —with the most conservative prediction reported.

Note

Min System Voltage should be set lower than ***Term Voltage*** .

6.9 Battery Trip Point (BTP)

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

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

- *OperationStatus()[BTP_INT]* is set when:
  - If ***Settings.Configuration.IO Config[BTP_MODE]*** is set to 0:
    - Current > 0 and RemCap > “clear” threshold (“charge set threshold”). This threshold is initialized at reset from ***Settings.BTP.Init Charge Set*** .
    - Current ≤ 0 and RemCap < “set” threshold (“discharge set threshold”). This threshold is initialized at reset from ***Settings.BTP.Init Discharge Set*** .
- – If *Settings.Configuration.IO Config[BTP_MODE]* is set to 1:
    - Current > 0 and *RelativeStateofCharge()* > “clear” threshold (“charge SOC set threshold”). This threshold is initialized at reset from ***Settings.BTP.Init Charge Set*** .
    - Current ≤ 0 and *RelativeStateofCharge()* < “set” threshold (“discharge SOC set threshold”). This threshold is initialized at reset from ***Settings.BTP.Init Discharge Set*** .
- When *OperationStatus()[BTP_INT]* is set and if ***Settings.Configuration.IO Config[BTP_EN]*** is set, then the BTP_INT pin output is asserted.
  - If ***Settings.GPIO.BTP pin config[ACTIVE_HI]*** is set, it will assert high; otherwise, it will assert low.
- When either *BTPDischargeSet()* or *BTPChargeSet()* commands are received, *OperationStatus()[BTP_INT]* will clear and the pin will be deasserted. The new threshold is written to either *BTPDischargeSet()* or *BTPChargeSet()*.
- At reset, the pin is set to the deasserted state.
  - If ***[ACTIVE_HI]*** is changed, one of the BTP commands must be reset or sent to “clear" the state.

6.10 Cell Interconnect IR Compensation

The ***Cell 1..4 Interconnect Resistance*** settings (user-measured values) compensate cell voltages for the related IR drop of the cell interconnect wire resistance.

6.11 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.

6.12 RSOC 1% Hold

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

6.13 Accumulated Charge Measurement

The BQ41Z50 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 BQ41Z50 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.

Chapter 7
Cell Balancing

7.1 Introduction

The BQ41Z50 can balance cells either based on state-of-charge or voltage.

The BQ41Z50 can determine the chemical state-of-charge of each cell using the Impedance Track™ algorithm. The cell balancing algorithm used in the device decreases the differences in imbalanced cells in a fully charged state gradually, which prevents fully charged cells from becoming overcharged, causing excessive degradation. This increases overall pack energy by preventing premature charge termination.

The algorithm determines the amount of charge needed to fully charge each cell. There is a bypass FET in parallel with each cell connected to the gas gauge. The FET is enabled for each cell with a charge greater than the lowest charged cell to reduce charge current through those cells. Each FET is enabled for a precalculated time as calculated by the cell balancing algorithm. When any bypass FET is turned on, then the *OperationStatus()[CB]* operation status flag is set; otherwise, the *[CB]* flag is cleared.

The gas gauge balances the cells by balancing the SOC difference. Thus, a field updated QMax (***Update Status*** = 0E) is required prior to any attempt of cell balance time calculation. This ensures the accurate SOC delta is calculated for the cell balancing operation. If the Qmax update has only occurred once (***Update Status*** = 06), then the gauge will only attempt to calculate the cell balance time if a fully charged state is reached, *GaugingStatus()[FC]* = 1.

The cell balancing is enabled if ***Settings:Balancing Configuration [CB]*** = 1. State-of-charge based cell balancing is enabled if ***Balancing Configuration [CBV]*** = 0 and voltage based cell balancing is enabled if ***Balancing Configuration [CBV]*** = 1. The State-of-charge based cell balancing at rest can be enabled separately by setting ***Balancing Configuration [CBR]*** = 1 when ***Balancing Configuration [CBV]*** = 0. Likewise, the voltage based cell balancing at rest can be enabled separately by setting ***Balancing Configuration [CBV_REST]*** = 1 when ***Balancing Configuration [CBV]*** = 1. If ***Settings:Balancing Configuration [CB]*** = 0, all cell balancing operations are disabled.

The cell balancing at rest can be configured by determining the data flash ***Min Start Balance Delta*** , ***Relax Balance Interval*** , and ***Min RSOC for Balancing*** . For the data flash setting description, see Section 17.4.22. The gas gauge balances cells by bypassing the energy. It is recommended to perform cell balancing at rest when there is capacity in the battery pack.

7.2 Cell Balancing Setup

The BQ41Z50 is required to be in RELAX mode before it can determine if the cells are unbalanced and how much balancing is required. The BQ41Z50 enters RELAX mode when:

|*Current()*|< ***Quit Current*** for at least ***Dsg Relax Time*** when coming from DISCHARGE mode or ***Chg Relax Time*** when coming from CHARGE mode.

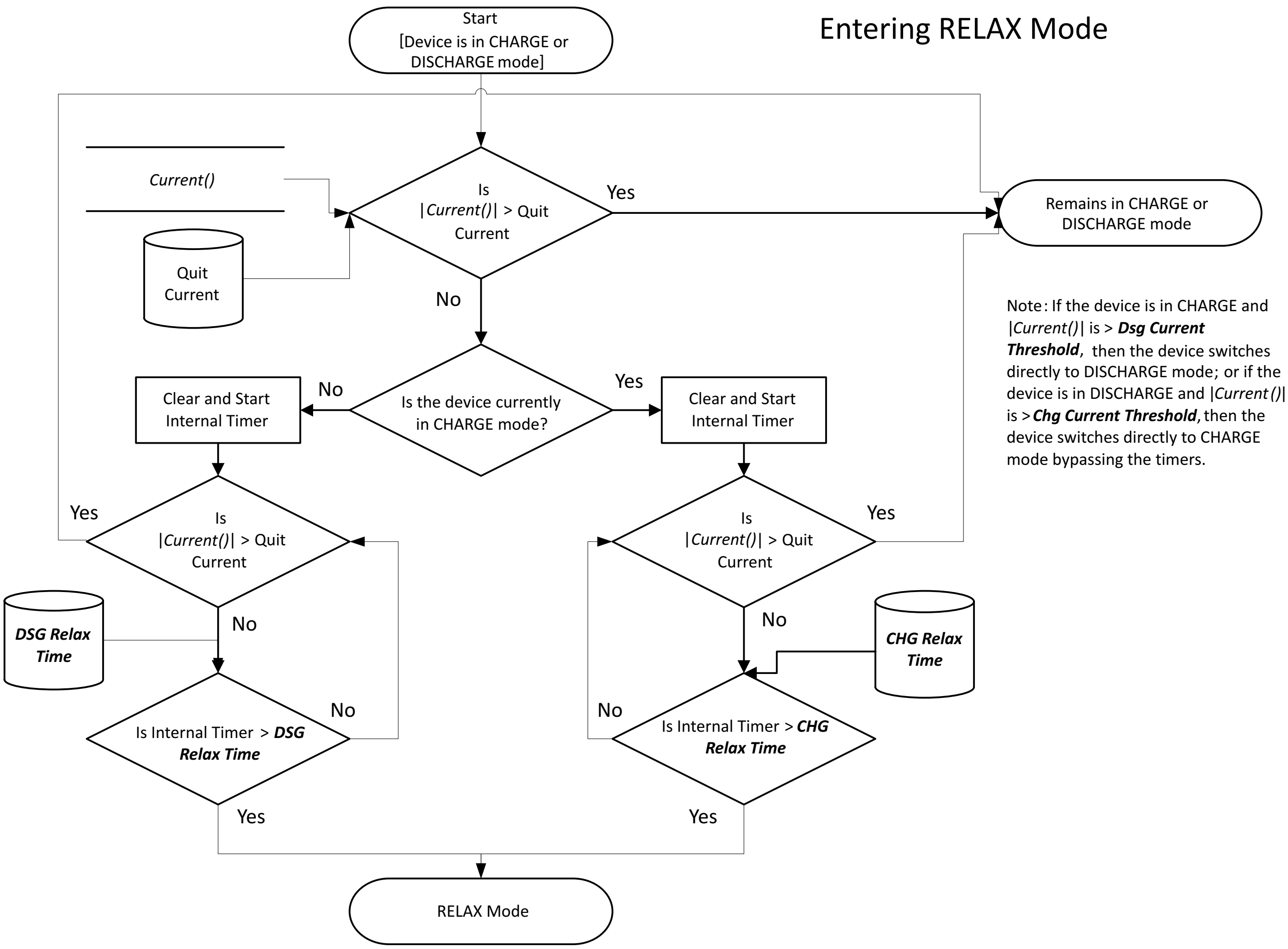


Figure 7-1. Entering CHARGE or RELAX Mode

Once in RELAX mode, the BQ41Z50 will take an OCV measurement after one of the following events occurs:

1. A dV/dt condition of < 4 µV/s is satisfied,
2. Five hours from when |*Current()*| < ***Quit Current*** ,
3. Upon gas gauge reset,
4. An IT Enable command is issued.

The determination of when to update the OCV data is part of the normal Impedance Track™ algorithm and is not specific to the cell balancing algorithm.

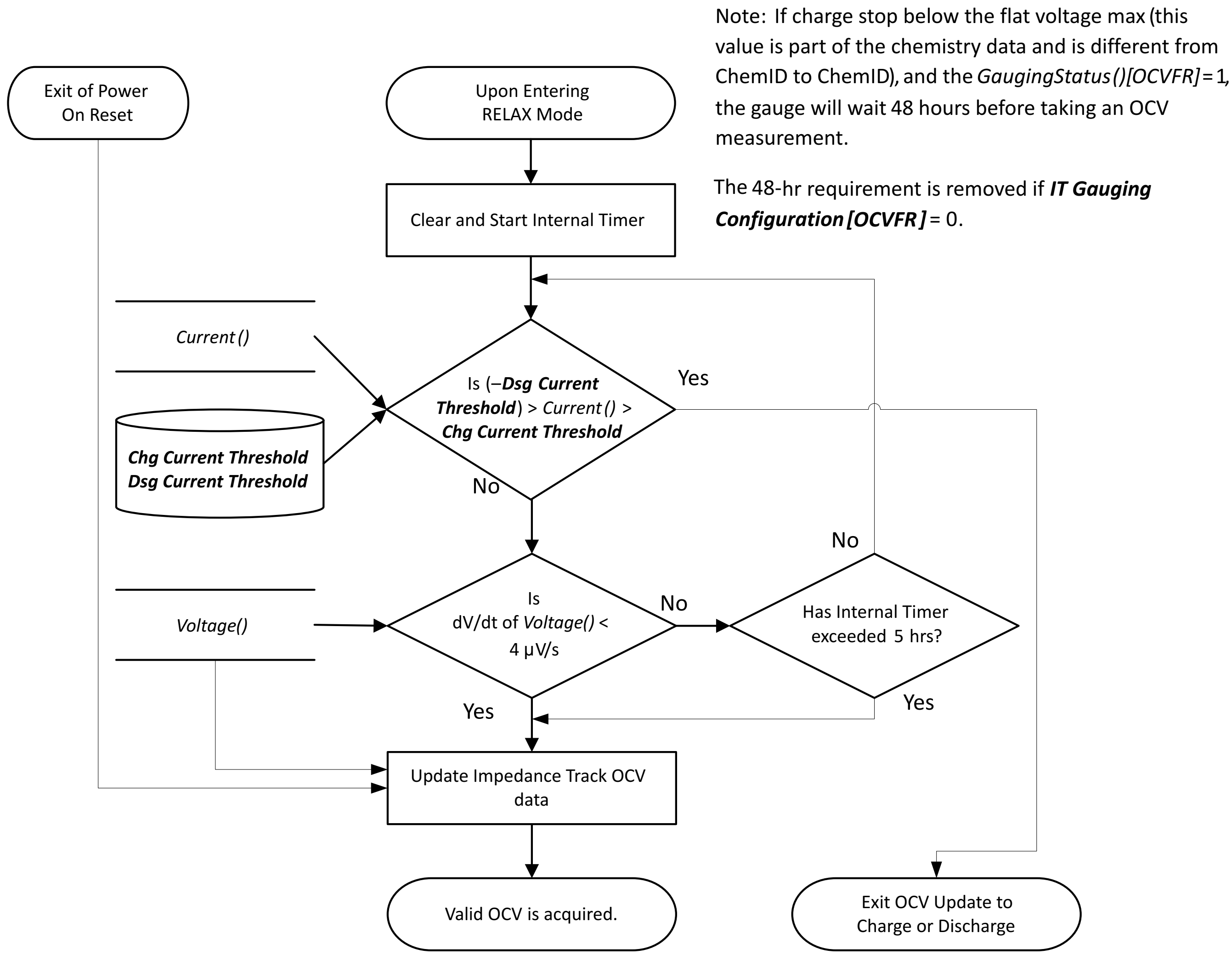


Figure 7-2. OCV Measurement

The BQ41Z50 then calculates the amount of charge difference between cells with a higher state-of-charge than the lowest cell SOC. The value, dQ, is determined for each cell based by converting the measured OCV to Depth-of-Discharge (DOD) percentages using a temperature-compensated DOD versus OCV table lookup table. If the measured OCV does not coincide with a specific table entry, then the DOD value is linearly interpolated from the two adjacent DODs of the respective table adjacent OCVs.

The delta in DOD% between each cell and the cell of lowest SOC is multiplied by the respective cells QMax to create dQ: for example, dQ = CellnDOD – CellLOWEST_SOC DOD × CellnQMax (mAh).

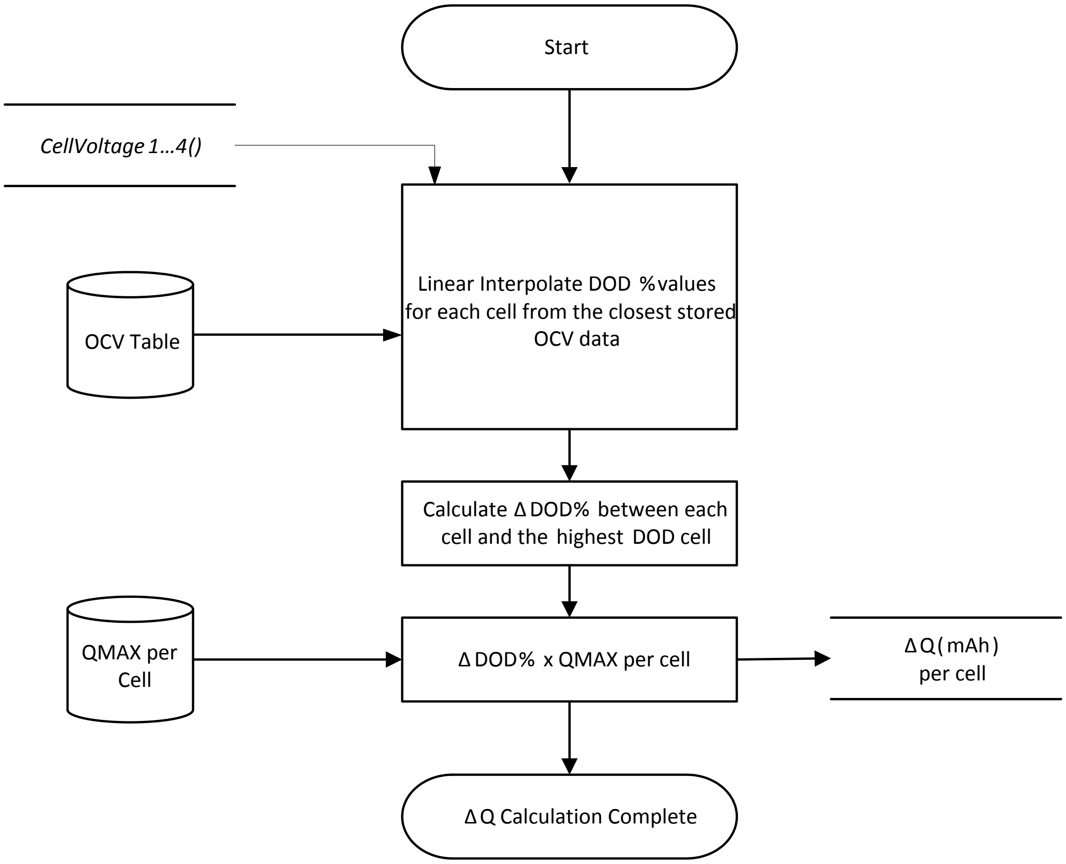


Figure 7-3. ΔQ Calculation

The BQ41Z50 calculates the required balancing time using dQ and ***Bal Time/mAh Cell 1*** (for Cell 1) or Bal Time/mAh Cell 2–4 (for cells 2–4). The values of ***Bal Time/mAh Cell 1*** and ***Bal Time/mAh Cell 2–4*** are fixed values determined based on key system factors and are calculated by:

Internal Cell Balancing:

Bal Time/mAh Cell 1-4 = 3600 mAs * (2 * RCVx + Rcb) / (V_{CELL} * Duty)

External Cell Balancing:

Bal Time/mAh Cell 1-4 = 3600 mAs * [(2 * RCVx + Rcb) || R_{ext}]/ (V_{CELL} * Duty)

Where:

V_{CELL} = average cell voltage (for example, 3700 mV for most chemistries)

RVCx = resistor value in series to VCx input (for example, 100 Ω, based on the reference schematic)

R_{cb} = cell balancing FET R_{dson}, which is 200 Ω (Max)

DUTY = cell balancing duty cycle, which is 95% typ

The cell balancing time for each cell to be balanced is calculated by: dQCelln × ***Bal Time/mAh Cell 1*** for Cell 1 or and dQCelln × ***Bal Time/mAh Cell 2–4*** for Cell 2–4. The cell balancing time is stored in the 16-bit RAM register ***CellnBalanceTimer*** , providing a maximum calculated time of 65535 s (or 18.2 hrs). This update only occurs if a valid QMax update has been made; otherwise, they are all set to 0.

7.3 Balancing Multiple Cells

The BQ41Z50 can balance multiple cells simultaneously if internal cell balancing is selected, ***Balancing Configuration[CBM]*** = 0.

If external cell balancing is selected, ***[CBM]*** = 1, the gauge will perform a rotation of cell balancing with only one cell to be balanced at a time, starting on the cell with highest dQ. For example, at time 0, Cell 1 has the highest dQ while Cell 2 has the second highest dQ on a 3-series pack. Cell balancing will start to balance Cell 1 first. As time progresses, the dQ in the Cell 1 reduces, and Cell 2 becomes the cell with the highest dQ. The gauge then switches to balance Cell 2. The cell balancing rotation between Cell 1 and Cell 2 continues until all the cells are balanced.

7.4 Cell Balancing Operation

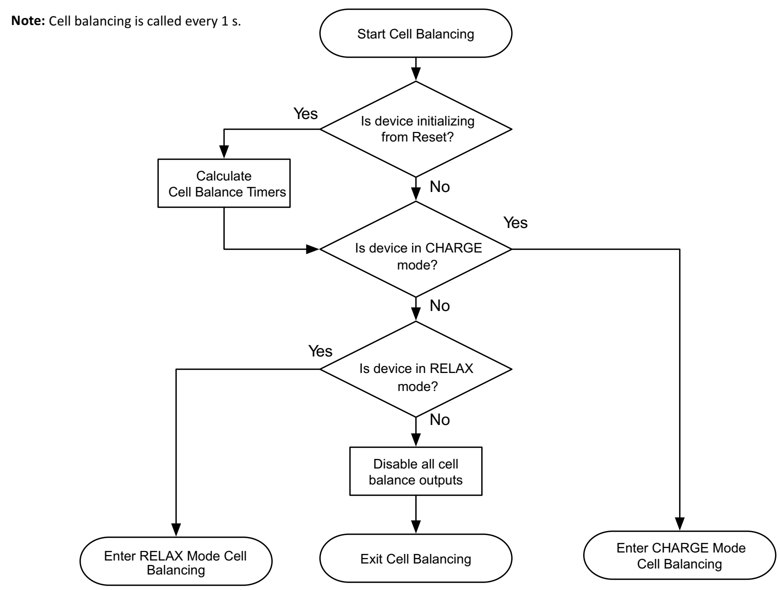


Figure 7-4. Cell Balance Mode Detection

The BQ41Z50 calls the cell balancing algorithm every 1 s during normal operation. Cell balancing is not called when the device is in SLEEP mode. All algorithm decisions are made on this same 1-s timer.

In RELAX mode, if cell balancing at rest is enabled, ***Balancing Configuration[CBR]*** = 1, the gauge will verify if the dv/dt condition is met at the entry of the RELAX mode. If so, then the cell balance at rest will start when all of the conditions below are met:

- Any of the precalculated cell balance timer is non-zero AND
- *RelativeStateofCharge()* > ***Min RSOC for Balancing***

The gauge will attempt to recalculate the cell balancing time in RELAX mode every ***Relax Balance Interval*** . The cell balancing time is updated if the conditions below are met:

- The Relax Balance Interval has passed AND
- A OCV measurement is taken AND
- The max cell voltage delta > ***Min Start Balance Delta***

On exit of the RELAX mode, cell balancing time is recalculated as long as a valid OCV update is available.

Note

Cell balancing is paused during OCV measurement.

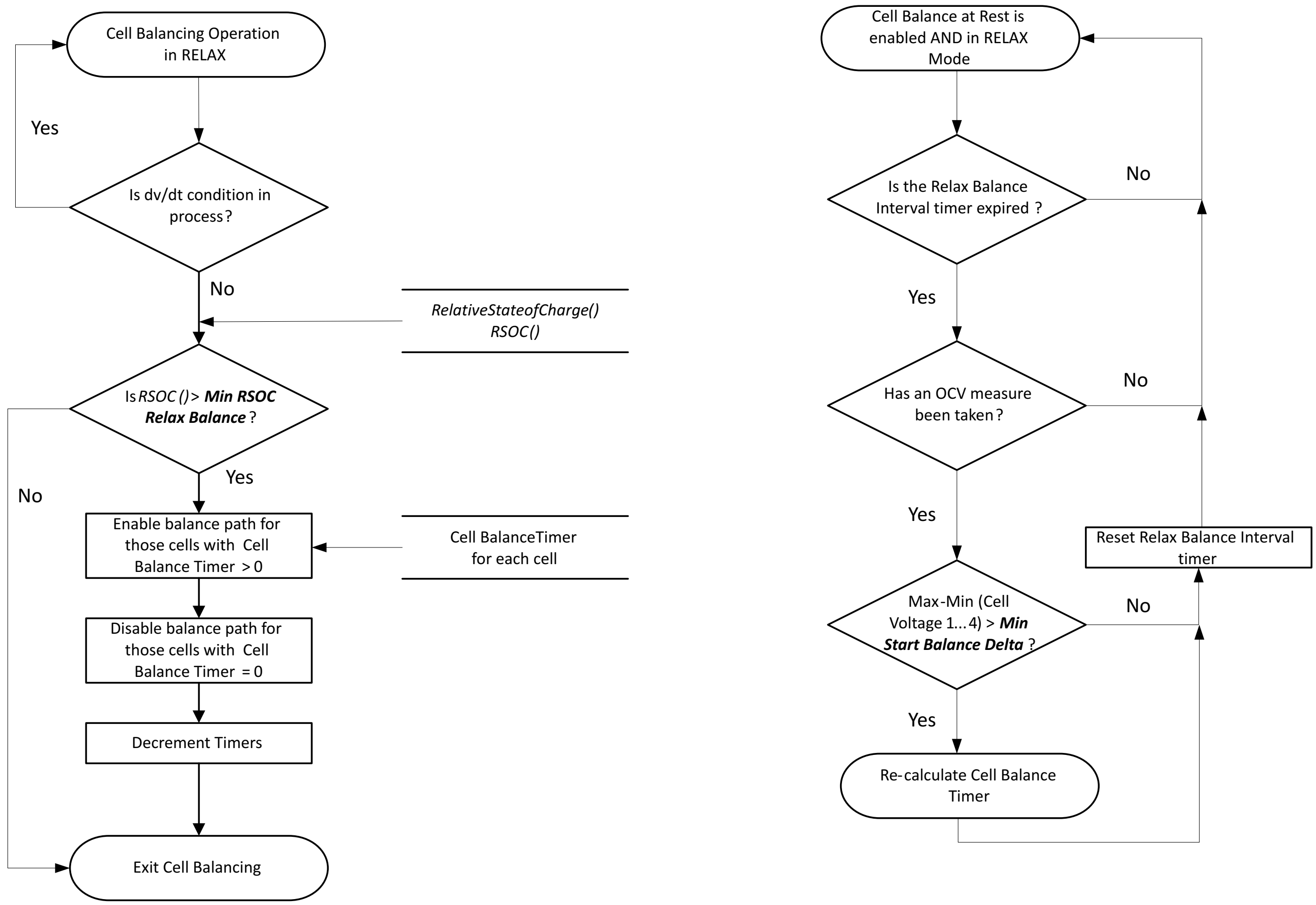


Figure 7-5. Cell Balance Operation in RELAX Mode

When the BQ41Z50 is in CHARGE mode, it follows these steps during cell balancing:

1. Check if any of the precalculated cell balance timers are > 0.
2. The cell balance FETs are turned ON for the corresponding cell balance timers that are ≠ 0.

Note

There are no SOC restrictions controlling the enabling of cell balancing in CHARGE mode.

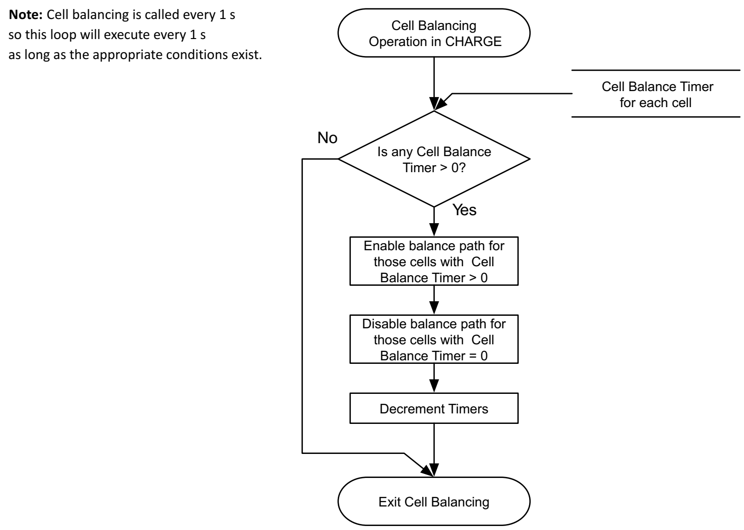


Figure 7-6. Cell Balance Operation in CHARGE Mode

Cell balancing in sleep can be enabled, by setting ***Balancing Configuration[CBS]*** .

Once enabled, cell balancing in sleep will start under the following conditions:

1. The BQ41Z50 device has been in SLEEP for a duration > ***Start Time for Bal in Sleep*** (default 100 hrs) AND
2. The value of RSOC > ***Start Rsoc for Bal in Sleep*** (default 95%).

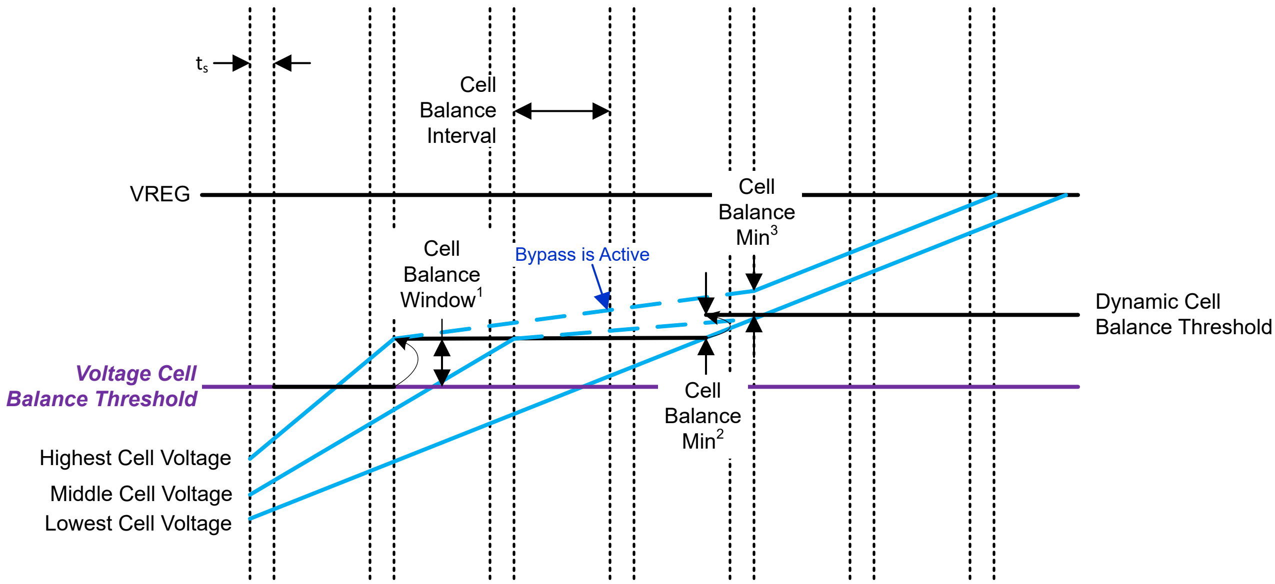
Once the cell balancing in sleep is started, it will end when The value of RSOC < ***End Rsoc for Bal in Sleep*** (default 60%).

7.5 Voltage based Cell Balancing

An alternative voltage based cell balancing is available to the BQ41Z50 device. It is enabled in CHARGE mode when ***Settings:Balancing Configuration [CBV]*** = 1 and charging current is detected, or in REST mode if ***Settings:Balancing Configuration [CBV]*** = 1 and ***Settings:Balancing Configuration [CBV_REST]*** = 1. The operation balances the cells by enabling the bypass around those cells above the threshold set in ***Voltage Cell Balance Threshold*** if the maximum difference in cell voltages exceeds the value programmed in ***Voltage Cell Balance Min*** . During cell balancing, the BQ41Z50 measures the cell voltages at an interval set in ***Voltage Cell Balance Interval*** .

The cell(s) to be balanced are prioritized by highest cell voltage but the BQ41Z50 will not try to balance adjacent cells. If adjacent cells need to be balanced, the BQ41Z50 will alternate between the highest and next-highest adjacent cells until they are balanced.

When the voltage based cell balancing is activated while the device is in CHARGE mode, the BQ41Z50 either selects the appropriate cell to discharge or adjusts the cell balance threshold up by the value programmed in ***Voltage Cell Balance Window*** when all cells exceed the cell balance threshold or the highest cell exceeds the cell balance threshold by the cell balance window. Voltage Based Cell Balancing in CHARGE mode shows how the cell balancing operates in CHARGE mode when this feature is activated. More in-depth details and data on this voltage based cell balancing algorithm during CHARGE mode can be found in: http://www.ti.com/lit/slva155.



[1] Cell balance threshold is adjusted up by ***Voltage Cell Balance Window*** because the highest cell voltage exceeds ***Voltage Cell Balance Threshold*** + ***Voltage Cell Balance Window***
[2] Cell balance threshold is adjusted up by ***Voltage Cell Balance Min*** because the voltage of the lowest cell voltage exceeds the cell balance threshold
[3] Cell balance stops because the difference between the highest and lowest cell voltages is below the value of ***Voltage Cell Balance Min***

Figure 7-7. Voltage Based Cell Balancing in CHARGE mode

When cell balancing operation is activated in REST mode, the dynamic cell balance threshold will automatically be set to the voltage level which is ***Voltage Cell Balance Min*** above the lowest cell voltage, without ***Voltage Cell Balance Window*** adjustment, and continue to decrease as the cell voltages decrease over time due to leakage while remaining above the ***Voltage Cell Balance Threshold*** voltage level. This ensures the cell balancing operation continues to operate in REST if the maximum difference in cell voltages exceeds the value programmed in ***Voltage Cell Balance Min*** , without over discharging the batteries in case the voltage level programmed in ***Voltage Cell Balance Threshold*** is significantly lower than the lowest cell voltage.

The cell balancing operation completes when the maximum difference in cell voltages is less than the value programmed in ***Voltage Cell Balance Min*** . Upon completion while the lowest cell voltage is still above the voltage level programmed in ***Voltage Cell Balance Threshold*** , if a fast leaking cell causes the maximum difference in cell voltages to widen again beyond ***Voltage Cell Balance Min*** , the voltage base cell balancing at REST operation will re-activate. When the device exits REST mode or when any of the cell voltage falls below the programmed value of ***Voltage Cell Balance Threshold*** , cell balancing at REST operation will stop even before the balancing is completed. Figure 7-8 shows how the cell balancing operates in REST mode when this feature is activated.

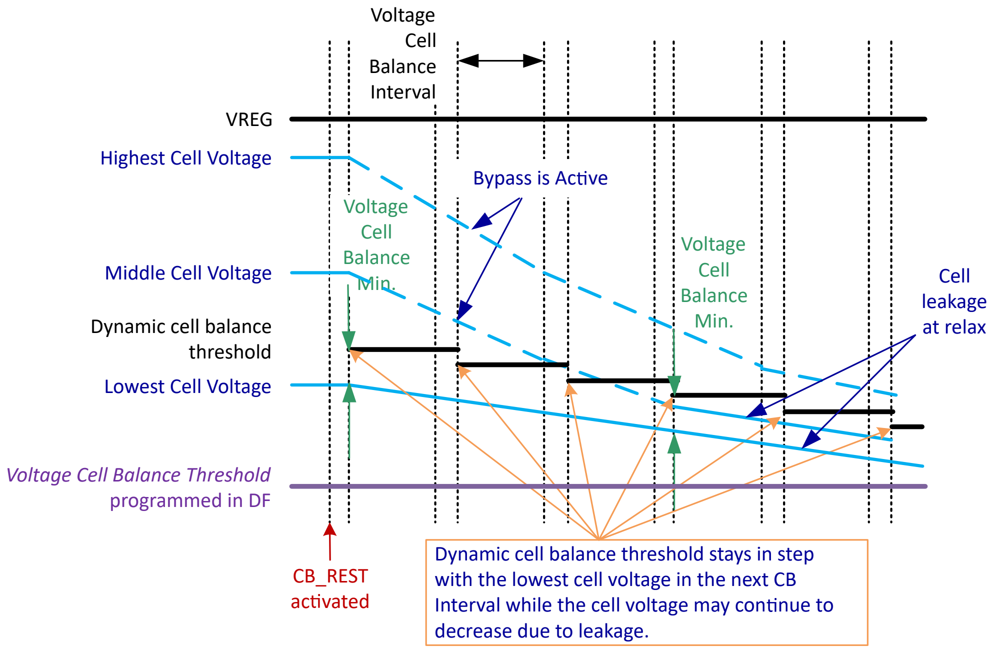


Figure 7-8. Voltage based Cell Balancing in REST mode

Cell balancing occurs on non-adjacent cells at the same time. The cell balance threshold is reset to the value in ***Voltage Cell Balance Threshold*** at the start of every charge and reset cycle. The threshold is only adjusted once during any balance interval.

The configuration data flash is stored in ***Advanced Charging Algorithms: Cell Balancing Config*** . The starting and rest conditions for voltage based balancing are same as state-of-charge based cell balancing.

LED Display

8.1 Introduction

The device has an LED display that shows various status information when a high-to-low transition of the $\overline{DISP}$ pin is detected.

The LED display is disabled if *SafetyStatus()[CUV]* or *[CUVC]* = 1 or if the device is in SHUTDOWN mode.

The detailed settings can be refered in LED Pins Mask.

8.2 LED Display of State-of-Charge / PERMANENT FAILURE / State-of-Health

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

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

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

(1) If ***[LEDCHG]*** = 1, then the LED display will stay on (that is, no $\overline{DISP}$ pin press is needed), showing the state-of-charge during charging while *Current()* > ***Charge Current Threshold*** .

If SOC drops below the flash alarm thresholds in charge or discharge, then the LED display also flashes with ***LED Flash Period*** per the ***CHG Flash Alarm*** or ***DSG Flash Alarm*** settings shown below.

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

In PERMANENT FAILURE mode the *StateOfCharge()* display is replaced with the PERMANENT FAILURE mode display with of LED 2 blinking.

If ***[LEDPF1, LEDPF0]*** = 0,1, then the LED display shows PF Error Code for ***LED Hold Time*** after SOC if $\overline{DISP}$ is held low for LED Hold Time (default)..

If ***[LEDPF1, LEDPF0]*** = 1,1, then the PF Error Code shown after SOC.

Table 8-1. PF Error Code

PF Flag	Priority	LED3	LED2	LED1
None	0	Blinks with ***LED Blink Period***	Off	Off

Table 8-1. PF Error Code (continued)

PF Flag	Priority	LED3	LED2	LED1
SUV	0	Blinks with ***LED Blink Period***	On	Off
SOV	1	Blinks with ***LED Blink Period***	Flashes with ***LED Flash Period***	Off
SOCC	2	Blinks with ***LED Blink Period***	Off	On
SOCD	3	Blinks with ***LED Blink Period***	On	On
SOT	4	Blinks with ***LED Blink Period***	Flashes with ***LED Flash Period***	On
COVL	5	Blinks with ***LED Blink Period***	Off	Flashes with ***LED Flash Period***
SOTF	6	Blinks with ***LED Blink Period***	On	Flashes with ***LED Flash Period***
QIM	7	Blinks with ***LED Blink Period***	Flashes with ***LED Flash Period***	Flashes with ***LED Flash Period***
CB	8	Blinks with ***LED Blink Period***	Off	Blinks with ***LED Blink Period***
IMP	9	Blinks with ***LED Blink Period***	On	Blinks with ***LED Blink Period***
CD	10	Flashes with ***LED Flash Period***	Blinks with ***LED Blink Period***	Off
VIMR	11	Off	Blinks with ***LED Blink Period***	Off
VIMA	12	On	Blinks with ***LED Blink Period***	Off
AOCDL	13	Flashes with ***LED Flash Period***	Blinks with ***LED Blink Period***	On
AOCCL	14	Off	Blinks with ***LED Blink Period***	On
ASCDL	15	On	Blinks with ***LED Blink Period***	On
CFETF	16	Flashes with ***LED Flash Period***	Blinks with ***LED Blink Period***	Flashes with ***LED Flash Period***
DFETF	17	Off	Blinks with ***LED Blink Period***	Flashes with ***LED Flash Period***
OCDL	18	On	Blinks with ***LED Blink Period***	Flashes with ***LED Flash Period***
FUSE	19	Flashes with ***LED Flash Period***	Blinks with ***LED Blink Period***	Blinks with ***LED Blink Period***
AFER	20	Off	Blinks with ***LED Blink Period***	Blinks with ***LED Blink Period***
AFEC	21	On	Off	Off
2LVL	22	Flashes with ***LED Flash Period***	Off	Off
NTC	23	Off	Off	Off
RSVD	24	On	On	On
PFFORCE	25	Flashes with ***LED Flash Period***	On	On
DFW	26	Off	On	On
TMPC	27	On	Flashes with ***LED Flash Period***	Flashes with ***LED Flash Period***

Table 8-1. PF Error Code (continued)

PF Flag	Priority	LED3	LED2	LED1
TS1	28	Flashes with ***LED Flash Period***	Flashes with ***LED Flash Period***	Flashes with ***LED Flash Period***
TS2	29	Off	Flashes with ***LED Flash Period***	Flashes with ***LED Flash Period***
TS3	30	On	Blinks with ***LED Blink Period***	Blinks with ***LED Blink Period***
TS4	31	Flashes with ***LED Flash Period***	Blinks with ***LED Blink Period***	Blinks with ***LED Blink Period***

8.3 LED Display on Exit of a Reset

If the ***[LEDR]*** = 1 and a reset occurs, then on exit from reset, the LED display shows the state-of-charge or PF error code for ***LED Hold Time*** .

8.4 LED Display Control Through AlternateManufacturerAccess()

The gauge provides 0x44 *AlternateManufacturerAccess()* commands for testing purposes. The *AlternateManufacturerAccess() 0x002C LED Toggle* command can toggle the LED display on and off. The *AlternateManufacturerAccess() 0x002C LED Display Press* command can trigger the LED display and simulate 100% RSOC to demonstrate with all LEDs in actions.

Chapter 9
IATA Support

The gauge provides International Air Transport Association (IATA) support with the following commands and procedures.

9.1 Initiating IATA Shutdown (Before Shipping)

1. Initiate IATA shutdown through either a) a separate *IATA_SHUTDOWN()* MAC command, or b) the standard *ShutdownMode()* MAC command (works in SEALED and UNSEALED modes):
   a. With the *IATA_SHUTDOWN()* MAC command, the device sets the ***[IATA_SHUT]*** bit when SBS RSOC is lower than ***IATA RSOC Threshold*** for ***IATA Delay Time*** .
   b. With the standard *ShutdownMode()* MAC command, the ***[IATA_SHUT]*** bit must be set to enable ***IATA_SHUTDOWN*** .
   c. The *IATA_SHUTDOWN()* MAC command is ignored if ***IATA Delay Time*** has not expired.
2. Check if true RSOC is below (less than or equal to) a certain ***IATA RSOC Threshold*** , then continue to Step 3. If not, then stop shutdown and clear the ***[IATA_SHUT]*** bit.
   a. If ***IATA RSOC Threshold*** = 0%, then the gauge will not check or care about the condition of the true RSOC. It clears the ***[IATA_SHUT]*** bit and enters the normal command shutdown (Step 4).
3. Store the true remaining capacity and FCC in the data flash registers ***IATA RM*** and ***IATA FCC*** , respectively.
4. Enter the device command shutdown procedure.
5. Shut down the gauge (same as before).

9.2 After Wakeup (Charging Is Connected for a Short Period to Wake)

1. Check if the ***[IATA_SHUT]*** bit is set. If it is, continue with Step 2. If not, then True FCC and RC are used.
   a. The ***[IATA_SHUT]*** bit should always be cleared in this step.
2. Check the following conditions: If all are true (AND), continue with Step 3. If ANY are NOT True, then True FCC and RC are used.
   a. The delta cell voltage difference between max cell voltage and min cell voltage is within an ***IATA DeltaV Threshold*** (The default is 50 mV. If this threshold is set to 0 V, this delta cell voltage check is disabled.) AND
   b. The temperature is greater than or equal to (≥) ***IATA MIN Temperature*** (default 10C) and less than or equal to (≤) ***IATA MAX Temperature*** (default 40C) AND
   c. Min cell voltage is greater than or equal to (≥) ***IATA Min Voltage*** (default 3000 mV) and less than or equal to (≤) ***IATA MAX Voltage*** (default 3600 mV).
3. Display the remaining capacity and FCC from the DF registers ***IATA RM*** and ***IATA FCC*** , respectively (***[ISTORE_FCC]*** , ***[ISTORE_RM]*** bits are set [the default]). Must be ready before the INIT (battery status) is ready. The ***[ISTORE_FCC]*** and ***[ISTORE_RM]*** configuration bits, when set, define whether the stored value or true value is displayed during the ***IATA Delay Time*** period. However, the ***IATA Delay Time*** can be set to zero OR to a value greater than zero.
   a. If ***IATA Delay Time*** > 0:
      - On wake up from IATA shutdown, the remaining capacity and FCC will be displayed from ***IATA RM*** and ***IATA FCC*** , respectively, for the duration programmed in ***IATA Delay Time*** . At the end of this period, the displayed values will be transitioned from stored value to the true value of remaining

capacity and FCC using the smoothing engine. Smoothing must be enabled. If it is not, the display will jump to the true values immediately.

b. If ***IATA Delay Time*** = 0:
   - On wake up from IATA shutdown, if true RSOC ≤ ***IATA Wake AbsRSOC*** (default 10%), then the true value of remaining capacity and FCC will only be displayed.
   - On wake up from IATA shutdown, if true RSOC > ***IATA Wake AbsRSOC*** (default 10%), then the remaining capacity and FCC will be displayed from ***IATA RM*** and ***IATA FCC*** . Subsequently, the Delta true RSOC (change in true RSOC from wakeup) is monitored. The display will switch from the ***IATA RM*** and ***IATA FCC*** values to the true value of remaining capacity and FCC only if Delta true RSOC ≥ ***IATA Delta RSOC*** (default 3%).

   At this point, if smoothing is not enabled, the display will jump to the true values immediately. However, if smoothing is enabled, the displayed values will transition from the stored value to the true value of remaining capacity and FCC using the smoothing engine.

4. There are two additional MAC commands, *IATA_RM()* and *IATA_FCC()*, that read ***IATA RM*** and ***IATA FCC*** , respectively, and that work in SEALED and UNSEALED modes.

Chapter 10

TMP468 Temperature Sensor Support

10.1 Description

The BQ41Z50 device can support the use of a single external TMP468 High Accuracy Temperature Sensor in addition to the native temperature measurement features. The 8 external and 1 internal temperature measurements can be individually enabled or disabled for use within the device firmware for use with gauging or protection when ***DA Configuration [TMP468_EN]*** = 1. If ***DA Configuration [TMP468_EN]*** = 0 then the TMP468 is not enabled or accessed and no additional temperature data is available. The default value for ***DA Configuration [TMP468_EN]*** = 0.

10.2 Physical Interface

The TMP468 is an I2C compliant slave with SCL on pin 12 (TS3) and SDA on pin 13 (TS4). The TMP468 I2C slave address is configured externally to the TMP468 so the same address value (hex) must be programmed into ***TMP468:Address*** for the device to be able to communicate with the TMP468.

The TMP468 configuration is reloaded if the value returned from the TMP468 local temperature reading indicats that the TMP468 has been reset. Upon loading of the configuration the device waits for a TMP468 conversion upate and have a successful attempt at a data read prior to determination of a need to reload again.

10.3 Configuration of TMP468

Once the TM468 is enabled then it is required to be configured via programming of its internal registers. The required configuration is stored in data flash in the same format as the TMP468 in 36 registers with an associated pointer value. The TMP468 has 36 configuration registers so there are 36 data flash pairs of ***TMP_CONFIG_ADDRn*** and ***TMP_CONFIG_DATAn*** where n is the pointer value. Upon boot of the device then this data is loaded to the TMP468.

Normally the TMP468 configuration is loaded only upon power up of the device however, if it required to be reloaded then a MAC( ) command ***ManufacturerAccess() 0x008A TMP_CFG_RELOAD*** can be written to the device and a reload will be executed the next time the TMP468 is accessed.

10.4 TMP468 Communication Validation

If a scheduled communication to the TMP468 fails, then *PFAlert()[TMPC]* is set and a retry occurs at the next scheduled interval. Each time a communication fails, the internal TMP468 fail counter increments, and if the counter reaches the ***TMPC Threshold*** , then the device enters PF mode and sets *PFStatus() [TMPC]* if ***Enabled PF D [TMPC]*** is set. The internal TMP468 fail counter is decremented after each ***TMPC Delay*** time.

10.5 TMP468 Temperature Data Access

The TMP468 is accessed and temperature data read out at the same rate as the device native temperature sensors are measured, ie: in NORMAL, every 250ms and in SLEEP, every ***Measure Time***.

The array of temperature sensor data is also made available via the ***ManufacturerAccess() 0x0081*** **TMPRead1( )** command if needed by the host.

If communications to the TMP468 is lost then then an immediate retry occurs, if communications continues to fail then a retry will occur at the next scheduled time. If this again fails then after one further retry at the next scheduled time slot the device firmware will operate as if ***[TMP468_EN]*** = 0. The device will continue to retry communications each scheduled period until communications is restored. If communications is restored then normal operation will resume per the TMP468 and device data flash configuration.

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10.6 TMP468 Temperature Data Use by the Device

When enabled the extra temperature data from the TMP468 can be used for either Cell or FET Temperature.

To enable the use of a specific external TMP468 temperature sensor its corresponding bit in ***Ext TMP Temperature Enable*** should be set. The TMP468 internal temperature sensor, which even if enabled in the TMP468, is not used within the device . However, if it is enabled it can be read via ***ManufacturerAccess() 0x0081*** *TMPRead1( )*.

To select a particular external TMP468 temperature sensor for use for CELL or FET temperature then the corresponding selection bit in ***Ext TMP Temperature Mode*** should be set.

The ***DA Configuration [CTEMP1], [CTEMP0]*** functionality remains the same regardless of the setting of ***DA Configuration [TMP468_EN].***

10.7 TMP468 Pass Through Access Commands

The ***ManufacturerAccess() 0x0081 TMPRead1( )***, ***ManufacturerAccess() 0x0082 TMPRead2( )***, ***ManufacturerAccess() 0x0083 TMPRead3( )*** and ***ManufacturerAccess() 0x0084 TMPRead4( )*** read-block commands return the full register array of the TMP468.

The ***ManufacturerAccess() 0x008B TMPWrite( )*** write-word command allows a register to be written with the 1st byte being the TMP468 register pointer (hex) and second byte the data to be written (hex). If the register pointer value received by this command is of a register that is locked or read only then the payload is still sent to the TMP468 even though it will have no impact.

10.8 TMP468 Power Management in BQ41Z50 Power Modes

Each time new TMP468 data is required the BQ41Z50 will power up the TMP468, extract the new data and then place it in SHUTDOWN to ensure minimal power is consumed in all BQ41Z50 power modes. The BQ41Z50 will perform the following steps:

- Power up the TMP468 device in a single shot measurment mode.
- Wait for TMP468 temperature conversion to complete (approximately 142ms for all TMP468 internal and external channels)
- Read the TMP468 temperature data array
- Place TMP468 in SHUTDOWN mode.

When the BQ41Z50 is in SHUTDOWN mode the TMP468 will remain in its SHUTDOWN mode.

Chapter 11

General Purpose Input Output (GPIO) Capability

11.1 Description

The BQ41Z50 supports GPIO capability on the three LED pins and the $\overline{\text{DISP}}$ pin when they are not used for LED operation.

Note

GPIO and LED functionality cannot coexist: It is not possible for some pins to function for the gauge LED operation, while others are used as GPIOs. However, when the pins are used as GPIOs, the user can attach an LED and control the pin manually using the commands described below.

When *ManufacturingStatus()[LED_EN]* = 0 and *IO Config()[GPIO_EN]* = 1, then the LED and $\overline{\text{DISP}}$ pins can be used as GPIOs.

The DF byte ***GPIO Sealed Access Config*** is provided to determine whether the GPIO can be controlled or read when the gauge is SEALED. In some cases, they will be preferred controllable while SEALED, and not in other cases.

A GPIO that is configured as an output can also be read. A GPIO that is configured as an input cannot be written to drive high or low. The DF byte ***Flag Map Set Up*** holds the default configuration for the four GPIO pins.

When the read-only subcommand *GPIORead()* is sent by the host, the level of the GPIO pins is reflected in the data read back. When GPIO mode is selected and the write-only subcommand *GPIOWrite()* is sent by the host, the pins may be configured as outputs driven low, outputs driven high, or hi-Z (which is the setting that will generally be used if the pins are intended to be used as inputs).

Note

When the gauge goes into SHUTDOWN mode, these pins will be set to hi-Z.

In addition, assertion of pins can be controlled via the ***Settings.Flag Map.Set Up Configuration 1..4*** scheme to assert upon particular status bits in the device. There are four such configurations for use described in ***Settings.Flag Map.Set Up Configuration 1..4*** .

Chapter 12
Lifetime Data Collection

12.1 Description

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

- Every 10 hours if RAM content is different from flash
- In permanent fail, before data flash updates are disabled
- Before scheduled shutdown
- Before low voltage shutdown and the voltage is above the ***Valid Update Voltage***

The Lifetime Data stops collecting under following conditions:

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

When the gauge is unsealed, the following *ManufacturingStatus()* can be used for testing Lifetime Data.
- *LifetimeDataReset()* can be used to reset the Lifetime Data.
- *LifetimeDataFlush()* can be used to flush out RAM Lifetime Data to data flash.
- *LifetimeDataSpeedupMode()* can be used to increase the rate the Lifetime Data is incremented.

The collection of the following data starts when ***[LF_EN]*** is set.

- Total firmware runtime
- Voltage
  - Maximum/minimum cell voltage for each cell
  - ***Maximum Delta Cell Voltage*** at any given time (that is, the max cell imbalance voltage)
- Current
  - Maximum charge/discharge current
  - Maximum average discharge current
  - Maximum average discharge power
- For safety events that trigger the *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 Charge Termination
- 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 resets, partial resets, and watchdog resets
  - Number of shutdowns
- Cell balancing (This data is stored with a resolution of 1 second up to over 100 years.)
  - Cell balancing time for each cell

- Temperature in CHARGE, DISCHARGE and RELAX modes
  - Max/Min Cell Temp
  - Delta Cell Temp (max delta cell temperature across the thermistors that are used to report cell temperature)
  - Max/Min Int Temp Sensor
  - Max FET Temp
  - Max/Min Temp for all thermistors (TS1–TS4)
  - Max/Min Temp for all TMP468 thermistors (TMP468_1–TMP468_8)
- State of Health
  - Minimum SOH FCC
- Time (This data is stored with a resolution of 1 second up to over 100 years.)
  - Total runtime
  - Time spent in different *RelativeStateOfCharge() – Temperature()* ranges
    - Eight programmable*RelativeStateOfCharge()* ranges for each of the eight programmable temperature ranges
    - 64*RelativeStateOfCharge() – Temperature()* runtime values

Table 12-1. Time Spent in *RelativeStateOfCharge() – Temperature()* Ranges

	RSOC A	RSOC B	RSOC C	RSOC D	RSOC E	RSOC F	RSOC G	RSOC H
LFT_UUT								
LFT_UT								
LFT_LT								
LFT_STL								
LFT_RT								
LFT_STH								
LFT_HT								
LFT_OT								

12.2 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.

Chapter 13
Device Security

13.1 Introduction

There are three levels of secured operation within the device. To switch between the levels, different operations are needed with different keys. The three levels are SEALED, UNSEALED, and FULL ACCESS. The BQ41Z50 device also supports SHA-1, and ECC authentication with the host system.

13.2 SHA-1 Description

SHA-128 (SHA-1) auhentication is based on secure hash algorithm described in FIPS 180-4 to compute a condensed representation of a message or data also known as hash. For messages < 2^{64}, the algorithm produces a 160-bit output called a digest.

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

The BQ41Z50 device generates a SHA-1 input block of 288 bits (160-bit message + 128-bit key). The device pads the key and messages according to the pad requirements specified by FIPS 180-4.

Detailed information about the SHA algorithm can be found here:

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

13.3 HMAC Description

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

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

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

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

13.4 SHA-1 Authentication

1. Generate 160-bit message M using a random number generator that meets approved random number generators described in FIPS PUB 140–2.
2. Generate SHA-1 input block B1 of 512 bits (total input = 128-bit authentication key KD + 160-bit message M + 1 + 159 0s + 100100000).
3. Generate SHA-1 hash HMAC1 using B1.
4. Generate SHA-1 input block B2 of 512 bits (total input = 128-bit authentication key KD + 160-bit hash HMAC1 + 1 + 159 0s + 100100000).
5. Generate SHA-1 hash HMAC2 using B2.

6. With no active *Authenticate()* data waiting, write 160-bit message M to *Authenticate()* in the format: 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTT, where AA is LSB.
7. Wait 250 ms, then read *Authenticate()* for HMAC3.
8. Compare host HMAC2 with device HMAC3. If it matches, both host and device have the same key KD and the device is authenticated.

13.5 ECC Description

Information will be available when the application note is ready.

13.6 Security Modes

13.6.1 FULL ACCESS or UNSEALED to SEALED

The MAC *Seal Device()* command instructs the device to limit access to the SBS functions and data flash space, and sets the *[SEC1][SEC0]* flags. In SEALED mode, standard SBS functions have access (per the *Smart Battery Data Specification*). Most of the extended SBS functions and data flash are not accessible. Refer to Chapter 16 where each command has documented the accessibility information. Once in SEALED mode, the gauge can never permanently return to UNSEALED or FULL ACCESS modes.

13.6.2 SEALED to UNSEALED

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

The default UNSEAL key is 0x0414 and 0x3672. To go from SEALED to UNSEALED, these two words must be sent to *ManufacturerAccess() (MAC)*, first 0x0414 followed by 0x3672, both sent sequentially with the second word sent within 4 seconds of the first.

13.6.3 UNSEALED to FULL ACCESS

UNSEALED to FULL ACCESS instructs the device to allow full access to all SBS commands and data flash. The BQ41Z50 device is shipped from TI in this mode. The keys for UNSEALED to FULL ACCESS can be read and changed via the *SecurityKey()* MAC command when in FULL ACCESS mode. Changing from UNSEALED to FULL ACCESS is performed by using the *ManufacturerAccess()* command, by writing the first word of the Full Access Key to *ManufacturerAccess()*, followed by the second word of the Full Access Key to *ManufacturerAccess()*. The two words must be sent within 4 s. In FULL ACCESS mode, the command to go to boot ROM can be sent.

Note

If the gauge is sealed, it will always return to the SEALED state after POR even if the gauge is unsealed prior to a POR. If the SREC of a sealed gauge is extracted and then programmed into another gauge, the other gauge will also power up in the SEALED state. The only way to permanently restore the UNSEALED state is to reflash the gauge with an unsealed SREC.

13.6.4 DF Read Only Access in SEALED

Host can read from data flash addresses 0x4000-0x5FFF in SEALED mode if DF Read Only mode is active. A two-word DF Ready Only MAC sequence is required to enable DF Read Only mode. 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 and ***Settings:Auth Config[DF_READ_EN]***

=1 host can read data flash in SEALED mode for ***DF Read Only Timeout*** time. The timeout is extended by further ***DF Read Only Timeout*** on successful data flash read.

Chapter 14

Manufacture Production

14.1 Manufacture Testing

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

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

14.2 Calibration

Refer to the *bq40zxx Manufacture, Production, and Calibration Application Note* (SLUA734) for the detailed calibration procedure.

The BQ41Z50 device has integrated routines that support calibration of current, voltage, and temperature readings, accessible after writing 0xF081 or 0xF082 to *ManufacturerAccess()* . While the calibration is active, the raw ADC data is available on *ManufacturerData()*. The BQ41Z50 device stops reporting calibration data on *ManufacturerData()* if any other MAC commands are sent or the device is reset or sealed.

Note

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

ManufacturingStatus()[CAL_EN] works to:

- bypass min voltage checks for saving data flash when it sets;
- prevent low voltage shutdown when it sets (command based shutdown is still allowed);
- block *OperationStatus()[CAL]* entry when it is cleared.

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

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

Value	Format	Description
ZZ	byte	8-bit counter, increments when raw ADC values are refreshed (every 250 ms)
YY	byte	Output status *ManufacturerAccess()* = 0xF081: 1 *ManufacturerAccess()* = 0xF082: 2
AAaa	2's comp	Current (coulomb counter)
BBbb	2's comp	Cell Voltage 1
CCcc	2's comp	Cell Voltage 2
DDdd	2's comp	Cell Voltage 3
EEee	2's comp	Cell Voltage 4
FFff	2's comp	PACK Voltage
GGgg	2's comp	BAT Voltage
HHhh	2's comp	Cell Current 1
IIii	2's comp	Cell Current 2
JJjj	2's comp	Cell Current 3
KKkk	2's comp	Cell Current 4

14.2.1 Calibration Data Flash

14.2.1.1 Voltage

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

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

14.2.1.2 Current

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

14.2.1.3 Current Offset

14.2.1.3.1 CC Offset

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

Description: This is the sum of samples when the coulomb counter inputs are internally shorted. This offset is used for *Current()* measurement.

14.2.1.3.2 Coulomb Counter Offset Samples

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

Description: ***Coulomb Counter Offset Samples*** is used for averaging.

14.2.1.3.3 Board Offset

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

Description: This is the sum of coulomb counts when zero current is flowing across the sense resistor.

14.2.1.4 CC Auto Config

Class	Subclass	Name	Type	Min	Max	Default	Units
Calibration	Current Offset	CC Auto Config	H1	0x00	0x07	0x03	Hex

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

SpecificationInformation() values

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

OFFSET_TAKEN (Bit 2): ***CC Auto Offset*** is taken.

1 = ***CC Auto Offset*** has been measured.

0 = ***CC Auto Offset*** has not been measured.

AUTO_NESTON (Bit 1): NEST Circuit ON

1 = When ***[OFFSET_TAKEN]*** = 1, FW automatically controls the HW NEST circuit for best current and cell current measurements.

0 = HW NEST circuit is always on. Individual cell current measurement may have error relative to *Current()*, but the *Current()* accuracy is not impacted.

AUTO_CAL_EN (Bit 0): ***CC Auto Offset*** calibration enable

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

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

14.2.1.5 CC Auto Offset

Class	Subclass	Name	Type	Min	Max	Default
Calibration	Current Offset	CC Auto Offset	I2	–10000	10000	0

Description: ***CC Offset*** collected via ***CC Auto Offset Calibration*** . This offset is used for cell current measurement and is different than ***CC Offset*** .

14.2.1.6 Temperature

14.2.1.6.1 Internal Temp Offset

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

Description: Internal temperature sensor reading offset

14.2.1.6.2 External 1 Temp Offset

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

Description: TS1 temperature sensor reading offset

14.2.1.6.3 External 2 Temp Offset

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

Description: TS2 temperature sensor reading offset

14.2.1.6.4 External 3 Temp Offset

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

Description: TS3 temperature sensor reading offset

14.2.1.6.5 External 4 Temp Offset

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

Description: TS4 temperature sensor reading offset

14.2.1.7 Internal Temp Model

14.2.1.7.1 Int Gain

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

Description: Internal temperature gain

14.2.1.7.2 Int Base Offset

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

Description: Internal temperature base offset

14.2.1.7.3 Int Minimum AD

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

Description: Minimum AD count used for calculation

14.2.1.7.4 Int Maximum Temp

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

Description: Maximum Temperature boundary

14.2.1.8 External Thermistor Cell Temp Model

Translation of resistance measurement to temperature for NTC thermistors is computed using two polynomials (denoted as "a" and "b"). The default coefficients are optimized for a 10-KΩ at 25°C thermistor.

14.2.1.8.1 Coefficient a1

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

Description: Cell temperature calculation polynomial a1

14.2.1.8.2 Coefficient a2

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

Description: Cell temperature calculation polynomial a2

14.2.1.8.3 Coefficient a3

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

Description: Cell temperature calculation polynomial a3

14.2.1.8.4 Coefficient a4

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

Description: Cell temperature calculation polynomial a4

14.2.1.8.5 Coefficient a5

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

Description: Cell temperature calculation polynomial a5

14.2.1.8.6 Coefficient b1

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

Description: Cell temperature calculation polynomial b1

14.2.1.8.7 Coefficient b2

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

Description: Cell temperature calculation polynomial b2

14.2.1.8.8 Coefficient b3

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

Description: Cell temperature calculation polynomial b3

14.2.1.8.9 Coefficient b4

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

Description: Cell temperature calculation polynomial b4

14.2.1.8.10 Rc0

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

Description: ADC reading at 25°C for calibration point of the translation polynomials

14.2.1.8.11 Adc0

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

Description: ADC reading at 25°C to shift the polynomial calibration point

14.2.1.8.12 Rpad

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

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

Description: Pad Resistance (0 to use factory calibration) contribution to thermistor impedance AD conversion.

14.2.1.8.13 Rint

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

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

Description: Internal pullup resistance (0 to use factory calibration) for thermistor excitation

14.2.1.9 FET Temp Model Using an External Thermistor

The default model is the same as that for cell temperature measurement.

14.2.1.9.1 Coefficient a1

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

Description: FET temperature calculation polynomial a1.

14.2.1.9.2 Coefficient a2

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

Description: FET temperature calculation polynomial a2

14.2.1.9.3 Coefficient a3

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

Description: FET temperature calculation polynomial a3

14.2.1.9.4 Coefficient a4

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

Description: FET temperature calculation polynomial a4

14.2.1.9.5 Coefficient a5

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

Description: FET temperature calculation polynomial a5

14.2.1.9.6 Coefficient b1

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

Description: FET temperature calculation polynomial b1

14.2.1.9.7 Coefficient b2

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

Description: FET temperature calculation polynomial b2

14.2.1.9.8 Coefficient b3

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

Description: FET temperature calculation polynomial b3

14.2.1.9.9 Coefficient b4

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

Description: FET temperature calculation polynomial b4

14.2.1.9.10 Rc0

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

Description: Resistance at 25°C

14.2.1.9.11 Adc0

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

Description: ADC reading at 25°C

14.2.1.9.12 Rpad

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

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

Description: Pad Resistance (0 to use factory calibration)

14.2.1.9.13 Rint

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

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

Description: Pullup resistor resistance (0 to use factory calibration)

14.2.1.10 Current Deadband

14.2.1.10.1 Deadband

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

Description: Pack-based Deadband to report 0 mA

14.2.1.10.2 Coulomb Counter Deadband

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

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

Chapter 15
Device SMBus Address

The BQ41Z50 SMBus address (default 0x16) can be changed. The target address should be programmed in ***Address*** and the 2's complement of that value should be programmed in ***Address Check*** .

The BQ41Z50 will check these values upon exit from POR, and if the two data flash values are not valid or the programmed address is 0x00 or 0xFF, then the device defaults to 0x16.

Table 15-1. Address

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

Table 15-2. Address Check

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

For details on SMBus specifications, visit http://www.smbus.org/specs/.

Chapter 16
SBS Commands

16.1 0x00 ManufacturerAccess() and 0x44 ManufacturerBlockAccess()

ManufacturerBlockAccess() provides a method of reading and writing data in the Manufacturer Access System (MAC). This block MAC access method is standard for the BQ40Zxy family. The MAC command is sent via *ManufacturerBlockAccess()* by the SMBus block protocol. The result is returned on *ManufacturerBlockAccess()* via an SMBus block read.

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

1. With Impedance Track™ disabled, send *Gauging()* (0x0021) to *ManufacturerBlockAccess()*
    a. SMBus block write. Command = 0x44. Data = 21 00 (data must be sent in little endian)
2. IT is enabled, *ManufacturingStatus()[GAUGE_EN]* = 1.

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

1. Send *Chemical ID()* to *ManufacturerBlockAccess().*
    a. SMBus block write. Command = 0x44. Data sent = 06 00 (data must be sent in little endian)
2. Read the result from *ManufacturerBlockAccess().*
    a. SMBus block read. Command = 0x44. Data read = 06 00 00 01 (each data entity is returned in little endian).
    b. The first 2 bytes, “06 00”, is the MAC command.
    c. The second 2 bytes, “00 01”, is the chem ID returning in little endian. That is 0x0100, chem ID 100.

For backwards compatibility with the bq30zxy families, sending MAC commands via *ManufacturerAccess()* (0x00) as well as the returning data on *ManufacturerData()* are supported in BQ41Z50.

Note

Note that MAC commands are sent through *ManufacturerAccess()* (0x00) by an SMBus write word protocol. The result reading from *ManufacturerData()* does not include the MAC command.

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

1. With Impedance Track™ disabled, send *Gauging()* (0x0021) to *ManufacturerAccess()*.
    a. SMBus word write. Command = 0x00. Data = 00 21 (Data to address 0x00 is big endian.)
2. IT is enabled, *ManufacturingStatus()[GAUGE_EN]* = 1.

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

1. Send *Chemical ID()* to *ManufacturerAccess().*
    a. SMBus word write. Command = 0x00. Data sent = 00 06 (data to address 0x00 is big endian).
2. Read the result from *ManufacturerData().*
    a. SMBus block read. Command = 0x23. Data read = 00 01 (each data entity is returned in little endian).
    b. That is 0x0100, chem ID 100.

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

Table 16-1. ManufacturerAccess() Command List

Command	Function	Access	Format	Data Read on 0x44 or 0x23	Data Read on 0x2F	Available in SEALED Mode	Type	Unit
0x0001	DeviceType	R	Block	Yes	—	Yes	Hex	—
0x0002	FirmwareVersion	R	Block	Yes	—	Yes	Hex	—
0x0003	HardwareVersion	R	Block	Yes	—	Yes	Hex	—
0x0004	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	—
0x001E	PCHGFETToggle	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	—
0x0026	Fuse	W	—	—	—	—	Hex	—
0x0027	LEDDisplayEnable	W	—	—	—	—	Hex	—
0x0028	LifetimeDataReset	W	—	—	—	—	Hex	—
0x0029	PermanentFailData Reset	W	—	—	—	—	Hex	—
0x002A	BlackBoxRecorderReset	W	—	—	—	—	Hex	—
0x002B	LEDToggle	W	—	—	—	—	Hex	—
0x002C	LEDDisplayPress	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	—

Table 16-1. ManufacturerAccess() Command List (continued)

Command	Function	Access	Format	Data Read on 0x44 or 0x23	Data Read on 0x2F	Available in SEALED Mode	Type	Unit
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
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
0x0081	TMPRead1	R	Block	Yes	—	Yes	Hex	Hex
0x0082	TMPRead2	R	Block	Yes	—	Yes	Hex	Hex
0x0083	TMPRead3	R	Block	Yes	—	Yes	Hex	Hex
0x0084	TMPRead4	R	Block	Yes	—	Yes	Hex	Hex
0x0085	TMPRead5	R	Block	Yes	—	Yes	Hex	Hex
0x0086	TMPRead6	R	Block	Yes	—	Yes	Hex	Hex
0x0087	TMPRead7	R	Block	Yes	—	Yes	Hex	Hex
0x008A	TMPLoadConfig	W	Block	Yes	—	Yes	Hex	—
0x008B	TMPWrtieReg	W	Block	Yes	—	Yes	Hex	Hex
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

Table 16-1. ManufacturerAccess() Command List (continued)

Command	Function	Access	Format	Data Read on 0x44 or 0x23	Data Read on 0x2F	Available in SEALED Mode	Type	Unit
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	—

16.1.1 ManufacturerAccess() 0x0000

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

16.1.2 ManufacturerAccess() 0x0001 Device Type

The BQ41Z50 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

16.1.3 ManufacturerAccess() 0x0002 Firmware Version

The BQ41Z50 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

16.1.4 ManufacturerAccess() 0x0003 Hardware Version

The BQ41Z50 device can be checked for the hardware version of the IC. The hardware revision returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

16.1.5 ManufacturerAccess() 0x0004 Instruction Flash Signature

The BQ41Z50 device can return the instruction flash signature. The IF signature returns on a subsequent read on *ManufacturerBlockAccess()* or *ManufacturerData()*.

16.1.6 ManufacturerAccess() 0x0005 Static DF Signature

The BQ41Z50 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.

16.1.7 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()*.

16.1.8 ManufacturerAccess() 0x0008 Static Chem DF Signature

The BQ41Z50 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.

16.1.9 ManufacturerAccess() 0x0009 All DF Signature

The BQ41Z50 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.

16.1.10 ManufacturerAccess() 0x000A STORAGE Mode

This command activates STORAGE mode.

16.1.11 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.

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

To wake up the device, a voltage > ***Charger Present Threshold*** must apply to the PACK pin. The BQ41Z50 device will power up and a full reset is applied.

16.1.12 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	***DA Configuration[NR]*** = 0 AND *OperationStatus()[PRES]* = 0 AND |*Current()*| < ***Power:Sleep Current***	Turn off CHG FET, DSG FET, PCHG FET 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.
Activate	***DA Configuration[NR]*** = 1 AND |*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	***DA Configuration[NR]*** = 0 AND *OperationStatus()[PRES]* = 1	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode
Exit	|*Current()*| > Configuration:Sleep Current	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode
Exit	Wake Comparator trips	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode
Exit	*SafetyAlert()* flag or *PFAlert()* flag set	*OperationStatus()[SLEEPM]* = 0 Return to NORMAL mode

16.1.13 ManufacturerAccess() 0x001D Fuse Toggle

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

16.1.14 ManufacturerAccess() 0x001E PCHG FET Toggle

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

16.1.15 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.

16.1.16 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.

16.1.17 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 BQ41Z50 device remains on its latest gauging status prior to a reset.

16.1.18 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 BQ41Z50 device remains on its latest FET control status prior to a reset.

16.1.19 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 BQ41Z50 device remains on its latest ***Lifetime Data Collection*** setting prior to a reset.

16.1.20 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 BQ41Z50 device remains on its PF enable/disable setting prior to a reset.

16.1.21 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 BQ41Z50 device remains on its latest Black Box Recorder enable/ disable setting prior to a reset.

16.1.22 ManufacturerAccess() 0x0026 Fuse

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

In UNSEALED mode, the *ManufacturingStatus()[FUSE_EN]* status is copied to ***Mfg Status Init[FUSE_EN]*** when the command is received by the gauge. The BQ41Z50 device remains on its latest Fuse Control setting prior to a reset.

16.1.23 ManufacturerAccess() 0x0027 LED DISPLAY Enable

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

In UNSEALED mode, the *ManufacturingStatus()[LED_EN]* status is copied to ***Mfg Status Init[LED_EN]*** when the command is received by the gauge. The BQ41Z50 device remains on its latest setting prior to a reset.

16.1.24 ManufacturerAccess() 0x0028 Lifetime Data Reset

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

16.1.25 ManufacturerAccess() 0x0029 Permanent Fail Data Reset

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

16.1.26 ManufacturerAccess() 0x002A Black Box Recorder Reset

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

16.1.27 ManufacturerAccess() 0x002B LED Toggle

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

16.1.28 ManufacturerAccess() 0x002C LED Display Press

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

16.1.29 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.

16.1.30 ManufacturerAccess() 0x002E Lifetime Data Flush

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

16.1.31 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.

16.1.32 ManufacturerAccess() 0x0030 Seal Device

This command seals the device for the field, disabling certain SBS commands and access to data flash. See and Chapter 16 for details.

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

16.1.33 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.

16.1.34 ManufacturerAccess() 0x0037 Authentication Key

This command enables the update of the authentication key into the device. The BQ41Z50 device must be in FULL ACCESS mode for the authentication key to update.

To update a new authentication key:

- Send the *AuthenticationKey()* + the new 128-bit authentication key to *ManufacturerBlockAccess()* OR
- Send the *AuthenticationKey()* to *ManufacturerAccess()*, then send the 128-bit authentication key to *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 BQ41Z50 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.

16.1.35 ManufacturerAccess() 0x0041 Device Reset

This command resets the device.

Note

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

16.1.36 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

DCOT	CUVC	OTD	OTC	ASC DL	RSVD	AOC CL	RSVD	AOCD L	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

DCOT (Bit 15): Delta cell overtemperature

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 4): 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

16.1.37 *ManufacturerAccess() 0x0051 SafetyStatus*

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

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
RSVD	RSVD	OCDL	COVL	UTD	UTC	PCHGC	CHGV	CHGC	OC	RSVD	CTO	RSVD	PTO	RSVD	OTF

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DCOT	CUVC	OTD	OTC	ASCDL	ASCD	ASCCL	AOCC	AOCDL	AOCD	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

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

DCOT (Bit 15): Delta cell overtemperature

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

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

16.1.38 ManufacturerAccess() 0x0052 PFAlert

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

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
TS4	TS3	TS2	TS1	TMPC	RSVD	RSVD	RSVD	RSVD	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	ACCC L	AOCD L	VIMA	VIMR	CD	IMP	CB	QIM	SOTF	COVL	SOT	SOCD	SOCC	SOV	SUV

TS4 (Bit 31): Open thermistor–TS4 failure

1 = Detected

0 = Not detected

TS3 (Bit 30): Open thermistor–TS3 failure

1 = Detected

0 = Not detected

TS2 (Bit 29): Open thermistor–TS2 failure

1 = Detected

0 = Not detected

TS1 (Bit 28): Open thermistor–TS1 Failure

1 = Detected

0 = Not detected

TMPC (Bit 27): TMP468 Communication Failure

1 = Detected

0 = Not detected

RSVD (Bits 26–23): Reserved. Do not use.

2LVL (Bit 22): Second level protector failure

1 = Detected

0 = Not detected

AFEC (Bit 21): AFE communication failure

1 = Detected

0 = Not detected

AFER (Bit 20): AFE register failure

1 = Detected
0 = Not detected

FUSE (Bit 19): Chemical fuse failure
1 = Detected
0 = Not detected

OCDL (Bit 18): Overcurrent in discharge
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): Short circuit in discharge
1 = Detected
0 = Not detected

AOCCL (Bit 14): Short circuit in charge
1 = Detected
0 = Not detected

AOCDL (Bit 13): Overload in discharge
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

16.1.39 ManufacturerAccess() 0x0053 PFStatus

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

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
TS4	TS3	TS2	TS1	TMPC	DFW	FORCE	RSVD	NTC	2LVL	AFEC	AFER	FUSE	OCDL	DFETF	CFETF

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

TS4 (Bit 31): Open thermistor–TS4 failure

1 = Detected

0 = Not detected

TS3 (Bit 30): Open thermistor–TS3 failure

1 = Detected

0 = Not detected

TS2 (Bit 29): Open thermistor–TS2 failure

1 = Detected

0 = Not detected

TS1 (Bit 28): Open thermistor–TS1 failure

1 = Detected

0 = Not detected

TMPC (Bit 27): TMP468 Communication Failure

1 = Detected

0 = Not detected

DFW (Bit 26): Data flash wearout failure

1 = Detected

0 = Not detected

FORCE (Bit 25): Manual PF

RSVD (Bit 24): RSVD

NTC (Bit 23): NTC failure

1 = Detected

0 = Not detected

2LVL (Bit 22): Second level protector failure

1 = Detected

0 = Not detected

AFEC (Bit 21): AFE communication failure

1 = Detected

0 = Not detected

AFER (Bit 20): AFE register failure

1 = Detected

0 = Not detected

FUSE (Bit 19): Chemical fuse failure

1 = Detected

0 = Not detected

OCDL (Bit 18): Overcurrent in discharge

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): Short circuit in discharge

1 = Detected

0 = Not detected

AOCCL (Bit 14): Short circuit in charge

1 = Detected

0 = Not detected

AOCDL (Bit 13): Overload in discharge

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

16.1.40 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	CB	RSVD	-STORAGEM	SMBLCAL	INIT	SLEEPM	XL	CAL_OFFSET	CAL	AUTOCALM	AUTH	LED	SDM
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

SLEEP	XCHG	XDSG	PF	SS	SDV	SEC1	SEC0	BTP_ INT	EM SHUT	FUSE	ACTH R	PCHG	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

CB (Bit 28): Cell balancing status

1 = Active

0 = Inactive

RSVD (Bit 27): 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

LED (Bit 17): LED Display

1 = LED display is on.

0 = LED display is off.

SDM (Bit 16): Shutdown triggered via command

1 = Active

0 = Inactive

SLEEP (Bit 15): SLEEP mode conditions met

1 = Active

0 = Inactive

XCHG (Bit 14): Charging disabled

1 = Active

0 = Inactive

XDSG (Bit 13): Discharging disabled

1 = Active

0 = Inactive

PF (Bit 12): PERMANENT FAILURE mode status

1 = Active

0 = Inactive

SS (Bit 11): SAFETY 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 Section 6.9 for details.

EMSHUT (Bit 6): Emergency FET Shutdown

1 = Active

0 = Inactive

FUSE (Bit 5): Fuse status

1 = Active

0 = Inactive

ACTHR (Bit 4): Accumulated charge threshold

1 = Active

0 = Inactive

PCHG (Bit 3): Precharge FET status

1 = Active

0 = Inactive

CHG (Bit 2): CHG FET status

1 = Active

0 = Inactive

DSG (Bit 1): DSG FET status

1 = Active

0 = Inactive

PRES (Bit 0): System present low

1 = Active

0 = Inactive

16.1.41 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**).

16.1.42 ManufacturerAccess() 0x0056 GaugingStatus

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

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

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	PERF_ MODE	RSVD	RSVD	VLB	OCV FR	LDMD	RX	QMax	VDQ

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
NSFM	OCVP RED	SLP QMax	QEN	VOK	R_DIS	RSVD	REST	CF	DSG	EDV	BAL_ EN	TC	TD	FC	FD

RSVD (Bits 39–25): Reserved. Do not use.

PERF_MODE (Bit 24): performance mode

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

0 = Not active when ***DZT Gauging Configuration[PERF_MODE]*** is clear

VLB (Bit 21): Very low battery warning

1 = Detected

0 = Not detected

OCVFR (Bit 20): Open circuit voltage in flat region (during RELAX)

1 = Detected

0 = Not detected

LDMD (Bit 19): LOAD mode

1 = Constant Power

0 = Constant Current

RX (Bit 18): Resistance Update (toggles after every resistance update)

QMax (Bit 17): QMax Update (toggles after every QMax update)

VDQ (Bit 16): Discharge Qualified for Learning (opposite of the R_DIS flag)

1 = Detected

0 = Not detected

NSFM (Bit 15): Negative Scale Factor Mode

1 = Negative Ra Scaling Factor Detected

0 = Negative Ra Scaling Factor Not Detected

OCVPRED (Bit 14): 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 13): OCV update in SLEEP mode

1 = Active. OCV reading in process

0 = Inactive. Completed OCV reading

QEN (Bit 12): Impedance Track™ gauging (Ra and QMax updates are enabled.)

1 = Enabled

0 = Disabled

VOK (Bit 11): 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 10): Resistance updates

1 = Disabled

0 = Enabled

RSVD (Bit 9): Reserved. Do not use.

REST (Bit 8): Rest

1 = OCV reading taken

0 = OCV Rreading not taken or not in RELAX

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

BAL_EN (Bit 4): Cell balancing

1 = Cell balancing is possible if enabled.

0 = Cell balancing is not allowed.

TC (Bit 3): Terminate charge

1 = Detected

0 = Not detected

TD (Bit 2): Terminate discharge

1 = Detected

0 = Not detected

FC (Bits 1): Fully charged

1 = Detected

0 = Not detected

FD (Bit 0): Fully discharged

1 = Detected

0 = Not detected

16.1.43 ManufacturerAccess() 0x0057 ManufacturingStatus

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

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

7	6	5	4	3	2	1	0
BBR_EN	PF_EN	LF_EN	FET_EN	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.

LED_EN (Bit 9): LED display is enabled with the push button.

1 = LED display is on when the push button is pressed.

0 = LED display is off when the push button is pressed.

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

16.1.44 ManufacturerAccess() 0x0058 AFE Register

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

Status	Condition
Activate	0x0058 to *ManufacturerAccess()*

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

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

16.1.45 ManufacturerAccess() 0x005A No Load Rem Cap

This read block returns the equivalent of *RemainingCapacity()* under a no load condition.

1. *RemainingCapacity()* is calculated by the device with compensation based on Load Select (for example, max, average, current last run, and so on).
2. Because the RTC power consumption is expected to be relatively small, the new parameter provides a better representation of how much actual capacity is available when only powering the RTC circuit.

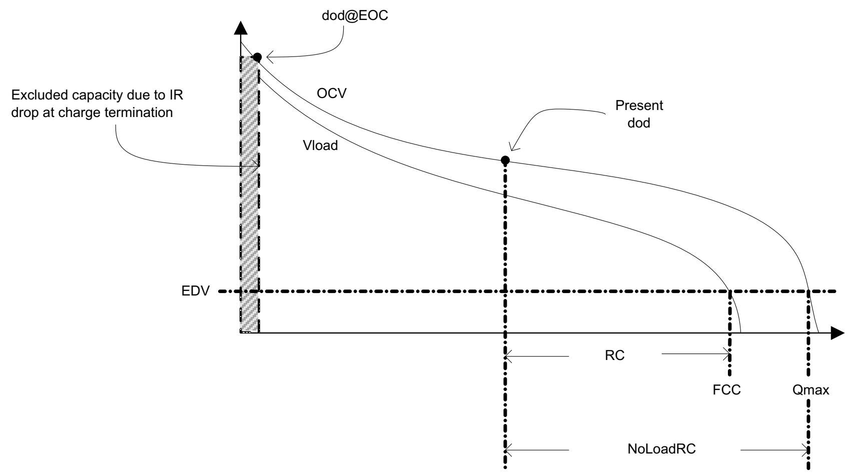

Figure 16-1. No Load

16.1.46 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

16.1.47 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

16.1.48 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	Cell 2 Max Voltage
CCcc	Cell 3 Max Voltage
DDdd	Cell 4 Max Voltage
EEee	Cell 1 Min Voltage
FFff	Cell 2 Min Voltage
GGgg	Cell 3 Min Voltage
HHhh	Cell 4 Min Voltage
IIii	Max Delta Cell Voltage
JJjj	Max Charge Current
KKkk	Max Discharge Current
LLll	Max Avg Dsg Current
MMmm	Max Avg Dsg Power

16.1.49 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	CB Time Cell 2
iHHhhGGgg	CB Time Cell 3
JJjjIIii	CB Time Cell 4

16.1.50 ManufacturerAccess() 0x0062 Lifetime Data Block 3

This command returns the ***Lifetime Data*** with the following format:

aaAAbbBB.

Value	Description
BBbbAAaa	Total FW Runtime

16.1.51 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

Value	Description
DDdd	Last CUV Event
EEee	No. of OCD1 Events
FFff	Last OCD1 Event
GGgg	No. of OCD2 Events
HHhh	Last OCD2 Event
IIii	No. of OCC1 Events
JJjj	Last OCC1 Event
KKkk	No. of OCC2 Events
LLll	Last OCC2 Event
MMmm	No. of AOCD Events
NNnn	Last AOCD Event
OOoo	No. of ASCD Events
PPpp	Last ASCD Event

16.1.52 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

16.1.53 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

16.1.54 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
PPppOOoo	Time Spent In LFT_LT RSOC H

16.1.55 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

16.1.56 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

16.1.57 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

Value	Description
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

16.1.58 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
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

16.1.59 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

16.1.60 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	Max Temp TS2 in RELAX mode
II	Max Temp TS3 in RELAX mode
JJ	Max Temp TS4 in RELAX mode
KK	Min Temp TS1 in RELAX mode

Value	Description
LL	Min Temp TS2 in RELAX mode
MM	Min Temp TS3 in RELAX mode
NN	Min Temp TS4 in RELAX mode
OO	Max Temp TMP468-1 in RELAX mode
PP	Max Temp TMP468-2 in RELAX mode
QQ	Max Temp TMP468-3 in RELAX mode
RR	Max Temp TMP468-4 in RELAX mode
SS	Max Temp TMP468-5 in RELAX mode
TT	Max Temp TMP468-6 in RELAX mode
UU	Max Temp TMP468-7 in RELAX mode
VV	Max Temp TMP468-8 in RELAX mode
XX	Min Temp TMP468-1 in RELAX mode
YY	Min Temp TMP468-2 in RELAX mode
ZZ	Min Temp TMP468-3 in RELAX mode
11	Min Temp TMP468-4 in RELAX mode
22	Min Temp TMP468-5 in RELAX mode
33	Min Temp TMP468-6 in RELAX mode
44	Min Temp TMP468-7 in RELAX mode
55	Min Temp TMP468-8 in RELAX mode

16.1.61 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
GG	Max Temp TS1 in CHARGE mode
HH	Max Temp TS2 in CHARGE mode
II	Max Temp TS3 in CHARGE mode
JJ	Max Temp TS4 in CHARGE mode
KK	Min Temp TS1 in CHARGE mode
LL	Min Temp TS2 in CHARGE mode
MM	Min Temp TS3 in CHARGE mode
NN	Min Temp TS4 in CHARGE mode
OO	Max Temp TMP468-1 in CHARGE mode
PP	Max Temp TMP468-2 in CHARGE mode
QQ	Max Temp TMP468-3 in CHARGE mode
RR	Max Temp TMP468-4 in CHARGE mode
SS	Max Temp TMP468-5 in CHARGE mode
TT	Max Temp TMP468-6 in CHARGE mode
UU	Max Temp TMP468-7 in CHARGE mode
VV	Max Temp TMP468-8 in CHARGE mode
XX	Min Temp TMP468-1 in CHARGE mode
YY	Min Temp TMP468-2 in CHARGE mode
ZZ	Min Temp TMP468-3 in CHARGE mode

Value	Description
11	Min Temp TMP468-4 in CHARGE mode
22	Min Temp TMP468-5 in CHARGE mode
33	Min Temp TMP468-6 in CHARGE mode
44	Min Temp TMP468-7 in CHARGE mode
55	Min Temp TMP468-8 in CHARGE mode

16.1.62 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	Max Temp TS2 in DISCHARGE mode
II	Max Temp TS3 in DISCHARGE mode
JJ	Max Temp TS4 in DISCHARGE mode
KK	Min Temp TS1 in DISCHARGE mode
LL	Min Temp TS2 in DISCHARGE mode
MM	Min Temp TS3 in DISCHARGE mode
NN	Min Temp TS4 in DISCHARGE mode
OO	Max Temp TMP468-1 in DISCHARGE mode
PP	Max Temp TMP468-2 in DISCHARGE mode
QQ	Max Temp TMP468-3 in DISCHARGE mode
RR	Max Temp TMP468-4 in DISCHARGE mode
SS	Max Temp TMP468-5 in DISCHARGE mode
TT	Max Temp TMP468-6 in DISCHARGE mode
UU	Max Temp TMP468-7 in DISCHARGE mode
VV	Max Temp TMP468-8 in DISCHARGE mode
XX	Min Temp TMP468-1 in DISCHARGE mode
YY	Min Temp TMP468-2 in DISCHARGE mode
ZZ	Min Temp TMP468-3 in DISCHARGE mode
11	Min Temp TMP468-4 in DISCHARGE mode
22	Min Temp TMP468-5 in DISCHARGE mode
33	Min Temp TMP468-6 in DISCHARGE mode
44	Min Temp TMP468-7 in DISCHARGE mode
55	Min Temp TMP468-8 in DISCHARGE mode

16.1.63 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

Value	Description
DD	No. of WDT Resets

16.1.64 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

16.1.65 ManufacturerAccess() 0x0071 DAStatus1

This command returns the cell voltages, PACK voltage, BAT voltage, cell currents, cell powers, power, and average power on *ManufacturerBlockAccess()* or *ManufacturerData()*.

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

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

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

16.1.66 ManufacturerAccess() 0x0072 DAStatus2

This command returns the internal temperature sensor, TS1, TS2, TS3, TS4, 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

Value	Description	Unit
CCcc	TS2 Temperature	0.1 K
DDdd	TS3 Temperature	0.1 K
EEee	TS4 Temperature	0.1 K
FFff	Cell Temperature	0.1 K
GGgg	FET Temperature	0.1 K
HHhh	Gauging Temperature	0.1 K
IIii	User Temperature (written by *ManufacturerAccess() 0x3008 WriteTemp()*)	0.1 K
JJjj	Uncompensated Cell Voltage 1	mV
KKkk	Uncompensated Cell Voltage 2	mV
LLll	Uncompensated Cell Voltage 3	mV
MMmm	Uncompensated Cell Voltage 4	mV

16.1.67 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	RaScale 1. Ra table scaling factor of Cell 2	—
KKkk	RaScale 2. Ra table scaling factor of Cell 3	—
LLll	RaScale 3. Ra table scaling factor of Cell 4	—
MMmm	CompRes 0. Last temperature compensated Resistance of Cell 1	2^{-10} Ω
NNnn	CompRes 1. Last temperature compensated Resistance of Cell 2	2^{-10} Ω
OOoo	CompRes 2. Last temperature compensated Resistance of Cell 3	2^{-10} Ω
PPpp	CompRes 3. Last temperature compensated Resistance of Cell 4	2^{-10} Ω

16.1.68 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.	—
HHhhGGgg	State Time. Time passed since the last state change (DISCHARGE, CHARGE, REST)	s
IIii	DOD0_0. Depth of discharge for Cell 1	—
JJjj	DOD0_1. Depth of discharge for Cell 2	—
KKkk	DOD0_2. Depth of discharge for Cell 3	—
LLll	DOD0_3. Depth of discharge for Cell 4	—
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	DODEOC 1. Depth of discharge at end of charge of Cell 2	—
RRrr	DODEOC 2. Depth of discharge at end of charge of Cell 3	—
SSss	DODEOC 3. Depth of discharge at end of charge of Cell 4	—

16.1.69 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	QMax 1. QMax of Cell 2	mAh
CCcc	QMax 2. QMax of Cell 3	mAh
DDdd	QMax 3. QMax of Cell 4	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	QMax DOD0_1. DOD0 saved to be used for next QMax update of Cell 2. The value is only valid when *[VOK]* = 1.	—
GGgg	QMax DOD0_2. DOD0 saved to be used for next QMax update of Cell 3 . The value is only valid when *[VOK]* = 1.	—

Value	Description	Unit
HHhh	QMax DOD0_3. DOD0 saved to be used for next QMax update of Cell 4. The value is only valid when *[VOK]* = 1.	—
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	—

16.1.70 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	Cell balance time 1. Calculated cell balancing time of Cell 2	s
CCcc	Cell balance time 2. Calculated cell balancing time of Cell 3	s
DDdd	Cell balance time 3. Calculated cell balancing time of Cell 4	s
EEee	Cell 1 balance DOD	—
FFff	Cell 1 balance DOD	—
GGgg	Cell 1 balance DOD	—
HHhh	Cell 1 balance DOD	—
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	—

16.1.71 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

16.1.72 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

16.1.73 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.

16.1.74 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

16.1.75 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.

16.1.76 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

Value	Description
NNnnMMmm	Time Spent In LFT_UUT RSOC G
PPppOOoo	Time Spent In LFT_UUT RSOC H

16.1.77 ManufacturerAccess() 0x0081 TMPRead1

This command returns the TMP468 temperature data with the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiII.

Value	Description
AAaa	TMP468 Internal Temperature Sensor
BBbb	TMP468 External Remote Temperature Sensor-1
CCcc	TMP468 External Remote Temperature Sensor-2
DDdd	TMP468 External Remote Temperature Sensor-3
EEee	TMP468 External Remote Temperature Sensor-4
FFff	TMP468 External Remote Temperature Sensor-5
GGgg	TMP468 External Remote Temperature Sensor-6
HHhh	TMP468 External Remote Temperature Sensor-7
IIii	TMP468 External Remote Temperature Sensor-8

16.1.78 ManufacturerAccess() 0x0082 TMPRead2

This command returns the TMP468 internal registers with the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHH.

Value	Description
AAaa	TMP468 Sofware Reset Register
BBbb	TMP468 THERM Status Register
CCcc	TMP468 THERM2 Status Register
DDdd	TMP468 Remote Channel OPEN Status Register
EEee	TMP468 Configuration Register
FFff	TMP468 THERM Hysteresis Register
GGgg	TMP468 Local THERM Limit Register
HHhh	TMP468 Local THERM2 Limit Register

16.1.79 ManufacturerAccess() 0x0083 TMPRead3

This command returns the TMP468 external temperature 1-4 registers with the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
AAaa	TMP468 Remote Temperature 1 Offset Register
BBbb	TMP468 Remote Temperature 1 η-Factor Correction Register
CCcc	TMP468 Remote Temperature 1 THERM Limit Register
DDdd	TMP468 Remote Temperature 1 THERM2 Limit Register
EEee	TMP468 Remote Temperature 2 Offset Register
FFff	TMP468 Remote Temperature 2 η-Factor Correction Register
GGgg	TMP468 Remote Temperature 2 THERM Limit Register
HHhh	TMP468 Remote Temperature 2 THERM2 Limit Register
IIii	TMP468 Remote Temperature 3 Offset Register
JJjj	TMP468 Remote Temperature 3 η-Factor Correction Register
KKkk	TMP468 Remote Temperature 3 THERM Limit Register
LLll	TMP468 Remote Temperature 3 THERM2 limit Register
MMmm	TMP468 Remote temperature 4 Offset Register

Value	Description
NNnn	TMP468 Remote Temperature 4 η-Factor Correction Register
OOoo	TMP468 Remote Temperature 4 THERM Limit Register
PPpp	TMP468 Remote Temperature 4 THERM2 limit Register

16.1.80 ManufacturerAccess() 0x0084 TMPRead4

This command returns the TMP468 external temperature 5-8 registers with the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLLmmMMnnNNooOOppPP.

Value	Description
AAaa	TMP468 Remote Temperature 5 Offset Register
BBbb	TMP468 Remote Temperature 5 η-Factor Correction Register
CCcc	TMP468 Remote Temperature 5 THERM Limit Register
DDdd	TMP468 Remote Temperature 5 THERM2 Limit Register
EEee	TMP468 Remote Temperature 6 Offset Register
FFff	TMP468 Remote Temperature 6 η-Factor Correction Register
GGgg	TMP468 Remote Temperature 6 THERM Limit Register
HHhh	TMP468 Remote Temperature 6 THERM2 Limit Register
IIii	TMP468 Remote Temperature 7 Offset Register
JJjj	TMP468 Remote Temperature 7 η-Factor Correction Register
KKkk	TMP468 Remote Temperature 7 THERM Limit Register
LLll	TMP468 Remote Temperature 7 THERM2 limit Register
MMmm	TMP468 Remote temperature 8 Offset Register
NNnn	TMP468 Remote Temperature 8 η-Factor Correction Register
OOoo	TMP468 Remote Temperature 8 THERM Limit Register
PPpp	TMP468 Remote Temperature 8 THERM2 limit Register

16.1.81 ManufacturerAccess() 0x0085 TMPRead5

This command returns the TMP468 temperature data with the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiII.

Value	Description
AAaa	TMP468 Internal Temperature Sensor (Block Read Range - Auto Increment Pointer Register)
BBbb	TMP468 External Remote Temperature Sensor-1 (Block Read Range - Auto Increment Pointer Register)
CCcc	TMP468 External Remote Temperature Sensor-2 (Block Read Range - Auto Increment Pointer Register)
DDdd	TMP468 External Remote Temperature Sensor-3 (Block Read Range - Auto Increment Pointer Register)
EEee	TMP468 External Remote Temperature Sensor-4 (Block Read Range - Auto Increment Pointer Register)
FFff	TMP468 External Remote Temperature Sensor-5 (Block Read Range - Auto Increment Pointer Register)
GGgg	TMP468 External Remote Temperature Sensor-6 (Block Read Range - Auto Increment Pointer Register)
HHhh	TMP468 External Remote Temperature Sensor-7 (Block Read Range - Auto Increment Pointer Register)
IIii	TMP468 External Remote Temperature Sensor-8 (Block Read Range - Auto Increment Pointer Register)

16.1.82 ManufacturerAccess() 0x0086 TMPRead6

This command returns the TMP468 internal registers with the following format: aaAAbbBBccCC.

Value	Description
AAaa	TMP468 Lock Register. This locks the registers after initialization.
BBbb	TMP468 Manufacturers Identification Register
CCcc	TMP468 Device Identification/Revision Register

16.1.83 ManufacturerAccess() 0x0087 TMPRead7

This command returns the TMP468 temperature data converted into 0.1 K with the following format:

aaAAbbBBccCCddDDeeEEffFFggGGhhHHiiII.

Value	Description
AAaa	TMP468 Internal Temperature Sensor converted to 0.1 K
BBbb	TMP468 External Remote Temperature Sensor-1 converted to 0.1 K
CCcc	TMP468 External Remote Temperature Sensor-2 converted to 0.1 K
DDdd	TMP468 External Remote Temperature Sensor-3 converted to 0.1 K
EEee	TMP468 External Remote Temperature Sensor-4 converted to 0.1 K
FFff	TMP468 External Remote Temperature Sensor-5 converted to 0.1 K
GGgg	TMP468 External Remote Temperature Sensor-6 converted to 0.1 K
HHhh	TMP468 External Remote Temperature Sensor-7 converted to 0.1 K
IIii	TMP468 External Remote Temperature Sensor-8 converted to 0.1 K

16.1.84 ManufacturerAccess() 0x008A TMP Load Config

This command, available in SEALED and UNSEALED modes, is used to reload the TMP468 configuration.

16.1.85 ManufacturerAccess() 0x008B TMP Write Register

This command, available in SEALED and UNSEALED modes, is used to write to the TMP468 register. The first byte is a pointer to TMP468 register and the next two bytes are data.

16.1.86 ManufacturerAccess() 0x0098 AccumulationChargeEnable

This command enables accumulated charge measurement in the CHARGE direction by setting ***[ACCHG_EN]*** .

16.1.87 ManufacturerAccess() 0x0099 AccumulationDischargeEnable

This command enables accumulated charge measurement in the DISCHARGE direction by setting ***[ACDSG_EN]*** .

16.1.88 ManufacturerAccess() 0x009A AccumulationReset

This command resets the accumulated charge and time values, and clears *[ACTHR]* if previously triggered.

16.1.89 ManufacturerAccess() 0x009B AccumulationStop

This command stops the accumulated charge and time accumulation.

16.1.90 ManufacturerAccess() 0x009C AccumulationStart

This command starts the accumulated charge and time accumulation.

16.1.91 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

16.1.92 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

16.1.93 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

16.1.94 ManufacturerAccess() 0x00B0 ChargingVoltageOverride

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

16.1.95 ManufacturerAccess() 0x00B2 ChargingCurrentOverride

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

16.1.96 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

16.1.97 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).

16.1.98 ManufacturerAccess() 0x00F1 IATARm

This command is used in relation to IATA to read out the stored ***IATARm*** value.

16.1.99 ManufacturerAccess() 0x00F2 IATAFcc

This command is used in relation to IATA to read out the stored ***IATAFcc*** value.

16.1.100 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).

16.1.101 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.

16.1.102 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.

16.1.103 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	Cell Voltage 2
DDdd	Cell Voltage 3

Value	Description
EEee	Cell Voltage 4
FFff	PACK Voltage
GGgg	BAT Voltage
HHhh	Cell Current 1
IIii	Cell Current 2
JJjj	Cell Current 3
KKkk	Cell Current 4

16.1.104 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	Cell Voltage 2
DDdd	Cell Voltage 3
EEee	Cell Voltage 4
FFff	PACK Voltage
GGgg	BAT Voltage
HHhh	Cell Current 1
IIii	Cell Current 2
JJjj	Cell Current 3
KKkk	Cell Current 4

16.2 0x01 RemainingCapacityAlarm()

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

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x01	*RemainingCapacityAlarm()*	R/W			Word	U2	0	700	300	mAh cWh

Note

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

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

16.3 0x02 RemainingTimeAlarm()

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

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

16.4 0x03 BatteryMode()

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

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

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

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

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

1 = Reports in 10 mW or cWh

0 = Reports in mA or mAh (default)

CHGM (Bit 14): CHARGER Mode (R)

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)

1 = Disables alarm warning broadcasts to the host and smart battery charger (default)

0 = Enables alarm warning broadcasts to the host and smart battery charger

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

PB (Bit 9): Primary Battery

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 controller enabled

0 = Internal charge controller disabled (default)

CF (Bit 7): Condition Flag (R)

1 = Conditioning cycle requested

0 = Battery OK

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

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

1 = Primary or Secondary Battery Support

0 = Function is not supported. (default)

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

1 = Function is supported.

0 = Function is not supported. (default)

16.5 0x04 AtRate()

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

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

Note

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

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

16.6 0x05 AtRateTimeToFull()

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

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

Note

65535 indicates not being charged.

16.7 0x06 AtRateTimeToEmpty()

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

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

Note

65535 indicates not being discharged.

16.8 0x07 AtRateOK()

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

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

Note

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

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

16.9 0x08 Temperature()

This read-word function returns the temperature in units 0.1 K. The source of this temperature is configured by ***TSx Mode*** and ***[CTEMP1], [CTEMP0]*** bits in the ***DA Configuration*** . This temperature is used for all cell-related protections, permanent fail, and the advanced charging algorithm.

The temperature used for FET-related protections and permanent fail is FET Temperature, configured by the ***TSx Mode*** and ***FTEMP*** bits in ***DA Configuration*** , and is read with *DAStatus2()*.

The temperature used for gauging is Gauging Temperature, configured by the ***[TS1], [TS0]*** bits in the ***IT Gauging Ext*** configuration, and is read with *DAStatus2()*. The recommended configuration for Gauging Temperature is the minimum cell temperature.

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

16.10 0x09 Voltage()

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

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

16.11 0x0A Current()

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

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

16.12 0x0B AverageCurrent()

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

16.13 0x0C MaxError()

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

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

Condition	Action
Full device reset	*MaxError()* = 100%
RA-table only updated	*MaxError()* = 5%
QMax only updated	*MaxError()* = 3%
RA-table and QMax updated	*MaxError()* = 1%
Each *CycleCount()* increment after last valid QMax update	*MaxError()* increment by 0.05%
The ***Configuration:Max Error Time Cycle Equivalent*** period passed since the last valid QMax update	*MaxError()* increment by 0.05%.

16.14 0x0D RelativeStateOfCharge()

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

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

16.15 0x0E AbsoluteStateOfCharge()

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

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

16.16 0x0F RemainingCapacity()

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

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

Note

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

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

16.17 0x10 FullChargeCapacity()

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

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

Note

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

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

16.18 0x11 RunTimeToEmpty()

This read-word function returns the predicted minutes of run time based on the present rate of discharge.

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

Note

65535 = Battery is not being discharged.

16.19 0x12 AverageTimeToEmpty()

This read-word function returns the predicted minutes of run time based on *AverageCurrent()*.

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

Note

65535 = Battery is not being discharged.

16.20 0x13 AverageTimeToFull()

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

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

Note

65535 = Battery is not being charged.

16.21 0x14 ChargingCurrent()

This read-word function returns the desired charging current.

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

Note

65535 = Request maximum current

16.22 0x15 ChargingVoltage()

This read-word function returns the desired charging voltage.

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

Note

65535 = Request maximum voltage

16.23 0x16 BatteryStatus()

This read-word function returns various battery status information.

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

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

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

OCA (Bit 15): Overcharged Alarm

1 = Detected

0 = Not detected

TCA (Bit 14): Terminate Charge Alarm

1 = Detected

0 = Not detected

RSVD (Bit 13): Undefined

OTA (Bit 12): Overtemperature Alarm

1 = Detected

0 = Not detected

TDA (Bit 11): Terminate Discharge Alarm

1 = Detected

0 = Not detected

RSVD (Bit 10): Undefined

RCA (Bit 9): Remaining Capacity Alarm

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

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

RTA (Bit 8): Remaining Time Alarm

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

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

INIT (Bit 7): Initialization

1 = Gauge initialization is complete.

0 = Initialization is in progress.

DSG (Bit 6): Discharging or Relax

1 = Battery is in DISCHARGE or RELAX mode.

0 = Battery is in CHARGE mode.

FC (Bit 5): Fully Charged

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

0 = Battery not fully charged

FD (Bit 4): Fully Discharged

1 = Battery fully depleted

0 = Battery not depleted

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

0x0 = OK

0x1 = Busy

0x2 = Reserved Command

0x3 = Unsupported Command

0x4 = AccessDenied

0x5 = Overflow/Underflow

0x6 = BadSize

0x7 = UnknownError

0x8 = Incomplete

16.24 0x17 CycleCount()

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

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

16.25 0x18 DesignCapacity()

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

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

Note

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

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

16.26 0x19 DesignVoltage()

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

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

16.27 0x1A SpecificationInfo()

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

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

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

IPScale (Bits 15–12): IP Scale Factor

Not supported by the gas gauge

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

VScale (Bits 11–8): Voltage Scale Factor

Not supported by the gas gauge

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

Version (Bits 7–4): Version

0,0,0,1 = Version 1.0

0,0,1,1 = Version 1.1

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

Revision (Bits 3–0): Revision

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

16.28 0x1B ManufacturerDate()

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

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

Note

ManufacturerDate() value in the following format: Day + Month×32 + (Year–1980)×512

16.29 0x1C SerialNumber()

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

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

16.30 0x20 ManufacturerName()

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

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

16.31 0x21 DeviceName()

This read-block function returns the assigned pack name.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x21	*DeviceName()*	R	R	R	Block	S20+1	—	—	BQ41Z50	ASCII

16.32 0x22 DeviceChemistry()

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

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

16.33 0x23 ManufacturerData()

This read-block function returns ***ManufacturerInfo*** by default. The command also returns a response to MAC command in order to maintain compatibility of the MAC system in bq30zxy family.

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

16.34 0x2F Authenticate()

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

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

16.35 0x3C CellVoltage4()

This read-word function returns the Cell 4 voltage.

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

16.36 0x3D CellVoltage3()

This read-word function returns the Cell 3 voltage.

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

16.37 0x3E CellVoltage2()

This read-word function returns the Cell 2 voltage.

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

16.38 0x3F CellVoltage1()

This read-word function returns the Cell 1 voltage.

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

16.39 0x48 GPIORead()

This read-only command returns a 5-bit field, with each bit providing the input level read from each of the 5 pins, which can be configured as GPIOs. The command returns valid data for all pins that are configured as GPIO, including those that are configured to drive an output.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x48	*GPIORead()*	R	R	R	Word	U2	—	65535	0	—

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	RL4_PIN_8	RL3_PIN_7	RL2_PIN4	RL1_PIN_3	RL0_PIN_32

16.40 0x49 GPIOWrite()

This write-only command sets the output drive of each GPIO pin that is configured as a GPIO and enabled as output via ***GPIO_INT Output Enable*** . The data associated with pins not configured as GPIOs and output is not impacted. The command consists of 16-bit field-. The bits 0 to 4 are associated with each GPIO pin. The one bit set the output drive status as: 0 = drive output low; 1 = drive output high.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x49	*GPIOWrite()*	W	W	W	Word	U2	—	65535	0	—

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	RL4_PIN_8	RL3_PIN_7	RL2_PIN_4	RL1_PIN_3	RL0_PIN_32

RSVD (Bits 15–5): Reserved. Do not use.

RL4_PIN_8 (Bits 4): RL4_PIN_8 output drive

1 = Drive output high

0 = Drive output low

RL3_PIN_7 (Bits 3): RL3_PIN_7 output drive

1 = Drive output high

0 = Drive output low

RL2_PIN_4 (Bits 2): RL2_PIN_4 output drive

1 = Drive output high

0 = Drive output low

RL1_PIN_3 (Bits 1): RL1_PIN_3 output drive

1 = Drive output high

0 = Drive output low

RL0_PIN_32 (Bits 1): RL0_PIN_32 output drive

1 = Drive output high

0 = Drive output low

16.41 0x4A BTPDischargeSet()

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. The BTP set threshold is in mAh (RemCap) if *Settings.Configuration.IO Config[BTP_MODE]* is set to 0, and in % (StateOfCharge) if *Settings.Configuration.IO Config[BTP_MODE]* is set to 1.

SBS Cmd	Name	Access			Format	Size in Bytes	Min	Max	Default	Unit
		SE	US	FA						
0x4A	*BTPDischargeSet()*	R/W	R/W	R/W	I2	2	0	32767	150	mAh / %

16.42 0x4B BTPChargeSet()

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. The BTP set threshold is in mAh (RemCap) if *Settings.Configuration.IO Config[BTP_MODE]* is set to 0 and in % (StateOfCharge) if *Settings.Configuration.IO Config[BTP_MODE]* is set to 1.

SBS Cmd	Name	Access			Format	Size in Bytes	Min	Max	Default	Unit
		SE	US	FA						
0x4B	*BTPChargeSet()*	R/W	R/W	R/W	I2	2	0	32767	175	mAh/%

16.43 0x4F StateofHealth()

This read word command returns the SOH information of the battery in percentage of ***Design Capacity*** and ***Design Capacity cWh*** .

16.44 0x50 SafetyAlert()

This command returns the *SafetyAlert()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.45 0x51 SafetyStatus()

This command returns the *SafetyStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.46 0x52 PFAlert()

This command returns the *PFAlert()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.47 0x53 PFStatus()

This command returns the *PFStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.48 0x54 OperationStatus()

This command returns the *OperationStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.49 0x55 ChargingStatus()

This command returns the *ChargingStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.50 0x56 GaugingStatus()

This command returns the *GaugingStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.51 0x57 ManufacturingStatus()

This command returns the *ManufacturingStatus()* flags. For a description of each bit flag, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.52 0x58 AFERegister()

This command returns a snapshot of the AFE register settings. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.53 0x59 MaxTurboPwr()

This command reads the maximal peak power value for 10-ms pulse occurring on top of 10-s 2 C-rate pulse.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x59	*MaxTurboPwr()*	R	R	R	Word	I2	0	32767	na	cW

16.54 0x5A SusTurboPwr()

This command reads the maximal peak power value for 10-s pulse, sustained turbo power, in cW.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x5A	*SusTurboPwr()*	R	R	R	Word	I2	0	32767	na	cW

16.55 0x5B TurboPackR()

This command sets the ***Pack Resistance*** value of the battery pack serial resistance, including resistance associated with FETs, traces, sense resistors, and so on.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x5B	TurboPackR()	R	R/W	R/W	Word	I2	0	32767		mΩ

16.56 0x5C TurboSysR()

This command sets the ***System Resistance*** value of the system serial resistance along the path from the battery to the system power converter input that includes FETs, traces, sense resistors, and so on.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x5C	*TurboSysR()*	R/W	R/W	R/W	Word	I2	0	32767		mΩ

16.57 0x5D TurboEdv()

This command sets the minimal voltage at the system power converter input at which the system will still operate. This command writes to the data flash value ***Min System Voltage*** . It writes it once on the first use to adjust for possible changes in the system design from the time the battery pack was designed.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x5D	*TurboEdv()*	R/W	R/W	R/W	Word	I2	0	32767		mV

16.58 0x5E MaxTurboCurr()

This command reads the maximal peak current value, max turbo current, in mA. The gauge computes a new RAM value of max turbo current every second. Max turbo current is initialized to present the value of max turbo current on reset or power up.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x5E	*MaxTurboCurr()*	R	R	R	Word	I2	0	32767	—	mA

16.59 0x5F SusTurboCurr()

This command reads the sustained peak current value, sustained turbo current, in mA. The gauge computes a new RAM value sustained turbo current every second. Sustained turbo current is initialized to the present value of max turbo current on reset or power up.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x5F	*SusTurboCurr()*	—	R	R	Word	I2	0	32767	—	mA

16.60 0x60 LifetimeDataBlock1()

This command returns the first block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.61 0x61 LifetimeDataBlock2()

This command returns the second block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.62 0x62 LifetimeDataBlock3()

This command returns the third block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.63 0x63 LifetimeDataBlock4()

This command returns the fourth block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.64 0x64 LifetimeDataBlock5()

This command returns the fifth block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.65 0x65 LifetimeDataBlock6()

This command returns the sixth block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x65	*LifeTimeDataBlock6()*	—	R	R	Block	—	—	—	—	—

16.66 0x66 LifetimeDataBlock7()

This command returns the seventh block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x66	*LifeTimeDataBlock7()*	—	R	R	Block	—	—	—	—	—

16.67 0x67 LifetimeDataBlock8()

This command returns the eighth block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x67	*LifeTimeDataBlock8()*	—	R	R	Block	—	—	—	—	—

16.68 0x68 TurboRhfEffective()

This command returns the effective impedance based on the pack's ability to provide currents in the time frame of milliseconds. The value for Rhf of all cells is combined and added to any other non-cell pack resistance, such as ***Pack Resistance*** and ***System Resistance*** . Used in conjunction with *TurboVload()*, this helps to determine which trigger voltage threshold to use so that the system does not fall below its dropout voltage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x68	*TurboRhfEffective()*	R	R	R	Word	I2	0	32767	—	mΩ

16.69 0x69 TurboVload()

The value of *TurboVload()* is taken from the cell model and combined with that of the other cells, as Vload is a parameter modeling the entire pack. *TurboVload()* may be explained as the total voltage the cells would show after providing power for a long period; after all current stops, the voltage is measured about 1 ms afterwards.

Used in conjunction with *TurboRhfEffective()*, this helps to determine which trigger voltage threshold to use so that the system does not fall below its dropout voltage.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x69	*TurboVload()*	R	R	R	Word	I2	0	32767	—	mV

16.70 0x6A LifetimeDataBlock 11()

This command returns the eleventh block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x6A	*LifeTimeDataBlock11()*	—	R	R	Block	—	—	—	—	—

16.71 0x6B LifetimeDataBlock12()

This command returns the twelfth block of ***Lifetime Data*** . For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x6B	*LifeTimeDataBlock12()*	—	R	R	Block	—	—	—	—	—

16.72 0x70 ManufacturerInfo()

This command returns manufacturer information. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.73 0x71 DAStatus1()

This command returns the cell voltages, PACK voltage, BAT voltage, cell currents, cell powers, power, and average power. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.74 0x72 DAStatus2()

This command returns the internal temperature sensor, TS1, TS2, TS3, TS4, and cell, FET, and gauging temperatures. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

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

16.75 0x73 GaugeStatus1()

This command instructs the device to return Impedance Track™ gauging information. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x73	*GaugeStatus1()*	—	R	R	Block	—	—	—	—	—

16.76 0x74 GaugeStatus2()

This command instructs the device to return Impedance Track™ gauging information. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x74	*GaugeStatus2()*	—	R	R	Block	—	—	—	—	—

16.77 0x75 GaugeStatus3()

This command instructs the device to return Impedance Track™ gauging information. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x75	*GaugeStatus3()*	—	R	R	Block	—	—	—	—	—

16.78 0x76 CBStatus()

This command instructs the device to return cell balance time information. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x76	*CBStatus()*	—	R	R	Block	—	—	—	—	—

16.79 0x77 StateofHealth()

This command instructs the device to return the state-of-health full charge capacity and energy. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x77	*StateofHealth()*	—	R	R	Block	—	—	—	—	—

16.80 0x78 FilteredCapacity()

This command instructs the device to return the filtered capacity and energy even if ***[SMOOTH]*** = 0. For a description of returned data values, see the *ManufacturerAccess()* version of the same command in Section 16.1.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit
		SE	US	FA						
0x78	*FilteredCapacity()*	—	R	R	Block	—	—	—	—	—

Chapter 17

Data Flash Values

17.1 Data Formats

17.1.1 Unsigned Integer

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

0
U1 MSB

0	1
U2 LSB	U2 MSB

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

17.1.2 Integer

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

0
I1 MSB

0	1
I2 LSB	I2 MSB

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

17.1.3 Floating Point

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

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

Where:

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

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

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

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

17.1.4 Hex

Bit register definitions are stored in unsigned integer format.

17.1.5 String

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

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

17.2 Calibration

17.2.1 Cell 1..4 Interconnect Resistance

17.2.1.1 Cell 1 Interconnect Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Interconnect Resistance	Cell 1	I2	0	1000	0	mΩ

Description: This is the interconnect resistance value entered by the user that represents the interconnect resistance between the negative rail and the bottom of Cell 1, plus the interconnect resistance of the connection from the bottom of the first cell to the gauge. The measured *CellVoltage1()* is compensated for the voltage drop introduced by this resistance.

17.2.1.2 Cell 2 Interconnect Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Interconnect Resistance	Cell 2	I2	0	1000	0	mΩ

Description: This is the interconnect resistance value entered by the user that represents the interconnect resistance between the top of Cell 1 and the bottom of the Cell 2, plus the interconnect resistance of the connection from the bottom of Cell 2 to the gauge. The measured *CellVoltage2()* is compensated for the voltage drop introduced by this resistance.

17.2.1.3 Cell 3 Interconnect Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Interconnect Resistance	Cell 3	I2	0	1000	0	mΩ

Description: This is the interconnect resistance value entered by the user that represents the interconnect resistance between the top of Cell 2 and the bottom of the Cell 3, plus the interconnect resistance of the connection from the bottom of Cell 3 to the gauge. The measured *CellVoltage3()* is compensated for the voltage drop introduced by this resistance.

17.2.1.4 Cell 4 Interconnect Resistance

Class	Subclass	Name	Type	Min	Max	Default	Unit
Calibration	Interconnect Resistance	Cell 4	I2	0	1000	0	mΩ

Description: This is the interconnect resistance value entered by the user that represents the interconnect resistance between the top of Cell 3 and the bottom of the Cell 4, plus the interconnect resistance of the connection from the bottom of Cell 4 to the gauge. The measured *CellVoltage4()* is compensated for the voltage drop introduced by this resistance.

17.3 Settings

17.3.1 Configuration

17.3.1.1 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	PCHG_COMM

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

1 = PACK voltage

0 = Battery stack voltage

SLEEPCHG (Bit 6): CHG FET enabled during sleep

1 = CHG FET remains on during sleep

0 = CHG FET off during sleep (default)

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

1 = Charging and Precharging disabled, FET off

0 = FET active (default)

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

1 = Charging and Precharging disabled, FETs off

0 = FET active (default)

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

1 = Charging and Precharging disabled, FETs off

0 = FET active (default)

OTFET (Bit 2): FET action in OVERTEMPERATURE mode

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

0 = No FET action for overtemperature condition (default)

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

PCHG_COMM (Bit 0): Precharge FET selection

1 = CHG FET

0 = PCHG FET (default)

17.3.1.2 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)

17.3.1.3 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 BQ41Z50 device will clock stretch (up to the timeout for SMBus devices) during flash operations.

0 = The BQ41Z50 device will NACK any SMBus engine interrupt that occurs during a flash operation (program or erase).

Note: There is some potential for read errors with this bit. For example, when the master is reading data from the device, there is no NACK from the gauge; therefore, the "NACK" in the hardware releases the bus without writing new data to the SMBDA register, which means the read is whatever is present at the time. PECs should catch this error.

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)

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)

17.3.1.4 Auth Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Auth Config	H1	0x0	0x0C	0x00	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	DF_READ_EN	SHA1_ SECURE	RSVD	RSVD

RSVD (Bits 7–4): Reserved. Do not use.

DF_READ_ON (Bit 3): Enables data flash read in SEALED mode

1 = Enables data flash read in SEALED mode

0 = data flash read in SEALED mode not allowed (default)

SHA1_SECURE (Bit 2): Enables secure memory usage for encryption key storage

1 = Enables secure memory usage

0 = Disables secure memory usage

RSVD (Bits 1–0): Reserved. Do not use.

17.3.1.5 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	RSVD	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 (Bits 15–14): Reserved. Do not use.

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

17.3.1.6 IO Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	IO Config	H2	0x0	0x001F	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): GPIO control during permanent failure

1 = Enabled

0 = Disabled

GPIO_EN (Bit 3): GPIO Mode Enable

1 = Enabled

0 = Disabled

RSVD (Bit 2): Reserved. Do not use.

BTP_POL (Bit 1): Controls polarity of the BTP pin

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

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

BTP_EN (Bit 0): 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).

17.3.1.7 GPIO Sealed Access Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	GPIO Sealed Access Config	H2	0x0000	0x000F	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	LEDCNTLC_PIN22	LEDCNTLB_PIN21	LEDCNTLA_PIN20	DISP_PIN17

RSVD (Bits 15–4): Reserved. Do not use.

LEDCNTLC_PIN22 (Bit 3): LEDCNTLC (Pin 22) SEALED mode access

1 = Enabled

0 = Disabled

LEDCNTLB_PIN21 (Bit 2): LEDCNTLB (Pin 21) SEALED mode access

1 = Enabled

0 = Disabled

LEDCNTLA_PIN20 (Bit 1): LEDCNTLA (Pin 20) SEALED mode access

1 = Enabled

0 = Disabled

DISP_PIN17 (Bit 0): $\overline{\text{DISP}}$ (Pin 17) SEALED mode access

1 = Enabled

0 = Disabled

17.3.1.8 LED Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	LED Configuration	H2	0x0	0x0FFF	0x00D0	Hex

15	14	13	12	11	10	9	8
RSVD	RSVD	RSVD	RSVD	LED ONFC	BLINK MIDPT	LEDIF CUV	LED PFON

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

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

LEDONFC (Bit 11): Enables the LED display to stay on showing charge even after full charge (FC) has been achieved. With this bit set, the LED will stay on after FC until the ***LED FC Time*** has expired.

1 = Enables LED display functionality after FC until the ***LED FC Time*** has expired

0 = Disables LED display after FC

BLINKMIDPT (Bit 10): Enables LED blinking until the midpoint of each LED segment. The blinking occurs between the bottom and the midway point of each programmed segment level; thus, providing more granularity as to where the charge level is within that LED segment.

1 = Enables LED blinking until the midway point of each segment charge levels

0 = Disables LED blinking

LEDIFCUV (Bit 9): Enables LED display functionality even under CUV conditions without a charger connected (no charging occurring). This option should be used with care so as to not discharge the battery too low.

1 = Enables LED display functionality even under CUV conditions without a charger connected

0 = Disables LED display functionality even under CUV conditions without a charger connected

LEDPFON (Bit 8): LED in PF Mode Enable

1 = Display available in PF Mode

0 = Display not available in PF mode (default)

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

0, 0 = 0.94-mA average LED current

0, 1 = 1.87-mA average LED current

1, 0 = 2.81-mA average LED current

1, 1 = 3.75-mA average LED current (default)

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

0, 0 = PF Error Code not available

0, 1 = PF Error Code shown after SOC if $\overline{\text{DISP}}$ is held low for LED Hold Time (default)

1, 0 = PF Error code shown if the $\overline{\text{DISP}}$ button is pressed (high-to-low transition of the pin is detected).

1, 1 = PF Error Code shown after SOC

LEDMODE (Bit 3): LED Display Capacity Selector

1 = Display ASOC/DC

0 = Display RSOC (default)

LEDCHG (Bit 2): LED Display During Charging

1 = Enabled

0 = Disabled

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

1 = Enabled

0 = Disabled

LEDR (Bit 0): LED Display activation at exit of device reset

1 = Enabled

0 = Disabled

17.3.1.9 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)

17.3.1.10 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)

17.3.1.11 Balancing Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Balancing Configuration	H2	0x0	0x00FF	0x0001	Hex

7	6	5	4	3	2	1	0
CBV_REST	CBV	CBS	CB_RLX_DOD0EW	CB_CHG_DOD0EW	CBR	CBM	CB

CBV_REST (Bits 7): Enables voltage based cell balancing in REST mode

1 = Enables voltage based cell balancing while the device is in REST mode

0 = Disables voltage based cell balancing while the device is in REST mode (default)

CBV (Bit 6): Enables voltage based or state-of-charge based cell balancing

1 = Enables voltage based cell balancing

0 = Enables state-of-charge based cell balancing (default)

CBS (Bit 5): Cell balancing in sleep

1 = Enables CBS

0 = Disables CBS

CB_RLX_DOD0EW (Bit 4):

1 = Uses Error Weighted DOD0 for cell balancing time updates when in RELAX mode

0 = Uses DOD0 for cell balancing time updates when in RELAX mode

CB_CHG_DOD0EW (Bit 3):

1 = Uses Error Weighted DOD0 for cell balancing time updates when in CHARGE mode

0 = Uses DOD0 for cell balancing time updates when in CHARGE mode

CBR (Bit 2): Cell balancing at rest

1 = Enables cell balancing at rest

0 = Disables cell balancing at rest (default)

CBM (Bit 1): Internal versus external cell balancing

1 = Enables external cell balancing

0 = Enables internal cell balancing (default)

CB (Bit 0): Cell balancing

1 = Cell balancing enabled (default)

0 = Cell balancing disabled

17.3.1.12 IT Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	IT Gauging Configuration	H2	0x0000	0xFFFF	0xD0FE	Hex

15	14	13	12	11	10	9	8
DOD_R SCALE_EN	RELAX_ SMOOTH_OK	TDELTAV	SMOOTH	RELAX_ JUMP_OK	DELAY_ DROP_TO_0	CELL_TERM	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)

CELL_TERM (Bit 9): Cell Based Termination

1 = Cell based termination

0 = Stack voltage based termination (default)

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)

17.3.1.13 IT Gauging Ext

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	IT Gauging Ext	H2	0x0000	0x01FF	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 are used in conjunction to select which one of the individual temperature sensors (TS 1…4) is used by the IT algorithm.

1,1 = Not used

1,0 = Min Temperature is used (IT uses the temperature sensor with the lowest temperature)

0,1 = Avg Temperature is used (IT uses the average temperature of all 4 temperature sensors)

0,0 = Max Temperature is used (IT uses the temperature sensor with the highest temperature). (Default)

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%

17.3.1.14 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)

17.3.1.15 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	MaxLifeEn	ChgCurrReduceEn	SLOW_CRATE	CELL_VAL1	CELL_VAL0

RSVD (Bit 7–5): Reserved. Do not use.

MaxLifeEn (Bit 4): Enables MaxLife feature

1 = Enable MaxLife

0 = Disable MaxLife

ChgCurrReduceEn (Bit 3): Enables Charging Current Reduction in MaxLife

1 = Enable Charging Current Reduction Function

0 = Disable Charging Current Reduction Function

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

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)

17.3.1.16 Temperature Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Temperature Enable	H1	0x00	0x3F	0x06	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	USER_TS	TS4	TS3	TS2	TS1	TSint

RSVD (Bits 7–6): Reserved. Do not use.

USER_TS (Bit 5): Enables User TS

1 = Eanbles USER_TS

0 = Disables USER_TS (default)

TS4 (Bit 4): Enables TS4

1 = Enables TS4

0 = Disables TS4 (default)

TS3 (Bit 3): Enables TS3

1 = Enables TS3

0 = Disables TS3 (default)

TS2 (Bit 2): Enables TS2

1 = Enables TS2 (default)

0 = Disables TS2

TS1 (Bit 1): Enables TS1

1 = Enables TS1 (default)

0 = Disables TS1

TSint (Bit 0): Enables internal TS

1 = Enables internal TS

0 = Disables internal TS (default)

17.3.1.17 Ext TMP Temperature Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Ext TMP Temperature Enable	H1	0x00	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0

RS8	RS7	RS6	RS5	RS4	RS3	RS2	RS1

RS8 (Bit 7): Enable TMP468 Remote sensor RS8

1 = Enables TMP468 Remote sensor RS8 (default)

0 = Disables TMP468 Remote sensor RS8

RS7 (Bit 6): Enable TMP468 Remote sensor RS7

1 = Enables TMP468 Remote sensor RS7 (default)

0 = Disables TMP468 Remote sensor RS7

RS6 (Bit 5): Enable TMP468 Remote sensor RS6

1 = Enables TMP468 Remote sensor RS6 (default)

0 = Disables TMP468 Remote sensor RS6

RS5 (Bit 4): Enable TMP468 Remote sensor RS5

1 = Enables TMP468 Remote sensor RS5 (default)

0 = Disables TMP468 Remote sensor RS5

RS4 (Bit 3): Enable TMP468 Remote sensor RS4

1 = Enables TMP468 Remote sensor RS4 (default)

0 = Disables TMP468 Remote sensor RS4

RS3 (Bit 2): Enable TMP468 Remote sensor RS3

1 = Enables TMP468 Remote sensor RS3 (default)

0 = Disables TMP468 Remote sensor RS3

RS2 (Bit 1): Enable TMP468 Remote sensor RS2

1 = Enables TMP468 Remote sensor RS2 (default)

0 = Disables TMP468 Remote sensor RS3

RS1 (Bit 0): Enable TMP468 Remote sensor RS1

1 = Enables TMP468 Remote sensor RS1 (default)

0 = Disables TMP468 Remote sensor RS1

17.3.1.18 Temperature Mode

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Temperature Mode	H1	0x00	0x3F	0x04	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	USER_TS Mode	TS4 Mode	TS3 Mode	TS2 Mode	TS1 Mode	TSInt Mode

RSVD (Bits 7–6): Reserved. Do not use.

USER_TS Mode (Bit 5): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

TS4 Mode (Bit 4): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

TS3 Mode (Bit 3): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

TS2 Mode (Bit 2): Cell temperature or FET temperature

1 = FET temperature (default)

0 = Cell temperature

TS1 Mode (Bit 1): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

TSInt Mode (Bit 0): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

17.3.1.19 Ext TMP Temperature Mode

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	Ext TMP Temperature Mode	H1	0x00	0xFF	0x04	Hex

7	6	5	4	3	2	1	0
RS8 Mode	RS7 Mode	RS6 Mode	RS5 Mode	RS4 Mode	RS3 Mode	RS2 Mode	RS1 Mode

RS8 Mode (Bit 7): Cell temperature or FET temperature

1= FET temperature

0 = Cell temperature (default)

RS7 Mode (Bit 6): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

RS6 Mode (Bit 6): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

RS5 Mode (Bit 4): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

RS4 Mode (Bit 3): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

RS3 Mode (Bit 2): Cell temperature or FET temperature

1 = FET temperature (default)

0 = Cell temperature

RS2 Mode (Bit 1): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

RS1 Mode (Bit 0): Cell temperature or FET temperature

1 = FET temperature

0 = Cell temperature (default)

17.3.1.20 DA Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Configuration	DA Configuration	H2	0x0	0xFFFF	0x0012	Hex

15	14	13	12	11	10	9	8
CTEMP1	CTEMP0	RSVD	RSVD	RSVD	RSVD	TMP468_EN	EMSHUT_ PEXIT_DIS

7	6	5	4	3	2	1	0
FTEMP	DISCONN_EN	EMSHUT_EN	SLEEP	IN_SYSTEM _SLEEP	NR	CC1	CC0

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

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

TMP468_EN (Bit 9): Enables external temperature device TMP468

1 = Enables TMP468

0 = Disabled TMP468 (default 0)

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 = Enables

0 = Disables

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

0 = Disables (default)

NR (Bit 2): Use $\overline{\text{PRES}}$ in system detection

1 = NON-REMOVABLE mode

0 = Use $\overline{\text{PRES}}$, REMOVABLE mode (default)

CC1, CC0 (Bit 1,0): Cell Count

1,1 = 4 cells

1,0 = 3 cells (default)

0,1 = 2 cells

0,0 = 1 cell

17.3.1.21 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

17.3.1.22 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

17.3.2 Flag Map

17.3.2.1 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

17.3.2.2 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	The flag mapped to a GPIO pin
3 =	LEDCNTLA (Pin 3)
4 =	LEDCNTLB (Pin 4)
5 =	$\overline{\text{ALERT}}$ (Pin 5)
6 =	GPIO3 (Pin 6)
7 =	$\overline{\text{PRES/SHUTDN}}$ (Pin 7)
8 =	LEDCNTLC (Pin 8)
9 =	GPIO1 (Pin 9)
10 =	GPIO2 (pin 10)
32 =	$\overline{\text{DISP}}$ (pin 32)

17.3.2.3 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

17.3.2.4 Set Up 2 Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 2 Pin Number	U1	0x00	0xFF	0x00	#

Value	The flag mapped to a GPIO pin
3 =	LEDCNTLA (Pin 3)
4 =	LEDCNTLB (Pin 4)
5 =	$\overline{\text{ALERT}}$ (Pin 5)
6 =	GPIO3 (Pin 6)
7 =	$\overline{\text{PRES/SHUTDN}}$ (Pin 7)
8 =	LEDCNTLC (Pin 8)
9 =	GPIO1 (Pin 9)
10 =	GPIO2 (pin 10)
32 =	$\overline{\text{DISP}}$ (pin 32)

17.3.2.5 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

17.3.2.6 Set Up 3 Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 3 Pin Number	U1	0x00	0xFF	0x00	#

Value	The flag mapped to a GPIO pin
3 =	LEDCNTLA (Pin 3)
4 =	LEDCNTLB (Pin 4)
5 =	ALERT (Pin 5)
6 =	GPIO3 (Pin 6)
7 =	PRES/SHUTDN (Pin 7)
8 =	LEDCNTLC (Pin 8)
9 =	GPIO1 (Pin 9)
10 =	GPIO2 (pin 10)
32 =	DISP (pin 32)

17.3.2.7 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

17.3.2.8 Set Up 4 Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Flag Map	Set Up 4 Pin Number	U1	0x00	0xFF	0x00	#

Value	The flag mapped to a GPIO pin
3 =	LEDCNTLA (Pin 3)
4 =	LEDCNTLB (Pin 4)
5 =	$\overline{\text{ALERT}}$ (Pin 5)
6 =	GPIO3 (Pin 6)
7 =	$\overline{\text{PRES/SHUTDN}}$ (Pin 7)
8 =	LEDCNTLC (Pin 8)
9 =	GPIO1 (Pin 9)
10 =	GPIO2 (pin 10)
32 =	$\overline{\text{DISP}}$ (pin 32)

17.3.3 GPIO

17.3.3.1 Pres Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Pres Pin Number	U1	0	255	7	—

Description: Package pin number used for system pres pin.

17.3.3.2 Disconnect Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Disconnect Pin Number	U1	0	255	7	—

Description: Package pin number used for disconnect pin.

17.3.3.3 Emergency Shutdown Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Emergency Shutdown Pin Number	U1	0	255	7	—

Description: Package pin number used for ESHUT pin.

17.3.3.4 BTP Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	BTP Pin Number	U1	0	255	6	—

Description: Package pin number used for BTP interrupts.

17.3.3.5 BTP Pin Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	BTP Pin Config	H1	0x0	0x3F	0x32	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	OUT_VAL	PUSH_PULL	RSVD	RSVD	ACTIVE_HI	RSVD

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

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

OUT_VAL (Bit 5): Initial output value (if pin is an output)

1 = Initial output is high (default)

0 = Initial output is low

PUSH_PULL (Bit 4): If pin is an output, enable push pull.

1 = Driven high/low (default)

0 = Open Drain

RSVD (Bit 3 - 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.

17.3.3.6 Display Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Display Pin Number	U1	0	255	32	—

Description: Package pin number used for LED display.

17.3.3.7 Display Pin Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Display Pin Config	H1	0x0	0x02	0x02	Hex

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

RSVD (Bit 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.

17.3.3.8 GPIO_PF Pin Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_PF Pin Number	U1	0	255	9	—

Description: Package pin number used for indicating PF on GPIO.

17.3.3.9 LED Pins Mask

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	LED Pins Mask	H1	0x0	0x1F	0x16	—

Description: Mask of which pins are being used as LED.

- PIN8_LEDRL4 = 0x10
- PIN4_LEDRL2 = 0x04
- PIN3_LEDRL1 = 0x02
-

Note

The register selects pins in the RL port which are assigned to the LED display. Pins are not required to be sequential in the mask. For example setting ***LED Pins Mask*** to 0x16 would assign three pins (RL1, RL2 and RL4) as LED outputs, leaving RL0 and RL3 for other functions. The three pins assigned to LED's would still be referred to as LED1, LED2 and LED3. Note that the thresholds for the display should be set appropriately for the number of LED pins selected. LED outputs are always driven low to turn on the LED. The brightness configuration of the LEDs is done via ***LEDC1*** and ***LEDC0*** under ***Settings.Configuration.LED Configuration*** , which set a limit on the sinking current.

17.3.3.10 GPIO_INT Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_INT Enable	H1	0x0	0x1F	0x1F	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RL4_PIN_8_EN	RL3_PIN_7	RL2_PIN_4	RL1_PIN_3	RL0_PIN_32

RSVD (Bit 7-5): Reserved. Do not use.

RL4_PIN_8_EN (Bit 4): Initial function of RL4_PIN_8

1 = Enabled for GPIO (default)

0 = Disabled for GPIO

RL3_PIN_7 (Bit 3): Initial function of RL3_PIN_7

1 = Enabled for GPIO (default)

0 = Disabled for GPIO

RL2_PIN_4 (Bit 2): Initial function of RL2_PIN_4

1 = Enabled for GPIO (default)

0 = Disabled for GPIO

RL1_PIN_3 (Bit 1): Initial function of RL1_PIN_3

1 = Enabled for GPIO (default)

0 = Disabled for GPIO

RL0_PIN_32 (Bit 0): Initial function of RL0_PIN_32

1 = Enabled for GPIO (default)

0 = Disabled for GPIO

17.3.3.11 GPIO_INT Output Enable

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_INT Output Enable	H1	0x0	0x1F	0x1F	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RL4_PIN_8_EN	RL3_PIN_7	RL2_PIN_4	RL1_PIN_3	RL0_PIN_32

RSVD (Bit 7-5): Reserved. Do not use.

RL4_PIN_8_EN (Bit 4): Initial direction of RL4_PIN_8

1 = Enabled for output (default)

0 = Disabled for output. The pin read as inpubt using pulsed pull up

RL3_PIN_7 (Bit 3): Initial direction of RL3_PIN_7

1 = Enabled for output (default)

0 = Disabled for output. The pin read as inpubt using pulsed pull up

RL2_PIN_4 (Bit 2): Initial direction of RL2_PIN_4

1 = Enabled for output (default)

0 = Disabled for output. The pin read as inpubt using pulsed pull up

RL1_PIN_3 (Bit 1): Initial direction of RL1_PIN_3

1 = Enabled for output (default)

0 = Disabled for output. The pin read as inpubt using pulsed pull up

RL0_PIN_32 (Bit 0): Initial direction of RL0_PIN_32

1 = Enabled for output (default)

0 = Disabled for output. The pin read as inpubt using pulsed pull up

17.3.3.12 GPIO_INT Default Out

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	GPIO_INT Default Out	H1	0x0	0x1F	0x1F	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RL4_PIN_8_EN	RL3_PIN_7	RL2_PIN_4	RL1_PIN_3	RL0_PIN_32

RSVD (Bit 7-5): Reserved. Do not use.

RL4_PIN_8_EN (Bit 4): Initial value of RL4_PIN_8 (if it is an enabled output by ***GPIO_INT Output Enable***)

1 = Initial output is high (default)

0 = Initial output is low

RL3_PIN_7 (Bit 3): Initial value of RL3_PIN_7 (if it is an enabled output by ***GPIO_INT Output Enable***)

1 = Initial output is high (default)

0 = Initial output is low

RL2_PIN_4 (Bit 2): Initial value of RL2_PIN_4 (if it is an enabled output by ***GPIO_INT Output Enable***)

1 = Initial output is high (default)

0 = Initial output is low

RL1_PIN_3 (Bit 1): Initial value of RL1_PIN_3 (if it is an enabled output by ***GPIO_INT Output Enable***)

1 = Initial output is high (default)

0 = Initial output is low

RL0_PIN_32 (Bit 0): Initial value of RL0_PIN_32 (if it is an enabled output by ***GPIO_INT Output Enable***)

1 = Initial output is high (default)

0 = Initial output is low

17.3.3.13 Sealed Access Config

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	GPIO	Sealed Access Config	H1	0x0	0x1F	0x1F	Hex

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RL4_PIN_8_EN	RL3_PIN_7	RL2_PIN_4	RL1_PIN_3	RL0_PIN_32

RSVD (Bit 7-5): Reserved. Do not use.

RL4_PIN_8_EN (Bit 4): RL4_PIN_8 SEALED mode access

1 = Enabled (default)

0 = Disabled

RL3_PIN_7 (Bit 3): RL3_PIN_7 SEALED mode access

1 = Enabled (default)

0 = Disabled

RL2_PIN_4 (Bit 2): RL2_PIN_4 SEALED mode access

1 = Enabled (default)

0 = Disabled

RL1_PIN_3 (Bit 1): RL1_PIN_3 SEALED mode access

1 = Enabled (default)

0 = Disabled

RL0_PIN_32 (Bit 0): RL0_PIN_32 SEALED mode access

1 = Enabled (default)

0 = Disabled

17.3.4 Fuse

17.3.4.1 Permanent Fail Fuse A

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse A	H1	0x00	0xFF	0x00	—

7	6	5	4	3	2	1	0
QIM	SOTF	RSVD	SOT	SOCD	SOCC	SOV	SUV

Fuse blow action for *PFStatus()* bits:

QIM (Bit 7): QMax Imbalance

1 = Enabled

0 = Disabled (default)

SOTF (Bit 6): Safety Overtemperature FET

1 = Enabled

0 = Disabled (default)

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

SOT (Bit 4): Safety Overtemperature

1 = Enabled

0 = Disabled (default)

SOCD (Bit 3): Safety Overcurrent in Discharge

1 = Enabled

0 = Disabled (default)

SOCC (Bit 2): Safety Overcurrent in Charge

1 = Enabled

0 = Disabled (default)

SOV (Bit 1): Safety Cell Overvoltage

1 = Enabled

0 = Disabled (default)

SUV (Bit 0): Safety Cell Undervoltage

1 = Enabled

0 = Disabled (default)

17.3.4.2 Permanent Fail Fuse B

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse B	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0

RSVD	RSVD	RSVD	VIMA	VIMR	CD	IMP	CB

Fuse blow action for *PFStatus()* bits:

RSVD (Bits 7–5): Reserved. Do not use.

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)

17.3.4.3 Permanent Fail Fuse C

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse C	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0
NTC	2LVL	AFEC	AFER	FUSE	RSVD	DFETF	CFETF

Fuse blow action for *PFStatus()* bits:

NTC (Bit 7): Permanent Fail Flag Display

1 = Enables ***PFStatus[NTC]*** = 1 when NTC fault is triggered.

0 = Disables ***PFStatus[NTC]*** = 1 when NTC fault is triggered.

2LVL (Bit 6): 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 = Disabled (default)

FUSE (Bit 3): Fuse input to indicate a chemical fuse failure

1 = Enabled

0 = Disabled (default)

RSVD (Bit 2): Reserved. Do not use.

DFETF (Bit 1): Discharge FET

1 = Enabled

0 = Disabled (default)

CFETF (Bit 0): Charge FET

1 = Enabled

0 = Disabled (default)

17.3.4.4 Permanent Fail Fuse D

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Permanent Fail Fuse D	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0
TS4	TS3	TS2	TS1	RSVD	DFW	FORCE	RSVD

Fuse blow action for *PFStatus()* bits:

TS4 (Bit 7)

1 = Enabled

0 = Disabled (default)

TS3 (Bit 6)

1 = Enabled

0 = Disabled (default)

TS2 (Bit 5)

1 = Enabled

0 = Disabled (default)

TS1 (Bit 4)

1 = Enabled

0 = Disabled (default)

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

DFW (Bit 2): DF wearout

1 = Enabled

0 = Disabled (default)

FORCE (Bit 1): Manual PF

1 = Enabled

0 = Disabled (default)

RSVD (Bit 0)

17.3.4.5 Min Blow Fuse Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Min Blow Fuse Voltage	I2	0	32767	3500	mV

Description: Minimum voltage required to attempt fuse blow, pack based, FET failures bypass this requirement to blow the fuse

17.3.4.6 Fuse Blow Timeout

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	Fuse Blow Timeout	U1	0	255	30	s

Description: Time to keep the fuse blow voltage high

17.3.4.7 GPIO Timeout

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Fuse	GPIO Timeout	U2	0	65535	30	s

Description: Time to keep the GPIO control during permanent failure asserted. Set to 0 to disable timeout.

17.3.5 BTP

17.3.5.1 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.

17.3.5.2 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.

17.3.5.3 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.

17.3.5.4 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.

17.3.6 Sealed Access

17.3.6.1 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

17.3.6.2 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.

17.3.7 Lifetimes

17.3.7.1 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

17.3.7.2 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

17.3.7.3 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

17.3.7.4 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

Class	Subclass	Name	Type	Min	Max	Default	Unit
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.

17.3.8 Protection

17.3.8.1 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)

17.3.8.2 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	AOCD	OCD2	OCD1	OCC2	OCC1	COV	CUV

AOCDL (Bit 7): Overload in Discharge latch

1 = Enabled (default)

0 = Disabled

AOCD (Bit 6): Overload in Discharge

1 = Enabled (default)

0 = Disabled

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

17.3.8.3 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
DCOT	CUVC	OTD	OTC	ASCDL	ASCD	AOCCL	AOCC

DCOT (Bit 7): Delta cell overtemperature

1 = Enabled (default)

0 = Disabled

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

ASCD (Bit 2): Short circuit in discharge

1 = Enabled (default)

0 = Disabled

AOCCL (Bit 1): Short circuit in charge latch

1 = Enabled (default)

0 = Disabled

AOCC (Bit 0): Short circuit in charge

1 = Enabled (default)

0 = Disables the *SafetyAlert()* and *SafetyStatus()* flag only and does NOT disable the FET actions.

17.3.8.4 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

17.3.8.5 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

RSVD	RSVD	OCDL	COVL	UTD	UTC	PCHGC	CHGV

RSVD (Bits 7–6): Reserved. Do not use.

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

17.3.9 Permanent Failure

17.3.9.1 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)

17.3.9.2 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)

17.3.9.3 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	FUSE	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)

FUSE (Bit 3): Fuse

1 = Enabled

0 = Disabled (default)

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)

17.3.9.4 Enabled PF D

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Permanent Failure	Enabled PF D	H1	0x00	0xFF	0x00	Hex

7	6	5	4	3	2	1	0
TS4	TS3	TS2	TS1	RSVD	RSVD	FORCE	RSVD

TS4 (Bit 7)

1 = Enabled (default)

0 = Disabled

TS3 (Bit 6)

1 = Enabled (default)

0 = Disabled

TS2 (Bit 5)

1 = Enabled (default)

0 = Disabled

TS1 (Bit 4)

1 = Enabled (default)

0 = Disabled

RSVD (Bits 3–2): Reserved. Do not use.

FORCE (Bit 1): Manual PF. See *Manual Permanent Failure* for more information.

1 = Enabled (default)

0 = Disabled

RSVD (Bit 0): Reserved. Do not use.

17.3.10 AFE

17.3.10.1 OCC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCC	H1	0x0	0x7F	0x03	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 2mV * SC_OCC_SEL.

17.3.10.2 OCD1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD1	H1	0x0	0x7F	0x03	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 1. AOCD1 Voltage Threshold is -2mV * SC_OCD1_SEL.

17.3.10.3 OCD2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD2	H1	0x0	0x7F	0x04	Hex

7	6	5	4	3	2	1	0
RSVD	SC_OCD2_SEL						

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

SC_OCD2_SEL (Bits 6-0): Voltage threshold for overcurrent in discharge 2. AOCD2 Voltage threshold is -2mV * SC_OCD2_SEL.

17.3.10.4 Short Circuit Discharge

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Short Circuit Discharge	H1	0x0	0x7F	0x64	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 Voltage Threshold is -2.5mV * SC_SCD_SEL.

17.3.10.5 Over Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Over Temperature	U1	0	0x7F	0x5A	Hex

7	6	5	4	3	2	1	0
RSVD	SC_TEMP_SEL						

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

SC_TEMP_SEL (Bits 6-0): Threshold for HW Over Temperature function. R_{NTC_TS3} * 6 /(SC_TEMP_SEL - 6). R_{NTC_TS3} is the internal pullup resistance. The typical value is 18 kΩ.

17.3.10.6 Current Discharge Wake

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Current Discharge Wake	H1	0x70	0x7F	0x79	Hex

7	6	5	4	3	2	1	0
RSVD	SC_CD_WAKE_SEL_MSB			SC_CD_WAKE_SEL_LSB			

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

SC_CD_WAKE_SEL_MSB (Bits 6-4): These bits are used to set the voltage threshold of current discharge wake used by SC_CD_WAKE_SEL_LSB. They should always be set to 0x7.

SC_CD_WAKE_SEL_LSB (Bits 3-0): These bits are used to set voltage threshold of current discharge wake. With SC_CD_WAKE_SEL_MSB = 0x7, Current Voltage Threshold = -0.5mV * (SC_CD_WAKE_SEL_MSB + SC_CD_WAKE_SEL_LSB - 0x70). A value of ([SC_CD_WAKE_SEL_MSB] + [SC_CD_WAKE_SEL_LSB]) = 0x70 does set the threshold to 0mV and must not be selected as noise triggers the detection. SC_CD_WAKE_SEL_MSB should always be 0x7.

17.3.10.7 Current Charge Wake

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Current Charge Wake	H1	0x70	0x7F	0x79	Hex

7	6	5	4	3	2	1	0
RSVD	SC_CC_WAKE_SEL_MSB			SC_CC_WAKE_SEL_LSB			

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

SC_CC_WAKE_SEL_MSB (Bits 6-4): These bits are used to set the voltage threshold of current charge wake used by SC_CC_WAKE_SEL_LSB. They should always be set to 0x7.

SC_CC_WAKE_SEL_LSB (Bits 3-0): These bits are used to set voltage threshold of current charge wake. With SC_CC_WAKE_SEL_MSB = 0x7, Current Voltage Threshold = 0.5mV * (SC_CC_WAKE_SEL_MSB + SC_CC_WAKE_SEL_LSB - 0x70). A value of ([SC_CC_WAKE_SEL_MSB] + [SC_CC_WAKE_SEL_LSB]) = 0x70 does set the threshold to 0mV and must not be selected as noise triggers the detection. SC_CC_WAKE_SEL_MSB should always be 0x7.

17.3.10.8 OCC 1 Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCC 1 Delay 2	H1	0x0	0x07	0x07	Hex

7	6	5	4	3	2	1	0
RSVD					SC_OCC_FAULT_DLY2		

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

SC_OCC_FAULT_DLY2 (Bits 2-0): Upper 3 bit of the OCC_FAULT delay bits 10:8. DLY2 has to be written first and then DLY1.

17.3.10.9 OCC 1 Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCC 1 Delay 1	H1	0x0	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
SC_OCC_FAULT_DLY1							

SC_OCC_FAULT_DLY1 (Bits 7-0): Lower 8 bits of the OCC_FAULT delay bits 7:0. DLY2 has to be written first and then DLY1. Delay is (OCC_FAULT_DLY2 * 256 + OCC_FAULT_DLY1 + 1) * 0.55ms. 0x000 is disabled, 0x001 is 1.1ms, 0x002 is 1.65ms, 0x003 is 2.2ms, .., 0x7ff is 1126.4ms.

17.3.10.10 OCD 1 Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD 1 Delay 2	H1	0x0	0x07	0x07	Hex

7	6	5	4	3	2	1	0
RSVD					SC_OCD1_FAULT_DLY2		

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

SC_OCD1_FAULT_DLY2 (Bits 2-0): Upper 3 bit of the OCD1_FAULT delay bits 10:8. DLY2 has to be written first and then DLY1.

17.3.10.11 OCD 1 Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD 1 Delay 1	H1	0x0	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
SC_OCD1_FAULT_DLY1							

SC_OCD1_FAULT_DLY1 (Bits 7-0): Lower 8 bits of the OCD1_FAULT delay bits 7:0. DLY2 has to be written first and then DLY1. AOCD Delay is (OCD1_FAULT_DLY2 * 256 + OCD1_FAULT_DLY1 + 1) * 0.55ms. 0x000 is disabled, 0x001 is 1.1ms, 0x002 is 1.65ms, 0x003 is 2.2ms, .., 0x7ff is 1126.4ms.

17.3.10.12 OCD 2 Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD 2 Delay 2	H1	0x0	0x07	0x07	Hex

7	6	5	4	3	2	1	0
RSVD					SC_OCD2_FAULT_DLY2		

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

SC_OCD2_FAULT_DLY2 (Bits 2-0): Upper 3 bit of the OCD2_FAULT delay bits 10:8. DLY2 has to be written first and then DLY1.

17.3.10.13 OCD 2 Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD 2 Delay 1	H1	0x0	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
SC_OCD2_FAULT_DLY1							

SC_OCD2_FAULT_DLY1 (Bits 7-0): Lower 8 bits of the OCD2_FAULT delay bits 7:0. DLY2 has to be written first and then DLY1. Delay is (OCD2_FAULT_DLY2 * 256 + OCD2_FAULT_DLY1 + 1) * 0.55ms. 0x000 is disabled, 0x001 is 1.1ms, 0x002 is 1.65ms, 0x003 is 2.2ms, .., 0x7ff is 1126.4ms.

17.3.10.14 Short Circuit Discharge Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Short Circuit Discharge Delay	H1	0x0	0x3F	0x14	Hex

7	6	5	4	3	2	1	0
		SC_SCD_FAULT_DLY					

RSVD (Bits 7 - 6): Reserved. Do not use.

SC_SCD_FAULT_DLY (Bits 5-0): SCD_FAULT delay. ASCD Delay is (SCD_FAULT_DLY[5:1] * 91.5us + SCD_FAULT_DLY[0] * 30.5us + 61us). 0x00 is disable. 0x01 is 91.5us, 0x02 is 152.5us, 0x03 is 183us, 0x04 is 244us, .., 0x3f is 2928us.

17.3.10.15 Over Temperature Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	Over Temperature Delay	H1	0x0	0x1F	0x14	Hex

7	6	5	4	3	2	1	0
			SC_TEMP_FAULT_DLY				

RSVD (Bits 7-5): Reserved. Do not use.

SC_TEMP_FAULT_DLY (Bits 4-0): TEMP_FAULT_DLY * 1.0s + 1.1ms. 0x00 is disabled. 0x01 is 1.0011s, 0x02 is 2.0011s, .., 0x1f is 31.0011s.

17.3.10.16 OCD Wake Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD Wake Delay 2	H1	0x0	0x01	0x01	Hex

7	6	5	4	3	2	1	0
RSVD							SC_CD_WAKE_DLY2

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

SC_CD_WAKE_DLY2 (Bit 0): Upper 1 bit of CD_WAKE delay bit 8. DLY2 has to be written first and then DLY1.

17.3.10.17 OCD Wake Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCD Wake Delay 1	H1	0x0	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
SC_CD_WAKE_DLY1							

SC_CD_WAKE_DLY1 (Bits 7-0): Lower 8 bits of the CD_WAKE delay bits 7:0. DLY2 has to be written first and then DLY1. OCD Wake Delay is (CD_WAKE_DLY2 * 256 + CD_WAKE_DLY1 + 13) * 0.55ms. 0x000 is disabled, 0x001 is 1.1ms, 0x002 is 1.65ms, 0x003 is 2.2ms, .., 0x1ff is 288.2ms.

17.3.10.18 OCC Wake Delay 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCC Wake Delay 2	H1	0x0	0x01	0x01	Hex

7	6	5	4	3	2	1	0
RSVD							SC_CC_WAKE_DLY2

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

SC_CC_WAKE_DLY2 (Bit 0): Upper 1 bit of CC_WAKE delay bit 8. DLY2 has to be written first and then DLY1.

17.3.10.19 OCC Wake Delay 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	AFE	OCC Wake Delay 1	H1	0x0	0xFF	0xFF	Hex

7	6	5	4	3	2	1	0
SC_CC_WAKE_DLY1							

SC_CC_WAKE_DLY1 (Bits 7-0): Lower 8 bits of the CC_WAKE delay bits 7:0. DLY2 has to be written first and then DLY1. OCC Wake Delay is (CC_WAKE_DLY2 * 256 + CC_WAKE_DLY1 + 13) * 0.55ms. 0x000 is disabled, 0x001 is 1.1ms, 0x002 is 1.65ms, 0x003 is 2.2ms, .., 0x1ff is 288.2ms.

17.3.10.20 ZVCHG Exit Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Configuration	AFE	ZVCHG Exit Threshold	I2	0	80000	2200	mV

Description: *Voltage()* threshold where the gauge will exit ZVCHG mode when CFET is used for precharging.

17.3.11 Smart Temperature

17.3.11.1 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.

17.3.12 Manufacturing

17.3.12.1 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.

17.3.13 Accumulated Charge Measurement

17.3.13.1 Accum Discharge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Accumulated Charge	Discharge Threshold	I2	–32767	0	-1000	mAh

17.3.13.2 Accum Charge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	Accumulated Charge	Charge Threshold	I2	0	32767	1000	mAh

17.3.14 TMP468

17.3.14.1 Address

Class	Subclass	Name	Type	Min	Max	Default	Unit
Settings	TMP468	Address	H1	0x00	0xFF	48	hex

Description: Configure TMP468 target address

17.4 Advanced Charging Algorithm

17.4.1 Temperature Ranges

17.4.1.1 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

17.4.1.2 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.

17.4.1.3 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

17.4.1.4 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 .

17.4.1.5 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

17.4.1.6 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 .

17.4.1.7 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

17.4.1.8 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 .

17.4.1.9 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

17.4.1.10 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 .

17.4.1.11 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

17.4.1.12 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 .

17.4.2 PreCharging

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	PCHG	Current	I2	0	32767	88	mA

Description: Precharge *ChargingCurrent()*

17.4.3 Maintenance Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	MCHG	Current	I2	0	32767	44	mA

Description: Maintenance *ChargingCurrent()*

17.4.4 Voltage Range

17.4.4.1 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

17.4.4.2 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

17.4.4.3 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

17.4.4.4 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

17.4.4.5 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.

17.4.5 Degrade Mode 1

17.4.5.1 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.

17.4.5.2 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.

17.4.5.3 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.

17.4.5.4 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.

17.4.5.5 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.

17.4.6 Degrade Mode 2

17.4.6.1 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.

17.4.6.2 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.

17.4.6.3 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.

17.4.6.4 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.

17.4.6.5 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.

17.4.7 Degrade Mode 3

17.4.7.1 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.

17.4.7.2 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.

17.4.7.3 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.

17.4.7.4 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.

17.4.7.5 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.

17.4.8 Degrade Mode

17.4.8.1 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.

17.4.8.2 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.

17.4.8.3 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.

17.4.9 CS Degrade

17.4.9.1 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.

17.4.9.2 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 max cell voltage is compared to in the cell swelling control feature.

17.4.9.3 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.

17.4.9.4 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.

17.4.9.5 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.

17.4.10 Charge Voltage Override

17.4.10.1 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.

17.4.10.2 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()*.

17.4.11 Charge Current Override

17.4.11.1 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*.

17.4.11.2 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*.

17.4.12 Termination Config

17.4.12.1 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

17.4.12.2 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

17.4.12.3 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.

17.4.13 Charging Rate of Change

17.4.13.1 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.

17.4.13.2 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

17.4.14 Charge Loss Compensation

17.4.14.1 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

17.4.14.2 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

17.4.15 IR Correction

17.4.15.1 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.

17.4.16 Sealed Write

17.4.16.1 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.

17.4.16.2 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.

17.4.17 Low Temp Charging

17.4.17.1 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

17.4.17.2 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

17.4.17.3 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

17.4.17.4 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

17.4.18 Standard Temp Low Charging

17.4.18.1 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

17.4.18.2 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

17.4.18.3 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

17.4.18.4 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

17.4.19 Standard Temp High Charging

17.4.19.1 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

17.4.19.2 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

17.4.19.3 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

17.4.19.4 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

17.4.20 High Temp Charging

17.4.20.1 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

17.4.20.2 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

17.4.20.3 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

17.4.20.4 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

17.4.21 Rec Temp Charging

17.4.21.1 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

17.4.21.2 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

17.4.21.3 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

17.4.21.4 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

17.4.22 Cell Balancing Config

17.4.22.1 Voltage Cell Balance Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Voltage Cell Balance Threshold	I2	0	5000	3900	mV

Description: Threshold to allow cell balancing.

17.4.22.2 Voltage Cell Balance Window

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Voltage Cell Balance Window	I2	0	5000	100	mV

Description: Adjustment applied to Cell Balance Threshold if all cells exceed it or max cell is greater than ***Voltage Cell Balance Threshold*** + ***Voltage Cell Balance Min*** .

17.4.22.3 Voltage Cell Balance Min

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Voltage Cell Balance Min	I2	0	5000	40	mV

Description: Minimum imbalance to enable cell balance circuit.

17.4.22.4 Voltage Cell Balance Interval

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Voltage Cell Balance Interval	U2	0	255	20	s

Description: Voltage measurement frequency for cell balancing.

17.4.22.5 Balance Time per mAh Cell 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Balance Time per mAh Cell 1	U2	0	65535	367	s/mAh

Description: Required balance time per mAh for Cell 1. For information on how to calculate balancing time, see Section 7.1.

17.4.22.6 Balance Time per mAh Cell 2–4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Balance Time per mAh Cell 2–4	U2	0	65535	514	s/mAh

Description: Required balance time per mAh for Cells 2 to 4. For information on how to calculate balancing time, see Section 7.1.

17.4.22.7 Min Start Balance Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Min Start Balance Delta	U1	0	255	3	mV

Description: Minimum cell voltage delta to start cell balancing during ***Relax Balance Interval*** checks. This condition is checked in RELAX mode and so it only applies if cell balancing at rest is enabled.

17.4.22.8 Relax Balance Interval

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Relax Balance Interval	U4	0	4294967295	18000	s

Description: Interval during RELAX mode to check for cell imbalance. This parameter applies to cell balancing at rest only.

17.4.22.9 Min RSOC for Balancing

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charging Algorithm	Cell Balancing Config	Min RSOC for Balancing	U1	0	100	80	%

Description: Minimum *RelativeStateOfCharge()* threshold for cell balancing. This condition is checked during relaxation and so it only applies if cell balancing at rest is enabled.

17.4.22.10 Start Rsoc for Bal in Sleep

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Cell Balancing Config	Start Rsoc for Bal in Sleep	U1	0	100	95	%

Description: This sets the RSOC threshold below which cell balancing in sleep (if enabled) will be permitted to start. This works in conjunction with the ***Start time for Bal in Sleep*** requirement.

17.4.22.11 End Rsoc for Bal in Sleep

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Cell Balancing Config	End Rsoc for Bal in Sleep	U1	0	100	60	%

Description: This sets the RSOC threshold below which cell balancing in sleep (if enabled) if active will be terminated.

17.4.22.12 Start Time for Bal in Sleep

Class	Subclass	Name	Type	Min	Max	Default	Unit
Advanced Charge Algorithm	Cell Balancing Config	Start Time for Bal in Sleep	U2	0	65520	100	h

Description: This sets the minimum time threshold the gauge must be in sleep to allow below cell balancing in sleep (if enabled) to start. This works in conjunction with the ***Start Rsoc for Bal in Sleep*** requirement.

17.4.23 Elevated Degrade

17.4.23.1 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.

17.4.23.2 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.

17.4.23.3 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.

17.4.23.4 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.

17.4.23.5 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.

17.4.23.6 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

17.4.23.7 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

17.4.23.8 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

17.4.23.9 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.

17.4.23.10 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.

17.4.23.11 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.

17.4.23.12 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.

17.4.23.13 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.

17.4.23.14 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.

17.4.23.15 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.

17.4.23.16 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.

17.4.23.17 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.

17.4.23.18 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*** .

17.4.23.19 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.

17.4.23.20 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.

17.4.23.21 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.

17.4.23.22 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.

17.4.23.23 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.

17.4.23.24 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

Class	Subclass	Name	Type	Min	Max	Default	Unit
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.

17.4.23.25 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
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.

17.4.23.26 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.

17.5 Power

17.5.1 Power

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Power	Valid Update Voltage	I2	0	32767	3500	mV

Description: Min stack voltage threshold for Flash update

17.5.2 Shutdown

17.5.2.1 Shutdown Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Shutdown	Shutdown Voltage	I2	0	32767	1750	mV

Description: Cell-based shutdown voltage trip threshold

17.5.2.2 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

17.5.2.3 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

17.5.2.4 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*** .

17.5.2.5 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.

17.5.2.6 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

17.5.2.7 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.

17.5.3 Sleep

17.5.3.1 Sleep Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Sleep	Sleep Current	I2	0	32767	10	mA

Description: |*Current()*| threshold to enter SLEEP mode. If this parameter is set to 0, then the ***deadband*** will effectively become the ***Sleep Current*** setting, because any current below the ***deadband*** will set the *Current()* = 0 mA.

17.5.3.2 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.

17.5.3.3 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.

17.5.3.4 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.

17.5.3.5 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

17.5.3.6 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.

17.5.4 Ship

17.5.4.1 FET Off Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Ship	FET Off Time	U1	0	127	10	s

Description: Delay time to turn off FETs prior to entering SHUTDOWN mode. This setting should not be longer than the ***Ship Delay*** setting.

17.5.4.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Ship	Delay	U1	0	254	20	s

Description: Delay time to enter SHUTDOWN mode after FETs are turned off.

17.5.4.3 Auto Ship Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Ship	Auto Ship time	U2	0	65535	1440	min

Description: The BQ41Z50 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.

17.5.5 Power Off

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	Power Off	Timeout	U2	0	65535	30	min

Description: Timeout to exit the Emergency FET Shutdown condition

17.5.6 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

17.5.7 System Present

17.5.7.1 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 PRES pin samples required to determine if battery is inserted or removed.

17.5.8 Storage

17.5.8.1 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.

17.5.8.2 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.

17.5.9 Power Events

17.5.9.1 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.

17.5.10 IATA

17.5.10.1 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.

17.5.10.2 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.

17.5.10.3 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.

17.5.10.4 IATA DeltaV Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA DeltaV Threshold	U1	0	255	50	mV

Description: Holds the Delta threshold allowed between the max cell voltage and the min cell voltage in the pack. If this threshold is exceeded, only the True (that is, present) value of FCC and RC are displayed on wake up from IATA shutdown.

17.5.10.5 IATA Delta RSOC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Power	IATA	IATA Delta RSOC	U1	0	100	3	%

Description: On wake up from IATA shutdown, if ***IATA Delay Time*** = 0 and if true RSOC is > ***IATA Wake AbsRSOC*** , then only after a change in true RSOC ≥ ***IATA Delta RSOC*** is detected, will the display switch from the stored ***IATA RM*** and ***IATA FCC*** values to the true value of remaining capacity and FCC.

17.5.10.6 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.

17.5.10.7 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.

17.5.10.8 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.

17.5.10.9 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.

17.5.10.10 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.

17.5.11 IATA STORE

17.5.11.1 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.

17.5.11.2 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.

17.5.11.3 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.

17.5.11.4 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.

17.5.11.5 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.

17.5.12 Unintended Wakeup

17.5.12.1 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.

17.5.12.2 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.

17.6 LED Support

17.6.1 LED Config

17.6.1.1 LED Flash Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Flash Period	U2	32	65535	512	msec

Description: LED flashing period for alarm display

17.6.1.2 LED Blink Period

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Blink Period	U2	32	65535	1024	msec

Description: LED blinking period for state-of-charge display

17.6.1.3 LED Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Delay	U2	16	65535	100	msec

Description: Delay time from LED to LED for state-of-charge display

17.6.1.4 LED Hold Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED Hold Time	U1	1	63	16	0.25 s

Description: LED display active time

17.6.1.5 LED FC Time

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	LED FC Time	U1	0	96	4	15 min

Description: This threshold sets the time the LED will be left on after FC is achieved (assuming the ***[LEDONFC]*** bit is set). It is set in segments of 15 min. It is not recommended to leave the LED on for extended periods after FC is achieved due to the potential of short charge / discharge cycling, which can reduce the battery life.

17.6.1.6 CHG Flash Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Flash Alarm	I1	0	100	10	%

Description: *RelativeStateOfCharge()* alarm threshold during charging

17.6.1.7 CHG Thresh 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 1	I1	0	100	0	%

Description: *RelativeStateOfCharge()* threshold for LED1 during charging

17.6.1.8 CHG Thresh 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 2	I1	0	100	20	%

Description: *RelativeStateOfCharge()* threshold for LED2 during charging

17.6.1.9 CHG Thresh 3

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 3	I1	0	100	40	%

Description: *RelativeStateOfCharge()* threshold for LED3 during charging

17.6.1.10 CHG Thresh 4

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 4	I1	0	100	60	%

Description: *RelativeStateOfCharge()* threshold for LED4 during charging

17.6.1.11 CHG Thresh 5

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	CHG Thresh 5	I1	0	100	80	%

Description: *RelativeStateOfCharge()* threshold for LED5 during charging

17.6.1.12 DSG Flash Alarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Flash Alarm	I1	0	100	10	%

Description: *RelativeStateOfCharge()* alarm threshold during discharging

17.6.1.13 DSG Thresh 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 1	I1	0	100	0	%

Description: *RelativeStateOfCharge()* threshold for LED1 during discharging

17.6.1.14 DSG Thresh 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 2	I1	0	100	20	%

Description: *RelativeStateOfCharge()* threshold for LED2 during discharging

17.6.1.15 DSG Thresh 3

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 3	I1	0	100	40	%

Description: *RelativeStateOfCharge()* threshold for LED3 during discharging

17.6.1.16 DSG Thresh 4

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 4	I1	0	100	60	%

Description: *RelativeStateOfCharge()* threshold for LED4 during discharging

17.6.1.17 DSG Thresh 5

Class	Subclass	Name	Type	Min	Max	Default	Unit
LED Support	LED Config	DSG Thresh 5	I1	0	100	80	%

Description: *RelativeStateOfCharge()* threshold for LED5 during discharging

17.7 System Data

17.7.1 Manufacturer Info

Class	Subclass	Name	Type	Min	Max	Default	Units
System Data	Manufacturer Data	ManufacturerInfo	S33	—	—	abcdefghijklmnopqrstuvw zxy012345	—

Description: *ManufacturerInfo()* value

17.7.2 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
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

17.7.3 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.

17.7.4 Integrity

17.7.4.1 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.

17.7.4.2 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.

17.7.4.3 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.

17.8 SBS Configuration

17.8.1 Data

17.8.1.1 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

17.8.1.2 Serial Number

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Serial Number	H2	0x0000	0xFFFF	0x0001	Hex

Description: *SerialNumber()* value

17.8.1.3 Manufacturer Name

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Manufacturer Name	S20+1	—	—	Texas Instruments	ASCII

Description: *ManufacturerName()* value

17.8.1.4 Device Name

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Device Name	S20+1	—	—	BQ41Z50	ASCII

Description: *DeviceName()* value

17.8.1.5 Device Chemistry

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Device Chemistry	S4+1	—	—	LION	ASCII

Description: *DeviceChemistry()* value

17.8.1.6 Remaining Capacity Alarm

17.8.1.6.1 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

17.8.1.6.2 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

17.8.1.7 RemainingTimeAlarm

Class	Subclass	Name	Type	Min	Max	Default	Unit
SBS Configuration	Data	Remaining Time Alarm	U2	0	65535	10	min

Description: *RemainingTimeAlarm()* value

17.8.1.8 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)

17.8.1.9 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)

17.8.1.10 VLB Remaining Capacity

17.8.1.10.1 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.

17.8.1.10.2 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.

17.8.1.11 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.

17.8.1.12 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.

17.8.1.13 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*** .

17.9 Lifetimes

17.9.1 Voltage

17.9.1.1 Cell 1 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 1 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 1

17.9.1.2 Cell 2 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 2 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 2

17.9.1.3 Cell 3 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 3 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 3

17.9.1.4 Cell 4 Max Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 4 Max Voltage	I2	0	32767	0	mV

Description: Maximum reported cell voltage 4

17.9.1.5 Cell 1 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 1 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 1

17.9.1.6 Cell 2 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 2 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 2

17.9.1.7 Cell 3 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 3 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 3

17.9.1.8 Cell 4 Min Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Cell 4 Min Voltage	I2	0	32767	32767	mV

Description: Minimum reported cell voltage 4

17.9.1.9 Max Delta Cell Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Voltage	Max Delta Cell Voltage	I2	0	32767	0	mV

Description: Maximum reported delta between cell voltages 1..4

17.9.2 Current

17.9.2.1 Max Charge Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Charge Current	I2	0	32767	0	mA

Description: Maximum reported *Current()* in charge direction

17.9.2.2 Max Discharge Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Discharge Current	I2	–32768	0	0	mA

Description: Maximum reported *Current()* in discharge direction

17.9.2.3 Max Avg Dsg Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Avg Dsg Current	I2	–32768	0	0	mA

Description: Maximum reported *AverageCurrent()* in discharge direction

17.9.2.4 Max Avg Dsg Power

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Current	Max Avg Dsg Power	I2	–32768	0	0	cW

Description: Maximum reported average power in the discharge direction

17.9.3 Temperature-Relax

17.9.3.1 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

17.9.3.2 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

17.9.3.3 Max Delta Cell Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Delta Cell Temp	U1	0	255	0	°C

Description: Maximum reported temperature delta in RELAX mode for TSx inputs configured as cell temperature

17.9.3.4 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

17.9.3.5 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

17.9.3.6 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

17.9.3.7 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

17.9.3.8 Max Temp TS2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TS2	U1	0	255	0	°C

Description: Maximum reported TS2 in RELAX mode

17.9.3.9 Max Temp TS3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TS3	U1	0	255	0	°C

Description: Maximum reported TS3 in RELAX mode

17.9.3.10 Max Temp TS4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TS4	U1	0	255	0	°C

Description: Maximum reported TS4 in RELAX mode

17.9.3.11 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

17.9.3.12 Min Temp TS2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TS2	I1	–128	127	127	°C

Description: Minimum reported TS2 in RELAX mode

17.9.3.13 Min Temp TS3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TS3	I1	–128	127	127	°C

Description: Minimum reported TS3 in RELAX mode

17.9.3.14 Min Temp TS4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TS4	I1	–128	127	127	°C

Description: Minimum reported TS4 in RELAX mode

17.9.3.15 Max Temp TMP468-1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-1	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 1 in RELAX mode.

17.9.3.16 Max Temp TMP468-2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-2	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 2 in RELAX mode.

17.9.3.17 Max Temp TMP468-3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-3	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 3 in RELAX mode

17.9.3.18 Max Temp TMP468-4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-4	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 4 in RELAX mode

17.9.3.19 Max Temp TMP468-5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-5	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 5 in RELAX mode

17.9.3.20 Max Temp TMP468-6

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-6	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 6 in RELAX mode

17.9.3.21 Max Temp TMP468-7

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-7	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 7 in RELAX mode

17.9.3.22 Max Temp TMP468-8

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Max Temp TMP468-8	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 8 in RELAX mode

17.9.3.23 Min Temp TMP468-1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-1	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 1 in RELAX mode

17.9.3.24 Min Temp TMP468-2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-2	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 2 in RELAX mode

17.9.3.25 Min Temp TMP468-3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-3	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 3 in RELAX mode

17.9.3.26 Min Temp TMP468-4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-4	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 4 in RELAX mode

17.9.3.27 Min Temp TMP468-5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-5	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 5 in RELAX mode

17.9.3.28 Min Temp TMP468-6

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-6	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 6 in RELAX mode

17.9.3.29 Min Temp TMP468-7

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-7	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 7 in RELAX mode

17.9.3.30 Min Temp TMP468-8

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Relax	Min Temp TMP468-8	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 8 in RELAX mode

17.9.4 Temperature-Charge

17.9.4.1 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

17.9.4.2 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

17.9.4.3 Max Delta Cell Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Delta Cell Temp	U1	0	255	0	°C

Description: Maximum reported temperature delta in CHARGE mode for TSx inputs configured as cell temperature

17.9.4.4 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

17.9.4.5 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

17.9.4.6 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

17.9.4.7 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

17.9.4.8 Max Temp TS2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TS2	U1	0	255	0	°C

Description: Maximum reported TS2 in CHARGE mode

17.9.4.9 Max Temp TS3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TS3	U1	0	255	0	°C

Description: Maximum reported TS3 in CHARGE mode

17.9.4.10 Max Temp TS4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TS4	U1	0	255	0	°C

Description: Maximum reported TS4 in CHARGE mode

17.9.4.11 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

17.9.4.12 Min Temp TS2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TS2	I1	–128	127	127	°C

Description: Minimum reported TS2 in CHARGE mode

17.9.4.13 Min Temp TS3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TS3	I1	–128	127	127	°C

Description: Minimum reported TS3 in CHARGE mode

17.9.4.14 Min Temp TS4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TS4	I1	–128	127	127	°C

Description: Minimum reported TS4 in CHARGE mode

17.9.4.15 Max Temp TMP468-1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-1	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 1 in CHARGE mode

17.9.4.16 Max Temp TMP468-2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-2	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 2 in CHARGE mode.

17.9.4.17 Max Temp TMP468-3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-3	Ui	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 3 in CHARGE mode

17.9.4.18 Max Temp TMP468-4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-4	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 4 in CHARGE mode

17.9.4.19 Max Temp TMP468-5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-5	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 5 in CHARGE mode

17.9.4.20 Max Temp TMP468-6

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-6	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 6 in CHARGE mode

17.9.4.21 Max Temp TMP468-7

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-7	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 7 in CHARGE mode

17.9.4.22 Max Temp TMP468-8

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Max Temp TMP468-8	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 8 in CHARGE mode

17.9.4.23 Min Temp TMP468-1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-1	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 1 in CHARGE mode

17.9.4.24 Min Temp TMP468-2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-2	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 2 in CHARGE mode

17.9.4.25 Min Temp TMP468-3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-3	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 3 in CHARGE mode

17.9.4.26 Min Temp TMP468-4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-4	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 4 in CHARGE mode

17.9.4.27 Min Temp TMP468-5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-5	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 5 in CHARGE mode

17.9.4.28 Min Temp TMP468-6

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-6	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 6 in CHARGE mode

17.9.4.29 Min Temp TMP468-7

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-7	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 7 in CHARGE mode

17.9.4.30 Min Temp TMP468-8

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Charge	Min Temp TMP468-8	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 8 in CHARGE mode

17.9.5 Temperature-Discharge

17.9.5.1 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

17.9.5.2 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

17.9.5.3 Max Delta Cell Temp

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Delta Cell Temp	U1	0	255	0	°C

Description: Maximum reported temperature delta in DISCHARGE mode for TSx inputs configured as cell temperature

17.9.5.4 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

17.9.5.5 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

17.9.5.6 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

17.9.5.7 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

17.9.5.8 Max Temp TS2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TS2	U1	0	255	0	°C

Description: Maximum reported TS2 in DISCHARGE mode

17.9.5.9 Max Temp TS3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TS3	U1	0	255	0	°C

Description: Maximum reported TS3 in DISCHARGE mode

17.9.5.10 Max Temp TS4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TS4	U1	0	255	0	°C

Description: Maximum reported TS4 in DISCHARGE mode

17.9.5.11 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

17.9.5.12 Min Temp TS2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TS2	I1	–128	127	127	°C

Description: Minimum reported TS2 in DISCHARGE mode

17.9.5.13 Min Temp TS3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TS3	I1	–128	127	127	°C

Description: Minimum reported TS3 in DISCHARGE mode

17.9.5.14 Min Temp TS4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TS4	I1	–128	127	127	°C

Description: Minimum reported TS4 in DISCHARGE mode

17.9.5.15 Max Temp TMP468-1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-1	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 1 in DISCHARGE mode.

17.9.5.16 Max Temp TMP468-2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-2	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 2 in DISCHARGE mode.

17.9.5.17 Max Temp TMP468-3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-3	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 3 in DISCHARGE mode

17.9.5.18 Max Temp TMP468-4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-4	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 4 in DISCHARGE mode

17.9.5.19 Max Temp TMP468-5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-5	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 5 in DISCHARGE mode

17.9.5.20 Max Temp TMP468-6

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-6	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 6 in DISCHARGE mode

17.9.5.21 Max Temp TMP468-7

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-7	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 7 in DISCHARGE mode

17.9.5.22 Max Temp TMP468-8

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Max Temp TMP468-8	U1	0	255	0	°C

Description: Maximum reported TMP468 remote temperature 8 in DISCHARGE mode

17.9.5.23 Min Temp TMP468-1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-1	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 1 in DISCHARGE mode

17.9.5.24 Min Temp TMP468-2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-2	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 2 in DISCHARGE mode

17.9.5.25 Min Temp TMP468-3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-3	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 3 in DISCHARGE mode

17.9.5.26 Min Temp TMP468-4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-4	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 4 in DISCHARGE mode

17.9.5.27 Min Temp TMP468-5

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-5	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 5 in DISCHARGE mode

17.9.5.28 Min Temp TMP468-6

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-6	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 6 in DISCHARGE mode

17.9.5.29 Min Temp TMP468-7

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-7	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 7 in DISCHARGE mode

17.9.5.30 Min Temp TMP468-8

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Temperature-Discharge	Min Temp TMP468-8	I1	–128	127	127	°C

Description: Minimum reported TMP468 remote temperature 8 in DISCHARGE mode

17.9.6 Safety Events

17.9.6.1 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

17.9.6.2 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

17.9.6.3 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

17.9.6.4 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

17.9.6.5 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

17.9.6.6 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

17.9.6.7 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

17.9.6.8 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

17.9.6.9 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

17.9.6.10 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

17.9.6.11 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

17.9.6.12 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

17.9.6.13 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

17.9.6.14 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

17.9.6.15 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

17.9.6.16 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

17.9.6.17 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

17.9.6.18 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

17.9.6.19 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

17.9.6.20 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

17.9.6.21 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

17.9.6.22 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

17.9.6.23 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

17.9.6.24 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

17.9.7 Charging Events

17.9.7.1 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

17.9.7.2 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

17.9.8 Gauging Events

17.9.8.1 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

17.9.8.2 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

17.9.8.3 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

17.9.8.4 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

17.9.8.5 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

17.9.8.6 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

17.9.9 Cell Balancing

17.9.9.1 CB Time Cell 1

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 1	U4	0	4294967295	0	s

Description: Total performed cell balancing bypass time Cell 0

17.9.9.2 CB Time Cell 2

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 2	U4	0	4294967295	0	s

Description: Total performed cell balancing bypass time Cell 1

17.9.9.3 CB Time Cell 3

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 3	U4	0	4294967295	0	s

Description: Total performed cell balancing bypass time Cell 2

17.9.9.4 CB Time Cell 4

Class	Subclass	Name	Type	Min	Max	Default	Unit
Lifetimes	Cell Balancing	CB Time Cell 4	U4	0	4294967295	0	s

Description: Total performed cell balancing bypass time Cell 3

17.9.10 Time

17.9.10.1 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

17.9.10.2 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*** .

17.9.10.3 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*** .

17.9.10.4 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

Class	Subclass	Name	Type	Min	Max	Default	Unit
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*** .

17.9.10.5 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*** .

17.9.10.6 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*** .

17.9.10.7 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*** .

17.9.10.8 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*** .

17.9.10.9 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*** .

17.10 Protections

17.10.1 CUV—Cell Undervoltage

17.10.1.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Threshold	I2	0	32767	2500	mV

Description: Cell undervoltage trip threshold

17.10.1.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Delay	U1	0	255	2	s

Description: Cell undervoltage trip delay

17.10.1.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUV	Recovery	I2	0	32767	3000	mV

Description: Cell undervoltage recovery threshold

17.10.1.4 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.

17.10.2 CUVC—Cell Undervoltage

17.10.2.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUVC	Threshold	I2	0	32767	2400	mV

Description: Cell undervoltage trip threshold

17.10.2.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUVC	Delay	U1	0	255	2	s

Description: Cell undervoltage trip delay

17.10.2.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CUVC	Recovery	I2	0	32767	3000	mV

Description: Cell undervoltage recovery threshold

17.10.3 COV—Cell Overvoltage

17.10.3.1 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

17.10.3.2 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

17.10.3.3 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

17.10.3.4 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

17.10.3.5 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

17.10.3.6 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Delay	U1	0	255	2	s

Description: Cell overvoltage trip delay

17.10.3.7 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

17.10.3.8 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

17.10.3.9 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

17.10.3.10 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

17.10.3.11 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

17.10.3.12 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

17.10.3.13 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

17.10.3.14 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	COV	Reset	I2	0	255	15	s

Description: Cell overvoltage latch reset time

17.10.4 OCC1—Overcurrent In Charge 1

17.10.4.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC1	Threshold	I2	–32768	32767	6000	mA

Description: Overcurrent in Charge 1 trip threshold

17.10.4.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC1	Delay	U1	0	255	6	s

Description: Overcurrent in Charge 1 trip delay

17.10.5 OCC2—Overcurrent In Charge 2

17.10.5.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC2	Threshold	I2	–32768	32767	8000	mA

Description: Overcurrent in Charge 2 trip threshold

17.10.5.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCC2	Delay	U1	0	255	3	s

Description: Overcurrent in Charge 2 trip delay

17.10.6 OCC—Overcurrent In Charge Recovery

17.10.6.1 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

17.10.6.2 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

17.10.7 OCD1—Overcurrent In Discharge 1

17.10.7.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD1	Threshold	I2	–32768	32767	–6000	mA

Description: Overcurrent in Discharge 1 trip threshold

17.10.7.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD1	Delay	U1	0	255	6	s

Description: Overcurrent in Discharge 1 trip delay

17.10.8 OCD2—Overcurrent In Discharge 2

17.10.8.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD2	Threshold	I2	–32768	32767	–8000	mA

Description: Overcurrent in Discharge 2 trip threshold

17.10.8.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OCD2	Delay	U1	0	255	3	s

Description: Overcurrent in Discharge 2 trip delay

17.10.9 OCD—Overcurrent In Discharge Recovery

17.10.9.1 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

17.10.9.2 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

17.10.9.3 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

17.10.9.4 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

17.10.9.5 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

17.10.10 AOCD—Overload in Discharge

17.10.10.1 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

17.10.10.2 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

17.10.10.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCD	Recovery	U1	0	255	5	s

Description: Overload recovery time

17.10.10.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCD	Reset	U1	0	255	15	s

Description: Overload latch reset time

17.10.11 AOCC—Overcurrent In Charge

17.10.11.1 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

17.10.11.2 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

17.10.11.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	AOCC	Recovery	U1	0	255	5	s

Description: Short Circuit in Charge recovery time

17.10.11.4 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

17.10.12 ASCD—Short Circuit in Discharge

17.10.12.1 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

17.10.12.2 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

17.10.12.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	ASCD	Recovery	U1	0	255	5	s

Description: Short Circuit in Discharge recovery time

17.10.12.4 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

17.10.13 OTC—Overtemperature in Charge

17.10.13.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTC	Threshold	I2	–400	1200	550	0.1°C

Description: Overtemperature in Charge trip threshold

17.10.13.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTC	Delay	U1	0	255	2	s

Description: Overtemperature in Charge Cell trip delay

17.10.13.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTC	Recovery	I2	–400	1200	500	0.1°C

Description: Overtemperature in Charge Cell recovery threshold

17.10.14 OTD—Overtemperature in Discharge

17.10.14.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTD	Threshold	I2	–400	1200	600	0.1°C

Description: Overtemperature in Discharge trip threshold

17.10.14.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTD	Delay	U1	0	255	2	s

Description: Overtemperature in Discharge trip delay

17.10.14.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTD	Recovery	I2	–400	1200	550	0.1°C

Description: Overtemperature in Discharge recovery threshold

17.10.15 DCOT—Delta Cell Overtemperature

17.10.15.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	DCOT	Threshold	I2	0	150	150	0.1°C

Description: Delta Cell Overtemperature trip threshold

17.10.15.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	DCOT	Delay	U1	0	255	2	s

Description: Delta Cell Overtemperature trip delay

17.10.15.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	DCOT	Recovery	I2	0	150	50	0.1°C

Description: Delta Cell Overtemperature recovery threshold

17.10.16 OTF—Overtemperature FET

17.10.16.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Threshold	I2	–400	1500	800	0.1°C

Description: Overtemperature FET trip threshold

17.10.16.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Delay	U1	0	255	2	s

Description: Overtemperature FET trip delay

17.10.16.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OTF	Recovery	I2	–400	1500	650	0.1°C

Description: Overtemperature FET recovery threshold

17.10.17 UTC—Undertemperature in Charge

17.10.17.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTC	Threshold	I2	–400	1200	0	0.1°C

Description: Undertemperature in Charge trip threshold

17.10.17.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTC	Delay	U1	0	255	2	s

Description: Undertemperature in Charge Cell trip delay

17.10.17.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTC	Recovery	I2	–400	1200	50	0.1°C

Description: Undertemperature in Charge Cell recovery threshold

17.10.18 UTD—Undertemperature in Discharge

17.10.18.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Threshold	I2	–400	1200	0	0.1°C

Description: Undertemperature in Discharge trip threshold

17.10.18.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Delay	U1	0	255	2	s

Description: Undertemperature in Discharge trip delay

17.10.18.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	UTD	Recovery	I2	–400	1200	50	0.1°C

Description: Undertemperature in Discharge recovery threshold

17.10.19 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

17.10.20 PTO—PRECHARGE Mode Time Out

17.10.20.1 Charge Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Charge Threshold	I2	–32768	32767	2000	mA

Description: Precharge Timeout Current Threshold

17.10.20.2 Suspend Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Suspend Threshold	I2	–32768	32767	1800	mA

Description: Precharge Timeout Suspend Threshold

17.10.20.3 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Delay	U2	0	65535	1800	s

Description: Precharge Timeout Trip Delay

17.10.20.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PTO	Reset	I2	0	32767	2	mAh

Description: Precharge Timeout Reset Threshold

17.10.21 CTO—Fast Charge Mode Time Out

17.10.21.1 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

17.10.21.2 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

17.10.21.3 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Delay	U2	0	65535	54000	s

Description: Fast-Charge Timeout Trip Delay

17.10.21.4 Reset

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CTO	Reset	I2	0	32767	2	mAh

Description: Fast-Charge Timeout Reset Threshold

17.10.22 OC—Overcharge

17.10.22.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	Threshold	I2	–32768	32767	300	mAh

Description: Overcharge trip threshold

17.10.22.2 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	Recovery	I2	–32768	32767	2	mAh

Description: Overcharge recovery threshold

17.10.22.3 RSOC Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	OC	RSOC Recovery	U1	0	100	90	%

Description: Overcharge *RelativeStateOfCharge()* recovery threshold

17.10.23 CHGV—ChargingVoltage

17.10.23.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Threshold	I2	–32768	32767	500	mV

Description: *ChargingVoltage()* delta trip threshold

17.10.23.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Delay	U1	0	255	30	s

Description: *ChargingVoltage()* delta trip delay

17.10.23.3 Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGV	Recovery	I2	–32768	32767	–500	mV

Description: *ChargingVoltage()* delta recovery threshold

17.10.24 CHGC—ChargingCurrent

17.10.24.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Threshold	I2	–32768	32767	500	mA

Description: *ChargingCurrent()* delta trip threshold

17.10.24.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Delay	U1	0	255	2	s

Description: *ChargingCurrent()* delta trip delay

17.10.24.3 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Recovery Threshold	I2	–32768	32767	100	mA

Description: *ChargingCurrent()* delta recovery threshold

17.10.24.4 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	CHGC	Recovery Delay	U1	0	255	2	s

Description: *ChargingCurrent()* delta recovery delay

17.10.25 PCHGC—Pre-ChargingCurrent

17.10.25.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Threshold	I2	–32768	32767	50	mA

Description: *Pre-ChargingCurrent()* trip threshold

17.10.25.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Delay	U1	0	255	2	s

Description: *Pre-ChargingCurrent()* trip delay

17.10.25.3 Recovery Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Recovery Threshold	I2	–32768	32767	10	mA

Description: *Pre-ChargingCurrent()* recovery threshold

17.10.25.4 Recovery Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Protections	PCHGC	Recovery Delay	U1	0	255	2	s

Description: *Pre-ChargingCurrent()* recovery delay

17.11 Permanent Fail

17.11.1 SUV—Safety Cell Undervoltage

17.11.1.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SUV	Threshold	I2	0	32767	2200	mV

Description: Safety Cell Undervoltage trip threshold

17.11.1.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SUV	Delay	U1	0	255	5	s

Description: Safety Cell Undervoltage trip delay

17.11.2 SOV—Safety Cell Overvoltage

17.11.2.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOV	Threshold	I2	0	32767	4500	mV

Description: Safety Cell Overvoltage trip threshold

17.11.2.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOV	Delay	U1	0	255	5	s

Description: Safety Cell Overvoltage trip delay

17.11.3 SOCC—Safety Overcurrent in Charge

17.11.3.1 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

17.11.3.2 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

17.11.4 SOCD—Safety Overcurrent in Discharge

17.11.4.1 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

17.11.4.2 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

17.11.5 SOT—Overtemperature Cell

17.11.5.1 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

17.11.5.2 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

17.11.5.3 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

17.11.5.4 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

17.11.6 SOTF—Overtemperature FET

17.11.6.1 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

17.11.6.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	SOTF	Delay	U1	0	255	5	s

Description: Overtemperature FET trip delay

17.11.7 Open Thermistor—NTC Thermistor Failure

17.11.7.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	Threshold	I2	0	32767	2232	0.1 K

Description: Temperature threshold for open thermistor

17.11.7.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	Delay	U1	0	255	5	s

Description: Trip delay for open thermistor

17.11.7.3 FET Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	FET Delta	I2	0	1500	200	0.1 K

Description: Delta from internal temperature to enable Open Thermistor check for FET thermistors

17.11.7.4 Cell Delta

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	Open Thermistor	Cell Delta	I2	0	1500	200	0.1 K

Description: Delta from internal temperature to enable Open Thermistor check for cell thermistors

17.11.8 QIM—QMax Imbalance

17.11.8.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	QIM	Threshold	I2	0	32767	150	0.10%

Description: QMax Imbalance trip threshold

17.11.8.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	QIM	Delay	U1	0	255	2	updates

Description: QMax Imbalance trip delay

17.11.9 CB—Cell Balance

17.11.9.1 Max Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CB	Max Threshold	I2	0	32767	120	2 h

Description: Cell Balance max trip threshold

17.11.9.2 Delta Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CB	Delta Threshold	U1	0	255	20	2 h

Description: Cell Balance cell delta trip threshold

17.11.9.3 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CB	Delay	U1	0	255	2	cycles

Description: Cell Balance trip delay

17.11.10 VIMR—Voltage Imbalance At Rest

17.11.10.1 Check Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Check Voltage	I2	0	5000	3500	mV

Description: Voltage Imbalance At Rest Check Voltage

17.11.10.2 Check Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Check Current	I2	0	32767	10	mA

Description: Voltage Imbalance At Rest Check Current

17.11.10.3 Delta Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Delta Threshold	I2	0	5000	500	mV

Description: Voltage Imbalance At Rest trip threshold

17.11.10.4 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Delay	U1	0	255	5	s

Description: Voltage Imbalance At Rest Check trip delay

17.11.10.5 Duration

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMR	Duration	U2	0	65535	100	s

Description: Voltage Imbalance At Rest Check Duration

17.11.11 VIMA—Voltage Imbalance Active

17.11.11.1 Check Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Check Voltage	I2	0	5000	3700	mV

Description: Voltage Imbalance Active Check Voltage

17.11.11.2 Check Current

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Check Current	I2	0	32767	50	mA

Description: Voltage Imbalance Active Check Current

17.11.11.3 Delta Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Delta Threshold	I2	0	5000	200	mV

Description: Voltage Imbalance Active Trip Threshold

17.11.11.4 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	VIMA	Delay	U1	0	255	5	s

Description: Voltage Imbalance Active Check Trip Delay

17.11.12 IMP—Impedance Imbalance

17.11.12.1 Delta Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	IMP	Delta Threshold	I2	0	32767	300	%

Description: Impedance Imbalance Delta Threshold

17.11.12.2 Max Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	IMP	Max Threshold	I2	0	32767	400	%

Description: Impedance Imbalance Max Threshold

17.11.12.3 Ra Update Counts

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	IMP	Ra Update Counts	U1	0	255	2	counts

Description: Impedance Imbalance Trip Delay

17.11.13 CD—Capacity Degradation

17.11.13.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CD	Threshold	I2	0	32767	0	mAh

Description: Capacity Degradation Threshold

17.11.13.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	CD	Delay	U1	0	255	2	cycles

Description: Capacity Degradation Trip Delay

17.11.14 CFET—CHG FET Failure

17.11.14.1 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

17.11.14.2 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

17.11.15 DFET—DFET Failure

17.11.15.1 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

17.11.15.2 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

17.11.16 FUSE—FUSE Failure

17.11.16.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	FUSE	Threshold	I2	0	255	5	mA

Description: FUSE activation fail trip threshold

17.11.16.2 Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	FUSE	Delay	U1	0	255	5	s

Description: FUSE activation fail trip delay

17.11.17 AFER—AFE Register

17.11.17.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFER	Threshold	U1	0	255	100	—

Description: AFE Register comparison fail trip threshold

17.11.17.2 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

17.11.17.3 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

17.11.18 AFEC—AFE Communication

17.11.18.1 Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	AFEC	Threshold	U1	0	255	100	—

Description: AFE Communication fail trip threshold

17.11.18.2 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

17.11.19 TMPC—TMP468 Communication

17.11.19.1 TMPC Threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	TMPC	TMPC Threshold	U1	0	255	8	—

Description: TMP468 Communication fail trip threshold

17.11.19.2 TMPC Delay

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	TMPC	TMPC Delay	U1	0	255	5	s

Description: TMP468 communication counter decrement period

17.11.20 2LVL—2nd Level OV

Class	Subclass	Name	Type	Min	Max	Default	Unit
Permanent Fail	2LVL	Delay	U1	0	255	5	s

Description: 2nd Level Protector trip detection delay

17.12 PF Status

The data in this class is saved at the time of the PF event.

17.12.1 Device Status Data

17.12.1.1 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

17.12.1.2 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

17.12.1.3 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

17.12.1.4 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

17.12.1.5 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

17.12.1.6 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

17.12.1.7 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

17.12.1.8 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

17.12.1.9 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

17.12.1.10 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

17.12.1.11 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

17.12.1.12 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

17.12.1.13 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

17.12.1.14 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

17.12.1.15 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

17.12.1.16 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

17.12.1.17 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

17.12.1.18 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

17.12.1.19 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

17.12.1.20 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()*

17.12.1.21 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 16.1.41* for the bit definitions.

7	6	5	4	3	2	1	0
VCT	MCHG	SU	IN	HV	MV	LV	PV

17.12.1.22 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 16.1.41*for the bit definitions.

7	6	5	4	3	2	1	0
VCT	RSVD	RSVD	RSVD	RSVD	CCC	CVR	CCR

17.12.1.23 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	BAL_EN	TCA	TDA	FC	FD

17.12.1.24 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	RSVD	RSVD	OCVFR	LDMD	RX	QMAX	VDQ

7	6	5	4	3	2	1	0
NSFM	RSVD	SLPQ MAX	QEN	VOK	RDIS	RSVD	REST

17.12.2 Device Voltage Data (at the Time of PF Event)

17.12.2.1 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

17.12.2.2 Cell 2 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Cell 2 Voltage	I2	–32768	32767	0	mV

Description: Cell 2 voltage

17.12.2.3 Cell 3 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Cell 3 Voltage	I2	–32768	32767	0	mV

Description: Cell 3 voltage

17.12.2.4 Cell 4 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Cell 4 Voltage	I2	–32768	32767	0	mV

Description: Cell 4 voltage

17.12.2.5 Battery Direct Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Battery Direct Voltage	I2	–32768	32767	0	mV

Description: Battery voltage

17.12.2.6 Pack Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Voltage Data	Pack Voltage	I2	–32768	32767	0	mV

Description: PACK voltage

17.12.3 Device Current Data

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Current Data	Current	I2	–32768	32767	0	mV

Description: *Current()*

17.12.4 Device Temperature Data (at the Time of PF Event)

17.12.4.1 Internal Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	Internal Temperature	I2	–1	32767	0	0.1 K

Description: Internal temperature sensor temperature

17.12.4.2 External 1 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 1 Temperature	I2	–1	32767	0	0.1 K

Description: External TS1 temperature

17.12.4.3 External 2 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 2 Temperature	I2	–1	32767	0	0.1 K

Description: External TS2 temperature

17.12.4.4 External 3 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 3 Temperature	I2	–1	32767	0	0.1 K

Description: External TS3 temperature

17.12.4.5 External 4 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Temperature Data	External 4 Temperature	I2	–1	32767	0	0.1 K

Description: External TS4 temperature

17.12.5 Device Gauging Data (at the Time of PF Event)

17.12.5.1 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

17.12.5.2 Cell 2 DOD0

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Gauging Data	Cell 2 DOD0	I2	–32768	32767	0	—

Description: Cell 2 depth of discharge

17.12.5.3 Cell 3 DOD0

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Gauging Data	Cell 3 DOD0	I2	–32768	32767	0	—

Description: Cell 3 depth of discharge

17.12.5.4 Cell 4 DOD0

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	Device Gauging Data	Cell 4 DOD0	I2	–32768	32767	0	—

Description: Cell 4 depth of discharge

17.12.5.5 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

17.12.6 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.

17.12.6.1 OCC

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCC	H1	0x0	0x7F	0x03	Hex

Description: AFE OCC Register Contents

17.12.6.2 OCD1

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD1	H1	0x0	0x7F	0x03	Hex

Description: AFE OCD1 Register Contents

17.12.6.3 OCD2

Class	Subclass	Name	Type	Min	Max	Default	Unit
PF Status	AFE Regs	OCD2	H1	0x0	0x7F	0x04	Hex

Description: AFE OCD2 Register Contents

17.12.6.4 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

17.12.6.5 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

17.12.6.6 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

17.12.6.7 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

17.12.6.8 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

17.12.6.9 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

17.12.6.10 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

17.12.6.11 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

17.12.6.12 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

17.12.6.13 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

17.12.6.14 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

17.12.6.15 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

17.12.6.16 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

17.12.6.17 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

17.12.6.18 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

17.13 Black Box

17.13.1 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

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
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

17.13.2 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
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

17.14 Gas Gauging

17.14.1 Current Thresholds

17.14.1.1 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

17.14.1.2 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

17.14.1.3 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

17.14.1.4 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.

17.14.1.5 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.

17.14.2 Design

17.14.2.1 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.

17.14.2.2 Design Capacity cWh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Design	Design Capacity cWh	I2	144	32767	6336	cWh

Description: ***Design Capacity*** in cWh. This is reported by *DesignCapacity()* if ***[CAPM]*** = 1.

17.14.2.3 Design Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Design	Design Voltage	I2	0	32767	14400	mV

Description: Design Voltage. This is reported by *DesignVoltage()*.

17.14.3 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()*.

17.14.4 FD

17.14.4.1 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

17.14.4.2 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

17.14.4.3 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

17.14.4.4 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

17.14.5 FC

17.14.5.1 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

17.14.5.2 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

17.14.5.3 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

17.14.5.4 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

17.14.6 TD

GaugingStatus()[TD] sets *BatteryStatus()[TDA]* when in DISCHARGE mode.

17.14.6.1 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

17.14.6.2 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

17.14.6.3 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

17.14.6.4 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

17.14.7 TC

GaugingStatus()[TC] sets *BatteryStatus()[TCA]* when in CHARGE mode

17.14.7.1 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

17.14.7.2 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

17.14.7.3 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

17.14.7.4 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

17.14.8 State

17.14.8.1 QMax

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	State	QMax Cell 1	I2	0	32767	4400	mAh	QMax Cell 1
Gas Gauging	State	QMax Cell 2	I2	0	32767	4400	mAh	QMax Cell 2
Gas Gauging	State	QMax Cell 3	I2	0	32767	4400	mAh	QMax Cell 3
Gas Gauging	State	QMax Cell 4	I2	0	32767	4400	mAh	QMax Cell 4
Gas Gauging	State	QMax Pack	I2	0	32767	4400	mAh	QMax of the whole stack
Gas Gauging	State	Qmax Cycle Count	U2	0	65535	0	—	The *CycleCount()* when Qmax updated

17.14.8.2 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.

17.14.8.3 Cell 1–4 Chg Voltage at EoC

17.14.8.3.1 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

17.14.8.3.2 Cell 2 Chg Voltage at EoC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Cell 2 Chg Voltage at EoC	I2	0	32767	4200	mV

Description: Cell 2 voltage value at end of charge

17.14.8.3.3 Cell 3 Chg Voltage at EoC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Cell 3 Chg Voltage at EoC	I2	0	32767	4200	mV

Description: Cell 3 voltage value at end of charge

17.14.8.3.4 Cell 4 Chg Voltage at EoC

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	Cell 4 Chg Voltage at EoC	I2	0	32767	4200	mV

Description: Cell 4 voltage value at end of charge

17.14.8.4 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

17.14.8.5 Average Last Run

17.14.8.5.1 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

17.14.8.5.2 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

17.14.8.6 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

17.14.8.7 Temp

17.14.8.7.1 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

17.14.8.7.2 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

17.14.8.8 Max Avg Last Run

17.14.8.8.1 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

17.14.8.8.2 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

17.14.8.9 SOH FCC Max

17.14.8.9.1 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*** ..

17.14.8.9.2 SOH FCC Max cWh

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	State	SOH FCC Max cWh	I2	144	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*** .

17.14.8.10 SOH Temp

17.14.8.10.1 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

17.14.8.10.2 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

17.14.8.11 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*** .

17.14.9 Turbo Cfg

17.14.9.1 Min System Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	Turbo Cfg	Min System Voltage	I2	0	32767	9000	mV

Description: This is the minimum required system voltage on the battery pack terminals to be used for TURBO mode.

17.14.9.2 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

17.14.9.3 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

17.14.9.4 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.

17.14.9.5 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()*.

17.14.9.6 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.

17.14.10 IT-DZT Config

17.14.10.1 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.

17.14.10.2 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()*

17.14.10.3 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()*

17.14.10.4 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.

17.14.10.5 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.

17.14.10.6 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

17.14.10.7 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.

17.14.10.8 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.

17.14.10.9 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.

17.14.10.10 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.

17.14.10.11 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.

17.14.10.12 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*** .

17.14.10.13 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*** .

17.14.10.14 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

17.14.10.15 Term Min Cell V

Class	Subclass	Name	Type	Min	Max	Default	Unit
Gas Gauging	IT-DZT Cfg	Term Min Cell V	I2	0	32767	2800	mV

Description: Minimum cell termination voltage used when ***[CELL_TERM]*** = 1. This is intended to enable the IT algorithm to reach 0% before CUV is triggered; therefore, this value should be set at or above ***CUV:Threshold*** .

17.14.10.16 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.

17.14.10.17 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.

17.14.10.18 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.

17.14.10.19 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.

17.14.10.20 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).

17.14.10.21 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.

17.14.10.22 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.

17.14.10.23 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

17.14.10.24 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

17.14.10.25 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

17.14.10.26 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

17.14.10.27 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.

17.14.10.28 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.

17.14.11 Smoothing

17.14.11.1 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.

17.14.11.2 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).

17.14.11.3 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).

17.14.11.4 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.

17.14.12 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

17.14.13 Max Error

17.14.13.1 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*** .

17.14.13.2 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.

17.14.14 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***)

17.15 RA Table

17.15.1 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.

High Byte		Low Byte	
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

17.15.2 R_a1

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a1	Cell 1 R_A Flag	H2	0x0000	0xFFFF	0xFF55	Hex

Description:
This value indicates the validity of the cell impedance table for Cell 2. 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 2, as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a1	Cell 1 R_A 0	I2	0	32768	67	mΩ	Cell 1 resistance at grid point 0
RA Table	R_a1	Cell 1 R_A 1	I2	0	32768	71	mΩ	Cell 1 resistance at grid point 1
RA Table	R_a1	Cell 1 R_A 2	I2	0	32768	83	mΩ	Cell 1 resistance at grid point 2
RA Table	R_a1	Cell 1 R_A 3	I2	0	32768	110	mΩ	Cell 1 resistance at grid point 3
RA Table	R_a1	Cell 1 R_A 4	I2	0	32768	96	mΩ	Cell 1 resistance at grid point 4
RA Table	R_a1	Cell 1 R_A 5	I2	0	32768	77	mΩ	Cell 1 resistance at grid point 5
RA Table	R_a1	Cell 1 R_A 6	I2	0	32768	96	mΩ	Cell 1 resistance at grid point 6
RA Table	R_a1	Cell 1 R_A 7	I2	0	32768	86	mΩ	Cell 1 resistance at grid point 7
RA Table	R_a1	Cell 1 R_A 8	I2	0	32768	84	mΩ	Cell 1 resistance at grid point 8

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a1	Cell 1 R_A 9	I2	0	32768	82	mΩ	Cell 1 resistance at grid point 9
RA Table	R_a1	Cell 1 R_A 10	I2	0	32768	81	mΩ	Cell 1 resistance at grid point 10
RA Table	R_a1	Cell 1 R_A 11	I2	0	32768	92	mΩ	Cell 1 resistance at grid point 11
RA Table	R_a1	Cell 1 R_A 12	I2	0	32768	103	mΩ	Cell 1 resistance at grid point 12
RA Table	R_a1	Cell 1 R_A 13	I2	0	32768	123	mΩ	Cell 1 resistance at grid point 13
RA Table	R_a1	Cell 1 R_A 14	I2	0	32768	658	mΩ	Cell 1 resistance at grid point 14

17.15.3 R_a2

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a2	Cell 2 R_A Flag	H2	0x0000	0xFFFF	0xFF55	Hex

Description:
This value indicates the validity of the cell impedance table for Cell 3. 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 3, as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a2	Cell 2 R_A 0	I2	0	32768	67	mΩ	Cell 2 resistance at grid point 0
RA Table	R_a2	Cell 2 R_A 1	I2	0	32768	71	mΩ	Cell 2 resistance at grid point 1
RA Table	R_a2	Cell 2 R_A 2	I2	0	32768	83	mΩ	Cell 2 resistance at grid point 2
RA Table	R_a2	Cell 2 R_A 3	I2	0	32768	110	mΩ	Cell 2 resistance at grid point 3
RA Table	R_a2	Cell 2 R_A 4	I2	0	32768	96	mΩ	Cell 2 resistance at grid point 4
RA Table	R_a2	Cell 2 R_A 5	I2	0	32768	77	mΩ	Cell 2 resistance at grid point 5
RA Table	R_a2	Cell 2 R_A 6	I2	0	32768	96	mΩ	Cell 2 resistance at grid point 6
RA Table	R_a2	Cell 2 R_A 7	I2	0	32768	86	mΩ	Cell 2 resistance at grid point 7
RA Table	R_a2	Cell 2 R_A 8	I2	0	32768	84	mΩ	Cell 2 resistance at grid point 8
RA Table	R_a2	Cell 2 R_A 9	I2	0	32768	82	mΩ	Cell 2 resistance at grid point 9
RA Table	R_a2	Cell 2 R_A 10	I2	0	32768	81	mΩ	Cell 2 resistance at grid point 10
RA Table	R_a2	Cell 2 R_A 11	I2	0	32768	92	mΩ	Cell 2 resistance at grid point 11
RA Table	R_a2	Cell 2 R_A 12	I2	0	32768	103	mΩ	Cell 2 resistance at grid point 12
RA Table	R_a2	Cell 2 R_A 13	I2	0	32768	123	mΩ	Cell 2 resistance at grid point 13
RA Table	R_a2	Cell 2 R_A 14	I2	0	32768	658	mΩ	Cell 2 resistance at grid point 14

17.15.4 R_a3

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a3	Cell 3 R_A Flag	H2	0x0000	0xFFFF	0xFF55	Hex

Description:
This value indicates the validity of the cell impedance table for Cell 4. 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.

High Byte		Low Byte	
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 4, as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a3	Cell 3 R_A 0	I2	0	32768	67	mΩ	Cell 3 resistance at grid point 0
RA Table	R_a3	Cell 3 R_A 1	I2	0	32768	71	mΩ	Cell 3 resistance at grid point 1
RA Table	R_a3	Cell 3 R_A 2	I2	0	32768	83	mΩ	Cell 3 resistance at grid point 2
RA Table	R_a3	Cell 3 R_A 3	I2	0	32768	110	mΩ	Cell 3 resistance at grid point 3
RA Table	R_a3	Cell 3 R_A 4	I2	0	32768	96	mΩ	Cell 3 resistance at grid point 4
RA Table	R_a3	Cell 3 R_A 5	I2	0	32768	77	mΩ	Cell 3 resistance at grid point 5
RA Table	R_a3	Cell 3 R_A 6	I2	0	32768	96	mΩ	Cell 3 resistance at grid point 6
RA Table	R_a3	Cell 3 R_A 7	I2	0	32768	86	mΩ	Cell 3 resistance at grid point 7
RA Table	R_a3	Cell 3 R_A 8	I2	0	32768	84	mΩ	Cell 3 resistance at grid point 8
RA Table	R_a3	Cell 3 R_A 9	I2	0	32768	82	mΩ	Cell 3 resistance at grid point 9
RA Table	R_a3	Cell 3 R_A 10	I2	0	32768	81	mΩ	Cell 3 resistance at grid point 10
RA Table	R_a3	Cell 3 R_A 11	I2	0	32768	92	mΩ	Cell 3 resistance at grid point 11
RA Table	R_a3	Cell 3 R_A 12	I2	0	32768	103	mΩ	Cell 3 resistance at grid point 12
RA Table	R_a3	Cell 3 R_A 13	I2	0	32768	123	mΩ	Cell 3 resistance at grid point 13
RA Table	R_a3	Cell 3 R_A 14	I2	0	32768	658	mΩ	Cell 3 resistance at grid point 14

17.15.5 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.

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

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
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

17.15.6 R_a1x

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a1x	xCell 1 R_A Flag	H2	0x0000	0xFFFF	0xFFFF	Hex

Description:
This value indicates the validity of the cell impedance table for ***Cell 2*** . 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 2*** , as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a1x	xCell 1 R_A 0	I2	0	32768	67	mΩ	Cell 1 resistance at grid point 0
RA Table	R_a1x	xCell 1 R_A 1	I2	0	32768	71	mΩ	Cell 1 resistance at grid point 1
RA Table	R_a1x	xCell 1 R_A 2	I2	0	32768	83	mΩ	Cell 1 resistance at grid point 2
RA Table	R_a1x	xCell 1 R_A 3	I2	0	32768	110	mΩ	Cell 1 resistance at grid point 3
RA Table	R_a1x	xCell 1 R_A 4	I2	0	32768	96	mΩ	Cell 1 resistance at grid point 4
RA Table	R_a1x	xCell 1 R_A 5	I2	0	32768	77	mΩ	Cell 1 resistance at grid point 5
RA Table	R_a1x	xCell 1 R_A 6	I2	0	32768	96	mΩ	Cell 1 resistance at grid point 6
RA Table	R_a1x	xCell 1 R_A 7	I2	0	32768	86	mΩ	Cell 1 resistance at grid point 7
RA Table	R_a1x	xCell 1 R_A 8	I2	0	32768	84	mΩ	Cell 1 resistance at grid point 8
RA Table	R_a1x	xCell 1 R_A 9	I2	0	32768	82	mΩ	Cell 1 resistance at grid point 9
RA Table	R_a1x	xCell 1 R_A 10	I2	0	32768	81	mΩ	Cell 1 resistance at grid point 10
RA Table	R_a1x	xCell 1 R_A 11	I2	0	32768	92	mΩ	Cell 1 resistance at grid point 11
RA Table	R_a1x	xCell 1 R_A 12	I2	0	32768	103	mΩ	Cell 1 resistance at grid point 12
RA Table	R_a1x	xCell 1 R_A 13	I2	0	32768	123	mΩ	Cell 1 resistance at grid point 13
RA Table	R_a1x	xCell 1 R_A 14	I2	0	32768	658	mΩ	Cell 1 resistance at grid point 14

17.15.7 R_a2x

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a2x	xCell 2 R_A Flag	H2	0x0000	0xFFFF	0xFFFF	Hex

Description:
This value indicates the validity of the cell impedance table for Cell 3. 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.

High Byte		Low Byte	
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 3*** , as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a2x	xCell 2 R_A 0	I2	0	32768	67	mΩ	Cell 2 resistance at grid point 0
RA Table	R_a2x	xCell 2 R_A 1	I2	0	32768	71	mΩ	Cell 2 resistance at grid point 1
RA Table	R_a2x	xCell 2 R_A 2	I2	0	32768	83	mΩ	Cell 2 resistance at grid point 2
RA Table	R_a2x	xCell 2 R_A 3	I2	0	32768	110	mΩ	Cell 2 resistance at grid point 3
RA Table	R_a2x	xCell 2 R_A 4	I2	0	32768	96	mΩ	Cell 2 resistance at grid point 4
RA Table	R_a2x	xCell 2 R_A 5	I2	0	32768	77	mΩ	Cell 2 resistance at grid point 5
RA Table	R_a2x	xCell 2 R_A 6	I2	0	32768	96	mΩ	Cell 2 resistance at grid point 6
RA Table	R_a2x	xCell 2 R_A 7	I2	0	32768	86	mΩ	Cell 2 resistance at grid point 7
RA Table	R_a2x	xCell 2 R_A 8	I2	0	32768	84	mΩ	Cell 2 resistance at grid point 8
RA Table	R_a2x	xCell 2 R_A 9	I2	0	32768	82	mΩ	Cell 2 resistance at grid point 9
RA Table	R_a2x	xCell 2 R_A 10	I2	0	32768	81	mΩ	Cell 2 resistance at grid point 10
RA Table	R_a2x	xCell 2 R_A 11	I2	0	32768	92	mΩ	Cell 2 resistance at grid point 11
RA Table	R_a2x	xCell 2 R_A 12	I2	0	32768	103	mΩ	Cell 2 resistance at grid point 12
RA Table	R_a2x	xCell 2 R_A 13	I2	0	32768	123	mΩ	Cell 2 resistance at grid point 13
RA Table	R_a2x	xCell 2 R_A 14	I2	0	32768	658	mΩ	Cell 2 resistance at grid point 14

17.15.8 R_a3x

Class	Subclass	Name	Type	Min	Max	Default	Unit
RA Table	R_a3x	xCell 3 R_A Flag	H2	0x0000	0xFFFF	0xFFFF	Hex

Description:
This value indicates the validity of the cell impedance table for ***Cell 4*** . 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 4*** , as shown in the following table:

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a3x	xCell 3 R_A 0	I2	0	32768	67	mΩ	Cell 3 resistance at grid point 0
RA Table	R_a3x	xCell 3 R_A 1	I2	0	32768	71	mΩ	Cell 3 resistance at grid point 1
RA Table	R_a3x	xCell 3 R_A 2	I2	0	32768	83	mΩ	Cell 3 resistance at grid point 2
RA Table	R_a3x	xCell 3 R_A 3	I2	0	32768	110	mΩ	Cell 3 resistance at grid point 3
RA Table	R_a3x	xCell 3 R_A 4	I2	0	32768	96	mΩ	Cell 3 resistance at grid point 4
RA Table	R_a3x	xCell 3 R_A 5	I2	0	32768	77	mΩ	Cell 3 resistance at grid point 5
RA Table	R_a3x	xCell 3 R_A 6	I2	0	32768	96	mΩ	Cell 3 resistance at grid point 6
RA Table	R_a3x	xCell 3 R_A 7	I2	0	32768	86	mΩ	Cell 3 resistance at grid point 7
RA Table	R_a3x	xCell 3 R_A 8	I2	0	32768	84	mΩ	Cell 3 resistance at grid point 8

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
RA Table	R_a3x	xCell 3 R_A 9	I2	0	32768	82	mΩ	Cell 3 resistance at grid point 9
RA Table	R_a3x	xCell 3 R_A 10	I2	0	32768	81	mΩ	Cell 3 resistance at grid point 10
RA Table	R_a3x	xCell 3 R_A 11	I2	0	32768	92	mΩ	Cell 3 resistance at grid point 11
RA Table	R_a3x	xCell 3 R_A 12	I2	0	32768	103	mΩ	Cell 3 resistance at grid point 12
RA Table	R_a3x	xCell 3 R_A 13	I2	0	32768	123	mΩ	Cell 3 resistance at grid point 13
RA Table	R_a3x	xCell 3 R_A 14	I2	0	32768	658	mΩ	Cell 3 resistance at grid point 14

17.16 TMP468

17.16.1 Temp1 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp1 Configuration	Offset Ptr	H2	0x00	0xFF	0x40	Hex	Remote Temperature 1 Offset Register Pointer
TMP468	Temp1 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 1 Offset Register Data
TMP468	Temp1 Configuration	nFactor Ptr	H1	0x00	0xFF	0x41	Hex	Remote Temperature 1 η-Factor Register Pointer
TMP468	Temp1 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 1 η-Factor Register Data
TMP468	Temp1 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x42	Hex	Remote Temperature 1 THERM Limit Register Pointer
TMP468	Temp1 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 1 THERM Limit Register Data
TMP468	Temp1 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x43	Hex	Remote Temperature 1 THERM2 Limit Register Pointer
TMP468	Temp1 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 1 THERM2 Limit Register Data

17.16.2 Temp2 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp2 Configuration	Offset Ptr	H2	0x00	0xFF	0x48	Hex	Remote Temperature 2 Offset Register Pointer
TMP468	Temp2 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 2 Offset Register Data
TMP468	Temp2 Configuration	nFactor Ptr	H1	0x00	0xFF	0x49	Hex	Remote Temperature 2 η-Factor Register Pointer
TMP468	Temp2 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 2 η-Factor Register Data
TMP468	Temp2 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x4a	Hex	Remote Temperature 2 THERM Limit Register Pointer
TMP468	Temp2 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 2 THERM Limit Register Data
TMP468	Temp2 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x4b	Hex	Remote Temperature 2 THERM2 Limit Register Pointer
TMP468	Temp2 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 2 THERM2 Limit Register Data

17.16.3 Temp3 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp3 Configuration	Offset Ptr	H2	0x00	0xFF	0x50	Hex	Remote Temperature 3 Offset Register Pointer
TMP468	Temp3 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 3 Offset Register Data
TMP468	Temp3 Configuration	nFactor Ptr	H1	0x00	0xFF	0x51	Hex	Remote Temperature 3 η-Factor Register Pointer
TMP468	Temp3 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 3 η-Factor Register Data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp3 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x52	Hex	Remote Temperature 3 THERM Limit Register Pointer
TMP468	Temp3 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 3 THERM Limit Register Data
TMP468	Temp3 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x53	Hex	Remote Temperature 3 THERM2 Limit Register Pointer
TMP468	Temp3 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 3 THERM2 Limit Register Data

17.16.4 Temp4 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp4 Configuration	Offset Ptr	H2	0x00	0xFF	0x58	Hex	Remote Temperature 4 Offset Register Pointer
TMP468	Temp4 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 4 Offset Register Data
TMP468	Temp4 Configuration	nFactor Ptr	H1	0x00	0xFF	0x59	Hex	Remote Temperature 4 η-Factor Register Pointer
TMP468	Temp4 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 4 η-Factor Register Data
TMP468	Temp4 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x5a	Hex	Remote Temperature 4 THERM Limit Register Pointer
TMP468	Temp4 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 4 THERM Limit Register Data
TMP468	Temp4 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x5b	Hex	Remote Temperature 4 THERM2 Limit Register Pointer
TMP468	Temp4 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 4 THERM2 Limit Register Data

17.16.5 Temp5 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp5 Configuration	Offset Ptr	H2	0x00	0xFF	0x60	Hex	Remote Temperature 5 Offset Register Pointer
TMP468	Temp5 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 5 Offset Register Data
TMP468	Temp5 Configuration	nFactor Ptr	H1	0x00	0xFF	0x61	Hex	Remote Temperature 5 η-Factor Register Pointer
TMP468	Temp5 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 5 η-Factor Register Data
TMP468	Temp5 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x62	Hex	Remote Temperature 5 THERM Limit Register Pointer
TMP468	Temp5 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 5 THERM Limit Register Data
TMP468	Temp\5 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x63	Hex	Remote Temperature 5 THERM2 Limit Register Pointer
TMP468	Temp5 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 5 THERM2 Limit Register Data

17.16.6 Temp6 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp6 Configuration	Offset Ptr	H2	0x00	0xFF	0x68	Hex	Remote Temperature 6 Offset Register Pointer
TMP468	Temp6 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 6 Offset Register Data
TMP468	Temp6 Configuration	nFactor Ptr	H1	0x00	0xFF	0x69	Hex	Remote Temperature 6 η-Factor Register Pointer
TMP468	Temp6 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 6 η-Factor Register Data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp6 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x6a	Hex	Remote Temperature 6 THERM Limit Register Pointer
TMP468	Temp6 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 6 THERM Limit Register Data
TMP468	Temp6 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x6b	Hex	Remote Temperature 6 THERM2 Limit Register Pointer
TMP468	Temp6 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 6 THERM2 Limit Register Data

17.16.7 Temp7 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp7 Configuration	Offset Ptr	H2	0x00	0xFF	0x70	Hex	Remote Temperature 7 Offset Register Pointer
TMP468	Temp7 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 7 Offset Register Data
TMP468	Temp7 Configuration	nFactor Ptr	H1	0x00	0xFF	0x71	Hex	Remote Temperature 7 η-Factor Register Pointer
TMP468	Temp7 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 7 η-Factor Register Data
TMP468	Temp7 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x72	Hex	Remote Temperature 7 THERM Limit Register Pointer
TMP468	Temp7 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 7 THERM Limit Register Data
TMP468	Temp7 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x73	Hex	Remote Temperature 7 THERM2 Limit Register Pointer
TMP468	Temp7 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 7 THERM2 Limit Register Data

17.16.8 Temp8 Configuration

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
TMP468	Temp8 Configuration	Offset Ptr	H2	0x00	0xFF	0x78	Hex	Remote Temperature 8 Offset Register Pointer
TMP468	Temp8 Configuration	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 8 Offset Register Data
TMP468	Temp8 Configuration	nFactor Ptr	H1	0x00	0xFF	0x79	Hex	Remote Temperature 8 η-Factor Register Pointer
TMP468	Temp8 Configuration	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex	Remote Temperature 8 η-Factor Register Data
TMP468	Temp8 Configuration	ThermLimit1 Ptr	H1	0x00	0xFF	0x7a	Hex	Remote Temperature 8 THERM Limit Register Pointer
TMP468	Temp8 Configuration	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 8 THERM Limit Register Data
TMP468	Temp8 Configuration	ThermLimit2 Ptr	H1	0x00	0xFF	0x7b	Hex	Remote Temperature 8 THERM2 Limit Register Pointer
TMP468	Temp8 Configuration	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex	Remote Temperature 8 THERM2 Limit Register Data

17.17 Data Flash Summary

Table 17-1. Data Flash Table

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	120759	—
Calibration	Voltage	0x4008	BAT Gain	I4	–2147483648	2147483647	120759	—

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Calibration	Current	0x400C	CC Gain	I4	–2147483648	2147483647	50142	—
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	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	Temperature	0x401E	External2 Temp Offset	I2	–32768	32767	0	0.1°C
Calibration	Temperature	0x4020	External3 Temp Offset	I2	–32768	32767	0	0.1°C
Calibration	Temperature	0x4022	External4 Temp Offset	I2	–32768	32767	0	0.1°C
Calibration	Internal Temp Model	0x41C0	Int Gain	I4	–32768	32767	–19850	—
Calibration	Internal Temp Model	0x41C4	Int base offset	I2	–32768	32767	6232	—
Calibration	Internal Temp Model	0x41C6	Int Minimum AD	I2	–32768	32767	0	—
Calibration	Internal Temp Model	0x41C8	Int Maximum Temp	I2	0	32767	5754	0.1°K
Calibration	Cell Temperature Model	0x41CC	Coeff a1	I2	–32768	32767	–11130	—
Calibration	Cell Temperature Model	0x41CE	Coeff a2	I2	–32768	32767	19142	—
Calibration	Cell Temperature Model	0x41D0	Coeff a3	I2	–32768	32767	–19262	—
Calibration	Cell Temperature Model	0x41D2	Coeff a4	I2	–32768	32767	28203	—
Calibration	Cell Temperature Model	0x41D4	Coeff a5	I2	–32768	32767	892	—
Calibration	Cell Temperature Model	0x41D6	Coeff b1	I2	–32768	32767	328	—
Calibration	Cell Temperature Model	0x41D8	Coeff b2	I2	–32768	32767	–605	—
Calibration	Cell Temperature Model	0x41DA	Coeff b3	I2	–32768	32767	–2443	—
Calibration	Cell Temperature Model	0x41DC	Coeff b4	I2	–32768	32767	4696	—
Calibration	Cell Temperature Model	0x41DE	Rc0	I2	–32768	32767	6999	—
Calibration	Cell Temperature Model	0x41E0	Adc0	I2	–32768	32767	6999	—
Calibration	Cell Temperature Model	0x41E2	Rpad	I2	–32768	32767	1	—
Calibration	Cell Temperature Model	0x41E4	Rint	I2	–32768	32767	18000	—
Calibration	Fet Temperature Model	0x41E8	Coeff a1	I2	–32768	32767	–11130	—
Calibration	Fet Temperature Model	0x41EA	Coeff a2	I2	–32768	32767	19142	—
Calibration	Fet Temperature Model	0x41EC	Coeff a3	I2	–32768	32767	–19262	—
Calibration	Fet Temperature Model	0x41EE	Coeff a4	I2	–32768	32767	28203	—
Calibration	Fet Temperature Model	0x41F0	Coeff a5	I2	–32768	32767	892	—
Calibration	Fet Temperature Model	0x41F2	Coeff b1	I2	–32768	32767	328	—

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Calibration	Fet Temperature Model	0x41F4	Coeff b2	I2	–32768	32767	–605	—
Calibration	Fet Temperature Model	0x41F6	Coeff b3	I2	–32768	32767	–2443	—
Calibration	Fet Temperature Model	0x41F8	Coeff b4	I2	–32768	32767	4696	—
Calibration	Fet Temperature Model	0x41FA	Rc0	I2	–32768	32767	6999	—
Calibration	Fet Temperature Model	0x41FC	Adc0	I2	–32768	32767	6999	—
Calibration	Fet Temperature Model	0x41FE	Rpad	I2	–32768	32767	1	—
Calibration	Fet Temperature Model	0x4200	Rint	I2	–32768	32767	18000	—
Calibration	Current Deadband	0x4190	Deadband	U2	0	255	3	mA
Calibration	Current Deadband	0x4192	Coulomb Counter Deadband	U2	0	255	9	116 nV
Calibration	Interconnect Resistance	0x44F0	Cell 1	I2	0	1000	0	mΩ
Calibration	Interconnect Resistance	0x44F2	Cell 2	I2	0	1000	0	mΩ
Calibration	Interconnect Resistance	0x44F4	Cell 3	I2	0	1000	0	mΩ
Calibration	Interconnect Resistance	0x44F6	Cell 4	I2	0	1000	0	mΩ
Settings	Configuration	0x4210	Charging Configuration	H2	0x0	0xFFFF	0x0	Hex
Settings	Configuration	0x4212	Charging Configuration Ext	H2	0x00	0x0007	0x00	Hex
Settings	Configuration	0x42A0	Elevated Degrade Configuration	H2	0x0	0x00FF	0x0015	Hex
Settings	Configuration	0x434E	FET Options	H2	0x0	0x00FF	0x0020	Hex
Settings	Configuration	0x4350	Sbs Gauging Configuration	H2	0x0	0x003F	0x0004	Hex
Settings	Configuration	0x4352	Sbs Configuration	H2	0x0	0x00FF	0x0020	Hex
Settings	Configuration	0x4354	Auth Config	H2	0x0	0x000C	0x00	Hex
Settings	Configuration	0x4356	Power Config	H2	0x0	0x3D7F	0x0000	Hex
Settings	Configuration	0x435A	IO Config	H2	0x0	0x001F	0x0000	Hex
Settings	Configuration	0x4380	Temperature Enable	H2	0x0	0x003F	0x0006	Hex
Settings	Configuration	0x4382	Ext TMP Temperature Enable	H2	0x0	0x00FF	0x00FF	Hex
Settings	Configuration	0x4384	Temperature Mode	H2	0x0	0x003F	0x0004	Hex
Settings	Configuration	0x4386	Ext TMP Temperature Mode	H2	0x0	0x00FF	0x0004	Hex
Settings	Configuration	0x4388	DA Configuration	H2	0x0	0xFFFF	0x0012	Hex
Settings	Configuration	0x43F4	LED Configuration	H2	0x0	0x0FFF	0x00D0	Hex
Settings	Configuration	0x4400	DZT Gauging Configuration	H2	0x0	0x0001	0x0001	Hex
Settings	Configuration	0x44A0	Balancing Configuration	H2	0x0	0x00FF	0x0001	Hex
Settings	Configuration	0x44C0	IT Gauging Configuration	H2	0x0	0xFFFF	0xD0FE	Hex
Settings	Configuration	0x44C4	IT Gauging Ext	H2	0x0000	0x03FF	0x005A	Hex
Settings	Configuration	0x542C	SOC Flag Config A	H2	0x0	0x0FFF	0x0C8C	Hex
Settings	Configuration	0x542E	SOC Flag Config B	H2	0x0	0x00FF	0x008C	Hex
Settings	GPIO	0x53F0	Pres pin number	U1	0	255	7	—
Settings	GPIO	0x53F2	Disconnect pin number	U1	0	255	7	—
Settings	GPIO	0x53F4	Emergency Shutdown pin number	U1	0	255	7	—
Settings	GPIO	0x53F6	BTP pin number	U1	0	255	6	—
Settings	GPIO	0x53F7	BTP pin config	H1	0x0	0x02	0x02	Hex
Settings	GPIO	0x53F8	Display pin number	U1	0	255	32	—
Settings	GPIO	0x53F9	Display pin config	H1	0x0	0x02	0x0	Hex

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Settings	GPIO	0x53FA	GPIO_PF pin number	U1	0	255	9	—
Settings	GPIO	0x53FC	LED pins mask	H1	0x0	0x1F	0x16	—
Settings	GPIO	0x53FE	GPIO_INT Enable	H1	0x0	0x1F	0x1F	Hex
Settings	GPIO	0x53FF	GPIO_INT Output Enable	H1	0x0	0x1F	0x1F	Hex
Settings	GPIO	0x5400	GPIO_INT Default Out	H1	0x0	0x1F	0x00	Hex
Settings	GPIO	0x5401	Sealed Access Config	H1	0x0	0x1F	0x1F	Hex
Settings	Fuse	0x4340	PF Fuse A	H2	0x0	0x00FF	0x0	Hex
Settings	Fuse	0x4342	PF Fuse B	H2	0x0	0x00FF	0x0	Hex
Settings	Fuse	0x4344	PF Fuse C	H2	0x0	0x00FF	0x0	Hex
Settings	Fuse	0x4346	PF Fuse D	H2	0x0	0x00FF	0x0	Hex
Settings	Fuse	0x4348	Min Blow Fuse Voltage	I2	0	32767	3500	mV
Settings	Fuse	0x434A	Fuse Blow Timeout	U2	0	255	30	s
Settings	Fuse	0x434C	GPIO Timeout	U2	0	65535	30	s
Settings	BTP	0x435C	Init Discharge Set	I2	0	32767	150	mAh
Settings	BTP	0x435E	Init Charge Set	I2	0	32767	175	mAh
Settings	BTP	0x4360	Init Charge SoC Set	U2	0	100	10	%
Settings	BTP	0x4362	Init Discharge SoC Set	U2	0	100	5	%
Settings	Flag Map	0x4366	Set Up 1 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x4368	Set Up 1 pin number	U1	0	255	0	—
Settings	Flag Map	0x436A	Set Up 2 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x436C	Set Up 2 pin number	U1	0	255	0	—
Settings	Flag Map	0x436E	Set Up 3 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x4370	Set Up 3 pin number	U1	0	255	0	—
Settings	Flag Map	0x4372	Set Up 4 Configuration	H2	0x0000	0xFFFF	0x0000	Hex
Settings	Flag Map	0x4374	Set Up 4 pin number	U1	0	255	0	—
Settings	SMBus	0x4376	Address	H1	0x0	0xFF	0x16	—
Settings	SMBus	0x4377	Address Check	H1	0x0	0xFF	0xEA	—
Settings	Sealed Access	0x437A	DF Read Only Timeout	U2	0	255	10	s
Settings	Sealed Access	0x437C	MfgInfoC Write Timeout	U1	0	255	10	s
Settings	Lifetimes	0x4430	Lifetimes Configuration	H2	0x0	0x00FF	0x0000	Hex
Settings	Lifetimes	0x4433	Time RSOC Threshold A	U1	0	100	95	%
Settings	Lifetimes	0x4434	Time RSOC Threshold B	U1	0	100	90	%
Settings	Lifetimes	0x4435	Time RSOC Threshold C	U1	0	100	80	%
Settings	Lifetimes	0x4436	Time RSOC Threshold D	U1	0	100	50	%
Settings	Lifetimes	0x4437	Time RSOC Threshold E	U1	0	100	20	%
Settings	Lifetimes	0x4438	Time RSOC Threshold F	U1	0	100	10	%
Settings	Lifetimes	0x4439	Time RSOC Threshold G	U1	0	100	5	%
Settings	Lifetimes	0x443A	Temperature Hold-off Time	U2	0	255	5	s
Settings	Lifetimes	0x443C	LFT_T0 Temp	I2	2332	3932	2632	0.1°K
Settings	Lifetimes	0x443E	Hysteresis Temp LFT_T0	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4440	LFT_T1 Temp	I2	2332	3932	2732	0.1°K
Settings	Lifetimes	0x4442	Hysteresis Temp LFT_T1	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4444	LFT_T2 Temp	I2	2332	3932	2852	0.1°K
Settings	Lifetimes	0x4446	Hysteresis Temp LFT_T2	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4448	LFT_T5 Temp	I2	2332	3932	2932	0.1°K
Settings	Lifetimes	0x444A	Hysteresis Temp LFT_T5	I2	0	150	10	0.1°K
Settings	Lifetimes	0x444C	LFT_T6 Temp	I2	2332	3932	2982	0.1°K
Settings	Lifetimes	0x444E	Hysteresis Temp LFT_T6	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4450	LFT_T3 Temp	I2	2332	3932	3032	0.1°K

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Settings	Lifetimes	0x4452	Hysteresis Temp LFT_T3	I2	0	150	10	0.1°K
Settings	Lifetimes	0x4454	LFT_T4 Temp	I2	2332	3932	3282	0.1°K
Settings	Lifetimes	0x4456	Hysteresis Temp LFT_T4	I2	0	150	10	0.1°K
Settings	Protection	0x52D0	Enabled Protections A	H1	0x0	0xFF	0xFF	Hex
Settings	Protection	0x52D1	Enabled Protections B	H1	0x0	0xFF	0xFF	Hex
Settings	Protection	0x52D2	Enabled Protections C	H1	0x0	0xFF	0xD5	Hex
Settings	Protection	0x52D3	Enabled Protections D	H1	0x0	0xFF	0x0F	Hex
Settings	Protection	0x5360	Protection Configuration	H2	0x0	0x000F	0x0000	Hex
Settings	Permanent Failure	0x5220	Enabled PF A	H1	0x0	0xFF	0x0	Hex
Settings	Permanent Failure	0x5221	Enabled PF B	H1	0x0	0xFF	0x0	Hex
Settings	Permanent Failure	0x5222	Enabled PF C	H1	0x0	0xFF	0x0	Hex
Settings	Permanent Failure	0x5223	Enabled PF D	H1	0x0	0xFF	0x0	Hex
Settings	Smart Temperature	0x4398	Mid Point Temp	I2	2332	3932	2982	0.1°K
Settings	AFE	0x43A2	OCC	H1	0x0	0x7F	0x03	Hex
Settings	AFE	0x43A3	OCD 1	H1	0x0	0x7F	0x03	Hex
Settings	AFE	0x43A4	OCD 2	H1	0x0	0x7F	0x04	Hex
Settings	AFE	0x43A5	Short Circuit Discharge	H1	0x0	0x7F	0x64	Hex
Settings	AFE	0x43A6	Over Temperature	H1	0x0	0x7F	0x5A	Hex
Settings	AFE	0x43A7	Current Discharge Wake	H1	0x70	0x7F	0x79	Hex
Settings	AFE	0x43A8	Current Charge Wake	H1	0x70	0x7F	0x79	Hex
Settings	AFE	0x43A9	OCC 1 Delay 2	H1	0x0	0x07	0x07	Hex
Settings	AFE	0x43AA	OCC 1 Delay 1	H1	0x0	0xFF	0xFF	Hex
Settings	AFE	0x43AB	OCD 1 Delay 2	H1	0x0	0x07	0x07	Hex
Settings	AFE	0x43AC	OCD 1 Delay 1	H1	0x0	0xFF	0xFF	Hex
Settings	AFE	0x43AD	OCD 2 Delay 2	H1	0x0	0x07	0x07	Hex
Settings	AFE	0x43AE	OCD 2 Delay 1	H1	0x0	0xFF	0xFF	Hex
Settings	AFE	0x43AF	Short Circuit Discharge Delay	H1	0x0	0x3F	0x14	Hex
Settings	AFE	0x43B0	Over Temperature Delay	H1	0x0	0x1F	0x14	Hex
Settings	AFE	0x43B1	OCD Wake Delay 2	H1	0x0	0x01	0x01	Hex
Settings	AFE	0x43B2	OCD Wake Delay 1	H1	0x0	0xFF	0xFF	Hex
Settings	AFE	0x43B3	OCC Wake Delay 2	H1	0x0	0x01	0x01	Hex
Settings	AFE	0x43B4	OCC Wake Delay 1	H1	0x0	0xFF	0xFF	Hex
Settings	Manufacturing	0x5798	Mfg Status init	H2	0x0	0xFFFF	0x0000	Hex
Settings	Accumulated Charge	0x4460	Accum Discharge Threshold	I2	–32768	0	–1000	mAh
Settings	Accumulated Charge	0x4462	Accum Charge Threshold	I2	0	32767	1000	mAh
Settings	TMP468	0x5750	Address	H2	0x0	0x00FF	0x0048	Hex
Advanced Charge Algorithm	Temperature Ranges	0x4214	T1 Temp	I2	2332	3932	2732	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4216	Hysteresis Temp T1	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4218	T2 Temp	I2	2332	3932	2852	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x421A	Hysteresis Temp T2	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x421C	T5 Temp	I2	2332	3932	2932	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x421E	Hysteresis Temp T5	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4220	T6 Temp	I2	2332	3932	2982	0.1°K

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Temperature Ranges	0x4222	Hysteresis Temp T6	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4224	T3 Temp	I2	2332	3932	3032	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4226	Hysteresis Temp T3	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x4228	T4 Temp	I2	2332	3932	3282	0.1°K
Advanced Charge Algorithm	Temperature Ranges	0x422A	Hysteresis Temp T4	I2	0	150	10	0.1°K
Advanced Charge Algorithm	Pre-Charging	0x422C	Current	I2	0	32767	88	mA
Advanced Charge Algorithm	Maintenance Charging	0x422E	Current	I2	0	32767	44	mA
Advanced Charge Algorithm	Voltage Range	0x4230	Precharge Start Voltage	I2	0	32767	2500	mV
Advanced Charge Algorithm	Voltage Range	0x4232	Charging Voltage Low	I2	0	32767	2900	mV
Advanced Charge Algorithm	Voltage Range	0x4234	Charging Voltage Med	I2	0	32767	3600	mV
Advanced Charge Algorithm	Voltage Range	0x4236	Charging Voltage High	I2	0	32767	4000	mV
Advanced Charge Algorithm	Voltage Range	0x4238	Charging Voltage Hysteresis	U2	0	255	0	mV
Advanced Charge Algorithm	SoC Range	0x423A	Charging SoC Med	U2	0	100	50	%
Advanced Charge Algorithm	SoC Range	0x423C	Charging SoC High	U2	0	100	75	%
Advanced Charge Algorithm	SoC Range	0x423E	Charging SoC Hysteresis	U2	0	100	1	%
Advanced Charge Algorithm	Degrade Mode 1	0x4240	Cycle Threshold	U2	0	65535	50	—
Advanced Charge Algorithm	Degrade Mode 1	0x4242	SOH Threshold	U2	0	100	95	%
Advanced Charge Algorithm	Degrade Mode 1	0x4244	Runtime Threshold	U2	0	65535	8760	h
Advanced Charge Algorithm	Degrade Mode 1	0x4246	Voltage Degradation	I2	0	32767	10	mV
Advanced Charge Algorithm	Degrade Mode 1	0x4248	Current Degradation	U2	0	100	10	%
Advanced Charge Algorithm	Degrade Mode 2	0x424C	Cycle Threshold	U2	0	65535	150	—
Advanced Charge Algorithm	Degrade Mode 2	0x424E	SOH Threshold	U2	0	100	80	%
Advanced Charge Algorithm	Degrade Mode 2	0x4250	Runtime Threshold	U2	0	65535	17520	h
Advanced Charge Algorithm	Degrade Mode 2	0x4252	Voltage Degradation	I2	0	32767	40	mV
Advanced Charge Algorithm	Degrade Mode 2	0x4254	Current Degradation	U2	0	100	20	%
Advanced Charge Algorithm	Degrade Mode 3	0x4258	Cycle Threshold	U2	0	65535	350	—
Advanced Charge Algorithm	Degrade Mode 3	0x425A	SOH Threshold	U2	0	100	60	%
Advanced Charge Algorithm	Degrade Mode 3	0x425C	Runtime Threshold	U2	0	65535	26280	h
Advanced Charge Algorithm	Degrade Mode 3	0x425E	Voltage Degradation	I2	0	32767	70	mV
Advanced Charge Algorithm	Degrade Mode 3	0x4260	Current Degradation	U2	0	100	40	%

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Degrade Mode	0x4264	Cycle Count Start Runtime	U2	0	255	1	—
Advanced Charge Algorithm	Degrade Mode	0x4266	Runtime Update Interval	U2	0	18	10	h
Advanced Charge Algorithm	Degrade Mode	0x53D0	Runtime Degrade	U2	0	65535	0	hours
Advanced Charge Algorithm	CS Degrade	0x4268	Temperature Threshold	I2	0	32767	3232	0.1°K
Advanced Charge Algorithm	CS Degrade	0x426A	Voltage Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	CS Degrade	0x426C	Time Interval	U2	0	14400	300	s
Advanced Charge Algorithm	CS Degrade	0x426E	Delta Voltage	I2	0	32767	25	mV
Advanced Charge Algorithm	CS Degrade	0x4270	Min CV	I2	0	32767	3000	mV
Advanced Charge Algorithm	Charge Voltage Override	0x4274	CHGV Override Max	I2	0	32767	4500	mV
Advanced Charge Algorithm	Charge Voltage Override	0x4276	CHGV Override Min	I2	0	32767	2000	mV
Advanced Charge Algorithm	Charge Current Override	0x4278	CHGI Override Max	I2	0	32767	4500	mA
Advanced Charge Algorithm	Charge Current Override	0x427A	CHGI Override Min	I2	0	32767	100	mA
Advanced Charge Algorithm	Termination Config	0x427C	Charge Term Taper Current	I2	0	32767	250	mA
Advanced Charge Algorithm	Termination Config	0x4280	Charge Term Voltage Offset	I2	0	32767	75	mV
Advanced Charge Algorithm	Termination Config	0x4282	Charge Term Charging Voltage	I2	0	32767	4200	mV
Advanced Charge Algorithm	Charging Rate of Change	0x428C	Current Rate	I2	1	1000	1	steps
Advanced Charge Algorithm	Charging Rate of Change	0x428E	Voltage Rate	I2	1	255	1	steps
Advanced Charge Algorithm	Charge Loss Compensation	0x4292	CCC Current Threshold	I2	0	32767	3520	mA
Advanced Charge Algorithm	Charge Loss Compensation	0x4294	CCC Voltage Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	IR Correction	0x4296	Averaging Interval	U2	1	255	12	s
Advanced Charge Algorithm	Sealed Write	0x4298	Hold Off	U2	0	65535	2	s
Advanced Charge Algorithm	Sealed Write	0x429A	Lockout	U2	0	65535	7200	s
Advanced Charge Algorithm	Low Temp Charging	0x53A0	Voltage	I2	0	32767	4000	mV
Advanced Charge Algorithm	Low Temp Charging	0x53AA	Current Low	I2	0	32767	132	mA
Advanced Charge Algorithm	Low Temp Charging	0x53AC	Current Med	I2	0	32767	352	mA
Advanced Charge Algorithm	Low Temp Charging	0x53AE	Current High	I2	0	32767	264	mA
Advanced Charge Algorithm	Standard Temp Low Charging	0x53A2	Voltage	I2	0	32767	4200	mV
Advanced Charge Algorithm	Standard Temp Low Charging	0x53B0	Current Low	I2	0	32767	1980	mA
Advanced Charge Algorithm	Standard Temp Low Charging	0x53B2	Current Med	I2	0	32767	4004	mA
Advanced Charge Algorithm	Standard Temp Low Charging	0x53B4	Current High	I2	0	32767	2992	mA

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Standard Temp High Charging	0x53A4	Voltage	I2	0	32767	4200	mV
Advanced Charge Algorithm	Standard Temp High Charging	0x53B6	Current Low	I2	0	32767	1980	mA
Advanced Charge Algorithm	Standard Temp High Charging	0x53B8	Current Med	I2	0	32767	4004	mA
Advanced Charge Algorithm	Standard Temp High Charging	0x53BA	Current High	I2	0	32767	2992	mA
Advanced Charge Algorithm	High Temp Charging	0x53A6	Voltage	I2	0	32767	4000	mV
Advanced Charge Algorithm	High Temp Charging	0x53BC	Current Low	I2	0	32767	1012	mA
Advanced Charge Algorithm	High Temp Charging	0x53BE	Current Med	I2	0	32767	1980	mA
Advanced Charge Algorithm	High Temp Charging	0x53C0	Current High	I2	0	32767	1496	mA
Advanced Charge Algorithm	Rec Temp Charging	0x53A8	Voltage	I2	0	32767	4100	mV
Advanced Charge Algorithm	Rec Temp Charging	0x53C2	Current Low	I2	0	32767	2508	mA
Advanced Charge Algorithm	Rec Temp Charging	0x53C4	Current Med	I2	0	32767	4488	mA
Advanced Charge Algorithm	Rec Temp Charging	0x53C6	Current High	I2	0	32767	3520	mA
Advanced Charge Algorithm	Cell Balancing Config	0x44A2	Bal Time/mAh Cell 1	U2	0	65535	367	s/mAh
Advanced Charge Algorithm	Cell Balancing Config	0x44A4	Bal Time/mAh Cell 2-4	U2	0	65535	514	s/mAh
Advanced Charge Algorithm	Cell Balancing Config	0x44A6	Min Start Balance Delta	U2	0	255	3	mV
Advanced Charge Algorithm	Cell Balancing Config	0x44A8	Relax Balance Interval	U4	0	4294967295	18000	s
Advanced Charge Algorithm	Cell Balancing Config	0x44AC	Min Rsoc for Balancing	U2	0	100	80	%
Advanced Charge Algorithm	Cell Balancing Config	0x44AE	Start Rsoc for Bal in Sleep	U2	0	100	95	%
Advanced Charge Algorithm	Cell Balancing Config	0x44B0	End Rsoc for Bal in Sleep	U2	0	100	60	%
Advanced Charge Algorithm	Cell Balancing Config	0x44B2	Start Time for Bal in Sleep	U2	0	65520	100	hrs
Advanced Charge Algorithm	Cell Balancing Config	0x44B4	Voltage Cell Balance Threshold	I2	0	5000	3900	mV
Advanced Charge Algorithm	Cell Balancing Config	0x44B6	Voltage Cell Balance Window	I2	0	5000	100	mV
Advanced Charge Algorithm	Cell Balancing Config	0x44B8	Voltage Cell Balance Min	I2	0	5000	40	mV
Advanced Charge Algorithm	Cell Balancing Config	0x44BA	Voltage Cell Balance Interval	U2	0	255	20	s
Advanced Charge Algorithm	Elevated Degrade	0x42A2	ERM Reset RSoC Threshold	U2	0	100	85	%
Advanced Charge Algorithm	Elevated Degrade	0x42A4	ERM Reset Voltage Threshold	I2	0	32767	3700	mV
Advanced Charge Algorithm	Elevated Degrade	0x42A6	ERM RSoC Threshold	U2	0	100	90	%
Advanced Charge Algorithm	Elevated Degrade	0x42A8	ERM Voltage Threshold	I2	0	32767	4000	mV
Advanced Charge Algorithm	Elevated Degrade	0x42AA	ERM Time Threshold	U2	0	65535	10000	hours
Advanced Charge Algorithm	Elevated Degrade	0x42AC	ERETM RSoC Threshold	U2	0	100	90	%

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Elevated Degrade	0x42AE	ERETM Voltage Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	Elevated Degrade	0x42B0	ERETM Temperature Threshold	I2	2332	3932	3123	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x42B2	EVTM Voltage Low Threshold	I2	0	32767	4300	mV
Advanced Charge Algorithm	Elevated Degrade	0x42B4	EVTM Temperature Low Threshold	I2	2332	3932	3123	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x42B6	EVLTM TTH1	U2	0	65535	480	hours
Advanced Charge Algorithm	Elevated Degrade	0x42B8	EVLTM CV Delta 1	I2	0	32767	50	mV
Advanced Charge Algorithm	Elevated Degrade	0x42BA	EVLTM TTH2	U2	0	65535	720	hours
Advanced Charge Algorithm	Elevated Degrade	0x42BC	EVLTM CV Delta 2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	0x42BE	EVLTM TTH3	U2	0	65535	1680	hours
Advanced Charge Algorithm	Elevated Degrade	0x42C0	EVLTM CV Delta 3	I2	0	32767	150	mV
Advanced Charge Algorithm	Elevated Degrade	0x42C2	EVLTM TTH4	U2	0	65535	2880	hours
Advanced Charge Algorithm	Elevated Degrade	0x42C4	EVLTM CV Delta 4	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	0x42C6	EVLTM TTH5	U2	0	65535	5760	hours
Advanced Charge Algorithm	Elevated Degrade	0x42C8	EVLTM CV Delta 5	I2	0	32767	300	mV
Advanced Charge Algorithm	Elevated Degrade	0x42CA	EVTM Voltage Mid Threshold	I2	0	32767	4200	mV
Advanced Charge Algorithm	Elevated Degrade	0x42CC	EVTM Temperature Mid Threshold	I2	2332	3932	3173	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x42CE	EVMTM TTH1	U2	0	65535	240	hours
Advanced Charge Algorithm	Elevated Degrade	0x42D0	EVMTM CV Delta 1	I2	0	32767	50	mV
Advanced Charge Algorithm	Elevated Degrade	0x42D2	EVMTM TTH2	U2	0	65535	480	hours
Advanced Charge Algorithm	Elevated Degrade	0x42D4	EVMTM CV Delta 2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	0x42D6	EVMTM TTH3	U2	0	65535	1440	hours
Advanced Charge Algorithm	Elevated Degrade	0x42D8	EVMTM CV Delta 3	I2	0	32767	150	mV
Advanced Charge Algorithm	Elevated Degrade	0x42DA	EVMTM TTH4	U2	0	65535	2160	hours
Advanced Charge Algorithm	Elevated Degrade	0x42DC	EVMTM CV Delta 4	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	0x42DE	EVMTM TTH5	U2	0	65535	2400	hours
Advanced Charge Algorithm	Elevated Degrade	0x42E0	EVMTM CV Delta 5	I2	0	32767	300	mV
Advanced Charge Algorithm	Elevated Degrade	0x42E2	EVTM Voltage High Threshold	I2	0	32767	4100	mV
Advanced Charge Algorithm	Elevated Degrade	0x42E4	EVTM Temperature High Threshold	I2	2332	3932	3223	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x42E6	EVHTM TTH1	U2	0	65535	24	hours
Advanced Charge Algorithm	Elevated Degrade	0x42E8	EVHTM CV Delta 1	I2	0	32767	50	mV

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Advanced Charge Algorithm	Elevated Degrade	0x42EA	EVHTM TTH2	U2	0	65535	120	hours
Advanced Charge Algorithm	Elevated Degrade	0x42EC	EVHTM CV Delta 2	I2	0	32767	100	mV
Advanced Charge Algorithm	Elevated Degrade	0x42EE	EVHTM TTH3	U2	0	65535	336	hours
Advanced Charge Algorithm	Elevated Degrade	0x42F0	EVHTM CV Delta 3	I2	0	32767	200	mV
Advanced Charge Algorithm	Elevated Degrade	0x42F2	EVHTM TTH4	U2	0	65535	480	hours
Advanced Charge Algorithm	Elevated Degrade	0x42F4	EVHTM CV Delta 4	I2	0	32767	250	mV
Advanced Charge Algorithm	Elevated Degrade	0x42F6	EVHTM TTH5	U2	0	65535	720	hours
Advanced Charge Algorithm	Elevated Degrade	0x42F8	EVHTM CV Delta 5	I2	0	32767	300	mV
Advanced Charge Algorithm	Elevated Degrade	0x42FA	ERETM Temperature Max Threshold	I2	2332	3932	3223	0.1°K
Advanced Charge Algorithm	Elevated Degrade	0x42FC	ERETM Time Threshold	U2	0	65535	10000	hours
Advanced Charge Algorithm	Elevated Degrade	0x42FE	ERETM Charging Voltage	I2	0	32767	3900	mV
Advanced Charge Algorithm	Elevated Degrade	0x53E0	Accumulated ERM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x53E2	Accumulated ERETM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x53E4	Accumulated EVLTM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x53E6	Accumulated EVMTM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x53E8	Accumulated EVHTM Time	U2	0	65535	0	hours
Advanced Charge Algorithm	Elevated Degrade	0x53EA	ERETM Status	H2	0x0	0x00FF	0x0	—
Advanced Charge Algorithm	Elevated Degrade	0x53EC	EVTM Degrade	H2	0x0	0xFFFF	0x0	—
Advanced Charge Algorithm	Elevated Degrade	0x53EE	EVTM Active	H2	0x0	0xFFFF	0x0	—
Power	Shutdown	0x4310	Shutdown Voltage	I2	0	32767	1750	mV
Power	Shutdown	0x4312	Shutdown Time	U2	0	255	10	s
Power	Shutdown	0x4314	IO Shutdown Delay	U2	0	255	1	250 ms
Power	Shutdown	0x4316	IO Shutdown Timeout	U2	0	255	8	250 ms
Power	Shutdown	0x4318	PF Shutdown Voltage	I2	0	32767	1750	mV
Power	Shutdown	0x431A	PF Shutdown Time	U2	0	255	10	s
Power	Shutdown	0x431C	PS Shutdown Voltage	I2	0	32767	2500	mV
Power	Shutdown	0x431E	PS NoLoadResCap Threshold	I2	0	32767	0	mAh
Power	Shutdown	0x4322	Low RSoC Shutdown Threshold	U1	0	100	2	%
Power	Shutdown	0x4323	Low RSoC Shutdown Time	U1	0	255	24	h
Power	Shutdown	0x4324	Charger Present Threshold	I2	0	32767	3000	mV
Power	Power	0x4320	Valid Update Voltage	I2	0	32767	3500	mV
Power	Sleep	0x4326	Sleep Current	I2	0	32767	10	mA
Power	Sleep	0x4328	Low Current	I2	0	32767	5	mA
Power	Sleep	0x432A	Low Current Period	H2	0x0008	0x0040	0x0010	Hex
Power	Sleep	0x432C	Bus Timeout	U2	0	255	5	s
Power	Sleep	0x4332	Measure Time	U2	8	8	8	s

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Power	Sleep	0x4334	Current Time	U2	8	64	16	s
Power	Ship	0x4336	FET Off Time	U2	0	127	10	s
Power	Ship	0x4338	Delay	U2	0	254	20	s
Power	Ship	0x433A	Auto Ship Time	U2	0	65535	1440	min
Power	Power Off	0x433C	Timeout	U2	0	65535	30	min
Power	Manual FET Control	0x433E	MFC Delay	U1	0	255	60	0.25 s
Power	System Present	0x433F	SYS_PRES Delay	U1	1	8	1	Counts
Power	Storage Mode	0x4180	Storage Delay	U1	0	255	10	s
Power	Storage Mode	0x4181	Storage Ignore SMB Delay	U1	0	255	30	s
Power	Power Events	0x56B0	No Of Shutdowns	U1	0	255	0	events
Power	Power Events	0x56B1	No Of Partial Resets	U1	0	255	0	events
Power	Power Events	0x56B2	No Of Full Resets	U1	0	255	0	events
Power	Power Events	0x56B3	No Of Wdt Resets	U1	0	255	0	events
Power	IATA	0x4410	IATA Config	H2	0x0	0x00FF	0x0003	—
Power	IATA	0x4412	IATA Delay Time	U2	0	65535	10	s
Power	IATA	0x4414	IATA RSOC Threshold	U2	0	100	30	%
Power	IATA	0x4416	IATA DeltaV Threshold	U2	0	255	50	mV
Power	IATA	0x4418	IATA Delta RSOC	U2	0	100	3	%
Power	IATA	0x441A	IATA Wake AbsRsoc	U2	0	100	10	%
Power	IATA	0x441C	IATA Min Temperature	I2	2332	3932	2832	0.1°K
Power	IATA	0x441E	IATA Max Temperature	I2	2332	3932	3132	0.1°K
Power	IATA	0x4420	IATA Min Voltage	I2	0	32767	3000	mV
Power	IATA	0x4422	IATA Max Voltage	I2	0	32767	3600	mV
Power	IATA STORE	0x5450	IATA RM mAh	I2	0	32767	0	mAh
Power	IATA STORE	0x5452	IATA RM cWh	I2	0	32767	0	cWh
Power	IATA STORE	0x5454	IATA FCC mAh	I2	0	32767	0	mAh
Power	IATA STORE	0x5456	IATA FCC cWh	I2	0	32767	0	cWh
Power	IATA STORE	0x5458	IATA Flag	H2	0x0	0x00FF	0x0	—
Power	Unintended Wakeup	0x4480	Delay	U2	0	240	2	s
Power	Unintended Wakeup	0x4482	Count	U2	0	255	3	—
LED Support	LED Config	0x43D0	LED Flash Period	U2	32	65535	250	ms
LED Support	LED Config	0x43D2	LED Blink Period	U2	32	65535	500	ms
LED Support	LED Config	0x43D4	LED Delay	U2	16	65535	100	ms
LED Support	LED Config	0x43D6	LED Hold Time	U2	1	63	16	0.25 s
LED Support	LED Config	0x43D8	LED FC Time	U2	0	96	4	15 mins
LED Support	LED Config	0x43DC	CHG Flash Alarm	I2	0	100	10	%
LED Support	LED Config	0x43DE	CHG Thresh 1	I2	0	100	0	%
LED Support	LED Config	0x43E0	CHG Thresh 2	I2	0	100	30	%
LED Support	LED Config	0x43E2	CHG Thresh 3	I2	0	100	70	%
LED Support	LED Config	0x43E4	CHG Thresh 4	I2	0	100	100	%
LED Support	LED Config	0x43E6	CHG Thresh 5	I2	0	100	100	%
LED Support	LED Config	0x43E8	DSG Flash Alarm	I2	0	100	10	%
LED Support	LED Config	0x43EA	DSG Thresh 1	I2	0	100	0	%
LED Support	LED Config	0x43EC	DSG Thresh 2	I2	0	100	30	%
LED Support	LED Config	0x43EE	DSG Thresh 3	I2	0	100	70	%
LED Support	LED Config	0x43F0	DSG Thresh 4	I2	0	100	100	%
LED Support	LED Config	0x43F2	DSG Thresh 5	I2	0	100	100	%
System Data	Manufacturer Data	0x4100	Manufacturer Info A Length	U1	1	32	32	—

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
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
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

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
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 17-1. Data Flash Table (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	bq41z50	—
SBS Configuration	Data	0x40EE	Device Chemistry	S5	x	x	LION	—
SBS Configuration	Data	0x4470	Remaining AH Cap. Alarm	I2	0	32767	300	mAh
SBS Configuration	Data	0x4472	Remaining WH Cap. Alarm	I2	0	32767	432	cWh
SBS Configuration	Data	0x4474	Remaining Time Alarm	U2	0	65535	10	min
SBS Configuration	Data	0x4476	Initial Battery Mode	H2	0x0	0xFFFF	0x0081	Hex
SBS Configuration	Data	0x4478	Specification Information	H2	0x0	0xFFFF	0x0031	Hex
SBS Configuration	Data	0x4490	VLB Remaining Cap. mAH	I2	0	32767	176	mAh
SBS Configuration	Data	0x4492	VLB Remaining Cap. cWH	I2	0	32767	254	cWh
SBS Configuration	Data	0x4494	VLB Voltage	I2	0	5000	2850	mV
SBS Configuration	Data	0x4496	VLB Hold Time	U2	0	255	2	s
SBS Configuration	Data	0x4498	VLB Timeout	U2	0	255	120	s
Lifetimes	Voltage	0x5460	Cell 1 Max Voltage	I2	0	32767	0	mV
Lifetimes	Voltage	0x5462	Cell 2 Max Voltage	I2	0	32767	0	mV
Lifetimes	Voltage	0x5464	Cell 3 Max Voltage	I2	0	32767	0	mV
Lifetimes	Voltage	0x5466	Cell 4 Max Voltage	I2	0	32767	0	mV
Lifetimes	Voltage	0x5468	Cell 1 Min Voltage	I2	0	32767	32767	mV
Lifetimes	Voltage	0x546A	Cell 2 Min Voltage	I2	0	32767	32767	mV
Lifetimes	Voltage	0x546C	Cell 3 Min Voltage	I2	0	32767	32767	mV
Lifetimes	Voltage	0x546E	Cell 4 Min Voltage	I2	0	32767	32767	mV
Lifetimes	Voltage	0x5470	Max Delta Cell Voltage	I2	0	32767	0	mV
Lifetimes	Current	0x5474	Max Charge Current	I2	0	32767	0	mA
Lifetimes	Current	0x5476	Max Discharge Current	I2	–32768	0	0	mA
Lifetimes	Current	0x5478	Max Avg Dsg Current	I2	–32768	0	0	mA
Lifetimes	Current	0x547C	Max Avg Dsg Power	I2	–32768	0	0	cW
Lifetimes	Temperature-Relax	0x5480	Max Temp Cell	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5481	Min Temp Cell	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x5482	Max Delta Cell Temp	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5483	Max Temp Int Sensor	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5484	Min Temp Int Sensor	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x5485	Max Temp Fet	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5486	Max Temp TS1	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5487	Max Temp TS2	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5488	Max Temp TS3	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5489	Max Temp TS4	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x548A	Min Temp TS1	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x548B	Min Temp TS2	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x548C	Min Temp TS3	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x548D	Min Temp TS4	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x548E	Max Temp TMP486-1	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x548F	Max Temp TMP486-2	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5490	Max Temp TMP486-3	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5491	Max Temp TMP486-4	U1	0	255	0	°C

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Temperature-Relax	0x5492	Max Temp TMP486-5	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5493	Max Temp TMP486-6	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5494	Max Temp TMP486-7	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5495	Max Temp TMP486-8	U1	0	255	0	°C
Lifetimes	Temperature-Relax	0x5496	Min Temp TMP468-1	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x5497	Min Temp TMP468-2	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x5498	Min Temp TMP468-3	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x5499	Min Temp TMP468-4	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x549A	Min Temp TMP468-5	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x549B	Min Temp TMP468-6	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x549C	Min Temp TMP468-7	I1	–128	127	127	°C
Lifetimes	Temperature-Relax	0x549D	Min Temp TMP468-8	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x549E	Max Temp Cell	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x549F	Min Temp Cell	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54A0	Max Delta Cell Temp	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54A1	Max Temp Int Sensor	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54A2	Min Temp Int Sensor	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54A3	Max Temp Fet	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54A4	Max Temp TS1	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54A5	Max Temp TS2	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54A6	Max Temp TS3	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54A7	Max Temp TS4	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54A8	Min Temp TS1	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54A9	Min Temp TS2	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54AA	Min Temp TS3	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54AB	Min Temp TS4	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54AC	Max Temp TMP486-1	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54AD	Max Temp TMP486-2	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54AE	Max Temp TMP486-3	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54AF	Max Temp TMP486-4	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54B0	Max Temp TMP486-5	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54B1	Max Temp TMP486-6	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54B2	Max Temp TMP486-7	U1	0	255	0	°C
Lifetimes	Temperature-Charge	0x54B3	Max Temp TMP486-8	U1	0	255	0	°C

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Temperature-Charge	0x54B4	Min Temp TMP468-1	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54B5	Min Temp TMP468-2	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54B6	Min Temp TMP468-3	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54B7	Min Temp TMP468-4	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54B8	Min Temp TMP468-5	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54B9	Min Temp TMP468-6	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54BA	Min Temp TMP468-7	I1	–128	127	127	°C
Lifetimes	Temperature-Charge	0x54BB	Min Temp TMP468-8	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54BC	Max Temp Cell	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54BD	Min Temp Cell	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54BE	Max Delta Cell Temp	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54BF	Max Temp Int Sensor	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54C0	Min Temp Int Sensor	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54C1	Max Temp Fet	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54C2	Max Temp TS1	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54C3	Max Temp TS2	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54C4	Max Temp TS3	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54C5	Max Temp TS4	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54C6	Min Temp TS1	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54C7	Min Temp TS2	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54C8	Min Temp TS3	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54C9	Min Temp TS4	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54CA	Max Temp TMP486-1	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54CB	Max Temp TMP486-2	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54CC	Max Temp TMP486-3	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54CD	Max Temp TMP486-4	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54CE	Max Temp TMP486-5	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54CF	Max Temp TMP486-6	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54D0	Max Temp TMP486-7	U1	0	255	0	°C
Lifetimes	Temperature-Discharge	0x54D1	Max Temp TMP486-8	U1	0	255	0	°C

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Temperature-Discharge	0x54D2	Min Temp TMP468-1	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54D3	Min Temp TMP468-2	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54D4	Min Temp TMP468-3	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54D5	Min Temp TMP468-4	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54D6	Min Temp TMP468-5	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54D7	Min Temp TMP468-6	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54D8	Min Temp TMP468-7	I1	–128	127	127	°C
Lifetimes	Temperature-Discharge	0x54D9	Min Temp TMP468-8	I1	–128	127	127	°C
Lifetimes	Safety Events	0x54DC	No Of COV Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54DE	Last COV Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54E0	No Of CUV Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54E2	Last CUV Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54E4	No Of OCD1 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54E6	Last OCD1 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54E8	No Of OCD2 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54EA	Last OCD2 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54EC	No Of OCC1 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54EE	Last OCC1 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54F0	No Of OCC2 Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54F2	Last OCC2 Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54F4	No Of AOCD Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54F6	Last AOCD Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54F8	No Of ASCD Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54FA	Last ASCD Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x54FC	No Of AOCC Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x54FE	Last AOCC Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x5500	No Of OTC Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x5502	Last OTC Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x5504	No Of OTD Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x5506	Last OTD Event	U2	0	32767	0	cycles
Lifetimes	Safety Events	0x5508	No Of OTF Events	U2	0	32767	0	events
Lifetimes	Safety Events	0x550A	Last OTF Event	U2	0	32767	0	cycles
Lifetimes	Charging Events	0x550C	No Valid Charge Term	U2	0	32767	0	events
Lifetimes	Charging Events	0x550E	Last Valid Charge Term	U2	0	32767	0	cycles
Lifetimes	Gauging Events	0x5510	No Of Qmax Updates	U2	0	32767	0	events
Lifetimes	Gauging Events	0x5512	Last Qmax Update	U2	0	32767	0	cycles
Lifetimes	Gauging Events	0x5514	No Of Ra Updates	U2	0	32767	0	events
Lifetimes	Gauging Events	0x5516	Last Ra Update	U2	0	32767	0	cycles
Lifetimes	Gauging Events	0x5518	No Of Ra Disable	U2	0	32767	0	events
Lifetimes	Gauging Events	0x551A	Last Ra Disable	U2	0	32767	0	cycles
Lifetimes	State of Health	0x551C	Min FCC-SOH mAh	I2	0	32767	0	mAh
Lifetimes	State of Health	0x551E	Min FCC-SOH cWh	I2	0	32767	0	cWh
Lifetimes	Cell Balancing	0x5520	Cb Time Cell 1	U4	0	4294967295	0	s

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Cell Balancing	0x5524	Cb Time Cell 2	U4	0	4294967295	0	s
Lifetimes	Cell Balancing	0x5528	Cb Time Cell 3	U4	0	4294967295	0	s
Lifetimes	Cell Balancing	0x552C	Cb Time Cell 4	U4	0	4294967295	0	s
Lifetimes	Time	0x5530	Total Fw Runtime	U4	0	4294967295	0	s
Lifetimes	Time	0x5534	Time Spent In UUT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5538	Time Spent In UUT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x553C	Time Spent In UUT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x5540	Time Spent In UUT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5544	Time Spent In UUT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5548	Time Spent In UUT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x554C	Time Spent In UUT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x5550	Time Spent In UUT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5554	Time Spent In UT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5558	Time Spent In UT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x555C	Time Spent In UT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x5560	Time Spent In UT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5564	Time Spent In UT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5568	Time Spent In UT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x556C	Time Spent In UT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x5570	Time Spent In UT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5574	Time Spent In LT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5578	Time Spent In LT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x557C	Time Spent In LT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x5580	Time Spent In LT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5584	Time Spent In LT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5588	Time Spent In LT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x558C	Time Spent In LT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x5590	Time Spent In LT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x5594	Time Spent In STL RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5598	Time Spent In STL RSOC B	U4	0	4294967295	0	s

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Time	0x559C	Time Spent In STL RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x55A0	Time Spent In STL RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x55A4	Time Spent In STL RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x55A8	Time Spent In STL RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x55AC	Time Spent In STL RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x55B0	Time Spent In STL RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x55B4	Time Spent In RT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x55B8	Time Spent In RT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x55BC	Time Spent In RT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x55C0	Time Spent In RT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x55C4	Time Spent In RT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x55C8	Time Spent In RT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x55CC	Time Spent In RT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x55D0	Time Spent In RT RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x55D4	Time Spent In STH RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x55D8	Time Spent In STH RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x55DC	Time Spent In STH RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x55E0	Time Spent In STH RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x55E4	Time Spent In STH RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x55E8	Time Spent In STH RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x55EC	Time Spent In STH RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x55F0	Time Spent In STH RSOC H	U4	0	4294967295	0	s
Lifetimes	Time	0x55F4	Time Spent In HT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x55F8	Time Spent In HT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x55FC	Time Spent In HT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x5600	Time Spent In HT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5604	Time Spent In HT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5608	Time Spent In HT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x560C	Time Spent In HT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x5610	Time Spent In HT RSOC H	U4	0	4294967295	0	s

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Lifetimes	Time	0x5614	Time Spent In OT RSOC A	U4	0	4294967295	0	s
Lifetimes	Time	0x5618	Time Spent In OT RSOC B	U4	0	4294967295	0	s
Lifetimes	Time	0x561C	Time Spent In OT RSOC C	U4	0	4294967295	0	s
Lifetimes	Time	0x5620	Time Spent In OT RSOC D	U4	0	4294967295	0	s
Lifetimes	Time	0x5624	Time Spent In OT RSOC E	U4	0	4294967295	0	s
Lifetimes	Time	0x5628	Time Spent In OT RSOC F	U4	0	4294967295	0	s
Lifetimes	Time	0x562C	Time Spent In OT RSOC G	U4	0	4294967295	0	s
Lifetimes	Time	0x5630	Time Spent In OT RSOC H	U4	0	4294967295	0	s
Protections	CUV	0x52D4	Threshold	I2	0	32767	2500	mV
Protections	CUV	0x52D6	Delay	U2	0	255	2	s
Protections	CUV	0x52D8	Recovery	I2	0	32767	3000	mV
Protections	CUV	0x52FC	Recovery Charger Present Time	U2	0	255	2	s
Protections	CUVC	0x52DA	Threshold	I2	0	32767	2400	mV
Protections	CUVC	0x52DC	Delay	U2	0	255	2	s
Protections	CUVC	0x52DE	Recovery	I2	0	32767	3000	mV
Protections	COV	0x52E0	Threshold Low Temp	I2	0	32767	4300	mV
Protections	COV	0x52E2	Threshold Standard Temp Low	I2	0	32767	4300	mV
Protections	COV	0x52E4	Threshold Standard Temp High	I2	0	32767	4300	mV
Protections	COV	0x52E6	Threshold High Temp	I2	0	32767	4300	mV
Protections	COV	0x52E8	Threshold Rec Temp	I2	0	32767	4300	mV
Protections	COV	0x52EA	Delay	U2	0	255	2	s
Protections	COV	0x52EC	Recovery Low Temp	I2	0	32767	3900	mV
Protections	COV	0x52EE	Recovery Standard Temp Low	I2	0	32767	3900	mV
Protections	COV	0x52F0	Recovery Standard Temp High	I2	0	32767	3900	mV
Protections	COV	0x52F2	Recovery High Temp	I2	0	32767	3900	mV
Protections	COV	0x52F4	Recovery Rec Temp	I2	0	32767	3900	mV
Protections	COV	0x52F8	Latch Limit	U2	0	255	0	—
Protections	COV	0x52FA	Counter Dec Delay	U2	0	255	10	s
Protections	COV	0x52FE	Reset	U2	0	255	15	s
Protections	OCC1	0x5300	Threshold	I2	–32768	32767	6000	mA
Protections	OCC1	0x5302	Delay	U2	0	255	6	s
Protections	OCC2	0x5304	Threshold	I2	–32768	32767	8000	mA
Protections	OCC2	0x5306	Delay	U2	0	255	3	s
Protections	OCC	0x5308	Recovery Threshold	I2	–32768	32767	–200	mA
Protections	OCC	0x530A	Recovery Delay	U2	0	255	5	s
Protections	OCD1	0x530C	Threshold	I2	–32768	32767	–6000	mA
Protections	OCD1	0x530E	Delay	U2	0	255	6	s
Protections	OCD2	0x5310	Threshold	I2	–32768	32767	–8000	mA
Protections	OCD2	0x5312	Delay	U2	0	255	3	s
Protections	OCD	0x5314	Recovery Threshold	I2	–32768	32767	200	mA
Protections	OCD	0x5316	Recovery Delay	U2	0	255	5	s
Protections	OCD	0x5318	Latch Limit	U2	0	255	0	—
Protections	OCD	0x531A	Counter Dec Delay	U2	0	255	10	s

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Protections	OCD	0x531C	Reset	U2	0	255	15	s
Protections	AOCD	0x5320	Latch Limit	U2	0	255	0	—
Protections	AOCD	0x5322	Counter Dec Delay	U2	0	255	10	s
Protections	AOCD	0x5324	Recovery	U2	0	255	5	s
Protections	AOCD	0x5326	Reset	U2	0	255	15	s
Protections	AOCC	0x5328	Latch Limit	U2	0	255	0	—
Protections	AOCC	0x532A	Counter Dec Delay	U2	0	255	10	s
Protections	AOCC	0x532C	Recovery	U2	0	255	5	s
Protections	AOCC	0x532E	Reset	U2	0	255	15	s
Protections	ASCD	0x5330	Latch Limit	U2	0	255	0	—
Protections	ASCD	0x5332	Counter Dec Delay	U2	0	255	10	s
Protections	ASCD	0x5334	Recovery	U2	0	255	5	s
Protections	ASCD	0x5336	Reset	U2	0	255	15	s
Protections	OTC	0x5338	Threshold	I2	2332	3932	3282	0.1°K
Protections	OTC	0x533A	Delay	U2	0	255	2	s
Protections	OTC	0x533C	Recovery	I2	2332	3932	3232	0.1°K
Protections	OTD	0x533E	Threshold	I2	2332	3932	3332	0.1°K
Protections	OTD	0x5340	Delay	U2	0	255	2	s
Protections	OTD	0x5342	Recovery	I2	2332	3932	3282	0.1°K
Protections	OTF	0x5344	Threshold	I2	2332	3932	3532	0.1°K
Protections	OTF	0x5346	Delay	U2	0	255	2	s
Protections	OTF	0x5348	Recovery	I2	2332	3932	3382	0.1°K
Protections	DCOT	0x534A	Threshold Delta	I2	0	500	150	0.1°K
Protections	DCOT	0x534C	Delay	U2	0	255	2	s
Protections	DCOT	0x534E	Recovery Delta	I2	0	500	50	0.1°K
Protections	UTC	0x5350	Threshold	I2	2332	3932	2732	0.1°K
Protections	UTC	0x5352	Delay	U2	0	255	2	s
Protections	UTC	0x5354	Recovery	I2	2332	3932	2782	0.1°K
Protections	UTD	0x5356	Threshold	I2	2332	3932	2732	0.1°K
Protections	UTD	0x5358	Delay	U2	0	255	2	s
Protections	UTD	0x535A	Recovery	I2	2332	3932	2782	0.1°K
Protections	HWD	0x535C	Delay	U2	0	255	10	s
Protections	PTO	0x52A0	Charge Threshold	I2	–32768	32767	2000	mA
Protections	PTO	0x52A2	Suspend Threshold	I2	–32768	32767	1800	mA
Protections	PTO	0x52A4	Delay	U2	0	65535	1800	s
Protections	PTO	0x52A6	Reset	I2	0	32767	2	mAh
Protections	CTO	0x52A8	Charge Threshold	I2	–32768	32767	2500	mA
Protections	CTO	0x52AA	Suspend Threshold	I2	–32768	32767	2000	mA
Protections	CTO	0x52AC	Delay	U2	0	65535	54000	s
Protections	CTO	0x52AE	Reset	I2	0	32767	2	mAh
Protections	OC	0x52B0	Threshold	I2	–32768	32767	300	mAh
Protections	OC	0x52B2	Recovery	I2	–32768	32767	2	mAh
Protections	OC	0x52B4	RSOC Recovery	U2	0	100	90	%
Protections	CHGV	0x52B6	Threshold	I2	–32768	32767	500	mV
Protections	CHGV	0x52B8	Delay	U2	0	255	30	s
Protections	CHGV	0x52BA	Recovery	I2	–32768	32767	–500	mV
Protections	CHGC	0x52BC	Threshold	I2	–32768	32767	500	mA
Protections	CHGC	0x52BE	Delay	U2	0	255	2	s
Protections	CHGC	0x52C0	Recovery Threshold	I2	–32768	32767	100	mA

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Protections	CHGC	0x52C2	Recovery Delay	U2	0	255	2	s
Protections	PCHGC	0x52C4	Threshold	I2	–32768	32767	50	mA
Protections	PCHGC	0x52C6	Delay	U2	0	255	2	s
Protections	PCHGC	0x52C8	Recovery Threshold	I2	–32768	32767	10	mA
Protections	PCHGC	0x52CA	Recovery Delay	U2	0	255	2	s
Permanent Fail	SUV	0x5224	Threshold	I2	0	32767	2200	mV
Permanent Fail	SUV	0x5226	Delay	U2	0	255	5	s
Permanent Fail	SOV	0x5228	Threshold	I2	0	32767	4500	mV
Permanent Fail	SOV	0x522A	Delay	U2	0	255	5	s
Permanent Fail	SOCC	0x522C	Threshold	I2	–32768	32767	10000	mA
Permanent Fail	SOCC	0x522E	Delay	U2	0	255	5	s
Permanent Fail	SOCD	0x5230	Threshold	I2	–32768	32767	–10000	mA
Permanent Fail	SOCD	0x5232	Delay	U2	0	255	5	s
Permanent Fail	SOT	0x5234	SOTC Threshold	I2	2332	4232	3382	0.1°K
Permanent Fail	SOT	0x5236	SOTC Delay	U2	0	255	5	s
Permanent Fail	SOT	0x5238	SOTD Threshold	I2	2332	4232	3432	0.1°K
Permanent Fail	SOT	0x523A	SOTD Delay	U2	0	255	5	s
Permanent Fail	SOTF	0x523C	Threshold	I2	2332	4232	3732	0.1°K
Permanent Fail	SOTF	0x523E	Delay	U2	0	255	5	s
Permanent Fail	Open Thermistor	0x5240	Threshold	I2	0	32767	2232	0.1°K
Permanent Fail	Open Thermistor	0x5242	Delay	U2	0	255	5	s
Permanent Fail	Open Thermistor	0x5244	Fet Delta	I2	0	1500	200	0.1°K
Permanent Fail	Open Thermistor	0x5246	Cell Delta	I2	0	1500	200	0.1°K
Permanent Fail	QIM	0x5248	Delta Threshold	I2	0	32767	150	0.1%
Permanent Fail	QIM	0x524A	Delay	U2	0	255	2	updates
Permanent Fail	CB	0x524C	Max Threshold	I2	0	32767	120	2 h
Permanent Fail	CB	0x524E	Delta Threshold	U2	0	255	20	2 h
Permanent Fail	CB	0x5250	Delay	U2	0	255	2	cycles
Permanent Fail	VIMR	0x5254	Check Voltage	I2	0	5000	3500	mV
Permanent Fail	VIMR	0x5256	Check Current	I2	0	32767	10	mA
Permanent Fail	VIMR	0x5258	Delta Threshold	I2	0	5000	500	mV
Permanent Fail	VIMR	0x525A	Delta Delay	U2	0	255	5	s
Permanent Fail	VIMR	0x5270	Duration	U2	0	65535	100	s
Permanent Fail	VIMA	0x525C	Check Voltage	I2	0	5000	3700	mV
Permanent Fail	VIMA	0x525E	Check Current	I2	0	32767	50	mA
Permanent Fail	VIMA	0x5260	Delta Threshold	I2	0	5000	200	mV
Permanent Fail	VIMA	0x5262	Delay	U2	0	255	5	s
Permanent Fail	IMP	0x5264	Delta Threshold	I2	0	32767	300	%
Permanent Fail	IMP	0x5266	Max Threshold	I2	0	32767	400	%
Permanent Fail	IMP	0x5268	Ra Update Counts	U2	0	255	2	Counts
Permanent Fail	CD	0x526C	Threshold	I2	0	32767	0	mAh
Permanent Fail	CD	0x526E	Delay	U2	0	255	2	cycles
Permanent Fail	CFET	0x5274	OFF Threshold	I2	0	500	5	mA
Permanent Fail	CFET	0x5276	OFF Delay	U2	0	255	5	s
Permanent Fail	DFET	0x5278	OFF Threshold	I2	–500	0	–5	mA
Permanent Fail	DFET	0x527A	OFF Delay	U2	0	255	5	s
Permanent Fail	FUSE	0x527C	Threshold	I2	0	255	5	mA
Permanent Fail	FUSE	0x527E	Delay	U2	0	255	5	s
Permanent Fail	AFER	0x5280	Threshold	U2	0	255	100	—

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Permanent Fail	AFER	0x5282	Delay Period	U2	0	255	2	s
Permanent Fail	AFER	0x5284	Compare Period	U2	0	255	5	s
Permanent Fail	AFEC	0x5288	Threshold	U2	0	255	100	—
Permanent Fail	AFEC	0x528A	Delay Period	U2	0	255	5	s
Permanent Fail	TMPC	0x528C	TMPC Threshold	U2	0	255	8	—
Permanent Fail	TMPC	0x528E	TMPC Delay	U2	0	255	5	s
Permanent Fail	2LVL	0x5290	Delay	U2	0	255	5	s
PF Status	Device Status Data	0x5660	Safety Alert A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5661	Safety Status A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5662	Safety Alert B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5663	Safety Status B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5664	Safety Alert C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5665	Safety Status C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5666	Safety Alert D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5667	Safety Status D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5668	PF Alert A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5669	PF Status A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x566A	PF Alert B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x566B	PF Status B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x566C	PF Alert C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x566D	PF Status C	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x566E	PF Alert D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x566F	PF Status D	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5670	Fuse Flag	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Status Data	0x5674	Operation Status A	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Status Data	0x5676	Operation Status B	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Status Data	0x5678	Temp Range	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x5679	Charging Status A	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x567A	Charging Status B	H1	0x0	0xFF	0x0	Hex
PF Status	Device Status Data	0x567E	Gauging Status	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Status Data	0x5680	IT Status	H2	0x0	0xFFFF	0x0	Hex
PF Status	Device Voltage Data	0x5682	Cell 1 Voltage	I2	–32768	32767	0	mV
PF Status	Device Voltage Data	0x5684	Cell 2 Voltage	I2	–32768	32767	0	mV
PF Status	Device Voltage Data	0x5686	Cell 3 Voltage	I2	–32768	32767	0	mV
PF Status	Device Voltage Data	0x5688	Cell 4 Voltage	I2	–32768	32767	0	mV
PF Status	Device Voltage Data	0x568A	Battery Direct Voltage	I2	–32768	32767	0	mV
PF Status	Device Voltage Data	0x568C	Pack Voltage	I2	–32768	32767	0	mV
PF Status	Device Current Data	0x568E	Current	I2	–32768	32767	0	mA
PF Status	Device Temperature Data	0x5690	Internal Temperature	I2	–1	32767	0	0.1°K
PF Status	Device Temperature Data	0x5692	External 1 Temperature	I2	–1	32767	0	0.1°K
PF Status	Device Temperature Data	0x5694	External 2 Temperature	I2	–1	32767	0	0.1°K
PF Status	Device Temperature Data	0x5696	External 3 Temperature	I2	–1	32767	0	0.1°K

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
PF Status	Device Temperature Data	0x5698	External 4 Temperature	I2	–1	32767	0	0.1°K
PF Status	Device Gauging Data	0x569A	Cell 1 Dod0	I2	–32768	32767	0	—
PF Status	Device Gauging Data	0x569C	Cell 2 Dod0	I2	–32768	32767	0	—
PF Status	Device Gauging Data	0x569E	Cell 3 Dod0	I2	–32768	32767	0	—
PF Status	Device Gauging Data	0x56A0	Cell 4 Dod0	I2	–32768	32767	0	—
PF Status	Device Gauging Data	0x56A2	Passed Charge	I2	–32768	32767	0	mAh
PF Status	AFE Regs	0x5640	OCC	H1	0x0	0x7F	0x03	Hex
PF Status	AFE Regs	0x5641	OCD 1	H1	0x0	0x7F	0x03	Hex
PF Status	AFE Regs	0x5642	OCD 2	H1	0x0	0x7F	0x04	Hex
PF Status	AFE Regs	0x5643	Short Circuit Discharge	H1	0x0	0x7F	0x64	Hex
PF Status	AFE Regs	0x5644	Over Temperature	H1	0x0	0x7F	0x5A	Hex
PF Status	AFE Regs	0x5645	Current Discharge Wake	H1	0x70	0x7F	0x79	Hex
PF Status	AFE Regs	0x5646	Current Charge Wake	H1	0x70	0x7F	0x79	Hex
PF Status	AFE Regs	0x5647	OCC 1 Delay 2	H1	0x0	0x07	0x07	Hex
PF Status	AFE Regs	0x5648	OCC 1 Delay 1	H1	0x0	0xFF	0xFF	Hex
PF Status	AFE Regs	0x5649	OCD 1 Delay 2	H1	0x0	0x07	0x07	Hex
PF Status	AFE Regs	0x564A	OCD 1 Delay 1	H1	0x0	0xFF	0xFF	Hex
PF Status	AFE Regs	0x564B	OCD 2 Delay 2	H1	0x0	0x07	0x07	Hex
PF Status	AFE Regs	0x564C	OCD 2 Delay 1	H1	0x0	0xFF	0xFF	Hex
PF Status	AFE Regs	0x564D	Short Circuit Discharge Delay	H1	0x0	0x3F	0x14	Hex
PF Status	AFE Regs	0x564E	Over Temperature Delay	H1	0x0	0x1F	0x14	Hex
PF Status	AFE Regs	0x564F	OCD Wake Delay 2	H1	0x0	0x01	0x01	Hex
PF Status	AFE Regs	0x5650	OCD Wake Delay 1	H1	0x0	0xFF	0xFF	Hex
PF Status	AFE Regs	0x5651	OCC Wake Delay 2	H1	0x0	0x01	0x01	Hex
PF Status	AFE Regs	0x5652	OCC Wake Delay 1	H1	0x0	0xFF	0xFF	Hex
Black Box	Safety Status	0x5370	1st Safety Status A	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5371	1st Safety Status B	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5372	1st Safety Status C	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5373	1st Safety Status D	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5374	1st Time to Next Event	U2	0	65535	0	s
Black Box	Safety Status	0x5376	1st Cycle Count	U2	0	65535	0	—
Black Box	Safety Status	0x5378	2nd Safety Status A	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5379	2nd Safety Status B	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x537A	2nd Safety Status C	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x537B	2nd Safety Status D	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x537C	2nd Time to Next Event	U2	0	65535	0	s
Black Box	Safety Status	0x537E	2nd Cycle Count	U2	0	65535	0	—
Black Box	Safety Status	0x5380	3rd Safety Status A	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5381	3rd Safety Status B	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5382	3rd Safety Status C	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5383	3rd Safety Status D	H1	0x0	0xFF	0x0	Hex
Black Box	Safety Status	0x5384	3rd Time to Next Event	U2	0	65535	0	s
Black Box	Safety Status	0x5386	3rd Cycle Count	U2	0	65535	0	—
Black Box	PF Status	0x5388	1st PF Status A	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x5389	1st PF Status B	H1	0x0	0xFF	0x0	Hex

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Black Box	PF Status	0x538A	1st PF Status C	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x538B	1st PF Status D	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x538C	1st Time to Next Event	U2	0	65535	0	s
Black Box	PF Status	0x538E	1st Cycle Count	U2	0	65535	0	—
Black Box	PF Status	0x5390	2nd PF Status A	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x5391	2nd PF Status B	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x5392	2nd PF Status C	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x5393	2nd PF Status D	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x5394	2nd Time to Next Event	U2	0	65535	0	s
Black Box	PF Status	0x5396	2nd Cycle Count	U2	0	65535	0	—
Black Box	PF Status	0x5398	3rd PF Status A	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x5399	3rd PF Status B	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x539A	3rd PF Status C	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x539B	3rd PF Status D	H1	0x0	0xFF	0x0	Hex
Black Box	PF Status	0x539E	3rd Cycle Count	U2	0	65535	0	—
Gas Gauging	Current Thresholds	0x438C	Dsg Current Threshold	I2	–32768	32767	100	mA
Gas Gauging	Current Thresholds	0x438E	Chg Current Threshold	I2	–32768	32767	50	mA
Gas Gauging	Current Thresholds	0x4390	Quit Current	I2	0	32767	10	mA
Gas Gauging	Current Thresholds	0x4392	Dsg Relax Time	U2	0	255	1	s
Gas Gauging	Current Thresholds	0x4394	Chg Relax Time	U2	0	255	60	s
Gas Gauging	Design	0x5420	Design Capacity mAh	I2	100	32767	4400	mAh
Gas Gauging	Design	0x5422	Design Capacity cWh	I2	144	32767	6336	cWh
Gas Gauging	Design	0x5424	Design Voltage	I2	0	32767	14400	mV
Gas Gauging	Cycle	0x5426	Cycle Count Percentage	U2	0	100	90	%
Gas Gauging	FD	0x5430	Set Voltage Threshold	I2	0	5000	3000	mV
Gas Gauging	FD	0x5432	Clear Voltage Threshold	I2	0	5000	3100	mV
Gas Gauging	FD	0x5434	Set % RSOC Threshold	U2	0	100	0	%
Gas Gauging	FD	0x5436	Clear % RSOC Threshold	U2	0	100	5	%
Gas Gauging	FC	0x5438	Set Voltage Threshold	I2	0	5000	4200	mV
Gas Gauging	FC	0x543A	Clear Voltage Threshold	I2	0	5000	4100	mV
Gas Gauging	FC	0x543C	Set % RSOC Threshold	U2	0	100	100	%
Gas Gauging	FC	0x543E	Clear % RSOC Threshold	U2	0	100	95	%
Gas Gauging	TD	0x5440	Set Voltage Threshold	I2	0	5000	3200	mV
Gas Gauging	TD	0x5442	Clear Voltage Threshold	I2	0	5000	3300	mV
Gas Gauging	TD	0x5444	Set % RSOC Threshold	U2	0	100	6	%
Gas Gauging	TD	0x5446	Clear % RSOC Threshold	U2	0	100	8	%
Gas Gauging	TC	0x5448	Set Voltage Threshold	I2	0	5000	4200	mV
Gas Gauging	TC	0x544A	Clear Voltage Threshold	I2	0	5000	4100	mV
Gas Gauging	TC	0x544C	Set % RSOC Threshold	U2	0	100	100	%
Gas Gauging	TC	0x544E	Clear % RSOC Threshold	U2	0	100	95	%
Gas Gauging	State	0x5410	Cycle Count	U2	0	65535	0	—
Gas Gauging	State	0x5760	Qmax Cell 1	I2	0	32767	4400	mAh
Gas Gauging	State	0x5762	Qmax Cell 2	I2	0	32767	4400	mAh
Gas Gauging	State	0x5764	Qmax Cell 3	I2	0	32767	4400	mAh
Gas Gauging	State	0x5766	Qmax Cell 4	I2	0	32767	4400	mAh
Gas Gauging	State	0x5768	Qmax Pack	I2	0	32767	4400	mAh
Gas Gauging	State	0x576A	Qmax Cycle Count	U2	0	65535	0	—
Gas Gauging	State	0x576C	Update Status	H1	0x0	0x0E	0x0	—
Gas Gauging	State	0x5770	Cell 1 Chg Voltage at EoC	I2	0	32767	4200	mV

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Gas Gauging	State	0x5772	Cell 2 Chg Voltage at EoC	I2	0	32767	4200	mV
Gas Gauging	State	0x5774	Cell 3 Chg Voltage at EoC	I2	0	32767	4200	mV
Gas Gauging	State	0x5776	Cell 4 Chg Voltage at EoC	I2	0	32767	4200	mV
Gas Gauging	State	0x5778	Current at EoC	I2	0	32767	250	mA
Gas Gauging	State	0x577A	Avg I Last Run	I2	–32768	32767	–2000	mA
Gas Gauging	State	0x577C	Avg P Last Run	I2	–32768	32767	–3022	cW
Gas Gauging	State	0x577E	Temp k	I2	0	32767	100	0.1°C/256 cW
Gas Gauging	State	0x5780	Temp a	I2	0	32767	1000	s
Gas Gauging	State	0x5782	Max Avg I Last Run	I2	–32768	32767	–2000	mA
Gas Gauging	State	0x5784	Max Avg P Last Run	I2	–32768	32767	–3022	cW
Gas Gauging	State	0x5786	Delta Voltage	I2	–32768	32767	0	mV
Gas Gauging	State	0x5788	SOH FCC Max mAh	I2	100	32767	4400	mAh
Gas Gauging	State	0x578A	SOH FCC Max cWh	I2	144	32767	6336	cWh
Gas Gauging	State	0x578C	SOH Temp k	I2	0	32767	100	0.1°C/256 cW
Gas Gauging	State	0x578E	SOH Temp a	I2	0	32767	1000	s
Gas Gauging	Turbo Cfg	0x5202	Min System Voltage	I2	0	32767	9000	mV
Gas Gauging	Turbo Cfg	0x5204	Ten Second Max C Rate	I2	–32768	0	–200	0.01°C-rate
Gas Gauging	Turbo Cfg	0x5206	Ten Millisecond Max C Rate	I2	–32768	0	–400	0.01°C-rate
Gas Gauging	Turbo Cfg	0x5208	High Frequency Resistance	I2	0	32767	36	mΩ
Gas Gauging	Turbo Cfg	0x520A	Reserve Energy %	U2	0	100	0	%
Gas Gauging	Turbo Cfg	0x520C	Turbo Adjustment Factor	U2	0	255	100	%
Gas Gauging	IT-DZT Cfg	0x44C6	Load Select	U1	0	7	7	—
Gas Gauging	IT-DZT Cfg	0x44C7	Fast Scale Load Select	U1	0	7	3	—
Gas Gauging	IT-DZT Cfg	0x44C8	Load Mode	U1	0	1	0	—
Gas Gauging	IT-DZT Cfg	0x44CC	User Rate-mA	I2	–9000	0	0	mA
Gas Gauging	IT-DZT Cfg	0x44CE	User Rate-cW	I2	–32768	0	0	cW
Gas Gauging	IT-DZT Cfg	0x44D0	Reserve Cap-mAh	I2	0	9000	0	mAh
Gas Gauging	IT-DZT Cfg	0x44D2	Reserve Cap-cWh	I2	0	32000	0	cWh
Gas Gauging	IT-DZT Cfg	0x44EE	Predict Ambient Time	U2	0	65535	2000	s
Gas Gauging	IT-DZT Cfg	0x4514	Ra Filter	U2	0	999	800	0.1%
Gas Gauging	IT-DZT Cfg	0x4518	Ra Max Delta	U2	0	255	15	%
Gas Gauging	IT-DZT Cfg	0x451C	Reference Grid	U2	0	14	4	—
Gas Gauging	IT-DZT Cfg	0x451E	Resistance Parameter Filter	U2	1	65535	65142	—
Gas Gauging	IT-DZT Cfg	0x4520	Near EDV Ra Param Filter	U2	1	65535	59220	—
Gas Gauging	IT-DZT Cfg	0x4522	Max Current Change %	U2	0	100	10	%
Gas Gauging	IT-DZT Cfg	0x4524	Resistance Update Voltage	I2	0	32767	50	mV
Gas Gauging	IT-DZT Cfg	0x455A	Qmax Delta	U2	3	100	5	%
Gas Gauging	IT-DZT Cfg	0x455C	Qmax Upper Bound	U2	100	255	130	%
Gas Gauging	IT-DZT Cfg	0x455E	OCV Pred Active T Limit	U2	100	65535	200	s
Gas Gauging	IT-DZT Cfg	0x4560	OCV Pred Transient T	U2	100	65535	300	s
Gas Gauging	IT-DZT Cfg	0x4562	OCV Pred Measure Time	U2	0	65535	200	s
Gas Gauging	IT-DZT Cfg	0x4564	Term Voltage	I2	0	32767	9000	mV
Gas Gauging	IT-DZT Cfg	0x4566	Term V Hold Time	U2	0	255	15	s
Gas Gauging	IT-DZT Cfg	0x4568	Term Voltage Delta	I2	0	32767	300	mV
Gas Gauging	IT-DZT Cfg	0x456A	Term Min Cell V	I2	0	32767	2800	mV
Gas Gauging	IT-DZT Cfg	0x456E	Res Relax Time	U2	0	65535	200	s
Gas Gauging	IT-DZT Cfg	0x4576	Max Simulation Iterations	U2	20	50	30	—

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Gas Gauging	IT-DZT Cfg	0x457A	Simulation Near Term Delta	I2	0	32767	250	mV
Gas Gauging	IT-DZT Cfg	0x4588	Fast Scale Start SOC	U2	0	100	10	%
Gas Gauging	IT-DZT Cfg	0x4596	Min Delta Voltage	I2	–32768	32767	0	mV
Gas Gauging	IT-DZT Cfg	0x4598	Max Delta Voltage	I2	–32768	32767	200	mV
Gas Gauging	IT-DZT Cfg	0x459A	DeltaV Max Voltage Delta	I2	–32768	32767	10	mV
Gas Gauging	IT-DZT Cfg	0x5790	Design Resistance	I2	1	32767	96	mΩ
Gas Gauging	IT-DZT Cfg	0x5792	Pack Resistance	I2	0	32767	0	mΩ
Gas Gauging	IT-DZT Cfg	0x5794	System Resistance	I2	0	32767	0	mΩ
Gas Gauging	Smoothing	0x44D4	Smooth Relax Time	U2	1	32767	1000	s
Gas Gauging	Smoothing	0x44D6	Term Smooth Start Cell V Delta	I2	0	32767	150	mV
Gas Gauging	Smoothing	0x44D8	Term Smooth Final Cell V Delta	I2	0	32767	100	mV
Gas Gauging	Smoothing	0x44DA	Term Smooth Time	U2	1	255	20	s
Gas Gauging	Max Error	0x44E2	Time Cycle Equivalent	U2	1	255	12	2 h
Gas Gauging	Max Error	0x44E4	Cycle Delta	U2	0	255	5	0.01%
Gas Gauging	Condition Flag	0x44E8	Max Error Limit	U2	0	100	100	%
Gas Gauging	SoH	0x45A0	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_a1	0x5040	Cell1 R_a flag	H2	0x0	0xFFFF	0xFF55	—
Ra Table	R_a1	0x5042	Cell1 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a1	0x5044	Cell1 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a1	0x5046	Cell1 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a1	0x5048	Cell1 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a1	0x504A	Cell1 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a1	0x504C	Cell1 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a1	0x504E	Cell1 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a1	0x5050	Cell1 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a1	0x5052	Cell1 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a1	0x5054	Cell1 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a1	0x5056	Cell1 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a1	0x5058	Cell1 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a1	0x505A	Cell1 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a1	0x505C	Cell1 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a1	0x505E	Cell1 R_a 14	I2	0	32767	658	mΩ
Ra Table	R_a2	0x5080	Cell2 R_a flag	H2	0x0	0xFFFF	0xFF55	—

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Ra Table	R_a2	0x5082	Cell2 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a2	0x5084	Cell2 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a2	0x5086	Cell2 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a2	0x5088	Cell2 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a2	0x508A	Cell2 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a2	0x508C	Cell2 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a2	0x508E	Cell2 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a2	0x5090	Cell2 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a2	0x5092	Cell2 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a2	0x5094	Cell2 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a2	0x5096	Cell2 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a2	0x5098	Cell2 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a2	0x509A	Cell2 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a2	0x509C	Cell2 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a2	0x509E	Cell2 R_a 14	I2	0	32767	658	mΩ
Ra Table	R_a3	0x50C0	Cell3 R_a flag	H2	0x0	0xFFFF	0xFF55	—
Ra Table	R_a3	0x50C2	Cell3 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a3	0x50C4	Cell3 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a3	0x50C6	Cell3 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a3	0x50C8	Cell3 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a3	0x50CA	Cell3 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a3	0x50CC	Cell3 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a3	0x50CE	Cell3 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a3	0x50D0	Cell3 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a3	0x50D2	Cell3 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a3	0x50D4	Cell3 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a3	0x50D6	Cell3 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a3	0x50D8	Cell3 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a3	0x50DA	Cell3 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a3	0x50DC	Cell3 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a3	0x50DE	Cell3 R_a 14	I2	0	32767	658	mΩ
Ra Table	R_a0x	0x5100	xCell0 R_a flag	H2	0x0	0xFFFF	0xFFFF	—
Ra Table	R_a0x	0x5102	xCell0 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a0x	0x5104	xCell0 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a0x	0x5106	xCell0 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a0x	0x5108	xCell0 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a0x	0x510A	xCell0 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a0x	0x510C	xCell0 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a0x	0x510E	xCell0 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a0x	0x5110	xCell0 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a0x	0x5112	xCell0 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a0x	0x5114	xCell0 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a0x	0x5116	xCell0 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a0x	0x5118	xCell0 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a0x	0x511A	xCell0 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a0x	0x511C	xCell0 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a0x	0x511E	xCell0 R_a 14	I2	0	32767	658	mΩ
Ra Table	R_a1x	0x5140	xCell1 R_a flag	H2	0x0	0xFFFF	0xFFFF	—
Ra Table	R_a1x	0x5142	xCell1 R_a 0	I2	0	32767	67	mΩ

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Ra Table	R_a1x	0x5144	xCell1 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a1x	0x5146	xCell1 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a1x	0x5148	xCell1 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a1x	0x514A	xCell1 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a1x	0x514C	xCell1 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a1x	0x514E	xCell1 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a1x	0x5150	xCell1 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a1x	0x5152	xCell1 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a1x	0x5154	xCell1 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a1x	0x5156	xCell1 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a1x	0x5158	xCell1 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a1x	0x515A	xCell1 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a1x	0x515C	xCell1 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a1x	0x515E	xCell1 R_a 14	I2	0	32767	658	mΩ
Ra Table	R_a2x	0x5180	xCell2 R_a flag	H2	0x0	0xFFFF	0xFFFF	—
Ra Table	R_a2x	0x5182	xCell2 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a2x	0x5184	xCell2 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a2x	0x5186	xCell2 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a2x	0x5188	xCell2 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a2x	0x518A	xCell2 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a2x	0x518C	xCell2 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a2x	0x518E	xCell2 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a2x	0x5190	xCell2 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a2x	0x5192	xCell2 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a2x	0x5194	xCell2 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a2x	0x5196	xCell2 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a2x	0x5198	xCell2 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a2x	0x519A	xCell2 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a2x	0x519C	xCell2 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a2x	0x519E	xCell2 R_a 14	I2	0	32767	658	mΩ
Ra Table	R_a3x	0x51C0	xCell3 R_a flag	H2	0x0	0xFFFF	0xFFFF	—
Ra Table	R_a3x	0x51C2	xCell3 R_a 0	I2	0	32767	67	mΩ
Ra Table	R_a3x	0x51C4	xCell3 R_a 1	I2	0	32767	71	mΩ
Ra Table	R_a3x	0x51C6	xCell3 R_a 2	I2	0	32767	83	mΩ
Ra Table	R_a3x	0x51C8	xCell3 R_a 3	I2	0	32767	110	mΩ
Ra Table	R_a3x	0x51CA	xCell3 R_a 4	I2	0	32767	96	mΩ
Ra Table	R_a3x	0x51CC	xCell3 R_a 5	I2	0	32767	77	mΩ
Ra Table	R_a3x	0x51CE	xCell3 R_a 6	I2	0	32767	96	mΩ
Ra Table	R_a3x	0x51D0	xCell3 R_a 7	I2	0	32767	86	mΩ
Ra Table	R_a3x	0x51D2	xCell3 R_a 8	I2	0	32767	84	mΩ
Ra Table	R_a3x	0x51D4	xCell3 R_a 9	I2	0	32767	82	mΩ
Ra Table	R_a3x	0x51D6	xCell3 R_a 10	I2	0	32767	81	mΩ
Ra Table	R_a3x	0x51D8	xCell3 R_a 11	I2	0	32767	92	mΩ
Ra Table	R_a3x	0x51DA	xCell3 R_a 12	I2	0	32767	103	mΩ
Ra Table	R_a3x	0x51DC	xCell3 R_a 13	I2	0	32767	123	mΩ
Ra Table	R_a3x	0x51DE	xCell3 R_a 14	I2	0	32767	658	mΩ
TMP468	Temp1 Configuration	0x56D0	Offset Ptr	H2	0x0	0x00FF	0x0040	Hex
TMP468	Temp1 Configuration	0x56D2	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
TMP468	Temp1 Configuration	0x56D4	nFactor Ptr	H2	0x0	0x00FF	0x0041	Hex
TMP468	Temp1 Configuration	0x56D6	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp1 Configuration	0x56D8	ThermLimit1 Ptr	H2	0x0	0x00FF	0x0042	Hex
TMP468	Temp1 Configuration	0x56DA	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp1 Configuration	0x56DC	ThermLimit2 Ptr	H2	0x0	0x00FF	0x0043	Hex
TMP468	Temp1 Configuration	0x56DE	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp2 Configuration	0x56E0	Offset Ptr	H2	0x0	0x00FF	0x0048	Hex
TMP468	Temp2 Configuration	0x56E2	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp2 Configuration	0x56E4	nFactor Ptr	H2	0x0	0x00FF	0x0049	Hex
TMP468	Temp2 Configuration	0x56E6	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp2 Configuration	0x56E8	ThermLimit1 Ptr	H2	0x0	0x00FF	0x004A	Hex
TMP468	Temp2 Configuration	0x56EA	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp2 Configuration	0x56EC	ThermLimit2 Ptr	H2	0x0	0x00FF	0x004B	Hex
TMP468	Temp2 Configuration	0x56EE	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp3 Configuration	0x56F0	Offset Ptr	H2	0x0	0x00FF	0x0050	Hex
TMP468	Temp3 Configuration	0x56F2	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp3 Configuration	0x56F4	nFactor Ptr	H2	0x0	0x00FF	0x0051	Hex
TMP468	Temp3 Configuration	0x56F6	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp3 Configuration	0x56F8	ThermLimit1 Ptr	H2	0x0	0x00FF	0x0052	Hex
TMP468	Temp3 Configuration	0x56FA	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp3 Configuration	0x56FC	ThermLimit2 Ptr	H2	0x0	0x00FF	0x0053	Hex
TMP468	Temp3 Configuration	0x56FE	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp4 Configuration	0x5700	Offset Ptr	H2	0x0	0x00FF	0x0058	Hex
TMP468	Temp4 Configuration	0x5702	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp4 Configuration	0x5704	nFactor Ptr	H2	0x0	0x00FF	0x0059	Hex
TMP468	Temp4 Configuration	0x5706	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp4 Configuration	0x5708	ThermLimit1 Ptr	H2	0x0	0x00FF	0x005A	Hex
TMP468	Temp4 Configuration	0x570A	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp4 Configuration	0x570C	ThermLimit2 Ptr	H2	0x0	0x00FF	0x005B	Hex
TMP468	Temp4 Configuration	0x570E	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
TMP468	Temp5 Configuration	0x5710	Offset Ptr	H2	0x0	0x00FF	0x0060	Hex
TMP468	Temp5 Configuration	0x5712	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp5 Configuration	0x5714	nFactor Ptr	H2	0x0	0x00FF	0x0061	Hex
TMP468	Temp5 Configuration	0x5716	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp5 Configuration	0x5718	ThermLimit1 Ptr	H2	0x0	0x00FF	0x0062	Hex
TMP468	Temp5 Configuration	0x571A	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp5 Configuration	0x571C	ThermLimit2 Ptr	H2	0x0	0x00FF	0x0063	Hex
TMP468	Temp5 Configuration	0x571E	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp6 Configuration	0x5720	Offset Ptr	H2	0x0	0x00FF	0x0068	Hex
TMP468	Temp6 Configuration	0x5722	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp6 Configuration	0x5724	nFactor Ptr	H2	0x0	0x00FF	0x0069	Hex
TMP468	Temp6 Configuration	0x5726	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp6 Configuration	0x5728	ThermLimit1 Ptr	H2	0x0	0x00FF	0x006A	Hex
TMP468	Temp6 Configuration	0x572A	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp6 Configuration	0x572C	ThermLimit2 Ptr	H2	0x0	0x00FF	0x006B	Hex
TMP468	Temp6 Configuration	0x572E	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp7 Configuration	0x5730	Offset Ptr	H2	0x0	0x00FF	0x0070	Hex
TMP468	Temp7 Configuration	0x5732	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp7 Configuration	0x5734	nFactor Ptr	H2	0x0	0x00FF	0x0071	Hex
TMP468	Temp7 Configuration	0x5736	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp7 Configuration	0x5738	ThermLimit1 Ptr	H2	0x0	0x00FF	0x0072	Hex
TMP468	Temp7 Configuration	0x573A	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp7 Configuration	0x573C	ThermLimit2 Ptr	H2	0x0	0x00FF	0x0073	Hex
TMP468	Temp7 Configuration	0x573E	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex
TMP468	Temp8 Configuration	0x5740	Offset Ptr	H2	0x0	0x00FF	0x0078	Hex
TMP468	Temp8 Configuration	0x5742	Offset Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp8 Configuration	0x5744	nFactor Ptr	H2	0x0	0x00FF	0x0079	Hex
TMP468	Temp8 Configuration	0x5746	nFactor Data	H2	0x0000	0xFFFF	0x0000	Hex
TMP468	Temp8 Configuration	0x5748	ThermLimit1 Ptr	H2	0x0	0x00FF	0x007A	Hex
TMP468	Temp8 Configuration	0x574A	ThermLimit1 Data	H2	0x0000	0xFFFF	0x7FC0	Hex

Table 17-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
TMP468	Temp8 Configuration	0x574C	ThermLimit2 Ptr	H2	0x0	0x00FF	0x007B	Hex
TMP468	Temp8 Configuration	0x574E	ThermLimit2 Data	H2	0x0000	0xFFFF	0x7FC0	Hex

Appendix A
AFE Threshold and Delay Settings

A.1 Overload in Discharge Protection (AOCD1 and AOCD2)

Table A-1. Overload in Discharge Protection Threshold

Setting[(1)]	Threshold (AOCD1)[(3)]	Setting[(2)]	Threshold (AOCD2)[(3)]
0x00	0 mV	0x00	0 mV
0x01	-2 mV	0x01	-2 mV
0x02	-4 mV	0x02	-4 mV
0x03	-6 mV	0x03	-6 mV
...	...	...	...
0x7F	-254 mV	0x7F	-254 mV

(1) The data flash setting ***Settings:AFE:OCD 1[6:0]*** sets the voltage threshold of AOCD1.
(2) The data flash setting ***Settings:AFE:OCD 2[6:0]*** sets the voltage threshold of AOCD2.
(3) The voltage threshold is ***Settings:AFE:OCD*** * -2mV.

Table A-2. Overload in Discharge Protection Delay

Setting (OCD 1 Delay 2)[(1)]	Setting (OCD 1 Delay 1)[(1)]	Time[(3)]	Setting (OCD 2 Delay 2)[(2)]	Setting (OCD 2 Delay 1)[(2)]	Time[(4)]
0x00	0x00	-[(5)]	0x00	0x00	-[(5)]
0x00	0x01	1.10 ms	0x00	0x01	1.10 ms
0x00	0x02	1.65 ms	0x00	0x02	1.65 ms
0x00	0x03	2.20 ms	0x00	0x03	2.20 ms
0x00	0x04	2.75 ms	0x00	0x04	2.75 ms
0x00	0x05	3.30 ms	0x00	0x05	3.30 ms
0x00	0x06	3.85 ms	0x00	0x06	3.85 ms
...	...	...	...	...	...
0x07	0xFF	1126.40 ms	0x07	0xFF	1126.40 ms

(1) The data flash setting ***Settings:AFE:OCD 1 Delay 1[7:0]*** and ***Settings:AFE:OCD 1 Delay 2[2:0]*** sets the delay time of AOCD1.
(2) The data flash setting ***Settings:AFE:OCD 2 Delay 1[7:0]*** and ***Settings:AFE:OCD 2 Delay 2[2:0]*** sets the delay time of AOCD2.
(3) The delay time is (***Settings:AFE:OCD 1 Delay 2*** * 256 + ***Settings:AFE:OCD 1 Delay 1*** + 1) * 0.55ms.
(4) The delay time is (***Settings:AFE:OCD 2 Delay 2*** * 256 + ***Settings:AFE:OCD 2 Delay 1*** + 1) * 0.55ms.
(5) Set both delay time DF to 0 disables this feature.

A.2 Overcurrent in Charge Protection (AOCC)

Table A-3. Short Circuit in Charge Protection Threshold

Setting[(1)]	Threshold[(2)]
0x00	0 mV
0x01	2 mV
0x02	4 mV
0x03	6 mV
...	...

Table A-3. Short Circuit in Charge Protection Threshold (continued)

Setting(1)	Threshold(2)
0x7F	254 mV

(1) The data flash setting ***Settings:AFE:OCC[6:0]*** sets the voltage threshold.
(2) The voltage threshold is ***Settings:AFE:OCC*** * 2mV.

Table A-4. Short Circuit in Charge Protection Delay

Setting (OCC 1 Delay 2)(1)	Setting (OCC 1 Delay 1)(1)	Time(2)
0x00	0x00	-(3)
0x00	0x01	1.10 ms
0x00	0x02	1.65 ms
0x00	0x03	2.20 ms
0x00	0x04	2.75 ms
0x00	0x05	3.30 ms
0x00	0x06	3.85 ms
...	...	...
0x07	0xFF	1126.40 ms

(1) The data flash setting ***Settings:AFE:OCC 1 Delay 1[7:0]*** and ***Settings:AFE:OCC 1 Delay 2[2:0]*** sets the delay time.
(2) The delay time is (***Settings:AFE:OCC 1 Delay 2*** * 256 + ***Settings:AFE:OCC 1 Delay 1*** + 1) * 0.55ms.
(3) Set both delay time DF to 0 disables this feature.

A.3 Short Circuit in Discharge Protection (ASCD)

Table A-5. Short Circuit in Discharge Protection Threshold

Setting	Threshold
0x00	0 mV
0x01	-2.5 mV
0x02	-5.0 mV
0x03	-7.5 mV
...	...
0x7F	-317.5 mV

Table A-6. Short Circuit in Discharge Protection Delay

Setting	Time
0x00	-(1)
0x01	91.5 µs
0x02	152.5 µs
0x03	183 µs
0x04	244 us
0x05	274.5 us
0x06	335.5 us
...	...
0x3F	2928 us

(1) Set both delay time DF to 0 disables this feature.

A.4 Over Temperature Protection

Table A-7. Over Temperature Protection Threshold

Setting1	Threshold2
0x18	6000 Ω (40°C)3
0x20	4154 Ω (50°C)

Table A-7. Over Temperature Protection Threshold (continued)

Setting1	Threshold2
0x2A	3000 Ω (60°C)
0x36	2250 Ω (70°C)
0x47	1662 Ω (80°C)
0x5C	1256 Ω (90°C)
0x75	973 Ω (100°C)
0x7F	893 Ω (105°C)

1. The data flash setting ***Settings:AFE:Over Temperature[6:0]*** sets the temperature threshold.
2. The temperature threshold is R_{NTC_TS3} / (***Settings:AFE:Over Temperature[6:0]*** -6). R_{NTC_TS3} is the internal pullup resistance, its typical value is 18 kΩ.
3. Expected temperature threshold in the list is based on a 103AT NTC thermistor.

Table A-8. Over Temperature Protection Delay

Setting1	Time2
0x0	–3
0x01	1.0011 s
0x02	2.0011 s
0x03	3.0011 s
...	...
0x1F	31.0011 s

1. The data flash setting ***Settings:AFE:Over Temperature Delay[4:0]*** sets the delay time.
2. The delay time is 1.1ms + ***Settings:AFE:Over Temperature Delay[4:0]*** * 1s.
3. Set both delay time DF to 0 disables this feature.

A.5 Current Wake Detector

Table A-9. Current Wake in Charge Threshold

Setting(1)	Threshold(2)
0x70	0.5 mV
0x72	1.0 mV
0x73	1.5 mV
...	...
0x7F	8.0 mV

(1) The data flash setting ***Settings:AFE:Current Charge Wake*** sets the voltage threshold.
(2) The voltage threshold is (***Settings:AFE:Current Charge Wake*** - 0x70 + 1) * 0.5mV.

Table A-10. Current Wake in Charge Delay

Setting (OCC Wake Delay 2)	Setting (OCC Wake Delay 1)	Delay Time
0x0	0x00	-(1)
0x0	0x01	7.70 ms
0x0	0x02	8.25 ms
0x0	0x03	8.80 ms
...	...	...
0x1	0xFF	288.20 ms

(1) Curent wake in charge is disabled when ***OCC Wake Delay 2*** and ***OCC Wake Delay 1*** are set to 0.

Table A-11. Current Wake in Discharge Threshold

Setting[(1)]	Threshold[(2)]
0x71	-0.5 mV
0x72	-1.0 mV
0x73	-1.5 mV
...	...
0x7F	-7.5 mV

(1) The data flash setting ***Settings:AFE:Current Discharge Wake*** sets the voltage threshold.
(2) The voltage threshold is (***Settings:AFE:Current Discharge Wake*** - 0x70) * -0.5mV.

Table A-12. Current Wake in Discharge Delay

Setting (OCD Wake Delay 2)	Setting (OCD Wake Delay 1)	Delay Time[(1)]
0x0	0x00	-
0x0	0x01	7.70 ms
0x0	0x02	8.25 ms
0x0	0x03	8.80 ms
...	...	...
0x1	0xFF	288.20 ms

(1) Curent wake in discharge is disabled when ***OCD Wake Delay 2*** and ***OCD Wake Delay 1*** are set to 0.

Appendix B
Sample Filter Settings

Table B-1. Sample V/I/P Filter Settings and Associated Low-Pass Filter Time Constants

Average V/I/P Filter[(1)]	Effective Low-Pass Time Constant
10	0.25 seconds
50	0.5 seconds
145	1 second
200	3 seconds

(1) The data flash setting ***Calibration:Filter:Average V/I/P*** sets this threshold.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from June 30, 2024 to April 30, 2025 (from Revision * (June 2024) to Revision A (April 2025)) **Page**

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