bq30z55-V100R1

Technical Reference

Literature Number: SLUU511
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Contents

Preface

Read this First

This manual discusses the modules and peripherals of the bq30z55-V100R1 devices, and how each is used to build a complete battery pack gas gauge and protection solution.

Notational Conventions

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

- SBS commands are set in italic; for example, *Voltage*.
- SBS bits and flags are capitalized, set in italic and enclosed with square brackets; for example, *[TCA]*.
- Data flash values are set in bold italic; for example, ***CUV Threshold***.
- All data flash bits and flags are capitalized, set in bold italic and enclosed with square brackets, for example, ***[NR]***.

All SBS commands, data flash values, and flags mentioned in a chapter are listed at the end of each chapter for reference.

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)

The reference format for data flash values is: DF:Class Name:Subclass Name(Subclass ID):Value Name(Offset)[Flag], for example:

DF:1st Level Safety:Voltage(576):CUV Threshold(13), or

DF:ChargeControl:ChargingFaults(482)Charge Fault Cfg(8)[OC].

Introduction

The bq30z55-V100R1 device provides a feature-rich gas gauging solution for 2-series cell to 4-series cell battery-pack applications. The device has extended capabilities, including:

- SBS Data Updates Every 250 ms; Values Are Filtered, Not Averaged
- Unseal via Authentication with Keys in IF, Enhanced Security
- Advanced Impedance Track Algorithm v3.75 with Cell Balancing During Rest
- Fast Host-Side Calibration
- Fast Qmax Learning
- Independent Function Enable/Disable: FET, IT, BB, LT, PF, FUSE, LED
- Cell and FET Temperature Configuration Options and up to Five Independently Selectable Sources for Each Option
- Manufacturer Access Commands for Test: Fuse, FET, LED, Toggle
- Extended Lifetimes Tracking
- Black Box Recorder

Calibration

2.1 Overview

The device has integrated routines that support calibration of current, voltage, and temperature readings, accessible after writing 0xF080 to 0xF082 to ManufacturerAccess(). When the calibration routines are activated, the ManufacturerStatus()[CAL] flag is set, and raw ADC data is available on ManufacturerData().

ManufacturerAccess( )	Description
0xF02d	Enable/Disable Calibration Mode in **ManufactureringStatus()**
0xF080	Disable raw ADC data output on **ManufacturerData()**
0xF081	Output raw ADC data of voltage, current, and temperature on **ManufacturerData()**
0xF082	Output raw ADC data of voltage, current, and temperature on **ManufacturerData()**. This mode includes a shunt of the coulomb counter input.

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

Value	Format	Description
ZZ	byte	8-bit counter, increments when raw ADC values are refreshed, typically every 250 ms
YY	byte	Output status **ManufacturerAccess( )** = 0xF081: 1 **ManufacturerAccess( )** = 0xF082: 2
AAaa	2's comp	**ManufacturerAccess( )** = 0xF081: coulomb counter **ManufacturerAccess( )** = 0xF082, internal shorted 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	Internal temperature sensor
GGgg	2's comp	Temperature Sensor 1
HHhh	2's comp	Temperature Sensor 2
IIii	2's comp	Temperature Sensor 3
JJjj	2's comp	Temperature Sensor 4
KKkk	2's comp	PACK Voltage
LLll	2's comp	BAT Voltage

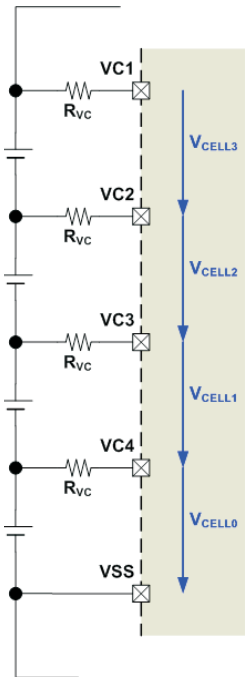
2.2 Combining Calibrations

Calibrations can be combined to shorten calibration time. Calibration times under four seconds are achievable using this method.

Table 2-1. Combining Calibrations

Time (s)	ZZ in ManufacturerData( )	Action
0	N	• Read DF values • Apply 0 mA current • Apply cell voltages • Apply known temperature • ManufacturerAccess() = 0xF082 • Poll ManufacturerData() for ZZ increment
0.25	N + 1	• Poll ManufacturerData() for ZZ increment
0.5	N + 2	• Store ManufacturerData ( ) block 1 • Poll ManufacturerData() for ZZ increment
0.75	N + 3	• Store ManufacturerData() block 2 • Poll ManufacturerData() for ZZ increment
1	N + 4	• Store ManufacturerData() block 3 • Poll ManufacturerData() for ZZ increment
1.25	N + 5	• Store ManufacturerData() block 4 apply Pack Voltage • ManufacturerAccess() = 0xF081 • Poll ManufacturerData() for ZZ increment
1.5	N + 6	• Poll ManufacturerData() for ZZ increment
1.75	N + 7	• Store ManufacturerData() block 5 • Poll ManufacturerData() for ZZ increment
2	N + 8	• Store ManufacturerData() block 6 • Poll ManufacturerData() for ZZ increment
2.25	N + 9	• Store ManufacturerData() block 7 • Poll ManufacturerData() for ZZ increment
2.5	N + 10	• Store ManufacturerData() block 8 • Apply calibration current • Poll ManufacturerData() for ZZ increment
2.75	N + 11	• Poll ManufacturerData() for ZZ increment
3	N + 12	• Store ManufacturerData() block 9 • Poll ManufacturerData() for ZZ increment
3.25	N + 13	• Store ManufacturerData() block 10 • Poll ManufacturerData() for ZZ increment
3.5	N + 14	• Store ManufacturerData() block 11 • Poll ManufacturerData() for ZZ increment
3.75	N + 15	• Store ManufacturerData() block 12 • Calculate CC Offset using blocks 1 to 4 • Calculate board Offset using blocks 5 to 8 • Calculate current gain using blocks 9 to 12 • Calculate Cell Voltage 1–4 using blocks 1 to 4 • Calculate Pack Voltage using blocks 5 to 8 • Calculate Temperatures using blocks 5 to 8 write values to data flash

2.3 Cell Voltage Calibration



1. Apply known voltages in mV to the cell voltage inputs:
   - V_{CELL1} between VC4 pin and VSS pin
   - V_{CELL2} between VC3 pin and VC4 pin
   - V_{CELL3} between VC2 pin and VC3 pin
   - V_{CELL4} between VC1 pin and VC2 pin
2. Send 0xF081 or 0xF082 to ManufacturerAccess( ) to enable raw cell voltage output on ManufacturerData( ).
3. Poll ManufacturerData( ) until ZZ increments by 2 before reading data.
4. Grab the ADC conversion readings of cell voltages from ManufacturerData( ):
   - ADC_{CELL1} = AAaa of ManufacturerData( ), is ADCCELL1 < 0x8000? If yes, use ADC_{CELL1}; otherwise, ADCCELL1 = AAaa – 0xFFFF + 0x0001
   - ADC_{CELL2} = BBbb of ManufacturerData( ), is ADC_{CELL2} < 0x8000? If yes, use ADC_{CELL2}; otherwise, ADC_{CELL2} = BBbb – 0xFFFF + 0x0001
   - ADC_{CELL3} = CCcc of ManufacturerData( ), is ADC_{CELL3} < 0x8000? If yes, use ADC_{CELL3}; otherwise, ADC_{CELL3} = CCcc – 0xFFFF + 0x0001
   - ADC_{CELL4} = DDdd of ManufacturerData( ), is ADC_{CELL4} < 0x8000? If yes, use ADC_{CELL4}; otherwise, ADC_{CELL4} = DDdd – 0xFFFF + 0x0001
5. Average several readings for higher accuracy. Poll ManufacturerData( ) until ZZ increments, which indicates updated values.
6. Calculate gain values:

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

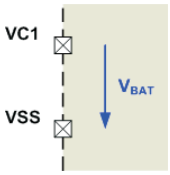
$$Alt\ Cell\ Scale2 = \frac{V_{CELL1} + V_{CELL2}}{ADC_{CELL1} + ADC_{CELL2}} * 2^{16}$$

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

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

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

2.4 BAT Voltage Calibration

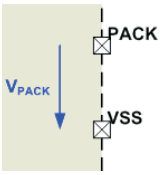


1. Apply known voltages in mV to the voltage input:
   - V_{BAT} between VC4 pin and VSS pin
2. Enter calibration mode if ManufacturerStatus()[CAL] = 0, send 0x002d to ManufacturerAccess()
3. Send 0xF081 or 0xF082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData()
4. Poll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

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

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

2.5 PACK Voltage Calibration



1. Apply known voltages in mV to the voltage input:
   - V_{PACK} between PACK pin and VSS pin
2. Enter calibration mode if ManufacturerStatus()[CAL] = 0, send 0x002d to ManufacturerAccess().
3. Send 0xF081 or 0xF082 to ManufacturerAccess() to enable raw cell voltage output on ManufacturerData().
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of pack voltage from ManufacturerData():

   ADC_{PACK} = KKkk of ManufacturerData(), is ADC_{PACK} < 0x8000? If yes, use ADC_{PACK}, otherwise ADC_{PACK} = –(0xFFFF – KKkk + 0x0001)
6. Average several readings for higher accuracy, poll ManufacturerData() until ZZ increments that indicates updates values.

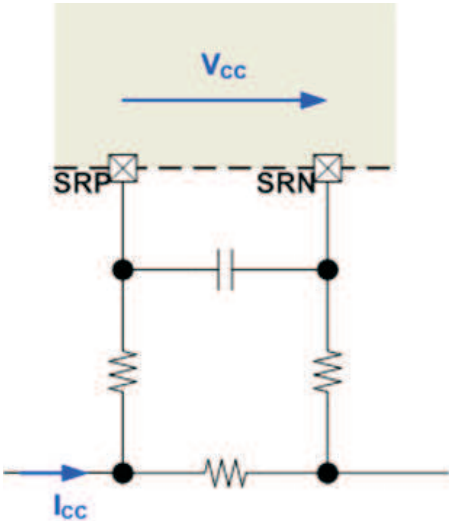
- ADC_{PACK} = [ADC_{PACK}(reading n) + … + ADC_{PACK}(reading 1)]/n

7. Calculate gain value:

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

8. Update data flash with ***PACK Gain***.
9. Re-check voltage reading; repeat Steps 4 to 6 if readings not accurate.
10. Exit calibration mode by sending 0x002d to ManufacturerAccess() or continue with calibration.

2.6 Current Calibration



2.6.1 Offset Calibration

1. Apply a known current of 0 mA:
   - Make sure no current is flowing through the sense resistor connected between the SRP and SRN pins.
2. Send 0xF082 to ManufacturerAccess( ) to enable raw CC output on ManufacturerData( ) with CC shunt.
3. Read *Coulomb Counter Offset Samples* from data flash.
4. Poll ManufacturerData( ) until ZZ increments by 2 before reading data.
5. Grab the ADC conversion readings of current from ManufacturerData( ):
   - ADC_{CC} = AAaa of ManufacturerData( ), is ADC_{CC} < 0x8000? If yes, use ADC_{CC}; otherwise, ADC_{CC} = AAaa – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData( ) until ZZ increments, which indicates updated values.
   - ADC_{CC} = [ADC_{CC}(reading n) + … + ADC_{CC}(reading 1)]/n
7. Calculate offset value:

$$CC\ offset = ADC_{CC} * (Coulomb\ Counter\ Offset\ Samples)$$

8. Update the data flash with *CC Offset*.
9. Re-check the current reading. Repeat the steps if the reading is not accurate.

2.6.2 Board Offset Calibration

1. Apply a known current of 0 mA:
   - Make sure no current is flowing through the sense resistor connected between SRP pin and SRN pin.

2. Send 0xF081 to ManufacturerAccess( ) to enable raw CC output on ManufacturerData( ).
3. Read *Coulomb Counter Offset Samples* from data flash.
4. Poll ManufacturerData( ) until ZZ increments by 2 before reading data.
5. Grab the ADC conversion readings of current from ManufacturerData( ):
   - ADCCC = AAaa of ManufacturerData( ), is ADC_{CC} < 0x8000? If yes, use ADC_{CC}; otherwise, ADC_{CC} = AAaa – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData( ) until ZZ increments, which indicates updated values.
   - ADC_{CC} = [ADC_{CC}(reading n) + … + ADC_{CC}(reading 1)]/n
7. Calculate offset value:
   $Board\ offset = (ADC_{CC} - CC\ Offset / (Coulomb\ Counter\ Offset\ Samples)) * (Coulomb\ Counter\ Offset\ Samples)$
8. Update the data flash with *Board Offset*.
9. Re-check the current reading. Repeat the steps if the reading is not accurate.

2.6.3 Gain Calibration

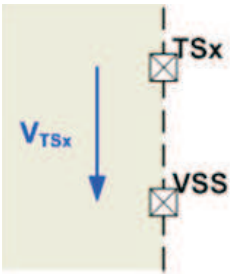
1. Apply a known current in mA to the current input.
   - Make sure current I_{CC} is flowing through the sense resistor connected between SRP pin and SRN pin.
2. Send 0xF081 to ManufacturerAccess( ) to enable raw CC output on ManufacturerData( ).
3. Read *Coulomb Counter Offset Samples* from data flash.
4. Poll ManufacturerData( ) until ZZ increments by 2 before reading data.
5. Grab the ADC conversion readings of current from ManufacturerData( ):
   - ADC_{CC} = AAaa of ManufacturerData( ), is ADC_{CC} < 0x8000? If yes, use ADC_{CC}; otherwise, ADC_{CC} = AAaa – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData( ) until ZZ increments, which indicates updated values.
   - ADC_{CC} = [ADC_{CC}(reading n) + … + ADC_{CC}(reading 1)]/n
7. Calculate gain values:

$$CC\ Gain = \frac{I_{CC}}{ADC_{CC} - \frac{(Board\ Offset) + (CC\ Offset)}{(Coulomb\ Counter\ Offset\ Samples)}}$$

$$Capacity\ Gain = CC\ Gain * 298261.6178$$

8. Update the data flash with CC Gain, *Capacity Gain*.
9. Re-check the current reading. Repeat the steps if the reading is not accurate.

2.6.4 Temperature Calibration



2.6.4.1 Internal Temperature Sensor Calibration (OPTION 1)

1. Apply a known temperature in 0.1ºC.

- Make sure temperature $Temp_{TINT}$ is applied to the device.

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

2.6.4.2 Internal Temperature Sensor Calibration (OPTION 2)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TINT}$ is applied to the device.
2. Read *Int Coeff 1*, *Int Coeff 2*, *Int Coeff 3*, *Int Coeff 4* from data flash.
3. Send 0xF081 or 0xF082 to ManufacturerAccess( ) to enable raw cell voltage output on ManufacturerData( ).
4. Poll ManufacturerData( ) until ZZ increments by 2 before reading data.
5. Grab the ADC conversion readings of temperature from Temperature( ):
   - ADCTINT = FFff of ManufacturerData( ), is ADC_{INT} < 0x8000? If yes, use ADC_{TINT}; otherwise, ADC_{TINT} = FFff – 0xFFFF + 0x0001.
6. Average several readings for higher accuracy. Poll ManufacturerData( ) until ZZ increments, which indicates updated values.
   - ADC_{TINT} = [ADC_{TINT}(reading n) + … + ADC_{TINT}(reading 1)]/n
7. Calculate temperature offset:
$$A = ADC_{TINT} / 2^{16}$$
$$T_{TINT} = ((INTCoeff\,1) * A^3 + (INTCoeff\,2) * A^2 + (INTCoeff\,3) * A + (INTCoeff\,4)) * 0.1 - 273.15$$
$$Internal\ Temperature\ Offset = TEMP_{TINT} - T_{TINT}$$
8. Update the data flash with the *Internal Temperature Offset*.
9. Re-check the temperature reading. Repeat the steps if the reading is not accurate.

2.6.4.3 TS1 Calibration (OPTION 1)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TS1}$ is applied to the thermistor connected to the TS1 pin.
2. Enable TS1 as the SBS temperature source by setting the Misc Configuration bit 7 to 0.
3. Grab the reported temperature from the SBS temperature.
4. Calculate the temperature offset:
$$TS1\ offset = TEMP_{TS1} - TS1$$
5. Update the data flash with the calculated value.
6. Re-check the current reading. Repeat the steps if the reading is not accurate.

2.6.4.4 TS1 Calibration (OPTION 2)

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TS1}$ is applied to the thermistor connected to the TS1 pin.
2. Read Coeff a1, Coeff a2, Coeff a3, Coeff a4, Coeff b1, Coeff b2, Coeff b3, Coeff b4 from data flash.
3. Send 0xF081 or 0xF082 to ManufacturerAccess( ) to enable raw cell voltage output on ManufacturerData( ).
4. Poll ManufacturerData( ) until ZZ increments by 2 before reading data.
5. Grab the ADC conversion readings of temperature from ManufacturerData( ):

- ADC_{TS1}= GGgg of ManufacturerData( ), is ADC_{TS1} < 0x8000? If yes, use ADC_{TS1}; otherwise, ADC_{TS1} = GGgg – 0xFFFF + 0x0001.

6. Average several readings for higher accuracy. Poll ManufacturerData( ) until ZZ increments, which indicates updated values.
   - ADC_{TS1} = [ADC_{TS1}(reading n) + … + ADC_{TS1}(reading 1)]/n
7. Calculate temperature offset:

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

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

$$T_{TS1} = ((CoeffB1)*B^{3} + (CoeffB2)*B^{2} + (CoeffB3)*B^{1} + (CoeffB4))*0.1 - 273.15$$

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

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

2.6.4.5 TS2 Calibration

1. Apply a known temperature in 0.1ºC.
   - Make sure temperature $Temp_{TS2}$ is applied to the thermistor connected to the TS2 pin.
2. Enable TS2 by setting the Secondary Thermistor to 1.
3. Grab the reported temperature from the extended command 0x7D.
4. Calculate temperature offset:

$$TS2\,offset = TEMP_{TS2} - TS2$$

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

2.6.4.6 TS3 Calibration

1. Apply a known temperature in 0.1ºC
2. Make sure temperature $Temp_{TS3}$ is applied to thermistor connected to TS3 pin
3. Read Coeff a1, Coeff a2, Coeff a3, Coeff a4, Coeff b1, Coeff b2, Coeff b3, Coeff b4 from data flash based on TS3 configuration to cell or FET temperature.
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of temperature from ManufacturerData():
   - ADC_{TS3} = IIii of ManufacturerData(), is ADC_{TS3} < 0x8000? If yes use ADC_{TS3}, otherwise ADC_{TS3} = –(0xFFFF – HHhh + 0x0001)
6. Average several readings for higher accuracy, poll ManufacturerData() until ZZ increments that indicates updates values.
   - ADC_{TS3} = [ADC_{TS3}(reading n) + … + ADC_{TS3}(reading 1)]/n
7. Calculate temperature offset:

$$A = \frac{ADC_{TS3}}{2^{15}}$$

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

$$T_{TS3} = ((Coeff\,B1)*B^{3} + (Coeff\,B2)*B^{2} + (Coeff\,B3)*B^{1} + (Coeff\,B4))*0.1 - 273.15$$

$$External\,3\,Temperature\,Offset = TEMP_{TS3} - T_{TS3}$$

8. Update the data flash with calculated with ***External 3 Temperature Offset***.
9. Re-check the temperature reading. Repeat the steps if the reading is not accurate.

2.6.4.7 TS4 Calibration

1. Apply a known temperature in 0.1ºC
2. Make sure temperature $Temp_{TS4}$ is applied to thermistor connected to TS4 pin.
3. Read ***Coeff a1***, ***Coeff a2***, ***Coeff a3***, ***Coeff a4***, ***Coeff b1***, ***Coeff b2***, ***Coeff b3***, ***Coeff b4*** from data flash based on TS4 configuration to cell or FET temperature.
4. Poll ManufacturerData() until ZZ increments by 2 before reading data.
5. Grab ADC conversion readings of temperature from ManufacturerData():
   - ADC_{TS4} = JJjj of ManufacturerData(), is ADC_{TS4} < 0x8000? If yes use ADC_{TS4}, otherwise ADC_{TS4} = –(0xFFFF – JJjj + 0x0001)
6. Average several readings for higher accuracy, poll ManufacturerData() until ZZ increments that indicates updates values.
   - ADC_{TS4} = [ADC_{TS4}(reading n) + … + ADC_{TS4}(reading 1)]/n
7. Calculate temperature offset:

$$A = \frac{ADC_{TS4}}{2^{15}}$$

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

$$T_{TS4} = ((Coeff\ B1)*B^{3} + (Coeff\ B2)*B^{2} + (Coeff\ B3)*B^{1} + (Coeff\ B4))*0.1 - 273.15$$

$$External\ 4\,Temperature\,Offset = TEMP_{TS4} - T_{TS4}$$

8. Update the data flash with calculated with ***External 4 Temperature Offset***.
9. Re-check the temperature reading. Repeat the steps if the reading is not accurate.

Protections

3.1 Introduction

All of the protection items can be enabled or disabled under Settings/Enabled Protections 0–15 and Settings/Enabled Protections 16–31.

3.2 Cell Undervoltage Protection

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

Status	Condition	Action
Normal	All Cell voltages in **Voltages()** > ***Threshold***	• **SafetyAlert()[CUV]** = 0 • **BatteryStatus()[TDA]** = 0
Alert	Any Cell voltages in **Voltages()** ≤ ***Threshold***	• **SafetyAlert()[CUV]** = 1 • If not charging, **BatteryStatus()[TDA]** = 1
Trip	Any Cell voltages in **Voltages()** continuous ≤ ***Threshold*** for ***Delay*** duration	• **SafetyAlert()[CUV]** = 0 • **SafetyStatus()[CUV]** = 1 • **BatteryStatus()[FD]** = 1 • Discharging not allowed
Recovery	**SafetyStatus()[CUV]** = 1 AND All Cell voltages in Voltages() > Recovery AND (CUV_RECOV_CHG = 0 OR (CUV_RECOV_CHG = 1 AND Charging Detected))	• **SafetyStatus()[CUV]** = 0 • **BatteryStatus()[FD]** = 0 • Discharging is allowed.

3.3 Cell Undervoltage Compensated Protection

The device can detect undervoltage in batteries and protect cells from damage by preventing further discharge. The protection is compensated by the Current() * CellResistance4..1.

Status	Condition	Action
Normal	All Cell voltages in Voltages() – Current() * Cell Resistance > Threshold	• **SafetyAlert()[CUVC]** = 0 • **BatteryStatus()[TDA]** = 0
Alert	Any Cell voltages in Voltages() – Current() * Cell Resistance ≤ Threshold	• **SafetyAlert()[CUVC]** = 1 • If not charging, **BatteryStatus()[TDA]** = 1
Trip	Any Cell voltages in Voltages() – Current() * Cell Resistance continuous ≤ Threshold for Delay duration	• **SafetyAlert()[CUVC]** = 0 • **SafetyStatus()[CUVC]** = 1 • **BatteryStatus()[FD]** = 1 • **BatteryStatus()[TDA]** = 0 • Discharging not allowed
Recovery	SafetyStatus()[CUVC] = 1 AND All Cell voltages in Voltages() > Recovery AND (CUV_RECOV_CHG = 0 OR (CUV_RECOV_CHG = 1 AND Charging Detected))	• **SafetyStatus()[CUVC]** = 0 • **BatteryStatus()[FD]** = 0 • Discharging allowed

3.4 Cell Overvoltage Protection

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

Status	Condition	Action
Normal	Temperature() ≤ T2 AND all Cell voltages in Voltages() < Threshold Low Temp	SafetyAlert()[COV] = 0
Normal	T2 < Temperature() ≤ T3 AND all Cell voltages in Voltages() < Threshold Standard Temp	SafetyAlert()[COV] = 0
Normal	T3 < Temperature() AND all Cell voltages in Voltages() < Threshold High Temp	SafetyAlert()[COV] = 0
Normal	T5 < Temperature() ≤ T6 AND all Cell voltages in Voltages() < Threshold Rec Temp	SafetyAlert()[COV] = 0
Alert	Temperature() ≤ T2 AND any Cell voltages in Voltages() ≥ Threshold Low Temp	SafetyAlert()[COV] = 1
Alert	T2 < Temperature() ≤ T3 AND any Cell voltages in Voltages() ≥ Threshold Standard Temp	SafetyAlert()[COV] = 1
Alert	T3 < Temperature() AND any Cell voltages in Voltages() ≥ Threshold High Temp	SafetyAlert()[COV] = 1
Alert	T5 < Temperature() ≤ T6 AND any Cell voltages in Voltages() ≥ Threshold Rec Temp	SafetyAlert()[COV] = 1
Trip	Temperature() ≤ T2 AND any Cell voltages in Voltages() continuous ≥ Threshold Low Temp for Delay duration	• SafetyAlert()[COV] = 0 • SafetyStatus()[COV] = 1 • If charging, BatteryStatus()[TCA] = 1 • If charging, BatteryStatus()[OCA] = 1 • Charging not allowed
Trip	T2 < Temperature() ≤ T3 AND any Cell voltages in Voltages() *continuous* ≥ Threshold Standard Temp for Delay duration	• SafetyAlert()[COV] = 0 • SafetyStatus()[COV] = 1 • If charging, BatteryStatus()[TCA] = 1 • If charging, BatteryStatus()[OCA] = 1 • Charging not allowed
Trip	T3 < Temperature() AND any Cell voltages in Voltages() *continuous* ≥ Threshold High Temp for Delay duration	• SafetyAlert()[COV] = 0 • SafetyStatus()[COV] = 1 • If charging, BatteryStatus()[TCA] = 1 • If charging, BatteryStatus()[OCA] = 1 • Charging not allowed
Trip	T5 < Temperature() ≤ T6 AND any Cell voltages in Voltages() continuous ≥ Threshold Rec Temp for Delay duration	• SafetyAlert()[COV] = 0 • SafetyStatus()[COV] = 1 • If charging, BatteryStatus()[TCA] = 1 • If charging, BatteryStatus()[OCA] = 1 • Charging not allowed
Recovery	SafetyStatus()[COV] = 1 AND Temperature() ≤ T2 AND all Cell voltages in Voltages() < Recovery Low Temp	• SafetyStatus()[COV] = 0 • BatteryStatus()[TCA] = 0 • BatteryStatus()[OCA] = 0 • Charging allowed
Recovery	SafetyStatus()[COV] = 1 AND T2 < Temperature() ≤ T3 AND all Cell voltages in Voltages() < Recovery Standard Temp	• SafetyStatus()[COV] = 0 • BatteryStatus()[TCA] = 0 • BatteryStatus()[OCA] = 0 • Charging allowed
Recovery	SafetyStatus()[COV] = 1 AND T3 < Temperature() AND all Cell voltages in Voltages() < Recovery High Temp	• SafetyStatus()[COV] = 0 • BatteryStatus()[TCA] = 0 • BatteryStatus()[OCA] = 0 • Charging allowed

Status	Condition	Action
Recovery	SafetyStatus()[COV] = 1 AND T5 < Temperature() ≤ T6 AND all Cell voltages in Voltages() < Recovery Rec Temp	• **SafetyStatus()[COV]** = 0 • **BatteryStatus()[**TCA**]** = 0 • **BatteryStatus()[OCA]** = 0 • Charging allowed

3.5 Overcurrent in Charge Protection

The device has a 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
Alert	**Current()** ≥ OCC2:Threshold	**SafetyAlert()[OCC2]** = 1
Trip	**Current()** continuous ≥ OCC1:Threshold for OCC1:Delay duration	• **SafetyAlert()[OCC1]** = 0 • **SafetyStatus()[OCC1]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed • Start recovery delay timer
Trip	**Current()** continuous ≥ OCC2:Threshold for OCC2:Delay duration	• **SafetyAlert()[OCC2]** = 0 • **SafetyStatus()[OCC2]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed • Start recovery delay timer
Recovery	**[SafetyStatus()[OCC1]** = 1 OR **SafetyStatus()[OCC2]** = 1] AND **Current()** < OCC:Recovery Threshold AND recovery delay timer running > OCC:Recovery Delay Time	• **SafetyStatus()[OCC1]** = 0 • **SafetyStatus()[OCC2]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed

3.6 Overcurrent in Discharge Protection

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

Status	Condition	Action
Normal	**Current()** > OCD1:Threshold	**SafetyAlert()[OCD1]** = 0
Normal	**Current()** > OCD2:Threshold	**SafetyAlert()[OCD2]** = 0
Alert	**Current()** ≤ OCD1:Threshold	**SafetyAlert()[OCD1]** = 1
Alert	**Current()** ≤ OCD2:Threshold	**SafetyAlert()[OCD2]** = 1
Trip	**Current()** continuous ≤ OCD1:Threshold for OCD1:Delay duration	• **SafetyAlert()[OCD1]** = 0 • **SafetyStatus()[OCD1]** = 1 • Discharging not allowed • Start recovery delay timer
Trip	**Current()** continuous ≤ OCD2:Threshold for OCD2:Delay duration	• **SafetyAlert()[OCD2]** = 0 • **SafetyStatus()[OCD2]** = 1 • Discharging not allowed • Start recovery delay timer
Recovery	**[SafetyStatus()[OCD1]** = 1 OR **SafetyStatus()[OCD2]** = 1] AND **Current()** > OCD:Recovery Threshold and recovery delay timer running > OCC:Recovery Delay Time	• **SafetyStatus()[OCD1]** = 0 • **SafetyStatus()[OCD2]** = 0 • Discharging allowed

3.7 Hardware-Based Protection

The device has three main hardware-based protections—OLD, SCC, and SCD—with adjustable current and delay time. The data flash protection Threshold and Delay settings are documented in Appendix A. By setting the [RSNS] bit under Settings:AFE State Control provide an option to divide the Threshold value into half. The Threshold settings are in mV, hence, the actual current that will trigger the protection is based on the RSNS resistor used in the schematic design.

All the hardware-based protections provides a short term Trip/Alert/Recovery protection to account for a current spike as well as a Trip/Alert/Latch protection for true faulty condition.

In general, when a fault is detected after the Delay time, both CHG and DSG FETs will be disabled (Trip stage). 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 true faulty condition, the device will enter the Trip stage after Delay time, and repeat the Trip/Alert/Recovery cycle. The internal fault counter is incremented every time the device goes through the Trip/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/Alert/Recovery/Latch stages are documented in each hardware-based protection sections below.

3.7.1 Overload in Discharge Protection

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

Status	Condition	Action
Normal	**Current()** > (Threshold / RSNS)	**SafetyAlert()[OLD]** = 0, if OLD counter = 0
Trip	**Current()** continuous ≤ (Threshold / RSNS) for Delay duration	• **SafetyStatus()[OLD]** = 1 • CHG FET and DSG FET disabled • Increment OLD counter
Alert	OLD counter > 0	• **SafetyAlert()[OLD]** = 1 • Decrement OLD counter by one after each Counter Dec Delay period
Recovery	**SafetyStatus()[OLD]** = 1 AND **SafetyStatus()[OLDL]** = 0 AND Recovery duration wait time	• **SafetyStatus()[OLD]** = 0 • CHG FET and DSG FET return to normal
Latch	OLD counter ≥ Latch Limit	• **SafetyStatus()[OLD]** = 0 • **SafetyStatus()[OLDL]** = 1 • Reset OLD counter • Disable recovery method • Enable reset method
Latch Reset (NR = 0)	**SafetyStatus()[OLDL]** = 1 AND System Configuration[NR] = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	• **SafetyStatus()[OLDL]** = 0 • CHG FET and DSG FET return to normal • Disable reset method • Enable recovery method
Latch Reset (NR = 1)	**SafetyStatus()[OLDL]** = 1 AND System Configuration[NR] = 1 AND Reset duration wait time	• **SafetyStatus()[OLDL]** = 0 • CHG FET and DSG FET return to normal • Disable reset method • Enable recovery method

3.7.2 Short Circuit in Charge Protection

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

Status	Condition	Action
Normal	**Current()** < (Threshold[2:0] / RSNS)	**SafetyAlert()[SCC]** = 0, if SCC counter = 0
Trip	**Current()** continuous ≥ (Threshold[2:0] / RSNS) for Threshold[7:4] duration	• **SafetyStatus()[SCC]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • CHG FET and DSG FET disabled • Increment SCC counter
Alert	SCC counter > 0	• **SafetyAlert()[SCC]** = 1 • Decrement SCC counter by one after each Counter Dec Delay period
Recovery	**SafetyStatus()[SCC]** = 1 AND **SafetyStatus()[SCCL]** = 0 AND Recovery duration wait time	• **SafetyStatus()[SCC]** = 0 • **BatteryStatus()[TCA]** = 0 • CHG FET and DSG FET return to normal
Latch	SCC counter ≥ Latch Limit	• **SafetyStatus()[SCC]** = 0 • **SafetyStatus()[SCCL]** = 1 • Reset SCC counter • Disable recovery method • Enable reset method
Latch Reset (NR = 0)	**SafetyStatus()[SCCL]** = 1 AND System Configuration[NR] = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	• **SafetyStatus()[SCCL]** = 0 • **BatteryStatus()[TCA]** = 0 • CHG FET and DSG FET return to normal • Disable reset method • Enable recovery method
Latch Reset (NR = 1)	**SafetyStatus()[SCCL]** = 1 AND System Configuration[NR] = 1 AND Reset duration wait time	• **SafetyStatus()[SCCL]** = 0 • **BatteryStatus()[TCA]** = 0 • CHG FET and DSG FET return to normal • Disable reset method • Enable recovery method

3.7.3 Short Circuit in Discharge Protection

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

Status	Condition	Action
Normal	**Current()** > (Threshold[2:0] / RSNS)	**SafetyAlert()[SCD]** = 0, if SCD counter = 0
Trip	**Current()** continuous ≤ (Threshold[2:0] / RSNS) for Threshold[7:4] duration	• **SafetyStatus()[SCD]** = 1 • CHG FET and DSG FET disabled • Increment SCD counter
Alert	SCD counter > 0	• **SafetyAlert()[SCD]** = 1 • Decrement SCD counter by one after each Counter Dec Delay period
Recovery	**SafetyStatus()[SCD]** = 1 AND **SafetyStatus()[SCDL]** = 0 AND Recovery duration wait time	• **SafetyStatus()[SCD]** = 0 • CHG FET and DSG FET return to normal
Latch	SCD counter ≥ Latch limit	• **SafetyStatus()[SCD]** = 0 • **SafetyStatus()[SCDL]** = 1 • Reset SCD counter • Disable recovery method • Enable reset method

Status	Condition	Action
Latch Reset (NR = 0)	**SafetyStatus()[SCDL]** = 1 AND System Configuration[NR] = 0 AND Low-high-low transition on $\overline{\text{PRES}}$ pin	• **SafetyStatus()[SCDL]** = 0 • CHG FET and DSG FET return to normal • Disable reset method • Enable recovery method
Latch Reset (NR = 1)	**SafetyStatus()[SCCL]** = 1 AND System Configuration[NR] = 1 AND Reset duration wait time	• **SafetyStatus()[SCDL]** = 0 • CHG FET and DSG FET return to normal • Disable reset method • Enable recovery method

3.8 Over Temperature in Charge Protection

The device has a over temperature protection for cells in charge direction.

Status	Condition	Action
Normal	Cell Temperature in Temperatures() < Threshold AND charging	SafetyAlert()[OTC] = 0
Alert	Cell Temperature in Temperatures() ≥ Threshold AND charging	SafetyAlert()[OTC] = 1
Trip	Cell Temperature in Temperatures() ≥ Threshold AND charging for Delay duration	• **SafetyAlert()[OTC]** = 0 • **SafetyStatus()[OTC]** = 1 • **BatteryStatus()[OTA]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging Disabled if Temperature Configuration[OTFET] = 1
Recovery	SafetyStatus()[OTC] AND Cell Temperature in Temperatures() < Recovery	• **SafetyStatus()[OTC]** = 0 • **BatteryStatus()[OTA]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed if Temperature Configuration[OTFET] = 1

3.9 Over Temperature in Discharge Protection

The device has a over temperature protection for cells in discharge direction.

Status	Condition	Action
Normal	Cell Temperature in Temperatures() < Threshold AND discharging	**SafetyAlert()[OTD]** = 0
Alert	Cell Temperature in Temperatures() ≥ Threshold AND discharging	**SafetyAlert()[OTD]** = 1
Trip	Cell Temperature in Temperatures() ≥ Threshold AND discharging for Delay duration	• **SafetyAlert()[OTD]** = 0 • **SafetyStatus()[OTD]** = 1 • **BatteryStatus()[OTA]** = 1 • Discharging Disabled if Temperature Configuration[OTFET] = 1
Recovery	SafetyStatus()[OTD] AND Cell Temperature in Temperatures() < Recovery	• **SafetyStatus()[OTD]** = 0 • **BatteryStatus()[OTA]** = 0 • Discharging allowed if Temperature Configuration[OTFET] = 1

3.10 Over Temperature FET Protection

The device has a over temperature protection to limit the FET temperature.

Status	Condition	Action
Normal	FET Temperature in Temperatures() < Threshold	**SafetyAlert()[OTF]** = 0
Alert	FET Temperature in Temperatures() ≥ Threshold	**SafetyAlert()[OTF]** = 1
Trip	FET Temperature in Temperatures() ≥ Threshold for Delay duration	• **SafetyAlert()[OTF]** = 0 • **SafetyStatus()[OTF]** = 1 • **BatteryStatus()[OTA]** = 1 • CHG FET and DSG FET off if Temperature Configuration[OTFET] =1
Recovery	SafetyStatus()[OTF] AND FET Temperature in Temperatures() < Recovery	• **SafetyStatus()[OTD]** = 0 • **BatteryStatus()[OTA]** = 0 • CHG FET and DSG FET return to normal

3.11 SBS Host Watchdog Protection

The device can check for 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 Delay duration	• **SafetyStatus()[HWD]** = 1 • Charging disabled, CHG FET off
Recovery	Valid SBS transaction detected	• **SafetyStatus()[HWD]** = 0 • CHG FET returns to normal, charging allowed

3.12 Pre-Charge Timeout Protection

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

Status	Condition	Action
Enable	**Current()** > Charge Threshold AND **ChargingStatus()[PV]** = 1	• Start PTO timer • **SafetyAlert()[PTO]** = 1 • **SafetyAlert()[PTOS]** = 0
Suspend or Recovery	**Current()** < Suspend Threshold	• Stop PTO timer • **SafetyAlert()[PTO]** = 1 • **SafetyAlert()[PTOS]** = 1
Trip	PTO time > Delay	• Stop PTO timer • **SafetyAlert()[PTO]** = 0 • **SafetyStatus()[PTO]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed
Reset	SafetyStatus()[PTO] = 1 AND System Configuration[NR] = 0 AND (Discharge by an amount of Reset OR low-high-low transition on $\overline{\text{PRES}}$)	• Stop and reset PTO timer • **SafetyAlert()[PTO]** = 0 • **SafetyAlert()[PTOS]** = 0 • **SafetyStatus()[PTO]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed
Reset	SafetyStatus()[PTO] = 1 AND System Configuration[NR] = 1 AND (Discharge by an amount of Reset)	• Stop and reset PTO timer • **SafetyAlert()[PTO]** = 0 • **SafetyAlert()[PTOS]** = 0 • **SafetyStatus()[PTO]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed

3.13 Fast Charge Timeout Protection

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

Status	Condition	Action
Enable	**Current()** > ***Charge Threshold*** AND (**ChargingStatus()[LV]** = 1 OR **ChargingStatus()[MV]** = 1 OR **ChargingStatus()[HV]** = 1)	• Start CTO timer • **SafetyAlert()[CTO]** = 1 • **SafetyAlert()[CTOS]** = 0
Suspend or Recovery	**Current()** < ***Suspend Threshold***	• Stop CTO timer • **SafetyAlert()[CTO]** = 1 • **SafetyAlert()[CTOS]** = 1
Trip	CTO time > ***Delay***	• Stop CTO timer • **SafetyAlert()[CTO]** = 0 • **SafetyStatus()[CTO]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed
Reset	**SafetyStatus()[CTO]** = 1 AND ***System Configuration[NR]*** = 0 AND (Discharge by an amount of Reset OR low-high-low transition on $\overline{\text{PRES}}$)	• Stop and reset CTO timer • **SafetyAlert()[CTO]** = 0 • **SafetyAlert()[CTOS]** = 0 • **SafetyStatus()[CTO]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed
Reset	**SafetyStatus()[CTO]** = 1 AND ***System Configuration[NR]*** = 1 AND (Discharge by an amount of ***Reset***)	• Stop and reset CTO timer • **SafetyAlert()[CTO]** = 0 • **SafetyAlert()[CTOS]** = 0 • **SafetyStatus()[CTO]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed

3.14 Overcharge Protection

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

Status	Condition	Action
Normal	**RemainingCapacity()** < **FullChargeCapacity()**	**SafetyAlert()[OC]** = 0
Alert	**RemainingCapacity()** ≥ **FullChargeCapacity()**	**SafetyAlert()[OC]** = 1
Trip	**RemainingCapacity()** ≥ **FullChargeCapacity()** + ***Threshold***	• **SafetyAlert()[OC]** = 0 • **SafetyStatus()[OC]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed
Recovery	**SafetyStatus()[OC]** = 1 ***System Configuration[NR]*** = 0 AND (Low-high-low transition on $\overline{\text{PRES}}$ pin OR continuous discharge of ***Recovery*** OR **RemainingStateOfCharge()** < RSOC Recovery)	• **SafetyStatus()[OC]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed
Recovery	**SafetyStatus()[OC]** =1 ***System Configuration[NR]*** = 1 AND continuous discharge of ***Recovery*** OR **RemainingStateOfCharge()** < ***RSOC Recovery***	• **SafetyStatus()[OC]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed

3.15 Over-ChargingVoltage() Protection

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

Status	Condition	Action
Normal	**Voltage()** < **ChargingVoltage()** + ***CHGV:Threshold***	**SafetyAlert()[CHGV]** = 0
Alert	**Voltage()** ≥ **ChargingVoltage()** + ***CHGV:Threshold***	**SafetyAlert()[CHGV]** = 1
Trip	**Voltage()** continuous ≥ **ChargingVoltage()** + ***CHGV:Threshold*** for ***CHGV:Delay*** period	• **SafetyAlert()[CHGV]** = 0 • **SafetyStatus()[CHGV]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed
Recovery	SafetyStatus()[CHGV] = 1 AND **Voltage()** ≤ **ChargingVoltage()** + ***CHGV Recovery***	• **SafetyStatus()[CHGV]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed

3.16 Over-Pre-ChargingCurrent() Protection

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

Status	Condition	Action
Normal	**Current()** < **ChargingCurrent()** + ***CHGC:Threshold***	**SafetyAlert()[CHGC]** = 0
Alert	**Current()** ≥ **ChargingCurrent()** + ***CHGC:Threshold***	**SafetyAlert()[CHGC]** = 1
Trip	**Current()** continuous ≥ **ChargingCurrent()** + ***CHGC:Threshold*** for ***CHGC:Delay*** period AND active precharging	• **SafetyAlert()[CHGC]** = 0 • **SafetyStatus()[CHGC]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed
Recovery	Low-high-low transition on $\overline{\text{PRES}}$ pin	• **SafetyStatus()[CHGC]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed

3.17 Over-ChargingCurrent() Protection

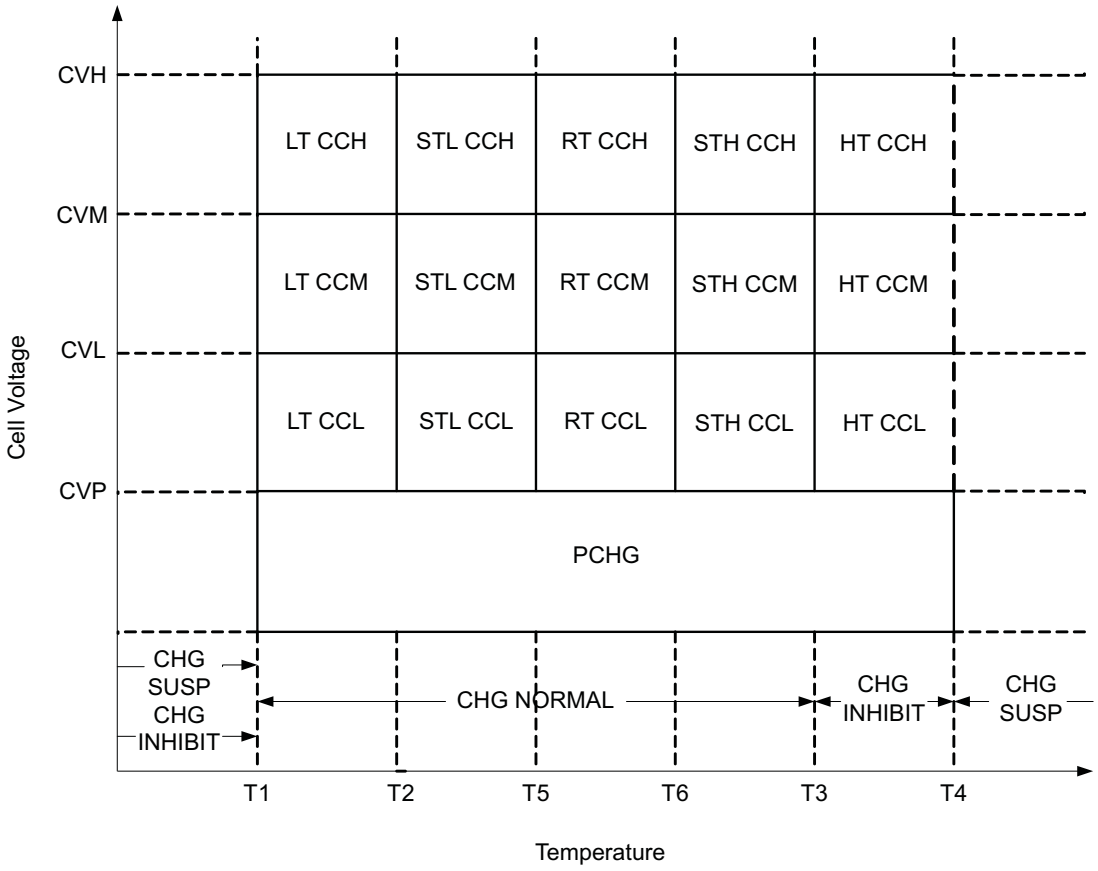
The device can stop charging if it measures a difference between the requested **ChargingCurrent()** and the delivered current from the charger.

Status	Condition	Action
Normal	**Current()** < **ChargingCurrent()** + ***CHGC:Threshold***	**SafetyAlert()[CHGC]** = 0
Alert	**Current()** ≥ **ChargingCurrent()** + ***CHGC:Threshold***	**SafetyAlert()[CHGC]** = 1
Trip	**Current()** continuous ≥ **ChargingCurrent()** + ***CHGC:Threshold*** for ***CHGC:Delay*** period	• **SafetyAlert()[CHGC]** = 0 • **SafetyStatus()[CHGC]** = 1 • If charging, **BatteryStatus()[TCA]** = 1 • Charging not allowed
Recovery	**SafetyStatus()[CHGC]** = 1 AND **Current()** ≤ **ChargingCurrent()** + ***CHGC Recovery***	• **SafetyStatus()[CHGC]** = 0 • **BatteryStatus()[TCA]** = 0 • Charging allowed

Advanced Charge Algorithm

4.1 Introduction

The device can change value of **ChargingVoltage()** and **ChargingCurrent()** based on **Temperature()** and **Cell Voltage1..4()**. The flexible charging algorithm can is JEITA compatible and can also meet ATL cell charge requirements. The **ChargingStatus()** register show the state of the charging algorithm.



4.2 Charge Temperature Ranges

The measured temperature is segmented into several temperature ranges. The charging algorithm adjusts **ChargingCurrent()** and **ChargingVoltage()** according to the temperature range. The temperature range need to be set to following:

T1 ≤ T2 ≤ T5 ≤ T6 ≤ T3 ≤ T4

Status	Condition	Action
Under Temp	**Temperature()** < T1	**ChargingStatus()[UT]** = 1
Low Temp	T1 < **Temperature()** < T2	**ChargingStatus()[LT]** = 1
Standard Temp Low	T2 < **Temperature()** < T5	**ChargingStatus()[STL]** = 1
Recommended	T5 < **Temperature()** < T6	**ChargingStatus()[RT]** = 1

Status	Condition	Action
Standard Temp High	T6 < **Temperature()** < T3	**ChargingStatus()[STH]** = 1
High Temp	T3 < **Temperature()** < T4	**ChargingStatus()[HT]** = 1
Over Temp	T4 < **Temperature()**	**ChargingStatus()[OT]** = 1

4.3 Voltage Range

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

ChargingVoltage Low ≤ ChargingVoltage Med ≤ ChargingVoltageHigh ≤ x Temp Charging:Voltage

Status	Condition	Action
Pre-Charge	Any Cell Voltages in Voltages() < Charging Voltage Low	**ChargingStatus()[PV]** = 1
Low	Charging Voltage Low < all Cell Voltages in Voltages() OR any Cell Voltages in Voltages() < Charging Voltage Med	**ChargingStatus()[LV]** = 1
Medium	Charging Voltage Med < all Cell Voltages in Voltages() OR any Cell Voltages in Voltages() < Charging Voltage High	**ChargingStatus()[MV]** = 1
High	Charging Voltage High < all Cell Voltages in Voltages()	**ChargingStatus()[HV]** = 1

A voltage hysteresis setting is available, and is applied when the voltage decreases.

4.4 Charging Current

The **ChargingCurrent()** value will change depending on charge algorithm.

ChargingStatus()										Action
UT	**LT**	**STL/STH**	**HT**	**RT**	**OT**	**PV**	**LV**	**MV**	**HV**	
1	0	0	0	0	0	x	x	x	x	**ChargingCurrent()** = *0*
0	x	x	x	x	0	1	0	0	0	**ChargingCurrent()** = PCHG:Current
0	1	0	0	0	0	0	1	0	0	**ChargingCurrent()** = Low Temp Charging:Current Low
0	1	0	0	0	0	0	0	1	0	**ChargingCurrent()** = Low Temp Charging:Current Med
0	1	0	0	0	0	0	0	0	1	**ChargingCurrent()** = Low Temp Charging:Current High
0	0	1	0	0	0	0	1	0	0	**ChargingCurrent()** = Standard Temp Charging:Current Low
0	0	1	0	0	0	0	0	1	0	**ChargingCurrent()** = Standard Temp Charging:Current Med
0	0	1	0	0	0	0	0	0	1	**ChargingCurrent()** = Standard Temp Charging:Current High
0	0	0	1	0	0	0	1	0	0	**ChargingCurrent()** = Standard Temp Charging:Current Low
0	0	0	1	0	0	0	0	1	0	**ChargingCurrent()** = Standard Temp Charging:Current Med
0	0	0	1	0	0	0	0	0	1	**ChargingCurrent()** = Standard Temp Charging:Current High
0	0	0	0	1	0	0	1	0	0	**ChargingCurrent()** = Rec Temp Charging:Current Low
0	0	0	0	1	0	0	0	1	0	**ChargingCurrent()** =Rec Temp Charging:Current Med

ChargingStatus()										Action
UT	LT	STL/STH	HT	RT	OT	PV	LV	MV	HV	
0	0	0	0	1	0	0	0	0	1	**ChargingCurrent()** = Rec Temp Charging:Current High
0	0	0	0	0	1	x	x	x	x	**ChargingCurrent()** = *0*

4.5 Charging Voltage

The **ChargingVoltage()** will change depending on the charge algorithm.

ChargingStatus()						Action
UT	LT	STL/STH	HT	RT	OT	
1	0	0	0	0	0	ChargingVoltage() = *0*
0	1	0	0	0	0	ChargingVoltage() = ***Low Temp Charging:Voltage*** * Number of cells
0	0	1	0	0	0	ChargingVoltage() = ***Standard Temp Charging:Voltage*** * Number of cells
0	0	0	1	0	0	ChargingVoltage() = ***High Temp Charging:Voltage*** * Number of cells
0	0	0	0	1	0	ChargingVoltage() = ***Rec Temp Charging:Voltage*** * Number of cells
0	0	0	0	0	1	ChargingCurrent() = *0*

A temperature hysteresis setting is available, and is applied when temperature decreases.

4.6 Valid Charge Termination

The charge termination condition has to be met to enable valid charge termination.

Status	Condition	Action
Charging	**GaugingStatus()[REST]** = 0 AND **GaugingStatus()[DSG]** = 0	Charge Algorithm active
Valid Charge Termination	(Charging AND AverageCurrent() continuous < Charge Term Taper Current AND Voltage() > ChargingVoltage()/Number of Cells + Charge Term Voltage AND Δcharge > Taper Charge) for two consecutive 40-s periods	• ChargingStatus()[VCT] sets • If SBS Configuration[FCSETVCT], **BatteryStatus[FC]** = 1 • If SBS Configuration[TCASETVCT], **BatteryStatus[TCA]** = 1 • If BatteryStatus[TCA], **ChargingStatus[MCHG]** = 1 • If ChargingStatus[MCHG]: – If Charging **Configuration[CHGFET]** = 1, CHG and PCHG FET off AND **ChargingCurrent()** = 0 – If Charging **Configuration[CHGFET]** = 0, CHG FET active and ChargingCurrent() = MaintainenceCurrent

4.7 Charge Inhibit

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

Status	Condition	Action
Normal	T1 < **Temperature()** < T3	• **ChargingStatus()[IN]** = 0 • **ChargingVoltage()** = charging algorithm • **ChargingCurrent()** = charging algorithm
Trip	**Temperature()** < T1	• **ChargingStatus()[IN]** = 1 • **ChargingVoltage()** = 0 • **ChargingCurrent()** = 0 • No charging allowed if **Charging Configuration[CHGIN]** = 1

Status	Condition	Action
Trip	**Temperature()** > T3 while no charging	• **ChargingStatus()[IN]** = 1 • **ChargingVoltage()** = 0 • **ChargingCurrent()** = 0 • No charging allowed if **Charging Configuration[CHGIN]** = 1

4.8 Charge Suspend

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

Status	Condition	Action
Normal	T1 < **Temperature()** < T4	• **ChargingStatus()[SU]** = 0 • **ChargingVoltage()** = charging algorithm • **ChargingCurrent()** = charging algorithm
Trip	**Temperature()** < T1	• **ChargingStatus()[SU]** = 1 • **ChargingVoltage()** = 0 • **ChargingCurrent()** = 0 • No charging allowed if Charging Configuration[CHGSU] = 1
Trip	**Temperature()** > T4	• **ChargingStatus()[SU]** = 1 • **ChargingVoltage()** = 0 • **ChargingCurrent()** = 0 • No charging allowed if **Charging Configuration[CHGSU]** = 1

4.9 ChargingVoltage() Rate of Change

The device can slope the value changes from one range to another to avoid jumping between different voltage ranges.

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

Status	Condition	Action
Trip	ChargingVoltage() Range Change	• **ChargingStatus()[CVR]** = 1 • **ChargingVoltage()** = OldRange + n * (New Range – Old Range)/Voltage Rate, n = 1.. Voltage Rate for Voltage Rate seconds

4.10 ChargingCurrent() Rate of Change

The device can slope the value changes from one range to another to avoid jumping between different current ranges.

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

Status	Condition	Action
Trip	ChargingCurrent() Range Change	• **ChargingStatus()[CVR]** = 1 • **ChargingVoltage()** = OldRange + n * (New Range – Old Range)/Voltage Rate, n = 1.. Voltage Rate for Voltage Rate seconds

4.11 Charging Loss Compensation

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

In constant current mode, the device can increase the **ChargingVoltage()** value to compensate the drop losses.

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 Sum(Cell Voltages in Voltages()) = Charging algorithm voltage	• **ChargingStatus()[CCC]** = 0 • **ChargingVoltage()** = Charge Algorithm
Active	Current() > CCC Current Threshold AND Sum(Cell Voltages in Voltages()) < Charging algorithm voltage	• **ChargingStatus()[CCC]** = 1 • **ChargingVoltage()** = Charge Algorithm + [**PackVoltage()** – Sum(CellVoltages in Voltages())]
Limit	**[PackVoltage()** – Sum(Cell Voltages in Voltages())] > CCC Voltage Threshold	**ChargingVoltage()** = Charge Algorithm + CCC Voltage

4.12 Panasonic Charge Mode

The device can reduce **ChargingCurrent()** if any cell voltages are greater than or equal to **ChargingVoltage()** / number of cells for a specified delay time.

Table 4-1. Panasonic Charge Mode

Status	Condition	Action
Normal	All Cell voltages in **Voltages()** < **ChargingVoltage()** / number of cells	No change to **ChargingCurrent()**
Enabled	Any Cell voltages in **Voltages()** ≥ **ChargingVoltage()** / number of cells for Near Full Charge Minimum Delay duration AND **ChargingCurrent()** > ***Near Full Minimum Charge Current***	**ChargingCurrent()** = **ChargingCurrent()** – ***Step Charge Current***
Disabled	All Cell voltages in Voltages() < ChargingVoltage() / number of cells OR **ChargingCurrent()** ≤ ***Near Full Minimum Charge Current*** OR valid charge termination detected	No change to **ChargingCurrent()**

Permanent Fail

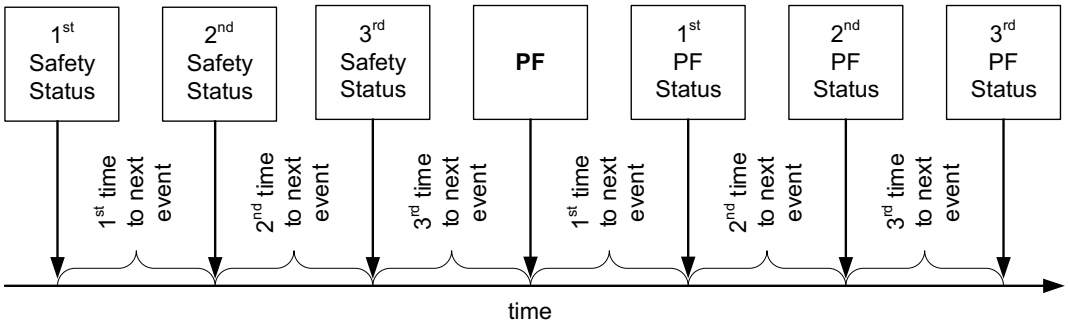
5.1 Introduction

The device can permanently disable the use of the battery pack in case of a severe failure. The following actions in sequence are taken in permanent fail (PF) mode when the Settings:Manufacturing Status[PF_EN] bit is enabled. An individual PF event can be enabled and disabled with **Settings:Enabled PF0–15** and **Settings:Enabled PF16–31** even after [PF_EN] bit is enabled.

1. Precharge, charge, and discharge FETs are turned off.
2. The following SBS data is changed: If charging, **BatteryStatus()[TCA]** = 1, if not charging,**BatteryStatus()[TDA]** = 1 , **ChargingCurrent()** = 0, **ChargingVoltage()** = 0
3. A backup of the internal AFE hardware registers are written to data flash: STATUS, STATE_CONTROL, OUTPUT_STATUS, FUNCTION_CONTROL, CELL_SEL , OCDV, OCDD, SCD1, SCD2
4. The black box data of the last three SafetyStatus() changes leading up to PF with time difference is written into data flash.
5. The cause of the permanent fail is logged into PFAlert and PFStatus.
6. Following SBS values are preserved in data flash for failure analysis:
   - SafetyAlert()
   - SafetyStatus()
   - PFAlert()
   - PFStatus()
   - OperationStatus()
   - ChargingStatus()
   - GaugingStatus()
   - Voltages()
   - Temperatures()
   - DOD()
7. Data flash writing is disabled, except subsequent PFStatus flags.
8. Subsequent PFs are appended to PFAlert and PFStatus in PF Status class. PF Status is also logged separately to the Black Box Recorder 1st, 2nd, and 3rd PF Status.
9. The FUSE pin is driven high if configured for specific failures.

5.2 Black Box Recorder

The black box recorder maintains the last three updates of **SafetyStatus()** in memory. In case of permanent failure, this information is written to data flash together with the first three updates of **PFStatus()** after the PF event.



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

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

5.3 Cell Undervoltage Permanent Fail

The device can permanently disable the battery in case of severe low level of cell voltage.

Status	Condition	Action
Normal	All Cell voltages in Voltages() > Threshold	• **PFAlert()[CUV]** = 0 • **BatteryStatus()[TDA]** = 0
Alert	Any Cell voltages in Voltages() ≤ Threshold	• **PFAlert()[CUV]** = 1 • If not charging, **BatteryStatus()[TDA]** = 1
Trip	Any Cell voltages in Voltages() continuous ≤ Threshold for Delay duration AND **Enabled PF 0–15[CUV]** = 1	• **PFAlert()[CUV]** = 0 • **PFStatus()[CUV]** = 1 • **BatteryStatus()[FD]** = 1 • If not charging, **BatteryStatus()[TDA]** = 1

5.4 Cell Overvoltage Permanent Fail

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

Status	Condition	Action
Normal	All Cell voltages in Voltages() < Threshold	**PFAlert()[COV]** = 0
Alert	Any Cell voltages in Voltages() ≥ Threshold	**PFAlert()[COV]** = 1
Trip	Any Cell voltages in Voltages() continuous ≥ Threshold for Delay duration AND Enabled PF 0–15[COV] = 1	• **PFAlert()[COV]** = 0 • **PFStatus()[COV]** = 1 • **BatteryStatus()[FC]** = 1 • If charging, **BatteryStatus()[OCA]** = 1

5.5 Copper Deposition Permanent Fail

The device can permanently disable the battery in case of severe low level of cell voltage. The copper deposition check checks cell voltages upon wake up from shutdown mode while keeping the charge and precharge FETs off until the check is complete.

Status	Condition	Action
Normal	All Cell voltages in Voltages() > Threshold	• **PFAlert()[CUDEP]** = 0 • **BatteryStatus()[TDA]** = 0
Alert	Any Cell voltages in Voltages() ≤ Threshold	• **PFAlert()[CUDEP]** = 1 • If not charging, **BatteryStatus()[TDA]** = 1
Trip	Any Cell voltages in Voltages() continuous ≤ Threshold for Delay duration AND **Enabled PF 0–15[CUDEP]** = 1	• **PFAlert()[CUDEP]** = 0 • **PFStatus()[CUDEP]** = 1 • **BatteryStatus()[FD]** = 1 • If not charging, **BatteryStatus()[TDA]** = 1

5.6 Overtemperature Cell Permanent Fail

The device can permanently disable the battery pack in case of severe over temperature of the cells.

Status	Condition	Action
Normal	Cell Temperature in Temperatures() < Threshold	**PFAlert()[OTCE]** = 0
Alert	Cell Temperature in Temperatures() ≥ Threshold AND Current() > OT Charge Threshold OR Current() < OT Discharge Threshold	**PFAlert()[OTCE]** = 1
Trip	Cell Temperature in Temperatures() continuous ≥ Threshold for Delay duration AND Current() > OT Charge Threshold OR Current() < OT Discharge Threshold	• **PFAlert()[OTCE]** = 0 • **PFStatus()[OTCE]** = 1

5.7 Overtemperature FET Permanent Fail

The device can permanently disable the battery pack in case of severe over temperature on the power FET.

Status	Condition	Action
Normal	FET Temperature in Temperatures() < Threshold	**PFAlert()[OTF]** = 0
Alert	FET Temperature in Temperatures() ≥ Threshold	**PFAlert()[OTF]** = 1
Trip	FET Temperature in Temperatures() continuous ≥ Threshold for Delay duration AND **Enabled PF 0–15[OTF]** = 1	• **PFAlert()[OTF]** = 0 • **PFStatus()[OTF]** = 1 • **BatteryStatus()[OTA]** = 1

5.8 QMax Imbalance Permanent Fail

The 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	Δ(*QMax Cell 0..3*) < Threshold	**PFAlert()[QIM]** = 0
Alert	Δ(*QMax Cell 0..3*) ≥ Threshold	**PFAlert()[QIM]** = 1
Trip	Δ(*QMax Cell 0..3*) continuous ≥ Threshold for Delay duration AND **Enabled PF 0–15[QIM]** = 1	• **PFAlert()[QIM]** = 0 • **PFStatus()[QIM]** = 1

5.9 Cell Balancing Permanent Fail

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

Status	Condition	Action
Normal	Δ(Time Cell 0..3) < Delta Threshold	**PFAlert()[CB]** = 0
Alert	Δ(Time Cell 0..3) ≥ Delta Threshold	**PFAlert()[CB]** = 1
Trip	Δ(Time Cell 0..3) continuous ≥ Delta Threshold for Delay duration AND **Enabled PF 0–15[CB]** = 1	• **PFAlert()[CB]** = 0 • **PFStatus()[CB]** = 1
Trip	Max (Time Cell 0..3) ≥ Max Threshold AND **Enabled PF 0–15[CB]** = 1	• **PFAlert()[CB]** = 0 • **PFStatus()[CB]** = 1

5.10 Capacity Degradation Permanent Fail

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

Status	Condition	Action
Normal	All(*QMax1..4*) > Threshold	**PFAlert()[CD]** = 0
Alert	Any(*QMax1..4*) ≤ Threshold	**PFAlert()[CD]** = 1
Trip	Any(*QMax1..4*) continuous ≤ Threshold for Delay cycles AND **Enabled PF 0–15[CD]** = 1	• **PFAlert()[CD]** = 0 • **PFStatus()[CD]** = 1

5.11 Impedance Permanent Fail

The 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 ***Design Resistance*** will be automatically calculated and updated during learning cycle and is part of the golden image).

Status	Condition	Action
Normal	Δ(Cell0..3 R_a at Reference Grid) < (Delta Threshold * Design Resistance)	**PFAlert()[IMP]** = 0
Alert	Δ(Cell0..3 R_a at Reference Grid) ≥ (Delta Threshold * Design Resistance)	**PFAlert()[IMP]** = 1
Trip	Δ(Cell0..3 R_a at Reference Grid) ≥ (Delta Threshold * Design Resistance) for Ra Update Counts AND **Enabled PF 0–15[IMP]** = 1	• **PFAlert()[IMP]** = 0 • **PFStatus()[IMP]** = 1
Trip	Δ(Cell0..3 R_a at Reference Grid) ≥ (Max Threshold * Design Resistance) AND **Enabled PF 0–15[IMP]** = 1	• **PFAlert()[IMP]** = 0 • **PFStatus()[IMP]** = 1

5.12 Voltage Imbalance at Rest Permanent Fail

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

Status	Condition	Action
Normal	• All Cell voltages in Voltages() < Check Voltage • |**Current()**| > Check Current • Δ(Cell voltages in Voltages()) < Delta Threshold	**PFAlert()[VIMR]** = 0
Alert	Any Cell voltages in Voltages() ≥ Check Voltage AND |**Current()**| continuous < Check Current for Duration AND Δ(Cell voltages in Voltages()) ≥ Delta Threshold	**PFAlert()[VIMR]** = 1

Status	Condition	Action
Trip	[Any Cell voltages in Voltages() ≥ Check Voltage AND |**Current()**| continuous < Check Current for Duration AND Δ(Cell voltages in Voltages()) ≥ Delta Threshold] for Delay duration AND **Enabled PF 0–15[VIMR]** = 1	• **PFAlert()[VIMR]** = 0 • **PFStatus()[VIMR]** = 1

5.13 Voltage Imbalance Active Permanent Fail

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

Status	Condition	Action
Normal	• All Cell voltages in Voltages() < Check Voltage • **Current()** < Check Current • Δ(Cell voltages in Voltages()) < Delta Threshold	**PFAlert()[VIMA]** = 0
Alert	Any Cell voltages in Voltages() ≥ Check Voltage AND **Current()** continuous > Check Current for Duration AND Δ(Cell voltages in Voltages()) ≥ Delta Threshold	**PFAlert()[VIMA]** = 1
Trip	[Any Cell voltages in Voltages() ≥ Check Voltage AND **Current()** continuous > Check Current for Duration AND Δ(Cell voltages in Voltages()) continuous ≥ Delta Threshold] for Delay duration AND **Enabled PF 0–15[VIMA]** = 1	• **PFAlert()[VIMA]** = 0 • **PFStatus()[VIMA]** = 1

5.14 Charge FET Permanent Fail

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

Status	Condition	Action
Normal	CHG FET off AND **Current()** < OFF Threshold	**PFAlert()[CFET]** = 0
Alert	CHG FET off AND **Current()** ≥ OFF Threshold	**PFAlert()[CFET]** = 1
Trip	CHG FET off AND **Current()** continuously ≥ OFF Threshold for Delay duration AND **Enabled PF 16–32[CFET]** = 1	• **PFAlert()[CFET]** = 0 • **PFStatus()[CFET]** = 1

5.15 Discharge FET Permanent Fail

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

Status	Condition	Action
Normal	DSG FET off AND **Current()** > OFF Threshold	**PFAlert()[DFET]** = 0
Alert	DSG FET off AND **Current()** ≤ OFF Threshold	**PFAlert()[DFET]** = 1
Trip	DSG FET off AND **Current()** continuously ≤ OFF Threshold for Delay duration AND **Enabled PF 16–32[DFET]** = 1	• **PFAlert()[DFET]** = 0 • **PFStatus()[DFET]** = 1

5.16 Thermistor Permanent Fail

The device can permanently disable the battery pack when it detects an open (internally pulled up) or short (grounded) failure in the thermistor circuit. When a fault is detected, the PFALER()[TH] bit will be set to 1. If the fault is still present after the Permanent Fail:ADC Delay time, the PFALER()[TH] bit will be cleared and PFStatus()[TH] will be set to 1.

5.17 Chemical Fuse Permanent Fail

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

Status	Condition	Action
Normal	FUSE pin = high AND |**Current()**| < Threshold	**PFAlert()[FUSE]** = 0
Alert	FUSE pin = high AND |**Current()**| ≥ Threshold	**PFAlert()[FUSE]** = 1
Trip	FUSE pin = high AND |**Current()**| continuous ≥ Threshold for Delay duration AND **Enabled PF 16–32[FUSE]** = 1	• **PFAlert()[FUSE]** = 0 • **PFStatus()[FUSE]** = 1

5.18 AFE Register Permanent Fail

The device compares the AFE hardware register periodically with a RAM backup. 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 Compare Period
Alert	AFE register fail counter > 0	• **PFAlert()[AFER]** = 1 • Decrement AFE register fail counter by one after each Delay Period • Compare AFE register and RAM backup every Compare Period
Trip	AFE register fail counter ≥ Threshold AND **Enabled PF 16–32[AFER]** = 1	• **PFAlert()[AFER]** = 0 • **PFStatus()[AFER]** = 1

5.19 AFE Communication Permanent Fail

The device monitors the internal communication to the AFE hardware. If the read or write fails exceed a limit within a 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 Delay period
Trip	Read and Write Fail counter ≥ Threshold AND **Enabled PF 16–32[AFEC]** = 1	• **PFAlert()[AFEC]** = 0 • **PFStatus()[AFEC]** = 1

5.20 Second Level Protection Permanent Fail

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

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

Status	Condition	Action
Normal	Reset AFE and FUSE pin = low AND no FUSE trigger by firmware	• PFAlert()[2LVL] = 0 • Reset internal PF 2LVL counter
Alert	FUSE pin = high AND no FUSE trigger by firmware	• PFAlert()[2LVL] = 1 • Increment internal PF 2LVL counter • Wait for PF 2LVL Delay time • Reset AFE
Trip	Internal PF 2LVL counter > Threshold AND **Enabled PF 16–32[2LVL]** = 1	• PFAlert()[2LVL] = 0 • PFStatus()[2LVL] = 1

5.21 PTC Permanent Fail

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

If the device detects PTC pin high state, the CHG and DSG FET are turned off. Pack is disabled permanently. State can only be reset by fully power cycle the device.

If PTC permanent fail is not used, the PTC pin should be connected to VSS with a 10-kΩ resistor.

Status	Condition	Action
Normal	Reset AFE and PTC pin = low AND no FUSE trigger by firmware	**PFStatus()[PTC]** = 0
Trip	PTC pin = high	• **PFStatus()[PTC]** = 1 • FUSE = high

5.22 Instruction Flash Checksum Permanent Fail

The device can permanently disable the battery in case it detects a difference between the stored IF checksum and the calculated IF checksum right after device reset.

Status	Condition	Action
Normal	Stored and calculated IF checksum match	**PFAlert()[IFC]** = 0
Trip	Stored and calculated IF checksum after reset don't match AND **Enabled PF 16–32[IFC]** = 1	• **PFAlert()[IFC]** = 0 • **PFStatus()[IFC]** = 1

5.23 Open Cell Voltage Connection Permanent Fail

The device can permanently disable the battery in case it detects a difference between the BAT pin voltage and the sum of the individual cell voltages.

Status	Condition	Action
Normal	|Sum(Cell voltages in Voltages())—BAT voltage in Voltages()| < Threshold	**PFAlert()[OCECO]** = 0
Alert	|Sum(Cell voltages in Voltages())—BAT voltage in Voltages()| ≥ Threshold	**PFAlert()[OCECO]** = 1
Trip	|Sum(Cell voltages in Voltages())—BAT voltage in Voltages()| continuous ≥ Threshold for Delay Period AND **Enabled PF 16–32[OCECO]** = 1	• **PFAlert()[OCECO]** = 0 • **PFStatus()[OCECO]** = 1

5.24 Data Flash Permanent Fail

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

Status	Condition	Action
Normal	Data flash write ok	**PFAlert()[DFW]** = 0
Trip	Data flash write not successful AND **Enabled PF 16–32[DFW]** = 1	• **PFAlert()[DFW]** = 0 • **PFStatus()[DFW]** = 1

Power Modes

To enhance battery life, the bq30z55-V100R1 supports different power modes to save power and minimize power consumption during operation.

6.1 Normal Mode

In Normal Mode, the device takes voltage, current and temperature readings every 250 ms, performs protection and gauging calculations, updates SBS data. Between these periods of activity, the device is in a reduced power state.

6.2 Sleep Mode

When the sleep conditions are met, the device goes to Sleep Mode with periodically wake-ups to reduce power consumption. The device returns to Normal Mode on SBS communication detection and current detection.

6.2.1 Device Sleep

When the sleep conditions are met, the device goes to Sleep Mode with periodical wake-ups to reduce power consumption. The device returns to Normal Mode on SBS communication detection and current detection.

Status	Condition	Action
Enable	***System Configuration[SLEEP]*** = 1	**OperationStatus()[SLEEP]** = 1
Activate	***System Configuration[NR]*** = 0 AND **OperationStatus()[PRES]** = 0 AND |**Current()**| < ***Sleep:Sleep Current*** AND SMBus clock and data lines low for 5 s.	• Turn off CHG FET, DSG FET, PCHG FET • Device goes to sleep • Device wakes up every ***Sleep Voltage Time*** period to measure voltage and temperature • Device wakes up every ***Sleep Current Time*** period to measure current
Activate	***System Configuration[NR]*** = 1 AND |Current()| < ***Sleep:Sleep Current*** AND SMBus clock and data lines low for 5 s.	• Turn off CHG FET, PHCG FET if ***System Configuration[SLEEPCHG]*** = 0 • Device goes to sleep • Device wakes up every ***Sleep Voltage Time*** period to measure voltage and temperature • Device wakes up every ***Sleep Current Time*** period to measure current
Exit	***System Configuration[NR]*** = 0 AND **OperationStatus()[PRES]** = 1	Return to Normal Mode
Exit	|Current()| > ***Sleep:Sleep Current***	Return to Normal Mode
Exit	SMBus clock and data lines high	Return to Normal Mode
Exit	Wake comparator trips	Return to Normal Mode
Exit	**SafetyAlert()** flag or **PFAlert()** flag set	Return to Normal Mode

6.2.1.1 Wake Function

The device can exit Sleep Mode, if enabled, by the presence of a voltage across SRP and SRN. The level of the current signal needed is programmed in Power:*Wake Current Reg*.

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

Reserved (Bits 7–3): Reserved, do not use.

IWAKE (Bit 2):

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

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

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

6.2.2 ManufacturerAccess Sleep

The device can be sent to sleep with **ManufacturerAccess()** if the sleep conditions are met. This function is used to test sleep exit conditions.

6.3 Ship Mode

In Ship Mode, the device enters a low power mode with no voltage, current, and temperature measurements.

6.3.1 Ship Hibernate Mode

In Ship Hibernate Mode, the device enters a low-power mode with no voltage, current, and temperature measurements, the FETs are turned off, and the MCU is in a halt state. The device will return to Normal Mode on SBS communication detection. The device can be configured to ship hibernate with discharge FET on through Settings:System Configuration[SHIPDSG]. The device can be send to this mode with ManufacturerAccess() Ship command.

6.3.2 Ship Shutdown Mode

In Ship Shutdown Mode, the device shuts down to minimize power consumption, and the FETs are turned off. The device will return to Normal Mode when voltage at PACK pin > VSTARTUP. The device can be sent to this mode with the **ManufacturerAccess() Shutdown** command. Charger voltage must not be present for the device to enter Ship Shutdown Mode.

6.4 Shutdown Mode

6.4.1 Voltage Based Shutdown

The device can be configured to shutdown at a programmable stack voltage threshold to minimize power consumption and avoid draining the battery. This function also works in Permanent Failure mode to prevent polymer cell swelling.

Status	Condition	Action
Enable	Min(Cell Voltage in Voltages()) < Shutdown Voltage	**OperationStatus()[SDV]**= 1
Activate	Min(Cell Voltage in Voltages()) continuous < Shutdown Voltage for Shutdown Time	The device disables everything and turns off.
Exit	Voltage at PACK pin > VSTARTUP	• **OperationStatus()[SDV]**= 0 • Return to Normal Mode

Gauging

7.1 Impedance Track

The device features the most advanced Impedance Track gauging algorithm v3.75, and is capable of supporting a maximum battery pack capacity of 32 Ah. The algorithm estimates run time and capacity.

The Impedance Track algorithm v3.75 features the following:

- Cell balancing during relax (CBR)
- Ability to learn Qmax without a rest period following the end of discharge (FAST_QMAX)
- Compatible with LiFePO4 chemistries (LFP_RELAX)
- Greatly improved low temperature accuracy
- Greatly improved RSOC convergence to 0% at EDV (RSOC_CONV)
- Detailed status information via SBS for convenient debug and evaluation (no GG logging necessary)
  - DOD0
  - Qpassed
  - Grid numbers
  - Ra calculations
  - Balance timers
- Option to apply low pass filter smoothing to RemCap and FCC (SMOOTH)
- Option to prevent RSOC jumps during discharge (RSOC_HOLD)

7.2 Gas Gauge Mode

Status	Condition	Action
Charge	Current() > Chg Current Threshold	• GaugingStatus()[DSG] = 0 • GaugingStatus()[REST] = 0
Relax	GaugingStatus()[DSG] = 0–1 transition AND |Current()| < Quit Current Threshold for Chg Relax Time	• GaugingStatus()[DSG] = 1 • GaugingStatus()[REST] = 1, if: • DOD0 updated and • OCV updated and • QMAX updated
Relax	GaugingStatus()[DSG] = 1–0 transition AND |Current()| < Quit Current Threshold for Dsg Relax Time	• GaugingStatus()[DSG] = 1 • GaugingStatus()[REST] = 1, if: • DOD0 updated and • OCV updated and • QMAX updated
Discharge	Current() < (–) Dsg Current Threshold	• GaugingStatus()[DSG] = 1 • GaugingStatus()[REST] = 0 • RA update

7.3 Panasonic FCC Limitation Function

The battery can inform the host of 90% RSOC after 90 minutes of charging time if Design Capacity is set correctly. When IT FCC > Limited FCC, the battery will report FCC = Limited FCC and RemCap = RSOC * Limited FCC. Under these conditions RSOC is computed normally. When IT FCC ≤ Limited FCC, the battery returns to normal operation.

Lifetime Data Collection

The device has extensive capabilities logging events over life of battery useful for analysis. The data is collected in RAM and only written DF under following conditions to avoid wear out of flash:

- Every 10 hours if RAM content is different from Flash
- In permanent fail, before data flash updates are disabled
- A reset counter increments
- Before scheduled shutdown
- Before low voltage shutdown

The lifetime data stops collecting under following conditions:

- After permanent fails
- Lifetime Data collection is disabled

Total firmware Runtime starts when lifetime data is enabled.

- Voltage
  - Max/Min Cell Voltage Each Cell
  - Max Delta Voltage
- Current
  - Max Charge/Discharge Current
  - Max Average Discharge Current
  - Max Average Discharge Power
- Safety Events (12 most common are tracked)
  - Number of Safety Events
  - Cycle Count at Last Safety Event(s)
- Charging Events
  - Number of Valid Charge Terminations
  - Cycle Count at Last Charge Termination
- Gauging Events
  - Number of QMAX updates
  - Cycle Count at Last QMAX update
  - Number of RA updates
  - Cycle Count at Last RA update
- Power Events: Number of Resets
- Cell Balancing
  - Cell Balancing Time each Cell
- Temperature
  - Max/Min Cell Temp
  - Delta Cell Temp
- Time
  - Total runtime
  - Time spent different temperature ranges

Device Security

9.1 Description

The device uses SHA-1 one way has function for device authentication by host system. Unseal and Full Access mode is also protected using SHA-1 authentication.

9.2 SHA-1 Description

The SHA-1 is known as a one-way hash function, meaning there is no known mathematical method of computing the input given only the output. The specification of the SHA-1, as defined by FIPS 180–2, states that the input consists of 512 bit blocks with a total input length less than 264 bits. Inputs which do not conform to integer multiples of 512 bit blocks are padded before any block is input to the hash function. The SHA-1 algorithm outputs 160 bits, commonly referred to as the digest.

(As of April 23, 2004 the latest revision is FIPS 180–2).SHA-1 or secure hash algorithm is used to compute a condensed representation of a message or data also known as hash. For messages < 2^64 the SHA-1 produces an 160-bit output called digest.

The device generates an SHA-1 input block of 288 bits (total input = 160 bit message + 128 bit key). To complete the 512 bit block size requirement of the SHA-1, the device pads the key and message with a 1, followed by 159 0's, followed by the 64 bit value for 288 (000¼00100100000), which conforms to the pad requirements specified by FIPS 180–2.

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

1. http://www.itl.nist.gov/fipspubs/fip180–1.htm
2. http://csrc.nist.gov/publications/fips
3. www.faqs.org/rfcs/rfc3174.html

9.3 HMAC Description

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

To compute the HMAC let H designate the SHA-1 hash function, M designate the message transmitted to the device, and KD designate the unique 128 bit unseal/full access/authentication key of the device. HMAC(M) is defined as:

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

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

9.4 Authentication

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

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

9.5 Unseal/Full Access

1. Send Unseal (0x0031) or Full Access (0x0032) command to **ManufacturerAccess()**.
2. Read 160-bit message M from **ManufacturerInput()** in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTT, where AA is LSB
3. Generate SHA-1 input block B1 of 512 bytes (total input =128-bit unseal/full access key KD + 160 bit message M + 1 + 159 0s + 100100000)
4. Generate SHA-1 hash HMAC1 using B1.
5. Generate SHA-1 input block B2 of 512 bytes (total input =128-bit unseal/full access key KD + 160 bit hash HMAC1 + 1 + 159 0s + 100100000)
6. Generate SHA-1 hash HMAC2 using B2.
7. Write 160-bit hash HMAC2 to **ManufacturerInput()** in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTT, where AA is LSB
8. Device compares hash HMAC2 with internal calculated hash HMAC3. If it matches, device allows unsealed/full access mode indicated with the **OperationStatus()[SEC1],[SEC0]** flags.

10.1 0x00 ManufacturerAccess()

The ManufacturerAccess() command has several functions depending on the data written to this command.

10.1.1 ManufacturerAccess() 0x0000 ManufacturerData

This command returns ManufacturerData() information.

Status	Condition	Action
Activate	0x0000 to ManufacturerAccess()	Output ManufacturerData() on ManufacturerData()

10.1.2 ManufacturerAccess() 0x0001 Device Type

The device can be checked for the IC part number.

Status	Condition	Action
Enable	0x0001 to ManufacturerAccess()	• Returns the IC part number on subsequent read on ManufacturerData() in following format: aaAA, where: • aaAA: device type

10.1.3 ManufacturerAccess() 0x0002 Firmware Version

The device can be checked for the firmware version of the IC.

Status	Condition	Action
Enable	0x0003 to ManufacturerAccess()	• Returns the firmware revision on ManufacturerData() in following format: ddDDvvVVbbBBTTzzZZRREE, where: • ddDD: Device Number • vvVV: Version • bbBB: build number • ttTT: Firmware type • zzZZ: Impedance Track Version • RR: reserved • EE: reserved
Enable	Write following sequence within 4 seconds; also works in sealed mode: 1. Block write to 0x22 with block size 62 2. Block write to 0x20 with block size 62 3. Block write to 0x22 with block size 62	• Returns the firmware revision on ManufacturerData() in following format: ddDDvvVVbbBBTTzzZZRREE, where: • ddDD: Device Number • vvVV: Version • bbBB: build number • ttTT: Firmware type • zzZZ: Impedance Track Version • RR: reserved • EE: reserved

10.1.4 ManufacturerAccess() 0x0003 Hardware Version

The device can be checked for the hardware version of the IC.

Status	Condition	Action
Enable	0x0002 to ManufacturerAccess()	Returns the hardware revision on subsequent read on ManufacturerData()

10.1.5 ManufacturerAccess() 0x0004 Instruction Flash Checksum

The device can return the instruction flash checksum.

Status	Condition	Action
Enable	0x0004 to ManufacturerAccess()	Returns the IF checksum on subsequent read on ManufacturerData() after a wait time of 250 ms

10.1.6 ManufacturerAccess() 0x0005 Data Flash Checksum

The device can return the data flash checksum.

Status	Condition	Action
Enable	0x0005 to ManufacturerAccess()	Returns the DF checksum on subsequent read on ManufacturerData() after a wait time of 250 ms. Only static DF items are included in the checksum. No items modified by the device or items that are different device to device are included.

10.1.7 ManufacturerAccess() 0x0006 Chemical ID

This command returns the chemical ID of the OCV tables used in the gauging algorithm.

Status	Condition	Action
Enable	0x0006 to ManufacturerAccess()	Returns the chemical ID on subsequent read on ManufacturerData()

10.1.8 ManufacturerAccess() 0x0010 Shutdown Mode

The device can be sent to shutdown mode before shipping to reduce power consumption to a minimum. The device will wake up when a voltage is applied to PACK.

Status	Condition	Action
Normal	OperationStatus()[SH] = 0	
Enable	0x0010 to ManufacturerAccess; when sealed, two times in a row	OperationStatus()[SD] = 1
Trip	[NR] = 1 AND Current() = 0 AND Voltage on PACK = 0	FETs are turned off after Power:Shutdown time. Device will enter shutdown mode after another passage of Power:Shutdown time. (i.e. 2x of the Shutdown time after the command is set and 1x of the Shutdown time after the FETs are off)
Trip	Delay after command is sent > Power:*Shutdown Time*	No charging or discharging is allowed; device is shutdown.

10.1.9 ManufacturerAccess() 0x0011 Sleep Mode

The device can be send to sleep with **ManufacturerAccess()** if the sleep conditions are met.

Status	Condition	Action
Enable	0x0011 to ManufacturerAccess()	OperationStatus()[SLEEPM] = 1
Activate	***Settings:System Configuration[NR]*** = 0 AND OperationStatus()[PRES] = 0 AND |Current()| < ***Power:Sleep Current***	• Turn off CHG FET, DSG FET, PCHG FET • Device goes to sleep • Device wakes up every Power***:Sleep Voltage Time*** period to measure voltage and temperature • Device wakes up every Power***:Sleep Current Time*** period to measure current
Activate	***Settings:System Configuration:System[NR]*** = 1 AND |Current()| < Power:Sleep Current	• Turn off DSG FET, PCHG FET • Turn off CHG FET if ***Settings:System Configuration[SLEEPCHG]*** = 0 • Device goes to sleep • Device wakes up every Power***:Sleep Voltage Time*** period to measure voltage and temperature • Device wakes up every Power***:Sleep Current Time*** period to measure current
Exit	***Settings:System Configuration[NR]*** = 0 AND OperationStatus()[PRES] = 1	• OperationStatus()[SLEEPM] = 0 • Return to Normal Mode
Exit	|Current()| > Power: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

10.1.10 ManufacturerAccess() 0x0012 Device Reset

This command resets the device.

Status	Condition	Action
Enable	0x0012 to ManufacturerAccess()	Reset the device

10.1.11 ManufacturerAccess() 0x001d Fuse Toggle

This command activate/deactivate FUSE pin for ease of manufacturing testing.

Status	Condition	Action
Disable	OperationStatus()[FUSE] = 1 AND 0x001d to ManufacturerAccess()	• OperationStatus()[FUSE] = 0 • FUSE pin drive low
Enable	OperationStatus()[FUSE] = 0 AND 0x001d to ManufacturerAccess()	• OperationStatus()[FUSE] = 1 • FUSE pin drive high

10.1.12 ManufacturerAccess() 0x001e PRE-CHG FET

This command turns on/off Pre-CHG FET drive function to ease testing during manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[FET][PCHG] = 0,1 AND 0x001e to ManufacturerAccess()	• ManufacturingStatus()[FET][PCHG] = 0,0 • precharge function defined with PCHG1,PCHG0 turns off
Enable	ManufacturingStatus()[FET][PCHG] = 0,0 AND 0x001e to ManufacturerAccess()	• ManufacturingStatus()[FET][PCHG] = 0,1 • precharge function defined with PCHG1,PCHG0 turns on

10.1.13 ManufacturerAccess() 0x001f CHG FET

This command turns on/off CHG FET drive function to ease testing during manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[FET][CHG] = 0,1 AND 0x001f to ManufacturerAccess()	• ManufacturingStatus()[FET][CHG] = 0,0 • CHG FET turns off
Enable	ManufacturingStatus()[FET][CHG] = 0,0 AND 0x001f to ManufacturerAccess()	• ManufacturingStatus()[FET][CHG] = 0,1 • CHG FET turns on

10.1.14 ManufacturerAccess() 0x0020 DSG FET

This command turns on/off DSG FET drive function to ease testing during manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[FET][DSG] = 0,1 AND 0x0020 to ManufacturerAccess()	• ManufacturingStatus()[FET][DSG] = 0,0 • DSG FET turns off
Enable	ManufacturingStatus()[FET][DSG] = 0,0 AND 0x0020 to ManufacturerAccess()	• ManufacturingStatus()[FET][DSG] = 0,1 • DSG FET turns on

10.1.15 ManufacturerAccess() 0x0021 Gauging

This command enables or disable the gauging function to ease testing during manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[Gauge] = 1 AND 0x0021 to ManufacturerAccess()	• ManufacturingStatus()[Gauge] = 0 • disable gauging feature
Enable	ManufacturingStatus()[Gauge] = 0 AND 0x0021 to ManufacturerAccess()	• ManufacturingStatus()[Gauge] = 1 • Enable gauging feature

10.1.16 ManufacturerAccess() 0x0022 FET Control

This command enables/disables control of the CHG, DSG, and PCHG FET by the firmware.

Status	Condition	Action
Disable	ManufacturingStatus()[FET] = 1 AND 0x0022 to ManufacturerAccess()	• ManufacturingStatus()[FET] = 0 • CHG, DSG and PCHG FET are disabled and remain OFF
Enable	ManufacturingStatus()[FET] = 0 AND 0x0022 to ManufacturerAccess()	• ManufacturingStatus()[FET] = 1 • CHG, DSG and PCHG FET are controlled by the firmware

10.1.17 ManufacturerAccess() 0x0023 Lifetime Data Collection

This command enables/disables Lifetime data collection for ease of manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[LF] = 1 AND 0x0023 to ManufacturerAccess()	• ManufacturingStatus()[LF] = 0 • Lifetime Data collection feature disabled
Enable	ManufacturingStatus()[LF] = 0 AND 0x0023 to ManufacturerAccess()	• ManufacturingStatus()[LF] = 1 • Lifetime Data collection feature enabled

10.1.18 ManufacturerAccess() 0x0024 Permanent Failure

This command enables/disables Permanent Failure for ease of manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[PF] = 1 AND 0x0024 to ManufacturerAccess()	• ManufacturingStatus()[PF] = 0 • Permanent Failure feature disabled
Enable	ManufacturingStatus()[PF] = 0 AND 0x0024 to ManufacturerAccess()	• ManufacturingStatus()[PF] = 1 • Permanent Failure feature enabled

10.1.19 ManufacturerAccess() 0x0025 Black Box Recorder

This command enables/disables Black box recorder function for ease of manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[BBR] = 1 AND 0x0025 to ManufacturerAccess()	• ManufacturingStatus()[BBR] = 0 • Black Box Recorder feature disabled
Enable	ManufacturingStatus()[BBR] = 0 AND 0x0025 to ManufacturerAccess()	• ManufacturingStatus()[BBR] = 1 • Black Box Recorder feature enabled

10.1.20 ManufacturerAccess() 0x0026 Fuse

This command enables/disables firmware fuse toggle function for ease of manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[FUSE] = 1 AND 0x0026 to ManufacturerAccess()	• ManufacturingStatus()[FUSE] = 0 • FUSE pin action disabled
Enable	ManufacturingStatus()[FUSE] = 0 AND 0x0026 to ManufacturerAccess()	• ManufacturingStatus()[FUSE] = 1 • FUSE pin action enabled

10.1.21 ManufacturerAccess() 0x0027 LED Enable

This command enables/disables LED Display function for ease of manufacturing.

Status	Condition	Action
Disable	ManufacturingStatus()[LED] = 1 AND 0x0027 to ManufacturerAccess()	• ManufacturingStatus()[LED] = 0 • LED Display action disabled
Enable	ManufacturingStatus()[LED] = 0 AND 0x0027 to ManufacturerAccess()	• ManufacturingStatus()[LED] = 1 • LED Display action enabled

10.1.22 ManufacturerAccess() 0x0028 Lifetime Data Reset

This command resets Lifetime data in data flash for ease of manufacturing.

Status	Condition	Action
Reset	0x0028 to ManufacturerAccess()	Clear Lifetime Data in DF

10.1.23 ManufacturerAccess() 0x0029 Permanent Fail Data Reset

This command resets PF data in data flash for ease of manufacturing.

Status	Condition	Action
Reset	0x0029 to ManufacturerAccess()	Clear PF Data in DF

10.1.24 ManufacturerAccess() 0x002a Black Box Recorder Reset

This command resets the black box recorder data in data flash for ease of manufacturing.

Status	Condition	Action
Reset	0x002a to ManufacturerAccess()	Clear Black Box Recorder data in DF

10.1.25 ManufacturerAccess() 0x002b LED Toggle

This command activate/deactivate configured LEDs for ease of manufacturing testing.

Status	Condition	Action
Disable	OperationStatus()[LED] = 1 AND 0x002b to ManufacturerAccess()	• OperationStatus()[LED] = 0 • LED disabled
Enable	OperationStatus()[LED] = 0 AND 0x002b to ManufacturerAccess()	• OperationStatus()[LED] = 1 • LED enabled

10.1.26 ManufacturerAccess() 0x002c LED Display On

This command simulates low-high-low detection on the /DISP pin for ease of manufacturing testing.

Status	Condition	Action
Activate	0x002c to ManufacturerAccess()	Simulates low-high-low detection on the $\overline{\text{DISP}}$ pin

10.1.27 ManufacturerAccess() 0x002d CAL Mode

This command enables output of the raw ADC and CC data on ManufacturerData().

Status	Condition	Action
Disable	ManufacturingStatus()[CAL] = 1 AND 0x002d to ManufacturerAccess()	• ManufacturingStatus()[CAL] = 0 • disable output of ADC and CC raw data on ManufacturingData()
Enable	ManufacturingStatus()[CAL] = 0 AND 0x002d to ManufacturerAccess()	• ManufacturingStatus()[CAL] = 1 • Enable output of ADC and CC raw data on ManufacturingData(), controllable with 0xF081 and 0xF082 on ManufacturerAccess()

10.1.28 ManufacturerAccess() 0x0030 Seal Device

This command seals the device for the field, disabling certain SBS commands and access to DF.

Status	Condition	Action
Sealed	OperationStatus()[SEC1,SEC0] = 0,1 or 1,0 AND 0x0030 to ManufacturerAccess()	• OperationStatus()[SEC1,SEC0] = 1,1 • Certain SBS Commands not available, see SBS table for details

10.1.29 ManufacturerAccess() 0x0031 UnSeal Device

This command unseals the device after valid SHA-1 authentication.

Status	Condition	Action
Initiate	OperationStatus()[SEC1,SEC0] = 1,1 AND 0x0031 to ManufacturerAccess()	• OperationStatus()[AUTH] = 1 • 160-bit random number message available at ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTT, where AA is LSB
Unseal	Correct 160-bit HMAC digest computed with random number + Unseal Key written to ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPP, where AA is LSB	• OperationStatus()[SEC1,SEC0] = 0,1 • OperationStatus()[AUTH] = 0 • device unsealed after 250 ms, for available SBS commands in unseal mode see SBS table.
Invalid	incorrect 160-bit hash written to ManufacturerInput()	• wait time 250 ms • OperationStatus()[SEC1,SEC0] = 0,0 • OperationStatus()[AUTH] = 0

10.1.30 ManufacturerAccess() 0x0032 Full Access Device

This command enable Full Access to the device after valid SHA-1 authentication.

Status	Condition	Action
Initiate	OperationStatus()[SEC1,SEC0] = 1,1 or 1,0 AND 0x0032 to ManufacturerAccess()	• OperationStatus()[AUTH] = 1 • 160-bit random number message available at ManufacturerInput() n the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTT, where AA is LSB
Full Access	Correct 160-bit HMAC digest computed with random number + Full Access Key written to ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPP, where AA is LSB	• OperationStatus()[SEC1,SEC0] = 1,1 • OperationStatus()[AUTH] = 0 • device enables full access after 250 ms, for available SBS commands in full access mode see SBS table.
Invalid	Incorrect 160-bit hash written to ManufacturerInput()	• wait time 250 ms • OperationStatus()[SEC1,SEC0] = 0,0 • OperationStatus()[AUTH] = 0

10.1.31 ManufacturerAccess() 0x0033 ROM Mode

This command enables the ROM mode for IF update.

Status	Condition	Action
ROM Mode	OperationStatus()[SEC1,SEC0] = 1,0 AND 0x0033 to ManufacturerAccess()	Device goes to ROM mode ready for update, use 0x08 to ManufacturerAccess() to return

10.1.32 ManufacturerAccess() 0x0034 Ship Mode

In ship mode the device enters a low power mode with no voltage, current and temperature measurements, FETs turned off and MCU in a halt state. The device will return to Normal Mode on SBS communication detection.

Status	Condition	Action
Enable	0x0034 to ManufacturerAccess()	OperationStatus()[SHIPM] = 1
Activate	|Current()| < Power***:Sleep Current*** AND No SBS communication for power***:Ship Mode Com Delay***	• Turn off CHG FET, PCHG FET • Turn off DSG FET, if Settings:System Configuration[SHIPDSG]=0 • No Voltage, Temperature or Current Measurements • No Gauging • MCU in halt state HFO turned off.
Exit	SBS communication to device	• OperationStatus()[SHIPM] = 0 • Return to Normal Mode

10.1.33 ManufacturerAccess() 0x0035 Unseal Key

This command enters a new Unseal key into the device.

Status	Condition	Action
initiate	OperationStatus()[SEC1,SEC0] = 1,0 AND 0x0035 to ManufacturerAccess()	• OperationStatus()[AUTH] = 1 • 160-bit random number message available at ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTT, where AA is LSB
Enter Key	Correct 128-bit Key written to ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPP, where AA is LSB	• Wait time 250 ms • OperationStatus()[AUTH] = 0 • device returns 160-bit digest at ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTT, where AA is LSB. Digest was calculated using the random number + key. compare with own calculations check validity of key.

10.1.34 ManufacturerAccess() 0x0036 Full Access Key

This command enters a new Full Access key into the device.

Status	Condition	Action
initiate	OperationStatus()[SEC1,SEC0] = 1,0 AND 0x0036 to ManufacturerAccess()	• OperationStatus()[AUTH] = 1 • 160-bit random number available at ManufacturerInput()

Status	Condition	Action
Enter Key	Correct 128-bit Key written to ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPP, where AA is LSB	• Wait time 250 ms • OperationStatus()[AUTH] = 0 • device returns 160-bit digest at ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTT, where AA is LSB. Digest was calculated using the random number + key. compare with own calculations check validity of key.

10.1.35 ManufacturerAccess() 0x0037 Authentication Key

This command enters a new authentication key into the device.

Status	Condition	Action
Initiate	OperationStatus()[SEC1,SEC0] = 1,0 AND 0x0037 to ManufacturerAccess()	• OperationStatus()[AUTH] = 1 • 160-bit random number available at ManufacturerInput()
Enter Key	Correct 128-bit Key written to ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPP, where AA is LSB	• Wait time 250 ms • OperationStatus()[AUTH] = 0 • device returns 160-bit HMAC digest at ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTT, where AA is LSB. The HMAC digest was calculated using the random number + key. compare with own calculations check validity of key.

10.1.36 ManufacturerAccess() 0x0050 SafetyAlert

This command returns the SafetyAlert() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0050 to ManufacturerAccess()	Output SafetyAlert() flags on ManufacturerData()

10.1.37 ManufacturerAccess() 0x0051 SafetyStatus

This command returns the SafetyStatus() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0051 to ManufacturerAccess()	Output SafetyStatus() flags on ManufacturerData()

10.1.38 ManufacturerAccess() 0x0052 PFAlert

This command returns the PFAlert() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0052 to ManufacturerAccess()	Output PFAlert() flags on ManufacturerData()

10.1.39 ManufacturerAccess() 0x0053 PFStatus

This command returns the PFStatus() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0053 to ManufacturerAccess()	Output PFStatus() flags on ManufacturerData()

10.1.40 ManufacturerAccess() 0x0054 OperationStatus

This command returns the OperationStatus() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0054 to ManufacturerAccess()	Output OperationStatus() flags on ManufacturerData()

10.1.41 ManufacturerAccess() 0x0055 ChargingStatus

This command returns the ChargingStatus() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0055 to ManufacturerAccess()	Output ChargingStatus() flags on ManufacturerData()

10.1.42 ManufacturerAccess() 0x0056 GaugingStatus

This command returns the GaugingStatus() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0056 to ManufacturerAccess()	Output GaugingStatus() flags on ManufacturerData()

10.1.43 ManufacturerAccess() 0x0057 ManufacturingStatus

This command returns the ManufacturingStatus() flags on ManufacturerData().

Status	Condition	Action
Activate	0x0057 to ManufacturerAccess()	Output ManufacturingStatus() flags on ManufacturerData()

10.1.44 ManufacturerAccess() 0x0058 AFE Register

This command returns the AFERegister() values on ManufacturerData().

Status	Condition	Action
Activate	0x0058 to ManufacturerAccess()	Output AFERegister() values on ManufacturerData()

10.1.45 ManufacturerAccess() 0x0060 Lifetime Data Block 1

This command returns the Lifetime data on ManufacturerData().

Status	Condition	Action
Activate	0x0060 to ManufacturerAccess()	Output 32 bytes of lifetime data values on ManufacturerData()

10.1.46 ManufacturerAccess() 0x0061 Lifetime Data Block 2

This command returns the Lifetime data on ManufacturerData().

Status	Condition	Action
Activate	0x0061 to ManufacturerAccess()	Output 27 bytes of lifetime data values on ManufacturerData()

10.1.47 ManufacturerAccess() 0x0062 Lifetime Data Block 3

This command returns the Lifetime data on ManufacturerData().

Status	Condition	Action
Activate	0x0062 to ManufacturerAccess()	Output 12 bytes of lifetime data values on ManufacturerData()

10.1.48 ManufacturerAccess() 0x0070 ManufacturerInfo

This command returns ManufacturerInfo on ManufacturerData().

Status	Condition	Action
Activate	0x0070 to ManufacturerAccess()	Output 32 bytes of ManufacturerInfo on ManufacturerData()

10.1.49 ManufacturerAccess() 0x0071 Voltages

This command returns the CellVoltages, PackVoltage and BatVoltage on ManufacturerData().

Status	Condition	Action
Activate	0x0071 to ManufacturerAccess()	Output 12 bytes of voltage data values on ManufacturerData()

10.1.50 ManufacturerAccess() 0x0072 Temperatures

This command returns the internal temp sensor, TS1, TS2, TS3, TS4, CellTemp and FETTemp on ManufacturerData().

Status	Condition	Action
Activate	0x0072 to ManufacturerAccess()	Output 14 bytes of temperature data values on ManufacturerData()

10.1.51 ManufacturerAccess() 0x0073 ITSTATUS1

This command instructs the device to return impedance track related gauging information on ManufacturerData().

Status	Condition	Action
Activate	0x0073 to ManufacturerAccess()	Output 30 bytes of IT data values on ManufacturerData()

10.1.52 ManufacturerAccess() 0x0074 ITSTATUS2

This command instructs the device to return impedance track related gauging information on ManufacturerData().

Status	Condition	Action
Activate	0x0074 to ManufacturerAccess()	Output 10 bytes of IT data values on ManufacturerData()

10.1.53 ManufacturerAccess() 0xF080 Exit Calibration Output Mode

This command returns the data acquisition to Normal Mode.

Status	Condition	Action
Activate	ManufacturerData()[CAL] = 1 AND 0xF080 to ManufacturerAccess()	Stop output of ADC or CC data on ManufacturerData() and return to normal data acquisition mode

10.1.54 ManufacturerAccess() 0xF081 Output CC and ADC for Calibration

This command let the device output the raw values of Coulomb counter, CellVoltage1, CellVoltage2, CellVoltage3, CellVoltage4, TS1, TS2, TS3, TS4, Tint, PACK, and BAT as block on ManufacturerData() with updates every 250 ms for calibration purpose.

The format of each value 2's complement, MSB first.

Status	Condition	Action
Disable	ManufacturingStatus()[CAL] = 1 AND 0xF080 to ManufacturerAccess()	• ManufacturingStatus()[CAL] = 0 • Stop output of ADC and CC data on ManufacturerData() and return to normal data acquisition mode
Enable	0xF081 to ManufacturerAccess()	• ManufacturingStatus()[CAL] = 1 • outputs the raw CC and AD values on ManufacturerData() in the format of ZZYYaaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLL, where: – ZZ: rolling 8-bit counter, increments when values are refreshed – YY: status, 1 when MAC() = 0xF081, 2 when MAC()=0xF082 – AAaa: Coulomb counter – BBaa: CellVoltage1 – CCaa: CellVoltage2 – DDaa: CellVoltage3 – EEee: CellVoltage4 – FFff: Tint – GGgg: TS1 – HHhh: TS2 – IIii TS3 – JJjj: TS4 – KKkk: PackVoltage – LLll: BatVoltage

10.1.55 ManufacturerAccess() 0xF082 Output shorted Cc AND ADC Offset for Calibration

This command let the device output the raw CC value on ManufacturerData().

The format of each value 2's complement, MSB first.

Status	Condition	Action
Disable	ManufacturingStatus()[CAL] = 1 AND 0xF080 to ManufacturerAccess()	• ManufacturingStatus()[CAL] = 0 • Stop output of ADC and CC data on ManufacturerData() and return to normal data acquisition mode

Status	Condition	Action
Enable	0xF082 to ManufacturerAccess()	• ManufacturingStatus()[CAL] = 1 • outputs the raw CC and AD values on ManufacturerData() in the format of ZZYYaaAAbbBBccCCddDDeeEEffFFggGGhhHHiiIIjjJJkkKKllLL, where: • ZZ: rolling 8-bit counter, increments when values are refreshed • YY: status, 1 when MAC() = 0xF081, 2 when MAC()=0xF082 • AAaa: Coulomb counter • BBaa: CellVoltage1 • CCaa: CellVoltage2 • DDaa: CellVoltage3 • EEee: CellVoltage4 • FFff: Tint • GGgg: TS1 • HHhh: TS2 • IIii TS3 • JJjj: TS4 • KKkk: PackVoltage • LLll: BatVoltage

10.1.56 ManufacturerAccess() 0x01yy DF Access Row Address

This command sets the DF row with address yy on ManufacturerInfo() for immediate read/write on ManufacturingInfo().

Status	Condition	Action
Activate	0x01yy to ManufacturerAccess()	Prepare DF 32-byte row with address yy on ManufacturerInfo() for block read or write.

10.2 0x01 RemainingCapacityAlarm()

This read/write word function sets a low capacity alarm threshold.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x01	RemainingCapacityAlarm()	R/W			Word	U2	0	65535	mAh	**BatteryMode()[CAPM]** = 0
									10 mWh	**BatteryMode()[CAPM]** = 1

10.3 0x02 RemainingTimeAlarm()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x02	RemainingTimeAlarm()	R/W			Word	U2	0	65535	min	

10.4 0x03 BatteryMode()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x03	BatteryMode()	R/W			Word	H2	0x0000	0xFFFF	Bit 0: ICC Internal_Charge_Controller ®) 0 = Function not supported Bit 1: PBC Primary_Battery_Support ®) 1 = Primary or Secondary Battery Support Bit 2: Reserved Bit 3: Reserved Bit 4: Reserved Bit 5: Reserved Bit 6: Reserved Bit 7: CF Condition_Flag ®) 0 = Battery OK 1 = Conditioning cycle requested Bit 8: CCE Charge_Controller_Enabled (R/W) 0 = Internal charge controller disabled
0x03	BatteryMode()	R/W			Word	H2	0x0000	0xFFFF	Bit 9: PB Primary_Battery (R/W) 0 = Battery operating in its secondary role (default) 1 = Battery operating in its primary role Bit 10: Reserved Bit 11: Reserved Bit 12: Reserved Bit 13: AM Alarm Mode (R/W) 0 = Enable AlarmWarning broadcasts to host and smart battery charger 1 = Disable AlarmWarning broadcasts to host and smart battery charger Bit 14: CHGM Charger_Mode (R/W) 0 = Enable ChargingVoltage() and ChargingCurrent() broadcasts to host and smart battery charger 1 = Disable ChargingVoltage() and ChargingCurrent() broadcasts to host and smart battery charger Bit 15: CAPM Capacity_Mode (R/W) 0 = Report in mA or mAh (default) 1 = Report in 10 mW or 10 mWh

10.5 0x04 AtRate()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Unit	Note
		SE	US	FA						
0x04	AtRate()	R/W			Word	I2	–32768	32767	mA	BatteryMode()[CAPM] = 0
									10 mW	BatteryMode()[CAPM] = 1

10.6 0x05 AtRateToFull()

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

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x05	AtRateToFull()	R			Word	U2	0	65534	min	65535 indicates not being charged

10.7 0x06 AtRateToEmpty()

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

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x05	AtRateToFull()	R			Word	U2	0	65534	min	65535 indicates not being charged

10.8 0x07 AtRateOK()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x07	AtRateOK()	R			Word					0 = not ok

10.9 0x08 Temperature()

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

10.10 0x09 Voltage()

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

10.11 0x0A Current()

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

10.12 0x0B AverageCurrent()

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

10.13 0x0C MaxError()

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

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x0C	MaxError()	R			Word	U2	0	100	%	

Status	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%
	Configuration:Max Error Time Cycle Equivalent period passed since last valid QMax update	**MaxError()** increment by 0.05%

10.14 0x0D RelativeStateOfCharge()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x0D	RelativeStateOfCharge()	R			Word	U2	0	100	%	

10.15 0x0E AbsoluteStateOfCharge()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x0E	AbsoluteStateOfCharge()	R			Word	U2	0	100	%	

10.16 0x0F RemainingCapacity()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x0F	RemainingCapacity()	R	R	R/W	Word	U2	0	65535	mAh	BatteryMode()[CAPM] = 0
									10 mWh	BatteryMode()[CAPM] = 1

10.17 0x10 FullChargeCapacity()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x10	FullChargeCapacity()	R	R	R/W	Word	U2	0	65535	mAh	BatteryMode()[CAPM] = 0
									10 mWh	BatteryMode()[CAPM] = 1

10.18 0x11 RunTimeToEmpty()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x11	RunTimeToEmpty()	R	R	R	Word	U2	0	65534	min	65535 = No being discharged

10.19 0x12 AverageTimeToEmpty()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x12	AverageTimeToEmpty()	R	R	R	Word	U2	0	65534	min	65535 = No being discharged

10.20 0x13 AverageTimeToFull()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x13	AverageTimeToFull()	R	R	R	Word	U2	0	65534	min	65535 = Not being discharged

10.21 0x14 ChargingCurrent()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x14	ChargingCurrent()	R	R	R	Word	U2	0	65534	mA	65535 = request maximum current

10.22 0x15 ChargingVoltage()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x15	ChargingVoltage()	R	R	R	Word	U2	0	65534	mV	65535 = request maximum voltage

10.23 0x16 BatteryStatus()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Note
		SE	US	FA					
0x16	BatteryStatus()	R	R	R	Word	H2			Bit 3:0: EC3,EC2,EC1,EC0 Error Code 0x0 = OK 0x1 = Busy 0x2 = Reserved Command 0x3 = Unsupported Command 0x4 = AccessDenied 0x5 = Overflow/Underflow 0x6 = BadSize 0x7 = UnknownError Bit 4: FD Fully Discharged 0 = Battery ok 1 = Battery fully depleted Bit 5: FC Fully Charged 0 = Battery not fully charged 01 = Battery fully charged Bit 6: DSG Discharging 0 = Battery is charging 1 = Battery is discharging Bit 7: INIT Initialization 0 = Inactive 1 = Active Bit 8: RTA Remaining Time Alarm 0 = Inactive 1 = Active
0x16	BatteryStatus()	R	R	R	Word	H2			Bit 9: RCA Remaining Capacity Alarm 0 = Inactive 1 = Active Bit 10: Reserved Undefined Bit 11: TDA Terminate Discharge Alarm 0 = Inactive 1 = Active Bit 12: OTA Over Temperature Alarm 0 = Inactive 1 = Active Bit 13: Reserved Undefined Bit 14: TCA Terminate Charge Alarm 0 = Inactive 1 = Active Bit 15: OCA Over Charged Alarm 0 = Inactive 1 = Active

10.24 0x17 CycleCount()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x17	CycleCount()	R	R	R	Word	U2	0	65534	cycles	65535 = 65535 or more cycles

10.25 0x18 DesignCapacity()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x18	DesignCapacity()	R	R	R	Word	U2	0	65535	mAh	BatteryMode()[CAPM] = 0
									10 mWh	BatteryMode()[CAPM] = 1

10.26 0x19 DesignVoltage()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x19	DesignVoltage()	R	R	R	Word	U2	0	65535	mV	

10.27 0x1A SpecificationInfo()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Note
		SE	US	FA					
0x1A	SpecificationInfo()	R	R	R	Word	H2	0x0000	0xFFFF	Bit 0,1,2,3: Revision Revision 0,0,0,1 = Version 1.0 and 1.1 (default) Bit 4,5,6,7: Version Version 0,0,0,1 = Version 1.0 0,0,1,1 = Version 1.10,0,1,1 = Version 1.1 with optional PEC support Bit 8,9,10,11: VScale 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

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Note
		SE	US	FA					
0x1A	SpecificationInfo()	R	R	R	Word	H2	0x0000	0xFFFF	Bit 12,13,14,15: IPScale Voltage 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()

10.28 0x1B ManufacturerDate()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Note
		SE	US	FA					
0x1B	ManufacturerDate()	R	R	R	Word				ManufacturerDate() value in following format:Day + Month*32 + (Year–1980)*256

10.29 0x1C SerialNumber()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x1C	SerialNumber()	R	R	R	Word					

10.30 0x20 ManufacturerName()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x20	ManufacturerName()	R	R	R	Block	S21				

10.31 0x21 DeviceName()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x21	DeviceName()	R	R	R	Block	S21				

10.32 0x22 DeviceChemistry()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x22	DeviceChemistry()	R	R	R	Block	S4				

10.33 0x23 ManufacturerData()

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

10.34 0x2F Authentication() AND ManufacturerInput()

This read/write block function provides SHA-1 authentication in default mode. It is also used to enable data flash read/writes and provides authentication input for sealed, unsealed, full access mode

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Unit	Note
		SE	US	FA						
0x2F	ManufacturerInput()	R/W	R/W	R/W	Block					

Status	Condition	Action
Authentication	No active ManufacturerInput() data waiting AND write 160-bit challenge to ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTT, where AA is LSB	• OperationStatus()[AUTH] = 1 • Wait 250 ms • OperationStatus()[AUTH] = 0 • Device returns 160-bit digest at ManufacturerInput() in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTT, where AA is LSB, using the challenge + authentication key. Compare with own calculations to confirm validity of key.
ManufacturerInfo	Valid word sent to ManufacturerAccess()	Output block based on ManufacturerAccess() input for one time readout. Note: 0xF081 and 0xF082 on ManufacturerAccess() will be available for multi-read out until cleared with 0xF080.

10.35 0x3C–0x3F Cell Voltages()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Unit	Note
		SE	US	FA							
0x3c	Cell 3 voltage	R	R	R	Word	I2	0	32767		mV	
0x3d	Cell 2 voltage	R	R	R	Word	I2	0	32767		mV	
0x3e	Cell 1 voltage	R	R	R	Word	I2	0	32767		mV	
0x3f	Cell 0 voltage	R	R	R	Word	I2	0	32767		mV	

10.36 0x49 InspectionBits()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x49	Inspection Bits		R/W	R/W	Word	U2			BMU can read/write the Inspection Bit Initial : 0000 PCB inspection done : 0001 Pack in-process inspection done : 0011 Pack Final inspection done : 0111

10.37 0x4a 2nd IC Confirmation

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x4a	2nd IC Confirmation		W	W	Word	U2			Write value 0x2706 to make pin RA5 go low. Reset will make pin go high again.

10.38 0x50 SafetyAlert()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x50	SafetyAlert()	N/A	R	R	Block				Bit 0: CUV—Cell Undervoltage 0 = Inactive 1 = Detected Bit 1: COV—Cell Overvoltage 0 = Inactive 1 = Detected Bit 2: OCC1—Overcurrent in Charge 1st Tier 0 = Inactive 1 = Detected Bit 3: OCC2—Overcurrent in Charge 2nd Tier 0 = Inactive 1 = Detected Bit 4: OCD1—Overcurrent in Discharge 1st Tier 0 = Inactive 1 = Detected Bit 5: OCD2—Overcurrent in Discharge 2nd Tier 0 = Inactive 1 = Detected Bit 6: OLD—Overload in discharge 0 = Inactive 1 = Detected Bit 7: Reserved Bit 8: SCC—Short circuit in charge 0 = Inactive 1 = Detected Bit 9: Reserved Bit 10: SCD—Short circuit in discharge 0 = Inactive 1 = Detected Bit 11: Reserved Bit 12: OTC—Over temperature in charge 0 = Inactive 1 = Detected Bit 13: OTD Over temperature in discharge 0 = Inactive 1 = Detected Bit 14: CUVC—I*R compensated CUV 0 = Inactive 1 = Detected Bit 15: Reserved

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x50	SafetyAlert()	N/A	R	R	Block				Bit 16: OTF—FET over temperature 0 = Inactive 1 = Detected Bit 17: HWD—SBS Host watchdog timeout 0 = Inactive 1 = Detected Bit 18: PTO—Pre-charging timeout 0 = Inactive 1 = Detected Bit 19: PTOS—Pre-charging timeout suspend 0 = Inactive 1 = Detected Bit 20: CTO—Charging timeout 0 = Inactive 1 = Detected Bit 21: CTOS—Charging timeout suspend 0 = Inactive 1 = Detected Bit 22: OC—Overcharge 0 = Inactive 1 = Detected Bit 23: CHGC—Charging Current higher than requested 0 = Inactive 1 = Detected Bit 24: CHGV—Charging Voltage higher than requested 0 = Inactive 1 = Detected Bit 25: Reserved Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

10.39 0x51 SafetyStatus()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x51	SafetyStatus()	N/A	R	R	Block				Bit 0: CUV—Cell UnderVoltage 0 = Inactive 1 = Detected Bit 1: COV—Cell Overvoltage 0 = Inactive 1 = Detected Bit 2: OCC1—Overcurrent in Charge 1st Tier 0 = Inactive 1 = Detected Bit 3: OCC2—Overcurrent in Charge 2nd Tier 0 = Inactive 1 = Detected Bit 4: OCD1—Overcurrent in Discharge 1st Tier 0 = Inactive 1 = Detected Bit 5: OCD2—Overcurrent in Discharge 2nd Tier 0 = Inactive 1 = Detected Bit 6: OLD—Overload in discharge 0 = Inactive 1 = Detected Bit 7: OLDL—Overload in discharge latch 0 = Inactive 1 = Detected Bit 8: SCC—Short circuit in charge 0 = Inactive 1 = Detected Bit 9: SCCL—Short circuit in charge latch 0 = Inactive 1 = Detected Bit 10: SCD—Short circuit in discharge 0 = Inactive 1 = Detected Bit 11: SCDL—Short circuit in discharge latch 0 = Inactive 1 = Detected

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x51	SafetyStatus()	N/A	R	R	Block				Bit 12: OTC—Over temperature in charge 0 = Inactive 1 = Detected Bit 13: OTD—Over temperature in discharge 0 = Inactive 1 = Detected Bit 14: CUVC—I*R compensated CUV 0 = Inactive 1 = Detected Bit 15: Reserved Bit 16: OTF—FET over temperature 0 = Inactive 1 = Detected Bit 17: HWD—SBS Host watchdog timeout 0 = Inactive 1 = Detected Bit 18: PTO—Pre-charging timeout 0 = Inactive 1 = Detected Bit 19: Reserved Bit 20: CTO—Charging timeout 0 = Inactive 1 = Detected Bit 21: Reserved Bit 22: OC—Overcharge 0 = Inactive 1 = Detected Bit 23: CHGC—Charging Current higher than requested 0 = Inactive 1 = Detected Bit 24: CHGV—Charging Voltage higher than requested 0 = Inactive 1 = Detected Bit 25: Reserved Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

10.40 0x52 PFAlert()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x52	PFAlert()	N/A	R	R	Block				Bit 0: CUV—Cell undervoltage 0 = Inactive 1 = Detected Bit 1: COV—Cell overvoltage 0 = Inactive 1 = Detected Bit 2: CUDEP—Copper deposition 0 = Inactive 1 = Detected Bit 3: Reserved Bit 4: OTCE—Overtemperature 0 = Inactive 1 = Detected Bit 5: Reserved Bit 6: OTF—Overtemperature FET 0 = Inactive 1 = Detected Bit 7: QIM—QMax Imbalance 0 = Inactive 1 = Detected Bit 8: CB—Cell balancing 0 = Inactive 1 = Detected Bit 9: IMP—Cell impedance 0 = Inactive 1 = Detected Bit 10: CD—Capacity Deterioration 0 = Inactive 1 = Detected Bit 11: VIMR—Voltage imbalance at Rest 0 = Inactive 1 = Detected Bit 12: VIMA—Voltage imbalance at Rest 0 = Inactive 1 = Detected Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x52	PFAlert()	N/A	R	R	Block				Bit 16: CFET—Charge FET 0 = Inactive 1 = Detected Bit 17: DFET—Discharge FET 0 = Inactive 1 = Detected Bit 18: TH—Thermistor 0 = Inactive 1 = Detected Bit 19: FUSE—Fuse 0 = Inactive 1 = Detected Bit 20: AFER—AFE Register 0 = n/a 1 = Detected Bit 21: AFEC—AFE Communication 0 = Inactive 1 = Detected Bit 22: 2LVL— FUSE input indicating fuse trigger by external 2nd level protection 0 = Inactive 1 = Detected Bit 23: Reserved Bit 24: Reserved Bit 25: OCECO—Open VCx 0 = n/a 1 = Detected Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

10.41 0x53 PFStatus()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x53	PFStatus()	N/A	R	R	Block				Bit 0: CUV—Cell undervoltage 0 = Inactive 1 = Active Bit 1: COV—Cell overvoltage 0 = Inactive 1 = Active Bit 2: CUDEP—Copper Deposition 0 = Inactive 1 = Active Bit 3: Reserved Bit 4: OTCE—Overtemperature 0 = Inactive 1 = Active Bit 5: Reserved Bit 6: OTF—Overtemperature FET 0 = Inactive 1 = Active Bit 7: QIM—QMax Imbalance 0 = Inactive 1 = Active Bit 8: CB—Cell balancing 0 = Inactive 1 = Active Bit 9: IMP—Cell impedance 0 = Inactive 1 = Active Bit 10: CD—Capacity Deterioration 0 = Inactive 1 = Active Bit 11: VIMR—Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 12: VIMA—Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x53	PFStatus()	N/A	R	R	Block				Bit 16: CFET—Charge FET 0 = Inactive 1 = Active Bit 17: DFET—Discharge FET 0 = Inactive 1 = Active Bit 18: TH—Thermistor 0 = Inactive 1 = Active Bit 19: FUSE—Fuse 0 = Inactive 1 = Active Bit 20: AFER—AFE Register 0 = n/a 1 = Active Bit 21: AFEC—AFE Communication 0 = Inactive 1 = Active Bit 22: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Inactive 1 = Active Bit 23:PTC—PTC by AFE 0 = Inactive 1 = Active Bit 24: IFC—Instruction Flash Checksum 0 = n/a 1 = IF checksum failure Bit 25: OCECO Open VCx 0 = n/a 1 = Active Bit 26: DFW—DF write failure 0 = n/a 1 = Active Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

10.42 0x54 OperationStatus()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x54	OperationStatus()	N/A	R	R	Block				Bit 0: $\overline{\text{PRES}}$—PRES input state 0 = $\overline{\text{PRES}}$ pin high 1 = $\overline{\text{PRES}}$ pin low detected Bit 1: DSG DSG FET Status 0 = Disabled 1 = Enabled Bit 2: CHG CHG FET Status 0 = Disabled 1 = Enabled Bit 3: PCHG PCHG FET Status 0 = Disabled 1 = Enabled Bit 4: GPOD GPOD FET Status 0 = Disabled 1 = Enabled Bit 5: FUSE FUSE input t0 = FUSE pin low 1 = FUSE pin high detected Bit 6: CB—Cell Balancing 0 = Inactive 1 = Active Bit 7: LED—LED Enable 0 = Inactive 1 = Active Bit 9:8: SEC1,SEC0 Security Mode0, 0 = Reserved 1, 0 = Full Access 0, 1 = Unsealed1,1 = Sealed
0x54	OperationStatus()	N/A	R	R	Block				Bit 10: CAL—Cal Raw ADC/CC output active 0 = Inactive 1 = Active Bit 11: SS—SafetyStatus 0 = Inactive 1 = Active Bit 12: PF—Permanent Failure 0 = Inactive 1 = Active Bit 13: XDSG—Discharging Disabled 0 = Inactive 1 = Active Bit 14: XCHG—Charging Disabled 0 = Inactive 1 = Active Bit 15: SLEEP—Sleep condition met 0 = Disabled 1 = Enabled Bit 16: SDM—Shutdown activated by ManufacturerAccess() 0 = Inactive 1 = Active Bit 17: SHIPM—Ship Mode activated with ManufacturerAccess() 0 = Inactive 1 = Active Bit 18: AUTH—Authentication ongoing 0 = Inactive 1 = Active

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x54	OperationStatus()	N/A	R	R	Block				Bit 19: AWD AFE Watchdog failure 0 = Inactive 1 = Active Bit 20: FVSFast Voltage Sampling 0 = Inactive 1 = Active Bit 21: CALORaw ADC/CC offset output 0 = Inactive 1 = Active Bit 22: SDV Shutdown activated by voltage 0 = Inactive 1 = Active Bit 23: SLEEPM Sleep mode active by ManufacturerAccess() 0 = Inactive 1 = Active Bit 24: INIT Initialization after full reset, cleared when SBS data calculated and available 0 = Inactive 1 = Active Bit 25: SMBLCAL CC auto offset calibration ongoing after SBS line goes low 0 = Inactive 1 = Active Bit 26: SLEEPQMAX QMAX update in sleepmode 0 = Inactive 1 = Active Bit 27: SLEEPC Checking current in Sleep Mode 0 = Inactive 1 = Active Bit 28: XLSBS Fast Mode 0 = Inactive 1 = Active Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

10.43 0x55 ChargingStatus()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x55 0x55	ChargingStatus()		R	R	Block				Bit 0: UT—Under Temperature Range 0 = Inactive 1 = Active Bit 1: LT—Low Temperature Range 0 = Inactive 1 = Active Bit 2: STL—Standard Temperature Low Range 0 = Inactive 1 = Active Bit 3: RT—RecommendedTemperature Range 0 = Inactive 1 = Active Bit 4: ST—Standard Temperature High Range 0 = Inactive 1 = Active Bit 5: HT—High Temperature Range 0 = Inactive 1 = Active Bit 6: OT—Over Temperature Range 0 = Inactive 1 = Active Bit 7: PV—Precharge Voltage Range 0 = Inactive 1 = Active Bit 8: LV—Low Voltage Range 0 = Inactive 1 = Active Bit 9: MV—Mid Voltage Range 0 = Inactive 1 = Active Bit 10: HV—High Voltage Range 0 = Inactive 1 = Active Bit 11: IN—Charge Inhibit 0 = Inactive 1 = Active Bit 12: SU—Charge Suspend 0 = Inactive 1 = Active Bit 13: CCR—ChargingCurrent() Rate 0 = Inactive 1 = Active Bit 14: CVR—ChargingVoltage() Rate 0 = Inactive 1 = Active Bit 15: CCC—ChargingCurrent() Compensation 0 = Inactive 1 = Active

10.44 0x56 GaugingStatus()

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Note
		SE	US	FA					
0x56	GaugingStatus()		R	R	Block				Bit 0: RESTDOD0, OCV and QMAX Updated 0 = not updated 1 = updated Bit 1: DSG Discharge detected 0 = Charging 1 = Discharging Bit 2: RU Resistance update 0 = Disabled 1 = enabled Bit 3: VOK Cell Voltage OK for QMAX update 0 = Inactive 1 = Active Bit 4: QEN QMax updates 0 = Disabled 1 = enabled Bit 5: FD FULLY Discharged detected by gauge algorithm 0 = Disabled 1 = enabled Bit 6: FC Fully Charged detected by gauge algorithm 0 = Disabled 1 = enabled Bit 7: NSFM negative scale factor mode 0 = Disabled 1 = enabled Bit 8: VDQ Discharge qualified for learning 0 = Disabled 1 = enabled Bit 9: QMAX QMAX updated. This flag toggles every time QMAX is updated. Bit 10: RX Resistance update. This flag toggles every time Resistance is updated. Bit 11: LDMD Load Mode 0 = Constant current mode 1 = Constant power mode Bit 12: OCVFR OCV in flat region 0 = OCV outside flat region 1 = OCV in flat region Bit 13: TDA Terminate Discharge Alarm set by gauging algorithm 0 = Disabled 1 = enabled Bit 14: TCA Terminate Charge Alarm set by gauging algorithm 0 = Disabled 1 = enabled Bit 15: LPF RelaxLiPh Relax Mode, only active with Chem ID 0x400 0 = Disabled 1 = enabled

10.45 0x57 ManufacturingStatus()

The enable bits FET_EN, LF_EN, PF_EN, BBR_EN, FUSE_EN, and LED_EN can be set in the golden image if packmaker does not want to send the individual enable commands. The only function that can not be enabled by setting DF Setting Manufacturing Status is IT Enable. The IT Enable cmd is needed to take DOD0 value for fast Qmax, etc.

SBS Cmd	Name	Access			Proto-col	Type	Min	Max	Default	Note
		SE	US	FA						
0x57	ManufacturingStatus()		R	R	Block				0x8000	Bit 0: PCHG PCHG Function, only available with FET = 0 0 = Disabled 1 = enabled Bit 1: CHG CHG FET, only available with FET = 0 0 = Disabled 1 = enabled Bit 2: DSG DSG FET, only available with FET = 0 0 = Disabled 1 =enabled Bit 3: GAUGE Gauging 0 = Disabled 1 = enabled (default) Bit 4: FET FET action 0 = Disabled 1 = enabled (default) Bit 5: LF Lifetime data collection 0 = Disabled 1 = enabled (default) Bit 6: PFPermanent Fail 0 = Disabled 1 = enabled (default) Bit 7: BBR Black box recorder 0 = Disabled 1 = enabled (default) Bit 8: FUSE FUSE action 0 = Disabled 1 = enabled (default) Bit 9: LED LED Display 0 = Disabled 1 = enabled (default) Bit 10: Reserved Bit 11: Reserved Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: CAL ADC or CC output on ManufacturerData() 0 = Disabled 1 = enabled (default)

10.46 0x58 AFERegisters()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x58	AFERegisters()		R	R	Block					Output AFE register values on ManufacturerData() in the following format: AABBCCDDEEFFGGHHIIJJKK where: • AA: STATUS register • BB: STATE_CONTROL register • CC: OUTPUT_CONTROL register • DD: OUTPUT_STATUS register • EE: FUNCTION_CONTROL register • FF: CELL_SEL register • GG: OCDV register • HH: OCDD register • II: SCC register • JJ: SCD1 register • KK: SCD2 register

10.47 0x60 Lifetime Data Block 1

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x60	Lifetime Data Block 1		R	R	Block					Output lifetimes values on ManufacturerData() in the following format: AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVWWXXVVZZ112233445566 where: • in the following format: • AA: Max Cell Voltage 1 • BB: Max Cell Voltage 2 • CC: Max Cell Voltage 3 • DD: Max Cell Voltage 4 • EE: Min Cell Voltage 1 • FF: Min Cell Voltage 2 • GG: Min Cell Voltage 3 • HH: Min Cell Voltage 4 • II: Max Delta Cell Voltage • JJ: Max Charge Current • KK: Max Discharge Current • LL: Max Average Discharge Current • MM: Max Average Discharge Power • NN: No Of COV Events • OO: Last COV Event • PP: No Of CUV Events • QQ: Last CUV Event • RR: No Of OCD1 Events • SS: Last OCD1 Event • TT: No Of OCD2 Events • UU: Last OCD2 Event • VV: No Of OCC1 Events • WW: Last OCC1 Event • XX: No Of OCC2 Events • YY: Last OCC2 Event • ZZ: No Of OLD Events • 11: Last OLD Event • 22: No Of SCD Events • 33: Last SCD Event • 44: No Of SCC Events • 55:Last SCC Event • 66: No Valid Charge Terminations

10.48 0x61 Lifetime Data Block 2

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x61	Lifetime Data Block 2		R	R	Block					Output lifetimes values on ManufacturerData() in the following format: • AABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTTUUVVWWXXVVZZ11 where: • AA: Last Valid Charge Termination • BB: No Of OTC Events • CC: Last OTC Event • DD: No Of OTD Events • EE: Last OTD Event • FF: No Of OTF Events • GG: Last OTF Event • HH: No Of QMax Updates • II: Last QMax Update • JJ: No Of RA Updates • KK: Last RA Update • LL: No Of RA Disables • MM:Last RA Disable • NN: No Of Shutdowns • OO: No Of Partial Resets • PP: No Of Full Resets • QQ: No Of WDT Resets • RR: CB Time Cell 1 • SS: CB Time Cell 2 • TT: CB Time Cell 3 • UU: CB Time Cell 4 • VV: Max Temp Cell • WW: Min Temp Cell • XX: Max Delta Cell Temp • YY:Max Temp Int Sensor • ZZ:Min Temp Int Sensor • 11: Max Temp FET

10.49 0x62 Lifetime Data Block 3

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x62	Lifetime Data Block 3		R	R	Block					Output lifetimes values on ManufacturerData() • in the following format: aaAAbbBBccCCddDDeeEEffFFggGGhhHH where: • AAaa: Total firmware Run Time • BBbb: Time Spent in UT • CCcc: Time Spent in LT • DDdd: Time Spent in STL *EEee: Time Spent in RT • FFff: Time Spent in STH • GGgg: Time Spent in HT • HHhh: Time Spent in OT

10.50 0x70 ManufacturerInfo()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x70	ManufacturerInfo()	R	R/W	R/W	Block					Instruct the device to return 32 bytes of ManufacturerInfo(). Output 32 bytes of ManufacturerInfo on ManufacturerData() in the following format: AABBCCDDEEFFGGHHIIJJKKLLMMNN OOPPQQRRSSTTUUVVWWXXVVZZ112233445566

10.51 0x71 Voltages()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x71	Voltages()	n/a	R	R	Block					Output 12 bytes of voltage data values on ManufacturerData() in the following format: aaAAbbBBccCCddDDeeEEffFF where: • AAaa: Cell Voltage 0 • BBbb: Cell Voltage 1 • CCcc: Cell Voltage 2 • DDdd: Cell Voltage 3 • EEee: BAT Voltage • FFff: PACK Voltage

10.52 0x72 Temperatures()

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x72	Temperatures()	n/a	R	R	Block					• Output 14 bytes of temperature data values on ManufacturerData() in the following format: aaAAbbBBccCCddDDeeEEffFF where: • AAaa: Int Temperature • BBbb: TS1 Temperature • CCcc: TS2 Temperature • DDdd: TS3 Temperature • EEee: TS4 Temperature • FFff: Cell Temperature • GGgg: FET Temperature

10.53 0x73 ITStatus1()

This read block function returns gauging algorithm related parameters.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x73	ITStatus1()	n/a	R	R	Block					Output 30 bytes of IT data values on ManufacturerData() in the following format: aaAAbbBBccCCddDDeeEEffFFGGggHHhhIIiiJJjjkkKKllLLmmMMnnNNooOO where: • AAaa: DOD0 Cell 0 • BBbb: DOD0 Cell 1 • CCcc: DOD0 Cell 2 • DDdd: DOD0 Cell 3 • EEee: Passed Charge since last DOD0 Update • FFff: QMax Cell 0 • GGgg: QMax Cell 1 • HHhh: QMax Cell 2 • IIii: QMax Cell 3 • JJjjKKkk: State Time • LLll: DOD EOC Cell 0 • MMmm: DOD EOC Cell 1 • NNnn: DOD EOC Cell 2 • OOoo: DOD EOC Cell 3

Attribute	Description	Format
DOD0_0	Depth of discharge cell 0	I2
DOD0_1	Depth of discharge cell 1	I2
DOD0_2	Depth of discharge cell 2	I2
DOD0_3	Depth of discharge cell 3	I2
ChargeDOD0Update	Passed charge since last DOD0 update	I2
QMax0	Qmax of cell 0	I2
QMax1	Qmax of cell 1	I2
QMax2	Qmax of cell 2	I2
QMax3	Qmax of cell 3	I2
StateTime	Time past since last state change (DSG,CHG,RST)	U4
DODEOC0	Depth of discharge cell at End of Charge cell 0	U2
DODEOC1	Depth of discharge cell at End of Charge cell 1	U2
DODEOC2	Depth of discharge cell at End of Charge cell 2	U2
DODEOC3	Depth of discharge cell at End of Charge cell 3	U2

10.54 0x74 ITStatus2()

This read block function returns gauging algorithm related parameters.

SBS Cmd	Name	Access			Protocol	Type	Min	Max	Default	Note
		SE	US	FA						
0x74	ITStatus2()		R	R	Block					Output 30 bytes of IT data values on ManufacturerData() in the following format: AABBCCDDEEFFggGGhhHHiiIIjjJJ kkKKllLLmmMMnnNNooOOppPPqq QQrrRR where: • AA: Pack Grid point • BB: Learned Status • CC: Grid Cell 0 • DD: Grid Cell 1 • EE: Grid Cell 2 • FF: Grid Cell 3 • GGgg: CompRes Cell 0 • HHhh: CompRes Cell 1 • IIii: CompRes Cell 2 • JJjj: CompRes Cell 3 • Kkkk: CB Time Cell 0 • LLll: CB Time Cell 1 • MMmm: CB Time Cell 2 • NNnn: CB Time Cell 3 • OOoo: RaScale0 • PPpp: RaScale1 • QQqq: RaScale2 • RRrr: RaScale3

Attribute	Description	Format
PackGrid	Active pack grid point (minimum of CellGrid0 to CellGrid3)	U1
LStatus	Learned status of resistance table	Bit 1,0: CFQMax status 0,0 = Battery OK 0,1 = QMax is first updated in learning cycle 1,0 = QMax and resistance table updated in learning cycle Bit 2: ITEN IT enable 0 = IT disabled 1 = IT enabled Bit 3: ITEN QMax update in Field 0 = QMax never updated in field 1 = Qmax updated in filed
CellGrid0	Active grid point cell 0	U1
CellGrid1	Active grid point cell 1	U1
CellGrid2	Active grid point cell 2	U1
CellGrid3	Active grid point cell 3	U1
CompRes0	Last calculated temperature compensated resistance cell 0	U2
CompRes1	Last calculated temperature compensated resistance cell 1	U2
CompRes2	Last calculated temperature compensated resistance cell 2	U2
CompRes3	Last calculated temperature compensated resistance cell 3	U2
CBTime0	Calculated cell balancing time cell 0	U2
CBTime1	Calculated cell balancing time cell 1	U2
CBTime2	Calculated cell balancing time cell 2	U2
CBTime3	Calculated cell balancing time cell 3	U2
RaScale0	Ra Table scaling factor cell 0	U2

Attribute	Description	Format
RaScale1	Ra Table scaling factor cell 1	U2
RaScale2	Ra Table scaling factor cell 2	U2
RaScale3	Ra Table scaling factor cell 3	U2

Data Flash Values and Device Configuration

11.1 Data Formats

11.1.1 Unsigned Integer

Unsigned integer are stored without changes as 1-byte, 2-byte or 4-byte values.

11.1.2 Integer

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

11.1.3 Floating Point

Floating point are stored using 4 byte format, where the MSB is the exponent, byte 3 to 0 the mantissa in unsigned integer format, with the MSB in byte 3 as sign bit.

Where:

Exp: Exponent

Mantissa: 23 bit mantissa with 24 bit as sign bit.

The floating point value is represented as:

11.1.4 Hex

Bit register definition are stored in unsigned integer format.

11.1.5 String

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

11.2 Protections

11.2.1 CUV—Cell Undervoltage

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	CUV	Threshold	I2	0	32767	2800	mV	Cell undervoltage trip threshold
Protections	CUV	Delay	U1	0	255	2	s	Cell undervoltage trip delay
Protections	CUV	Recovery	I2	0	32767	3000	mV	Cell undervoltage recovery threshold

11.2.2 CUVC—Cell Undervoltage Compensated

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	CUVC	Threshold	I2	0	32767	2900	mV	Cell undervoltage compensated trip threshold
Protections	CUVC	Delay	U1	0	255	2	s	Cell undervoltage compensated trip delay
Protections	CUVC	Recovery	I2	0	32767	3000	mV	Cell undervoltage compensated recovery threshold

11.2.3 COV—Cell Overvoltage

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	COV	Threshold Low Temp	I2	0	32767	4250	mV	Cell overvoltage low temperature range trip threshold
Protections	COV	Threshold Standard Temp	I2	0	32767	4250	mV	Cell overvoltage standard temperature range trip threshold
Protections	COV	Threshold High Temp	I2	0	32767	4250	mV	Cell overvoltage high temperature range trip threshold
Protections	COV	Threshold Rec Temp	I2	0	32767	4250	mV	Cell overvoltage recommended temperature range trip threshold
Protections	COV	Delay	U1	0	255	2	s	Cell overvoltage trip delay
Protections	COV	Recovery Low Temp	I2	0	32767	4150	mV	Cell overvoltage low temperature range recovery threshold
Protections	COV	Recovery Standard Temp	I2	0	32767	4150	mV	Cell overvoltage standard temperature recovery range threshold
Protections	COV	Recovery High Temp	I2	0	32767	4150	mV	Cell overvoltage high temperature range recovery threshold
Protections	COV	Recovery Rec Temp	I2	0	32767	4150	mV	Cell overvoltage recommended temperature range recovery threshold

11.2.4 OCC1—Overcurrent In Charge 1

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OCC1	Threshold	I2	–32768	32767	6000	mA	Overcurrent in Charge 1 trip threshold
Protections	OCC1	Delay	U1	0	255	6	s	Overcurrent in Charge 1 trip delay

11.2.5 OCC2—Overcurrent In Charge 2

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OCC2	Threshold	I2	–32768	32767	8000	mA	Overcurrent in Charge 2 trip threshold
Protections	OCC2	Delay	U1	0	255	3	s	Overcurrent in Charge 2 trip delay

11.2.6 OCC Overcurrent In Charge Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OCC	Recovery Threshold	I2	–32768	32767	–50	mA	Overcurrent in Charge 1 and 2 recovery threshold
Protections	OCC	Recovery Delay	U1	0	255	5	s	Overcurrent in Charge 1 and 2 recovery delay

11.2.7 OCD1—Overcurrent In Discharge 1

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OCD1	Threshold	I2	–32768	32767	–6000	mA	Overcurrent in Discharge 1 trip threshold
Protections	OCD1	Delay	U1	0	255	6	s	Overcurrent in Discharge 1 trip delay

11.2.8 OCD2—Overcurrent In Discharge 2

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OCD2	Threshold	I2	–32768	32767	–8000	mA	Overcurrent in Discharge 2 trip threshold
Protections	OCD2	Delay	U1	0	255	3	s	Overcurrent in Discharge 2 trip delay

11.2.9 OCD—Overcurrent In Discharge Recovery

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OCD	Recovery	I2	–32768	32767	50	mA	Overcurrent in Discharge 1 and 2 recovery threshold
Protections	OCD	Recovery Delay	U1	0	255	5	s	Overcurrent in Discharge 1 and 2 recovery delay

11.2.10 OLD—Over Load in Discharge

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OLD	Threshold	H1	0x00	0x0F	0x09	10 mV	Bit 3:0: Over Load Trip Threshold between SRP and SRN Threshold can be set from 50 mV to 200 mV with 10 mV step. If Settings:AFE State Control[RSNS] = 1, threshold value will be divided in half. See Appendix A for details.
Protections	OLD	Delay	H1	0x00	0x0F	0x0F	2 ms	Bit 3:0: Over Load Trip Delay Delay can be set from 1ms to 31 sec with 2 ms step. See Appendix A for details.
Protections	OLD	Latch Limit	U1	0	255	0	counts	Over load latch counter trip threshold
Protections	OLD	Counter Dec Delay	U1	0	255	10	s	Over load latch counter decrement delay
Protections	OLD	Recovery	U1	0	255	5	s	Over load recovery time
Protections	OLD	Reset	U1	0	255	15	s	Over load latch reset time

11.2.11 SCC—Short Circuit In Charge

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	SCC	Threshold	H1	0x00	0xFF	0x77		Bit 2:0: Short Circuit in Charge Threshold. Threshold can be set from 100 mV to 300 mV in 50mV step. If Settings:AFE State Control[RSNS] = 1, Threshold value will be divided in half. Bit 3: Reserved Bit 7:4: Short Circuit in Charge Delay Time Delay can be set from 0 µs to 915 µs in 61 µs step See Appendix A for details.
Protections	SCC	Latch Limit	U1	0	255	0		Short Circuit in Charge Latch counter trip threshold
Protections	SCC	Counter Dec Delay	U1	0	255	10	s	Short Circuit in Charge counter decrement delay
Protections	SCC	Recovery	U1	0	255	5	s	Short Circuit in Charge recovery time
Protections	SCC	Reset	U1	0	255	15	s	Short Circuit in Charge latch reset time

11.2.12 SCD1—Short Circuit In Discharge 1

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	SDC1	Threshold	H1	0x00	0xFF	0x77		Bit 2:0: Short Circuit in Discharge1 Threshold. Threshold can be set from 100 mV to 300 mV in 50 mV step. If Settings:AFE State Control[RSNS] = 1, Threshold value will be divided in half. Bit 3: Reserved Bit 7:4: Short Circuit in Discharge1 Delay Time Delay can be set from 0 µs to 915 µs in 61 µs step. If Settings:AFE State Control[SCDDx2] = 1, Delay Time value will be doubled. See Appendix A for details.

11.2.13 SCD2—Short Circuit in Discharge 2

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	SDC2	Threshold	H1	0x00	0xFF	0xE7		Bit 2:0: Short Circuit in Discharge2 Threshold. Threshold can be set from 100 mV to 300 mV in 50mV step. If Settings:AFE State Control[RSNS] = 1, Threshold value will be divided in half. Bit 3: Reserved Bit 7:4: Short Circuit in Discharge2 Delay Time Delay can be set from 0 µs to 458 µs in 30 µs step. If Settings:AFE State Control[SCDDx2] = 1, Delay Time value will be doubled. See Appendix A for details.

11.2.14 SCD—Short Circuit in Discharge

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	SCD	Latch Limit	U1	0	255	0		Short Circuit in Discharge Latch counter trip threshold
Protections	SCD	Counter Dec Delay	U1	0	255	10	s	Short Circuit in Discharge counter decrement delay
Protections	SCD	Recovery	U1	0	255	5	s	Short Circuit in Discharge recovery time
Protections	SCD	Reset	U1	0	255	15	s	Short Circuit in Discharge latch reset time

11.2.15 OTC—Over Temperature in Charge

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OTC	Threshold	I2	–400	1500	550	0.1°C	Over Temperature in Charge trip threshold
Protections	OTC	Delay	U1	0	255	2	s	Over Temperature in Charge Cell trip delay
Protections	OTC	Recovery	I2	–400	1500	500	0.1°C	Over Temperature in Charge Cell recovery threshold

11.2.16 OTD—Over Temperature in Discharge

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OTD	Threshold	I2	–400	1500	600	0.1°C	Over Temperature in Discharge trip threshold
Protections	OTD	Delay	U1	0	255	2	s	Over Temperature in Discharge trip delay
Protections	OTD	Recovery	I2	–400	1500	550	0.1°C	Over Temperature in Discharge recovery threshold

11.2.17 OTF—Over Temperature FET

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OTF	Threshold	I2	–400	1500	800	0.1°C	Over Temperature FET trip threshold
Protections	OTF	Delay	U1	0	255	2	s	Over Temperature FET trip delay
Protections	OTF	Recovery	I2	–400	1500	650	0.1°C	Over Temperature FET recovery threshold

11.2.18 HWD—Host Watchdog

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	HWD	Delay	U1	0	255	10	s	SBS Host watchdog trip delay

11.2.19 PTO—Pre Charge Mode Time Out

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	PTO	Charge Threshold	I2	–32768	32767	2000	mA	Pre-Charge Timeout Current Threshold
Protections	PTO	Suspend Threshold	I2	–32768	32767	1800	mA	Pre-Charge Timeout Suspend Threshold
Protections	PTO	Delay	U2	0	65535	1800	s	Pre-Charge Timeout trip delay
Protections	PTO	Reset	I2	–32768	32767	2	mA	Pre-Charge Timeout Reset Threshold

11.2.20 CTO—Fast Charge Mode Time Out

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	PTO	Charge Threshold	I2	–32768	32767	2500	mA	Fast-Charge Timeout Current Threshold
Protections	PTO	Suspend Threshold	I2	–32768	32767	2000	mA	Fast-Charge Timeout Suspend Threshold
Protections	PTO	Delay	U2	0	65535	54000	s	Fast-Charge Timeout trip delay
Protections	PTO	Reset	I2	–32768	32767	2	mA	Fast-Charge Timeout Reset Threshold

11.2.21 OC—Over Charge

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	OC	Threshold	I2	–32768	32767	300	mAh	Overcharge trip threshold
Protections	OC	Recovery	I2	–32768	32767	2	mAh	Overcharge recovery threshold
Protections	OC	RSOC Recovery	U1	0	100	90	%	Overcharge RemainingStateOfCharge() recovery threshold

11.2.22 CHGV—ChargingVoltage

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	CHGV	Threshold	I2	–32768	32767	500	mV	ChargingVoltage() delta trip threshold
Protections	CHGV	Delay	U1	0	255	30	s	ChargingVoltage() delta trip delay
Protections	CHGV	Recovery	I2	–32768	32767	–500	mV	ChargingVoltage() delta recovery threshold

11.2.23 CHGC —ChargingCurrent

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Protections	CHGC	Threshold	I2	–32768	32767	500	mA	ChargingCurrent() delta trip threshold
Protections	CHGC	Delay	U1	0	255	2	s	ChargingCurrent() delta trip delay
Protections	CHGC	Recovery	I2	–32768	32767	100	mA	ChargingCurrent() delta recovery threshold

11.3 Permanent Fail

11.3.1 CUV —Cell Undervoltage

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	CUV	Threshold	I2	0	32767	2500	mV	Cell Undervoltage trip threshold
Permanent Fail	CUV	Delay	U1	0	255	2	s	Cell Undervoltage trip delay

11.3.2 COV —Cell Overvoltage

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	COV	Threshold	I2	0	32767	4400	mV	Cell Overvoltage trip threshold
Permanent Fail	COV	Delay	U1	0	255	2	s	Cell Overvoltage trip delay

11.3.3 CUDEP—Copper Deposition

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	CUDEP	Threshold	I2	0	32767	2500	mV	Copper Deposition trip threshold
Permanent Fail	CUDEP	Delay	U1	0	255	2	s	Copper Deposition trip delay

11.3.4 OTCE—Over Temperature Cell

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	OTCE	Threshold	I2	–400	1500	650	0.1°C	Over Temperature Cell trip threshold
Permanent Fail	OTCE	Delay	U1	0	255	2	s	Over Temperature Cell trip delay

11.3.5 OTF—Over Temperature FET

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	OTF	Threshold	I2	–400	1500	1000	0.1°C	Over Temperature FET trip threshold
Permanent Fail	OTF	Delay	U1	0	255	2	s	Over Temperature FET trip delay

11.3.6 QIM—QMax Imbalance

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	QIM	Threshold	I2	0	32767	500	mAh	QMax Imbalance trip threshold
Permanent Fail	QIM	Delay	U1	0	255	2	updates	QMax Imbalance trip delay

11.3.7 CB —Cell Balance

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	CB	Max Threshold	I2	0	32767	120	2h	Cell Balance max trip threshold
Permanent Fail	CB	Delta Threshold	U1	0	32767	20	2h	Cell Balance cell delta trip threshold
Permanent Fail	CB	Delay	U1	0	255	2	cycles	Cell Balance trip delay

11.3.8 VIMR—Voltage Imbalance at Rest

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	VIMR	Check Voltage	I2	0	5000	3600	mV	Voltage Imbalance at Rest Check Voltage
Permanent Fail	VIMR	Check Current	I2	0	32767	10	mA	Voltage Imbalance at Rest Check Current
Permanent Fail	VIMR	Delta Threshold	I2	0	5000	200	mV	Voltage Imbalance at Rest trip threshold

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	VIMR	Delay	U1	0	255	2	s	Voltage Imbalance at Rest Check trip delay
Permanent Fail	VIMR	Duration	U2	0	65535	100	s	Voltage Imbalance at Rest Check Duration

11.3.9 VIMA—Voltage Imbalance Active

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	VIMA	Check Voltage	I2	0	5000	3600	mV	Voltage Imbalance active Check Voltage
Permanent Fail	VIMA	Check Current	I2	0	32767	10	mA	Voltage Imbalance active Check Current
Permanent Fail	VIMA	Delta Threshold	I2	0	5000	300	mV	Voltage Imbalance active trip threshold
Permanent Fail	VIMA	Delay	U1	0	255	2	s	Voltage Imbalance active Check trip delay

11.3.10 IMP—Impedance Imbalance

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	IMP	Delta Threshold	U1	0	32767	400	%	Impedance Imbalance delta threshold
Permanent Fail	IMP	Max Threshold	I2	0	32767	300	%	Impedance Imbalance max threshold
Permanent Fail	IMP	Delay	U1	0	255	2	RA updates	Impedance Imbalance trip delay

11.3.11 CD —Capacity Degradation

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	CD	Threshold	I2	0	32767	4200	mAh	Capacity Degradation threshold
Permanent Fail	CD	Delay	U1	0	255	2	cycles	Capacity Degradation trip delay

11.3.12 CFET —CHG FET Failure

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	CFET	OFF Threshold	I2	0	500	5	mA	CHG FET OFF current trip threshold
Permanent Fail	CFET	Delay	U1	0	255	2	s	CHG FET OFF trip delay

11.3.13 DFET—DFET Failure

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	DFET	OFF Threshold	I2	–500	0	–5	mA	DSG FET OFF current trip threshold
Permanent Fail	DFET	Delay	U1	0	255	2	s	DSG FET OFF trip delay

11.3.14 TH—NTC Thermistor Failure

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	TH	ADC High Threshold	U2	0	65535	32752	A/D counts	Thermistor open fail raw ADC trip threshold
Permanent Fail	TH	ADC Low Threshold	U2	0	65535	15	A/D counts	Thermistor short fail raw ADC trip threshold
Permanent Fail	TH	ADC Delay	U1	0	255	10	s	Thermistor fail trip delay

11.3.15 FUSE—FUSE Failure

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	FUSE	Threshold	I2	0	255	5	mA	FUSE activation fail trip threshold
Permanent Fail	FUSE	Delay	U1	0	255	2	s	FUSE activation fail trip delay

11.3.16 AFER—AFE Register

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	AFER	Threshold	U1	0	255	100	counts	AFE Register comparison fail trip threshold
Permanent Fail	AFER	Delay Period	U1	0	255	2	s	AFE Register comparison fail trip delay
Permanent Fail	AFER	Compare Period	U1	0	255	3	s	AFE Register comparison compare period

11.3.17 AFEC—AFE Communication

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	AFEC	Threshold	U1	0	255	100	counts	AFE Communication fail trip threshold
Permanent Fail	AFEC	Delay Period	U1	0	255	5	s	AFE Communication fail trip delay

11.3.18 2LVL—2nd Level OV

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	2LVL	Threshold	U1	0	255	2	s	2nd Level Protector trip detection delay

11.3.19 OCECO—Open Cell Connection

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Permanent Fail	OCECO	Threshold	U2	0	32767	5000	mV	Open Cell Tab Connection trip threshold
Permanent Fail	OCECO	Delay Period	U1	0	255	2	s	Open Cell Tab Connection trip delay

11.4 Advanced Charge Algorithm

11.4.1 Temperature Ranges

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Temperature Ranges	T1	I1	–128	127	0		T1 low temperature range lower limit
Advanced Charge Algorithms	Temperature Ranges	T2	I1	–128	127	12		T2 low temperature range to standard temperature range
Advanced Charge Algorithms	Temperature Ranges	T5	I1	–128	127	30		T5 recommended temperature range lower limit
Advanced Charge Algorithms	Temperature Ranges	T6	I1	–128	127	55		T6 recommended temperature range upper limit
Advanced Charge Algorithms	Temperature Ranges	T3	I1	–128	127	20		T3 standard temperature range to high temperature range
Advanced Charge Algorithms	Temperature Ranges	T4	I1	–128	127	25		T4 high temperature range upper limit
Advanced Charge Algorithms	Temperature Ranges	Hysteresis	I1	–128	127	0		Temperature Hysteresis, applied when temperature is decreasing

11.4.2 Low Temp Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Low Temp Charging	Voltage	U1	0	255	150	20 mV	Low temperature range ChargingVoltage()
Advanced Charge Algorithms	Low Temp Charging	Current Low	U1	0	255	3	%C	Low temperature range low voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	Low Temp Charging	Current Med	U1	0	255	8	%C	Low temperature range medium voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	Low Temp Charging	Current High	U1	0	255	6	%C	Low temperature range high voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()

11.4.3 Standard Temp Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Standard Temp Charging	Voltage	U1	0	255	210	20 mV	Standard temperature range ChargingVoltage()
Advanced Charge Algorithms	Standard Temp Charging	Current Low	U1	0	255	45	%C	Standard temperature range low voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	Standard Temp Charging	Current Med	U1	0	255	91	%C	Standard temperature range medium voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	Standard Temp Charging	Current High	U1	0	255	68	%C	Standard temperature range high voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()

11.4.4 High Temp Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	High Temp Charging	Voltage	U1	0	255	200	20 mV	High temperature range ChargingVoltage()
Advanced Charge Algorithms	High Temp Charging	Current Low	U1	0	255	23	%C	High temperature range low voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	High Temp Charging	Current Med	U1	0	255	45	%C	High temperature range medium voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	High Temp Charging	Current High	U1	0	255	34	%C	High temperature range high voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()

11.4.5 REC Temp Charging

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Rec Temp Charging	Voltage	U1	0	255	205	20 mV	Recommended temperature range ChargingVoltage()
Advanced Charge Algorithms	Rec Temp Charging	Current Low	U1	0	255	57	%C	Recommended temperature range low voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	Rec Temp Charging	Current Med	U1	0	255	102	%C	Recommended temperature range medium voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()
Advanced Charge Algorithms	Rec Temp Charging	Current High	U1	0	255	80	%C	Recommended temperature range high voltage range ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()

11.4.6 PCHG

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	PCHG	Current	U1	0	255	2	%C	Pre-Charge ChargingCurrent() in % DesignCapacity() or % of FullChargeCapacity()

11.4.7 MCHG

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	MCHG	Current	U1	0	255	1	%C	Maintenance ChargingCurrent() in % Design Capacity() or % of FullChargeCapacity()

11.4.8 Voltage Range

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Voltage Range	Charging Voltage Low	U1	0	255	125	20 mV	Pre-Charge Voltage range to Charging Voltage Low range
Advanced Charge Algorithms	Voltage Range	Charging Voltage Med	U1	0	255	180	20 mV	Charging Voltage Low range to Charging Voltage Med range
Advanced Charge Algorithms	Voltage Range	Charging Voltage High	U1	0	255	200	20 mV	Charging Voltage Med to Charging Voltage High range
Advanced Charge Algorithms	Voltage Range	Hysteresis	U1	0	255	0	20 mV	Charging Voltage Hysteresis applied when voltage is decreasing

11.4.9 Termination Config

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Termination Config	Charge Term Taper Current	I2	0	32767	250	mA	Valid Charge Termination taper current qualifier threshold
Advanced Charge Algorithms	Termination Config	Charge Term Voltage	I2	0	32767	75	mV	Valid Charge Termination delta voltage qualifier, max cell based

11.4.10 Cell Balancing Config

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Cell Balancing Config	Balance Time per mAh cell 0	U2	0	65535	367	s/mAh	Required balance time per mAh, calculated based on external resistor value at VCx pins using following formula: 3600 mA*s/(VCELL/(RVCX+RCB)*DUTY) /1000 where: VCELL = average cell voltage (3.7 V) RVCX = resistor value in series to VCx input (100 Ω) RCB = cell balancing FET RDSON (150 Ω)DUTY = cell balancing duty cycle (66%)
Advanced Charge Algorithms	Cell Balancing Config	Balance Time per mAh cell 1–3	U2	0	65535	514	s/mAh	Required balance time per mAh, calculated based on external resistor value at VCx pins using following formula: 3600 mA*s/(VCELL/(2*RVCX+RCB)*DUTY)/1000 where: VCELL = average cell voltage (3.7 V) RVCX = resistor value in series to VCx input (100 Ω) RCB = cell balancing FET RDSON (150 Ω) DUTY = cell balancing duty cycle (66%)
Advanced Charge Algorithms	Cell Balancing Config	Min Start Balance Delta	U1	0	255	3	mV	Minimum cell voltage delta to start cell balancing. This condition is checked in relaxation state and so it only applies if cell balancing at reset is enabled
Advanced Charge Algorithms	Cell Balancing Config	Relax Balance Interval	U4	0	4294967295	18000	s	Minimum relax time after cell balancing stopped to enable balancing again. This parameter applies to cell balancing at reset only.
Advanced Charge Algorithms	Cell Balancing Config	Min RSOC for Balancing	U1	0	100	80	%	Minimum **RelativeStateOfCharge()** threshold for cell balancing. This condition is checked during relaxation and so it only applies if cell balancing at reset is enabled

11.4.11 Charging Rate Of Change

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Charging Rate Of Change	Current Rate	U1	0	255	128	steps/s	Number of steps to add between any 2 **ChargingCurrent()** settings
Advanced Charge Algorithms	Charging Rate Of Change	Voltage Rate	U1	0	255	128	steps/s	Number of steps to add between any 2 **ChargingVoltage()** settings

11.4.12 Charge Loss Compensation

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Advanced Charge Algorithms	Charge Loss Compensation	CCC Current Threshold	U1	0	255	80	%C	Constant Current Charge mode **ChargingCurrent()** threshold to activate Charge Loss Compensation
Advanced Charge Algorithms	Charge Loss Compensation	CCC Voltage Threshold	U1	0	255	210	20 mV	Constant Current Charge mode max **ChargingVoltage()** increase limit

11.4.13 Panasonic Charge Configuration

Class	Subclass	Name	Type	Min	Max	Unit	Description
Advanced Charge Algorithms	Panasonic Charge Configuration	Near Full Minimum Charge Current	U2	0	65535	mA	Minimum allowable value for ChargingCurrent()
Advanced Charge Algorithms	Panasonic Charge Configuration	Near Full Maximum Charge Current	U2	0	65535	mA	Maximum allowable value for ChargingCurrent()
Advanced Charge Algorithms	Panasonic Charge Configuration	Near Full Charge Minimum Delay	U1	0	255	s	Minumum delay time required berfore reducing ChargingCurrent() by Step Charge Current value
Advanced Charge Algorithms	Panasonic Charge Configuration	Step Charge Current	U2	0	65535	mA	Sets amount of ChargingCurrent() reduction after Near Full Charge Minimum Delay time

11.5 System Data

11.5.1 Manufacturer Data

Class	Subclass	Name	Type	Min	Max	Unit	Description
System Data	Manufacturer Data	ManufacturerInfo	S33				**ManufacturerInfo()** value
System Data	Manufacturer Data	DF Checksum	U2	0	65535		Holding place for DF checksum, not modified or read by device, for reference only

11.6 SBS Configuration

11.6.1 Data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	Data	Remaining Ah Cap. Alarm	I2	0	32767	300	mAh	**RemainingCapacityAlarm()** value in mAh
SBS Configuration	Data	Remaining Wh Cap. Alarm	I2	0	32767	432	10 mWh	**RemainingCapacityAlarm()** value in 10 mWh
SBS Configuration	Data	Remaining Time Alarm	U2	0	65535	10	min	RemainingTimeAlarm() value

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	Data	Initial Battery Mode	H2	0x0000	0xFFFF	0x81		**BatteryMode()** value **Bit 0: ICC** Internal_Charge_Controller ®) 0 = Function not supported **Bit 1: PBC** Primary_Battery_Support ®) 1 = Primary or Secondary Battery Support Bit 2: Reserved Bit 3: Reserved Bit 4: Reserved Bit 5: Reserved Bit 6: Reserved Bit 7: CFCondition_Flag ®) 0 = Battery OK 1 = Conditioning cycle requested Bit 8: CCE Charge_Controller_Enabled (R/W) 0 = Internal charge controller disabled Bit 9: PB Primary_Battery (R/W) 0 = Battery operating in its secondary role (default) 1 = Battery operating in its primary role Bit 10: Reserved Bit 11: Reserved Bit 12: Reserved **Bit 13: AM** Alarm Mode (R/W) 0 = Enable Alarm Warning broadcasts to host and smart battery charger 1 = Disable Alarm Warning broadcasts to host and smart battery charger **Bit 14: CHGM** Charger_Mode (R/W) 0 = Enable **ChargingVoltage()** and **ChargingCurrent()** broadcasts to host and smart battery charger 1 = Disable **ChargingVoltage()** and **ChargingCurrent()** broadcasts to host and smart battery charger **Bit 15: CAPM** Capacity_Mode (R/W) 0 = Report in mA or mAh (default) 1 = Report in 10 mW or 10 mWh
SBS Configuration	Data	Design Voltage	I2	0	32767	14400	mV	**DesignVoltage()** value
SBS Configuration	Data	Specification Information	H2	0x0000	0xFFFF	0x31		**SpecificationInfo()** value in following format: **Bit 0,1,2,3: Revision** Revision 0,0,0,1 = Version 1.0 and 1.1 (default) **Bit 4,5,6,7: Version** 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 **Bit 8,9,10,11: VScale** 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 10E20,0,1,1 = reported voltages scaled by 10E3 **Bit 12,13,14,15: IPScale** Voltage 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()**
SBS Configuration	Data	Manufacturer Date	U2	0	65535			**ManufacturerDate()** value in following format:Day + Month*32 + (Year–1980)*256
SBS Configuration	Data	Serial Number	H2	0x0000	0xFFFF			**SerialNumber()** value
SBS Configuration	Data	Cycle Count	U2	0	65535		cycles	**CycleCount()** value
SBS Configuration	Data	Cycle Count Percentage	U1	0	255	90	%	Accumulated discharge of **FullChargeCapacity()** * (Cycle Count Percentage) to increment **CycleCount()**
SBS Configuration	Data	Max Error Limit	U1	0	100	100	%	MaxError() threshold to set **BatteryMode()[CF]**
SBS Configuration	Data	Design Capacity	I2	0	32767	4400	mAh	**DesignCapacity()** value in mAh
SBS Configuration	Data	Design Capacity	I2	0	32767	6336	10 mWh	**DesignCapacity()** value in 10 mWh

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	Data	Manufacturer Name	S21					**ManufacturerName()** value
SBS Configuration	Data	Device Name	S21					**DeviceName()** value
SBS Configuration	Data	Device Chemistry	S5					**DeviceChemistry()** value

11.6.2 FD

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	FD	Set Voltage Threshold	I2	0	5000	3000	mV	**BatteryStatus()[FD]** cell voltage set threshold
SBS Configuration	FD	Clear Voltage Threshold	I2	0	5000	3100	mV	**BatteryStatus()[FD]** cell voltage clear threshold
SBS Configuration	FD	Set RSOC % Threshold	U1	0	100	0	%	**BatteryStatus()[FD]RemainingStateOfCharge()** set threshold
SBS Configuration	FD	Clear RSOC % Threshold	U1	0	100	5	%	**BatteryStatus()[FD]RemainingStateOfCharge()** clear threshold

11.6.3 FC

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	FC	Set Voltage Threshold	I2	0	5000	4200	mV	**BatteryStatus()[FC]** cell voltage set threshold
SBS Configuration	FC	Clear Voltage Threshold	I2	0	5000	4100	mV	**BatteryStatus()[FC]** cell voltage clear threshold
SBS Configuration	FC	Set RSOC % Threshold	U1	0	100	100	%	**BatteryStatus()[FC]RemainingStateOfCharge()** set threshold
SBS Configuration	FC	Clear RSOC % Threshold	U1	0	100	95	%	**BatteryStatus()[FC] RemainingStateOfCharge()** clear threshold

11.6.4 TDA

Per the Smart Battery Data Specification 1.1, TDA is only active while discharging.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	TDA	Set Voltage Threshold	I2	0	5000	3200	mV	**BatteryStatus()[TDA]** cell voltage set threshold
SBS Configuration	TDA	Clear Voltage Threshold	I2	0	5000	3300	mV	**BatteryStatus()[TDA]** cell voltage clear threshold
SBS Configuration	TDA	Set RSOC % Threshold	U1	0	100	10	%	**BatteryStatus()[TDA] RemainingStateOfCharge()** set threshold
SBS Configuration	TDA	Clear RSOC % Threshold	U1	0	100	15	%	**BatteryStatus()[TDA] RemainingStateOfCharge()** clear threshold

11.6.5 TCA

Per the Smart Battery Data Specification 1.1, TCA is only active while charging.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	TCA	Set Voltage Threshold	I2	0	5000	4200	mV	**BatteryStatus()[TCA]** cell voltage set threshold
SBS Configuration	TCA	Clear Voltage Threshold	I2	0	5000	4100	mV	**BatteryStatus()[TCA]** cell voltage clear threshold
SBS Configuration	TCA	Set RSOC % Threshold	U1	0	100	100	%	**BatteryStatus()[TCA] RemainingStateOfCharge()** set threshold
SBS Configuration	TCA	Clear RSOC % Threshold	U1	0	100	95	%	**BatteryStatus()[TCA] RemainingStateOfCharge()** clear threshold

11.6.6 Max Error

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
SBS Configuration	Max Error	Time Cycle Equivalent	U1	0	255	12	2h	After valid QMAX update, each passed time period of Time Cycle Equivalent will increment of **MaxError()** by Cycle Delta. Time Cycle Equivalent is provided for packs which may not get frequent Qmax updates like stand-by batteries. Time Cycle Equivalent increments Max Error by 0.05% for every Time Cycle Equivalent time period following the last Qmax update.
SBS Configuration	Max Error	Cycle Delta	U1	0	255	5	0.01%	Each increment of **CycleCount()** after valid QMAX update will increment of **MaxError()** by Cycle Delta

11.7 Lifetimes

11.7.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Voltage	Max Voltage Cell 0	U1	0	255	0	20 mV	Maximum reported cell voltage 0
Lifetimes	Voltage	Max Voltage Cell 1	U1	0	255	0	20 mV	Maximum reported cell voltage 1
Lifetimes	Voltage	Max Voltage Cell 2	U1	0	255	0	20 mV	Maximum reported cell voltage 2
Lifetimes	Voltage	Max Voltage Cell 3	U1	0	255	0	20 mV	Maximum reported cell voltage 3
Lifetimes	Voltage	Min Voltage Cell 0	U1	0	255	255	20 mV	Minimum reported cell voltage 0
Lifetimes	Voltage	Min Voltage Cell 1	U1	0	255	255	20 mV	Minimum reported cell voltage 1
Lifetimes	Voltage	Min Voltage Cell 2	U1	0	255	255	20 mV	Minimum reported cell voltage 2
Lifetimes	Voltage	Min Voltage Cell 3	U1	0	255	255	20 mV	Minimum reported cell voltage 3
Lifetimes	Voltage	Max Delta Cell Voltage	U1	0	255	0	20 mV	Maximum reported delta between cell voltages 0 to 3

11.7.2 Current

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Current	Max Chg Current	U1	0	255	0	200 mA	Maximum reported **Current()** in charge direction
Lifetimes	Current	Max Dsg Current	U1	0	255	0	200 mA	Maximum reported **Current()** in discharge direction
Lifetimes	Current	Max Avg Dsg Current	U1	0	255	0	200 mA	Maximum reported **AverageCurrent()** in discharge direction
Lifetimes	Current	Max Avg Dsg Power	U1	0	255	0	W	Maximum reported Power in discharge direction

11.7.3 Safety Events

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Safety Events	No Of COV Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[COV]** events
Lifetimes	Safety Events	Last COV Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[COV]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of CUV Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[CUV]** events
Lifetimes	Safety Events	Last CUV Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[CUV]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OCD1 Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OCD1]** events
Lifetimes	Safety Events	Last OCD1 Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[OCD1]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OCD2 Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OCD2]** events
Lifetimes	Safety Events	Last OCD2 Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[OCD2]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OCC1 Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OCC1]** events
Lifetimes	Safety Events	Last OCC1 Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[OCC1]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OCC2 Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OCC2]** events
Lifetimes	Safety Events	Last OCC2 Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[OCC2]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OLD Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OLD]** events
Lifetimes	Safety Events	Last OLD Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[OLD]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of SCD Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[SCD]** events
Lifetimes	Safety Events	Last SCD Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[SCD]** event in **CycleCount()**cycles
Lifetimes	Safety Events	No Of SCC Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[SCC]** events
Lifetimes	Safety Events	Last SCC Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[SCC]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OTC Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OTC]** events
Lifetimes	Safety Events	Last OTC Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[OTC]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OTD Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OTD]** events
Lifetimes	Safety Events	Last OTD Event	U1	0	255	0	4 cycles	Last **SafetyStatus()[OTD]** event in **CycleCount()** cycles
Lifetimes	Safety Events	No Of OTF Events	U1	0	255	0	8 events	Total number of **SafetyStatus()[OTF]** events
Lifetimes	Safety Events	Last OTF Event	U1	0	255	0	4 cycles	**Last SafetyStatus()[OTF]** event in **CycleCount()** cycles

11.7.4 Charging Events

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Safety Events	No Of Valid Charge Terminations	U1	0	255	0	8 events	Total number of valid charge termination events
Lifetimes	Safety Events	Last Valid Charge Termination	U1	0	255	0	4 cycles	Last valid charge termination in **CycleCount()** cycles

11.7.5 Gauging Events

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Gauging Events	No Of QMAX Updates	U1	0	255	0	8 events	Total number of **GaugingStatus()[QMAX]** toggles
Lifetimes	Gauging Events	Last QMAX Update	U1	0	255	0	4 cycles	Last **GaugingStatus()[QMAX]** toggle in **CycleCount()** cycles
Lifetimes	Gauging Events	No Of RA Updates	U1	0	255	0	8 events	Total number of **GaugingStatus()[RX]** toggles
Lifetimes	Gauging Events	Last RA Update	U1	0	255	0	4 cycles	Last **GaugingStatus()[RX]** toggle in **CycleCount()** cycles
Lifetimes	Gauging Events	No Of RA Disable	U1	0	255	0	8 events	Total number of **GaugingStatus()[RU]** =1 events
Lifetimes	Gauging Events	Last RA Disable	U1	0	255	0	4 cycles	Last **GaugingStatus()[RU]** = 1 events in **CycleCount()** cycles

11.7.6 Power Events

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Power Events	No Of Shutdowns	U1	0	255	0	events	Total number of Shutdown events

11.7.7 Cell Balancing

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Cell Balancing	CB Time Cell 0	U1	0	255	0	2h	Total performed cell balancing bypass time cell 0
Lifetimes	Cell Balancing	CB Time Cell 1	U1	0	255	0	2h	Total performed cell balancing bypass time cell 1
Lifetimes	Cell Balancing	CB Time Cell 2	U1	0	255	0	2h	Total performed cell balancing bypass time cell 2
Lifetimes	Cell Balancing	CB Time Cell 3	U1	0	255	0	2h	Total performed cell balancing bypass time cell 3

11.7.8 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Temperature	Max Temp Cell	I1	–128	127	–128	°C	Maximum reported cell temperature
Lifetimes	Temperature	Min Temp Cell	I1	–128	127	127	°C	Minimum reported cell temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Temperature	Max Delta Temp Cell	I1	–128	127	0	°C	Maximum reported temperature delta for TSx inputs configured as cell temperature
Lifetimes	Temperature	Max Temp Int Sensor	I1	–128	127	–128	°C	Maximum reported internal temperature sensor temperature
Lifetimes	Temperature	Min Temp Int Sensor	I1	–128	127	127	°C	Minimum reported internal temperature sensor temperature
Lifetimes	Temperature	Max Temp FET	I1	–128	127	–128	°C	Maximum reported FET temperature

11.7.9 Time

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Lifetimes	Time	Total firmware Runtime	U2	0	65535	0	2 h	Total firmware runtime between resets
Lifetimes	Time	Time Spent in UT	U2	0	65535	0	2 h	Total firmware runtime spent below T1
Lifetimes	Time	Time Spent in LT	U2	0	65535	0	2 h	Total firmware runtime spent between T1 and T2
Lifetimes	Time	Time Spent in STL	U2	0	65535	0	2 h	Total firmware runtime spent between T2 and T5
Lifetimes	Time	Time Spent in RT	U2	0	65535	0	2 h	Total firmware runtime spent between T5 and T6
Lifetimes	Time	Time Spent in STH	U2	0	65535	0	2h	Total firmware runtime spent between T6 and T3
Lifetimes	Time	Time Spent in HT	U2	0	65535	0	2 h	Total firmware runtime spent between T3 and T4
Lifetimes	Time	Time Spent in OT	U2	0	65535	0	2 h	Total firmware runtime spent between above T6

11.8 Settings

11.8.1 Fuse

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Fuse	Permanent Fail Fuse 0–15	H2	0x0000	0xFFFF	0	Bit 0: CUV Cell undervoltage fuse activation 0 = Disabled 1 = Enabled (default) Bit 1: COV Cell overvoltage fuse activation 0 = Disabled 1 = Enabled (default) Bit 2: Reserved Bit 3: Reserved Bit 4: PF_OTCE Over temperature fuse activation 0 = Disabled 1 = Enabled (default) Bit 5: Reserved Bit 6: OTF Over temperature FET fuse activation 0 = Disabled 1 = Enabled (default) Bit 7: QIM QMax Imbalance fuse activation 0 = Disabled 1 = Enabled (default) Bit 8: CB Cell balancing fuse activation 0 = Disabled 1 = Enabled (default) Bit 9: IMP Cell impedance fuse activation 0 = Disabled 1 = Enabled (default) Bit 10: CD Capacity Deterioration fuse activation 0 = Disabled 1 = Enabled (default) Bit 11: VIMR Voltage imbalance at Rest fuse activation 0 = Disabled 1 = Enabled (default) Bit 12: VIMA Voltage imbalance at Rest fuse activation 0 = Disabled 1 = Enabled (default) Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Fuse	Permanent Fail Fuse 16–32	H2	0x0000	0xFFFF	0	Bit 0: CFETF Charge FET 0 = Disabled 1 = Enabled (default) Bit 1: DFETF Discharge FET 0 = Disabled 1 = Enabled (default) Bit 2: THERM Thermistor 0 = Disabled 1 = Enabled (default) Bit 3: Reserved Bit 4: AFE_PAFE Register 0 = n/a 1 = Enabled (default) Bit 5: AFE_CAFE Communication 0 = Disabled 1 = Enabled (default) Bit 6: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Disabled 1 = Enabled (default) Bit 7: Reserved Bit 8: Reserved Bit 9: OCECO Open VCx 0 = n/a 1 = Enabled (default) Bit 10: DFW DF wear out 0 = n/a 1 = Enabled (default) Bit 11: Reserved Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved
Settings	Fuse	Min Fuse Blow Voltage	I2	0	32767	8000	Minimum voltage required to attempt fuse blow, pack based, FET failures bypass this requirement to blow the fuse

11.8.2 Manufacturing

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Manufacturing	Manufacturing Status	H2	0x0000	0xFFFF	0x8000	Bit 0: PCHG_EN PCHG Function, only available with FET = 0 0 = Disabled 1 = Enabled Bit 1: CHG_EN CHG FET, only available with FET = 0 0 = Disabled 1 = Enabled Bit 2: DSG_ENDSG FET, only available with FET = 0 0 = Disabled 1 =Enabled Bit 3: GAUGE_EN Gauging 0 = Disabled 1 = Enabled (default) Bit 4: FET_EN FET action 0 = Disabled 1 = Enabled (default) Bit 5: LF_EN Lifetime data collection 0 = Disabled 1 = Enabled (default) Bit 6: PF_EN Permanent Fail 0 = Disabled 1 = Enabled (default) Bit 7: BBR_EN Black box recorder 0 = Disabled 1 = Enabled (default) Bit 8: FUSE_EN FUSE action 0 = Disabled 1 = Enabled (default) Bit 9: LED_EN LED Display 0 = Disabled 1 = Enabled (default) Bit 10: Reserved Bit 11: Reserved Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: CAL_EN ADC or CC output on **ManufacturerData()** 0 = Disabled 1 = Enabled (default)

11.8.3 Protection

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Protection	Enabled Protections 0–15	H2	0x0000	0xFFFF	0xFFFF	Bit 0: CUV Cell Undervoltage 0 = Disabled 1 = Enabled (default) Bit 1: COV Cell Overvoltage 0 = Disabled 1 = Enabled (default) Bit 2: OCC1 Overcurrent in Charge 1st Tier 0 = Disabled 1 = Enabled (default) Bit 3: OCC2 Overcurrent in Charge 2nd Tier 0 = Disabled 1 = Enabled (default) Bit 4: OCD1 Overcurrent in Discharge 1st Tier 0 = Disabled 1 = Enabled (default) Bit 5: OCD2 Overcurrent in Discharge 2nd Tier 0 = Disabled 1 = Enabled (default) Bit 6: AOLD Overload in Discharge 0 = Disabled 1 = Enabled (default) Bit 7: AOLDL Overload in Discharge latch 0 = Disabled 1 = Enabled (default) Bit 8: ASCC Short circuit in charge 0 = Disabled 1 = Enabled (default) Bit 9: ASCCL Short circuit in charge latch 0 = Disabled 1 = Enabled (default) Bit 10: ASCD Short circuit in discharge 0 = Disabled 1 = Enabled (default) Bit 11: ASCDL Short circuit in discharge latch 0 = Disabled 1 = Enabled (default) Bit 12: OTC Over temperature in charge 0 = Disabled 1 = Enabled (default) Bit 13: OTD Over temperature in discharge 0 = Disabled 1 = Enabled (default) Bit 14: CUVC I*R compensated CUV 0 = Disabled 1 = Enabled (default) Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Fuse	Enabled Protections 16–32	H2	0x0000	0xFFFF	0xFFFF	Bit 0: OTF FET over temperature 0 = Disabled 1 = Enabled (default) Bit 1: HWDF SBS Host watchdog timeout 0 = Disabled 1 = Enabled (default) Bit 2: PTO Pre-charging timeout 0 = Disabled 1 = Enabled (default) Bit 3: PTOS Pre-charging timeout suspend 0 = Disabled 1 = Enabled (default) Bit 4: CTO Charging timeout 0 = Disabled 1 = Enabled (default) Bit 5: CTOS Charging timeout suspend 0 = Disabled 1 = Enabled (default) Bit 6: OCOvercharge 0 = Disabled 1 = Enabled (default) Bit 7: CHGC ChargingCurrent() higher than requested 0 = Disabled 1 = Enabled (default) Bit 8: CHGV ChargingVoltage() higher than requested 0 = Disabled 1 = Enabled (default) Bit 9: Reserved Bit 10: Reserved Bit 11: Reserved Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

11.8.4 Permanent Failure

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Permanent Failure	Enabled PF 0–15	H2	0x0000	0xFFFF	0xFFFF	Bit 0: CUV Cell undervoltage 0 = Disabled 1 = Enabled (default) Bit 1: COV Cell overvoltage 0 = Disabled 1 = Enabled (default) Bit 2: CUDEP Copper Deposition 0 = Disabled 1 = Enabled (default) Bit 3: Reserved Bit 4: PF_OTCE Over temperature 0 = Disabled 1 = Enabled (default) Bit 5: Reserved Bit 6: OTF Over temperature FET 0 = Disabled 1 = Enabled (default) Bit 7: QIM QMax Imbalance 0 = Disabled 1 = Enabled (default) Bit 8: CB Cell balancing 0 = Disabled 1 = Enabled (default) Bit 9: IMP Cell impedance 0 = Disabled 1 = Enabled (default) Bit 10: CD Capacity Degradation 0 = Disabled 1 = Enabled (default) Bit 11: VIMR Voltage imbalance at Rest 0 = Disabled 1 = Enabled (default) Bit 12: VIMA Voltage imbalance at Rest 0 = Disabled 1 = Enabled (default) Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Permanent Failure	Enabled PF 16–32	H2	0x0000	0xFFFF	0xFFFF	Bit 0: CFET Charge FET 0 = Disabled 1 = Enabled (default) Bit 1: DFET Discharge FET 0 = Disabled 1 = Enabled (default) Bit 2: TH Thermistor 0 = Disabled 1 = Enabled (default) Bit 3: FUSE Fuse 0 = Disabled 1 = Enabled (default) Bit 4: AFER AFE Register 0 = n/a 1 = Enabled (default) Bit 5: AFEC AFE Communication 0 = Disabled 1 = Enabled (default) Bit 6: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Disabled 1 = Enabled (default) Bit 7: Reserved Bit 8: Reserved Bit 9: OCECO Open VCx 0 = n/a 1 = Enabled (default) Bit 10: DFW DF wearout 0 = n/a 1 = Enabled (default) Bit 11: Reserved Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

11.8.5 Configuration

11.8.5.1 Protection Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	Protection Configuration	H1	0x00	0xFF	0x01	Bit 0: Reserved Bit 1: CUV_RECOV_CHG require charge current to recover CUV and CUVC 0 = disable 1 = enable Bit 2: Reserved Bit 3: Reserved Bit 4: Reserved Bit 5: Reserved Bit 6: Reserved Bit 7: Reserved

11.8.5.2 Temperature Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	Temperature Configuration	H2	0x0000	0xFFFF	0x0087	Bit 0: internal TS enable internal 0 = disable internal TS (default) 1 = enable internal TS Bit 1: TS1 enable TS1 0 = disable TS1 1 = enable TS1 (default) Bit 2: TS2 enable TS2 0 = disable TS2 1 = enable TS2 (default) Bit 3: TS3 enable TS3 0 = disable TS3 (default) 1 = enable TS3 Bit 4: TS4 enable TS4 0 = disable TS4 (default) 1 = enable TS4 Bit 5: internal TS Mode Cell temp or FET temp 0 = Cell temp (default) 1 = FET temp Bit 6: TS1 Mode Cell temp or FET temp 0 = Cell temp (default) 1 = FET temp Bit 7: TS2 Mode Cell temp or FET temp 0 = Cell temp 1 = FET temp (default) Bit 8: TS3 Mode Cell temp or FET temp 0 = Cell temp (default) 1 = FET temp Bit 9: TS4 Mode Cell temp or FET temp 0 = Cell temp (default) 1 = FET temp Bit 10: CTEMP Cell Temperature protection source 0 = MAX (default) 1 = average Bit 11: FTEMP FET Temperature protection source 0 = Max (default) 1 = average Bit 12: OTFET Overtemperature FET action 0 = FET action (default) 1 = FET action disabled Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

11.8.5.3 LED Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	LED Configuration	H2	0x0000	0xFFFF	0x00D0	Bit 0: LEDR—LED display activation at device reset 0 = LED display not activated (default) 1 = LED display activated Bit 1: LEDRCA Flashing of LED display when [RCA] is set 0 = LED display does not flash (default) 1 = LED display does flash Bit 2: LEDCHG LED display during charging 0 = LED display not active (default) 1 = LED display active Bit 3: LEDMODE LED display capacity selector 0 = Display RSOC (default) 1 = Display ASOC/DC Bit 5,4: LEDPF1, LEDPF0 LED Display PF Error Code 0,0 = PF Error code not available 0,1 = PF Error code shown after SOC if DISP is held low for LED Hold Time (default) 1,0 = PF Error code not available 1,1 = PF Error code shown after SOC Bit 7,6: LEDC1, LEDC0 LED Sink Current 0,0 = no limit 0,1 = 3 mA 1,0 = 4 mA 1,1 = 5 mA (default) Bit 8: Reserved Bit 9: Reserved Bit 10: Reserved Bit 11: Reserved Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

11.8.5.4 Charging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	Charging Configuration	H	0x00	0xFF	0	Bit 1, 0: PCHG1, PCHG0 Precharge method 0, 0 = internal Precharge FET (not a valid option for bq30z55) 0, 1 = CHG FET (default) 1, 0 = GPOD pin 1, 1 = Precharge disabled Bit 2: CRATE—ChargeCurrent rate 0 = ChargeCurrent() %C calculation based on DesignCapacity()(default) 1 = ChargeCurrent() %C calculation based on FullChargeCapacity() Bit 3: CHGSU—FET action in charge suspend mode 0 = FET active (default) 1 = Charging and Precharging disabled, FETs off Bit 4: CHGIN—FET action in charge inhibit mode 0 = FET active (default) 1 = Charging and Precharging disabled, FETs off Bit 5: CHGFET—FET action on terminate charge alarm (TCA) 0 = FET active (default) 1 = Charging and Precharging disabled, FET off Bit 6: CCC—Constant Current Mode Loss Compensation 0 = Disabled (default) 1 = ChargingVoltage() and ChargingCurrent() values are compensated for voltage drop Bit 7: Reserved

11.8.5.5 System Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	System Configuration	H2	0x0000	0xFFFF	0x0032	Bit 1,0: CC1, CC0 Cell Count 0,0 = Reserved 0,1 = 2 cell 1,0 = 3 cell 1,1 = 4 cell (default) Bit 2: NR Use $\overline{\text{PRES}}$ in system detection. 0 = Use $\overline{\text{PRES}}$, removable mode (default). 1 = Non-removable mode Bit 3: SLEEPCHG—CHG FET enabled during sleep 0 = CHG FET off during sleep (default) 1 = CHG FET remains on during sleep Bit 4: SLEEP—Sleep Mode 0 = Disable Sleep Mode 1 = Enable Sleep Mode (default) Bit 5: CB—Cell balancing 0 = Disabled cell balancing 1 = Enable cell balancing (default) Bit 6: CBM—Cell balancing method 0 = Internal cell balancing (default) 1 = External cell balancing Bit 7: CBR—Cell balancing at rest 0 = Disable cell balancing at rest (default) 1 = Enable cell balancing at rest Bit 8: SHIPDSG—DSG FET enabled during ship mode 0 = Disable DSG FET at ship mode(default) 1 = Enable DSG FET at ship mode Bit 9: Reserved Bit 10: Reserved Bit 11: Reserved Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

11.8.5.6 Gauging Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	Gauging Configuration	H2	0x00	0xFF	0x1FDA	Bit 0: CCT Cycle count threshold 0 = use CC % of DesignCapacity() (default) 1 = use CC % of FullChargeCapacity() Bit 1: CSYNC Sync RemainingCapacity() with FullChargeCapacity() at valid charge termination 0 = RemainingCapacity() is not synchronized 1 = RemainingCapacity() is synchronized (default) Bit 2: RSOCL RelativeStateOfCharge() and RemainingCapacity() behavior at end of charge 0 = actual value shown (default) 1 = held at 99% until valid charge termination. On entering valid charge termination update to 100% Bit 3: RESCAP Reserve capacity calculation method 0 = light load 1 = use Load Select (default) Bit 4: LOCK0 Keep RemainingCapacity() and RelativeStateOfCharge() jumping back during relaxation after 0 and FD are reached during discharge. 0 = Disabled (default) 1 = Enabled Bit 5: SMOOTH Run RemainingCapacity() through a low pass filter to smooth out jumps at grid point update. Smoothing is disabled at end of discharge. Sample settings and associated low-pass filter time constants are in Table C-1. 0 = Disabled (default) 1 = Enabled Bit 6: OCVFR OCV look up disabled in flat region during charge until charged above flat region. Enabled again after Min Relax Time after Charge 0 = Disabled 1 = Enabled (default) Bit 7: DOD0EW DOD0 error weighting, calculates new DOD0 values from the newly read value and the previous value using their respective errors. DOD0 readings have an associated error based on elapsed time since reading, conditions at time of reading (reset, charge termination, etc), temperature, amount of relaxation at time of reading, etc. The feature provides more accurate DOD0 points. It was introduced in the bq20z45 device. 0 = Disabled 1 = Enabled (default)
Settings	Configuration	Gauging Configuration	H2	0x00	0xFF	0x1FDA	Bit 8: LFP_RELAX, LiFePO4 chemistry exhibits a unique slow relaxation 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 settled voltage could be close to or even below FlatVoltMax in some case. For chemID 4xx (LiFePO4) series, the condition to exit the long relax mode is: 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. With the above, Qmax update is literally disabled because dod will not be taken as long as it's in LFP_relax mode. By the time the GG exits the LFP_relax mode, the OCV is already in the flat zone. So Qmax update takes an alternative approach—once full charge happens (FC bit set), dod0=Dod_at_EOC is automatically assigned and valid for Qmax update; VOK is set if there's no Qmax update, or 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. If LFP_RELAX is set, the firmware automatically enables the feature upon detecting that the chemistry is 4xx series. If clear, the feature is disabled. Lithium Iron Phosphate Relax 0 = Disabled (default) 1 = Enabled

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	Gauging Configuration	H2	0x00	0xFF	0x1FDA	Bit 9: RSOC_CONV, addresses the convergence of RemCap to 0 at low temperatures and very high rates which may not be satisfactory because of the high granularity of resistance grids. If termination voltage is reached in DOD region with 10% grid interval or at the moment where voltage / SOC dependency is flat, error can be large. Fast resistance scaling will apply a scale factor to resistance in RemCap simulations leading up to 0. This scale factor is computed from actively measured resistance during the discharge. This measured resistance is an active number and may not be used for an Ra update. RSOC, fast resistance scaling 0 = Disabled 1 = Enabled (default) Bit 10: FAST_QMAX_LRN, Fast Qmax learning: eliminates previously required relaxation periods, to use enable IT with perfectly relaxed cells ~50% RSOC (37% minimum), discharge to empty, Qmax will be learned when discharge stops. Fast QMax learning, during discharge when update status is 6. Update status will change to 11 if fast learning is successful. 0 = Disabled 1 = Enabled (default) Bit 11: Reserved Bit 12: RSOC_HOLD, prevents RSOC rise during discharge. RSOC will be held until calculated value falls below actual state. 0 = Disabled (default) 1 = Enabled Bit 13: CUV_TERM, CUV discharge termination: Remaining Capacity and Full Capacity calculations to accommodate reaching 0% RSOC before reaching CUV. This is helpful when the cells are out of balance. 0 = Disabled 1 = Enabled (default) Bit 14: Reserved Bit 15: Reserved

11.8.5.7 SBS Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	SBS Configuration	H1	0x00	0xFF	0x20	Bit 0: BCAST Enable alert and charging broadcast from device to host 0 = Disabled (default) 1 = Enabled Bit 1: CPE PEC on charger broadcast 0 = Disabled (default) 1 = Enabled Bit 2: HPE PEC on host communication 0 = Disabled (default) 1 = Enabled Bit 3: XL Enable 400 kHz com mode 0 = Normal SBS bus speed (default) 1 = 400 kHz bus speed Bit 5,4: BLT1, BLT0 Bus low timeout 0,0 = no SBS bus low timeout 0,1 = 1-s SBS bus low timeout 1,0 = 2-s SBS bus low timeout (default) 1,1 = 3-s SBS bus low timeout Bit 6: Reserved Bit 7: Reserved
Settings	Configuration	SBS Data Config 0–15	H2	0x0000	0xFFFF	0x0CAF	Bit 0: TDASETV Enable TDA flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 1: TDACLEARV Enable TDA flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 2: TDASETRSOC Enable TDA flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 3: TDACLEARRSOC Enable TDA flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 4: TCASETV Enable TCA flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 5: TCACLEARV Enable TCA flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 6: TCASETRSOC Enable TCA flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 7: TCACLEARRSOC Enable TCA flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 8: TCACLEARCT Enable TCA flag clear valid charge termination 0 = Disabled 1 = Enabled (default) Bit 9: FCCLEARCT Enable FC flag clear by valid charge termination 0 = Disabled 1 = Enabled (default) Bit 10: FCSETVCT enable FC flag set on valid charge termination 0 = Disabled 1 = Enabled (default) Bit 11: TCASETVCT enable TCA flag set on valid charge termination 0 = Disabled 1 = Enabled (default) Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
		SBS Data Config 16–32	H1	0x00	0xFF	0xFF	Bit 0: FDSETV Enable FD flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 1: FDCLEARV Enable FD flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 2: FDSETRSOC Enable FD flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 3: FDCLEARRSOC Enable FD flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 4: FCSETV Enable FC flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 5: FCCLEARV Enable FC flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 6: FCSETRSOC Enable FC flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 7: FCCLEARRSOC Enable FC flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default)

11.8.5.8 SBS Data Configuration

Class	Subclass	Name	Type	Min	Max	Default	Description
Settings	Configuration	SBS Data Config 0–15	H2	0x0000	0xFFFF	0x0CAF	Bit 0: TDASETV enable TDA flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 1: TDACLEARV enable TDA flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 2: TDASETRSOC enable TDA flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 3: TDACLEARRSOC enable TDA flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 4: TCASETV enable TCA flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 5: TCACLEARV enable TCA flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 6: TCASETRSOC enable TCA flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 7: TCACLEARRSOC enable TCA flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 8: TCACLEARCT enable TCA flag clear valid charge termination 0 = Disabled 1 = Enabled (default) Bit 9: FCCLEARCT enable FC flag clear by valid charge termination 0 = Disabled 1 = Enabled (default) Bit 10: FCSETVCT enable FC flag set on valid charge termination 0 = Disabled 1 = Enabled (default) Bit 11: TCASETVCT enable TCA flag set on valid charge termination 0 = Disabled 1 = Enabled (default) Bit 12: Reserved Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved
		SBS Data Config 16–32	H1	0x00	0xFF	0xFF	Bit 0: FDSETV enable FD flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 1: FDCLEARV enable FD flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 2: FDSETRSOC enable FD flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 3: FDCLEARRSOC enable FD flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 4: FCSETV enable FC flag set by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 5: FCCLEARV enable FC flag clear by cell voltage threshold 0 = Disabled 1 = Enabled (default) Bit 6: FCSETRSOC enable FC flag set by RSOC threshold 0 = Disabled 1 = Enabled (default) Bit 7: FCCLEARRSOC enable FC flag clear by RSOC threshold 0 = Disabled 1 = Enabled (default)

11.8.6 AFE

Class	Subclass	Name	Type	Min	Max	Default	Description
Configuration	AFE	AFE State Control	H1	0x00	0xFF	0	AFE state after device start up Bit 0: Reserved Bit 1: Reserved Bit 2: Reserved Bit 3: Reserved Bit 4: RSNS Divide OLD, SCC, SDC1 and SCD2 voltage thresholds by 2 0 = Disabled (default) 1 = Enabled Bit 5: SCDDx2 double SCD1 and SCD2 delay thresholds 0 = Disabled (default) 1 = Enabled Bit 6: Reserved Bit 7: Reserved

11.9 Power

11.9.1 Power

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Power	Power	Valid Update Voltage	I2	0	7500	7500	mV	Min stack voltage threshold for Flash update, pack based

11.9.2 Shutdown

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Power	Shutdown	Shutdown Voltage	I2	0	32767	1750	mV	Cell based shutdown voltage trip threshold
Power	Shutdown	Shutdown Time	U2	0	255	10	s	Cell based shutdown voltage trip delay
Power	Shutdown	Charger Present Threshold	I2	0	32767	3000	mV	Pack pin charger present detect threshold, pack based

11.9.3 Sleep

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Power	Sleep	Sleep Current	I2	0	32767	10	mA	|Current()| threshold to enter Sleep Mode
Power	Sleep	Voltage Time	U1	0	255	5	s	Voltage sampling period in Sleep Mode
Power	Sleep	Current Time	U1	0	255	20	s	Current sampling period in Sleep Mode

11.9.4 Ship

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Power	Ship	Delay	I2	0	255	5	s	Ship mode entry delay
Power	Ship	Current	I2	–250	250	10	mA	|Current()| threshold to enter ship mode

11.10 Gas Gauging

11.10.1 Current Thresholds

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	Current Thresholds	Dsg Current Threshold	I2	–32768	32767	100	mA	Discharge mode Current() threshold
Gas Gauging	Current Thresholds	Chg Current Threshold	I2	–32768	32767	50	mA	Charge mode Current() threshold
Gas Gauging	Current Thresholds	Quit Current	I2	0	32767	10	mA	|Current()| threshold to enter rest mode

11.10.2 State

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	State	QMAX Cell 0	I2	0	32767	4400	mAh	QMAX Cell 0
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 Pack	I2	0	32767	4400	mAh	QMAX of the whole stack
Gas Gauging	State	Update Status	H1	0x00	0xFF	0		Bit 1:0: Update1, Update0 Update Status 0,0 = Impedance Track gauging and lifetime updating is disabled 0,1 = Ra table updated 1,0 = QMAX and Ra table have been updated Bit 2: Enable Impedance Track gauging and lifetime updating enable 0 = Disabled 1 = Enabled Bit 3: is_QMAX_Field_Updated QMax updated with FC and qualified OCV in charge and discharge 0 = Disabled 1 = Enabled (default) Bit 4: Reserved Bit 5: Reserved Bit 6: Reserved Bit 7: Reserved
Gas Gauging	State	Cell 0 Chg Voltage at EoC	I2	0	32767	4200	mV	Cell 0 voltage value at end of charge
Gas Gauging	State	Cell 1 Chg Voltage at EoC	I2	0	32767	4200	mV	Cell 1 voltage value at end of charge

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	State	Cell 2 Chg Voltage at EoC	I2	0	32767	4200	mV	Cell 2 voltage value at end of charge
Gas Gauging	State	Cell 3 Chg Voltage at EoC	I2	0	32767	4200	mV	Cell 3 voltage value at end of charge
Gas Gauging	State	Current at EoC	I2	–32768	32767	250	mA	Current at end of charge
Gas Gauging	State	Avg I Last Run	I2	–32768	32767	–2000	mA	Average current last discharge cycle
Gas Gauging	State	Avg P Last Run	I2	–32768	32767	–3022	10 mW	Average power last discharge cycle
Gas Gauging	State	Delta Voltage	I2	–32768	32767	0	mV	Voltage() delta between normal and short load spikes to optimize run time calculation
Gas Gauging	State	Max I Last Run	I2	–32768	32767	–2000	mA	Max current last discharge cycle
Gas Gauging	State	Max P Last Run	I2	–32768	32767	–3022	10 mW	Max power last discharge cycle

11.11 IT Config

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	IT Cfg	Load Select	U1	0	255	7		Defines Load compensation mode used by gauging algorithm:IF Load Mode = 0:0 = Avg I Last Run 1 = Present average discharge current 2 = Current 3 = AverageCurrent 4 = DesignCapacity/5 5 = AtRate (mA) 6 = User-Rate-mA 7 = Max Avg I Last RunIF Load Mode = 1:0 = Avg P Last Run 1 = Present average discharge power 2 = Current x Voltage 3 = AverageCurrent x Average Voltage 4 = DesignEnergy/5 5 = AtRate (10 mW) 6 = User-Rate-mW 7 = Max Avg P Last Run
Gas Gauging	IT Cfg	Load Mode	U1	0	255	0		Defines unit used by gauging algorithm:0 = Constant Current1 = Constant Power
Gas Gauging	IT Cfg	Ra Filter	U2	0	999	500	0.1%	Filter value used in Ra Updates, specifies what percentage or Ra update is from new value (100%—setting) vs. old value (setting)
Gas Gauging	IT Cfg	Ra Max Delta	U1	0	255	15	% of Design Resistance	Maximum value of allowed Ra change

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Gas Gauging	IT Cfg	Design Resistance						Averaged cell resistance at Reference Grid point. Automatically updated when Update Status is set to 0x6 by the gauge. To automatically update again set Update Status to 0x4 or manually set when Update Status is set to 0x6.
Gas Gauging	IT Cfg	Reference Grid	UI	0	15	4		Reference grid point used by Design Resistance
Gas Gauging	IT Cfg	Term Voltage	I2	0	32767	9000	mV	Min stack voltage to be used for capacity calculation
Gas Gauging	IT Cfg	Term Voltage Delta	I2	0	32767	300	mV	Controls when the RSOC_CONV feature becomes active. The recommended setting is 3.5 –Term Voltage / Number Cells.
Gas Gauging	IT Cfg	User-Rate-mA	I2	–32768	32768	0	mA	Discharge rate used for capacity calculation selected by Load Select
Gas Gauging	IT Cfg	User-Rate-mW	I2	–32768	32768	0	10 mW	Discharge rate used for capacity calculation selected by Load Select
Gas Gauging	IT Cfg	Reserve Cap-mAh	I2	0	32768	0	mAh	Capacity reserved available when gauging algorithm reports 0% RemainingStateOfCharge()
Gas Gauging	IT Cfg	Reserve Cap-mWh	I2	0	32768	0	10 mW	Capacity reserved available when gauging algorithm reports 0% RemainingStateOfCharge()
Gas Gauging	IT Cfg	Max IR Correct	I2	0	32767	400	mV	Maximum allowable I*R voltage delta for correction
Gas Gauging	IT Cfg	RemCap Smoothing Filter	U1	0	255	250		RemainingCapacity() smoothing filter value. Sample settings and associated low-pass filter time constants are in Table C-1

11.12 RA Table

11.12.1 R_a0

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a0	Cell 0 R_A Flag	H2	0x0000	0xFFFF		High Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update .
RA Table	R_a0	Cell 0 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 0
RA Table	R_a0	Cell 0 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 1
RA Table	R_a0	Cell 0 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 2

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a0	Cell 0 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 3
RA Table	R_a0	Cell 0 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 4
RA Table	R_a0	Cell 0 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 5
RA Table	R_a0	Cell 0 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 6
RA Table	R_a0	Cell 0 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 7
RA Table	R_a0	Cell 0 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 8
RA Table	R_a0	Cell 0 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 9
RA Table	R_a0	Cell 0 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 10
RA Table	R_a0	Cell 0 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 11
RA Table	R_a0	Cell 0 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 12
RA Table	R_a0	Cell 0 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 13
RA Table	R_a0	Cell 0 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 14

11.12.2 R_a1

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a1	Cell 1 R_A Flag	H2	0x0000	0xFFFF		High-Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update
RA Table	R_a1	Cell 1 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 0
RA Table	R_a1	Cell 1 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 1
RA Table	R_a1	Cell 1 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 2
RA Table	R_a1	Cell 1 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 3
RA Table	R_a1	Cell 1 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 4
RA Table	R_a1	Cell 1 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 5
RA Table	R_a1	Cell 1 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 6
RA Table	R_a1	Cell 1 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 7
RA Table	R_a1	Cell 1 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 8
RA Table	R_a1	Cell 1 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 9
RA Table	R_a1	Cell 1 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 10
RA Table	R_a1	Cell 1 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 11
RA Table	R_a1	Cell 1 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 12
RA Table	R_a1	Cell 1 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 13
RA Table	R_a1	Cell 1 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 14

11.12.3 R_a2

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a2	Cell 2 R_A Flag	H2	0x0000	0xFFFF		High-Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update
RA Table	R_a2	Cell 2 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 0
RA Table	R_a2	Cell 2 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 1
RA Table	R_a2	Cell 2 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 2
RA Table	R_a2	Cell 2 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 3
RA Table	R_a2	Cell 2 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 4
RA Table	R_a2	Cell 2 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 5
RA Table	R_a2	Cell 2 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 6
RA Table	R_a2	Cell 2 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 7
RA Table	R_a2	Cell 2 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 8
RA Table	R_a2	Cell 2 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 9
RA Table	R_a2	Cell 2 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 10
RA Table	R_a2	Cell 2 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 11
RA Table	R_a2	Cell 2 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 12
RA Table	R_a2	Cell 2 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 13
RA Table	R_a2	Cell 2 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 14

11.12.4 R_a3

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a3	Cell 3 R_A Flag	H2	0x0000	0xFFFF		High-Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update
RA Table	R_a3	Cell 3 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 0
RA Table	R_a3	Cell 3 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 1
RA Table	R_a3	Cell 3 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 2
RA Table	R_a3	Cell 3 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 3

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a3	Cell 3 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 4
RA Table	R_a3	Cell 3 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 5
RA Table	R_a3	Cell 3 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 6
RA Table	R_a3	Cell 3 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 7
RA Table	R_a3	Cell 3 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 8
RA Table	R_a3	Cell 3 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 9
RA Table	R_a3	Cell 3 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 10
RA Table	R_a3	Cell 3 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 11
RA Table	R_a3	Cell 3 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 12
RA Table	R_a3	Cell 3 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 13
RA Table	R_a3	Cell 3 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 14

11.12.5 R_a0x

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a0x	xCell 0 R_A Flag	H2	0x0000	0xFFFF		High-Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update
RA Table	R_a0x	xCell 0 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 0
RA Table	R_a0x	xCell 0 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 1
RA Table	R_a0x	xCell 0 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 2
RA Table	R_a0x	xCell 0 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 3
RA Table	R_a0x	xCell 0 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 4
RA Table	R_a0x	xCell 0 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 5
RA Table	R_a0x	xCell 0 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 6
RA Table	R_a0x	xCell 0 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 7
RA Table	R_a0x	xCell 0 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 8
RA Table	R_a0x	xCell 0 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 9
RA Table	R_a0x	xCell 0 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 10

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a0x	xCell 0 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 11
RA Table	R_a0x	xCell 0 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 12
RA Table	R_a0x	xCell 0 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 13
RA Table	R_a0x	xCell 0 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 0 resistance at grid point 14

11.12.6 R_a1x

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a1x	xCell 1 R_A Flag	H2	0x0000	0xFFFF		High-Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and Cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update
RA Table	R_a1x	xCell 1 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 0
RA Table	R_a1x	xCell 1 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 1
RA Table	R_a1x	xCell 1 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 2
RA Table	R_a1x	xCell 1 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 3
RA Table	R_a1x	xCell 1 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 4
RA Table	R_a1x	xCell 1 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 5
RA Table	R_a1x	xCell 1 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 6
RA Table	R_a1x	xCell 1 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 7
RA Table	R_a1x	xCell 1 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 8
RA Table	R_a1x	xCell 1 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 9
RA Table	R_a1x	xCell 1 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 10
RA Table	R_a1x	xCell 1 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 11
RA Table	R_a1x	xCell 1 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 12
RA Table	R_a1x	xCell 1 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 13
RA Table	R_a1x	xCell 1 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 1 resistance at grid point 14

11.12.7 R_a2x

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a2x	xCell 2 R_A Flag	H2	0x0000	0xFFFF		High-Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update
RA Table	R_a2x	xCell 2 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 0
RA Table	R_a2x	xCell 2 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 1
RA Table	R_a2x	xCell 2 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 2
RA Table	R_a2x	xCell 2 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 3
RA Table	R_a2x	xCell 2 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 4
RA Table	R_a2x	xCell 2 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 5
RA Table	R_a2x	xCell 2 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 6
RA Table	R_a2x	xCell 2 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 7
RA Table	R_a2x	xCell 2 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 8
RA Table	R_a2x	xCell 2 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 9
RA Table	R_a2x	xCell 2 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 10
RA Table	R_a2x	xCell 2 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 11
RA Table	R_a2x	xCell 2 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 12
RA Table	R_a2x	xCell 2 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 13
RA Table	R_a2x	xCell 2 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 2 resistance at grid point 14

11.12.8 R_a3x

Class	Subclass	Name	Type	Min	Max	Unit	Description
RA Table	R_a3x	xCell 3 R_A Flag	H2	0x0000	0xFFFF		High-Byte: 0x00: Cell Impedance and QMAX updated 0x05: Relaxation mode and QMAX update in progress 0x55: Discharge mode and cell updated 0xFF: cell impedance never updated Low-Byte: 0x00: Table not used and QMAX updated 0x55: Table being used 0xFF: Table never used, no QMAX or cell impedance update
RA Table	R_a3x	xCell 3 R_A 0	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 0
RA Table	R_a3x	xCell 3 R_A 1	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 1
RA Table	R_a3x	xCell 3 R_A 2	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 2
RA Table	R_a3x	xCell 3 R_A 3	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 3
RA Table	R_a3x	xCell 3 R_A 4	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 4
RA Table	R_a3x	xCell 3 R_A 5	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 5
RA Table	R_a3x	xCell 3 R_A 6	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 6
RA Table	R_a3x	xCell 3 R_A 7	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 7
RA Table	R_a3x	xCell 3 R_A 8	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 8
RA Table	R_a3x	xCell 3 R_A 9	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 9
RA Table	R_a3x	xCell 3 R_A 10	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 10
RA Table	R_a3x	xCell 3 R_A 11	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 11
RA Table	R_a3x	xCell 3 R_A 12	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 12
RA Table	R_a3x	xCell 3 R_A 13	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 13
RA Table	R_a3x	xCell 3 R_A 14	I2	–32768	32768	2^–10 Ω	Cell 3 resistance at grid point 14

11.13 PF Status

11.13.1 Device Status Data

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Safety Alert 0–15	H2	0x0000	0xFFFF	0	SafetyAlert() bit 0 to bit 15 Bit 0: CUV Cell Undervoltage 0 = Inactive 1 = Detected Bit 1: COV Cell Overvoltage 0 = Inactive 1 = Detected Bit 2: OCC1 Overcurrent in Charge 1st Tier 0 = Inactive 1 = Detected Bit 3: OCC2 Overcurrent in Charge 2nd Tier 0 = Inactive 1 = Detected Bit 4: OCD1 Overcurrent in Discharge 1st Tier 0 = Inactive 1 = detected Bit 5: OCD2 Overcurrent in Discharge 2nd Tier 0 = Inactive 1 = detected Bit 6: OLD Overload in discharge 0 = Inactive 1 = detected Bit 7: OLDL Overload in discharge latch 0 = Inactive 1 = detected Bit 8: SCC Short circuit in charge 0 = Inactive 1 = detected Bit 9: SCCL Short circuit in charge latch 0 = Inactive 1 = detected Bit 10: SCD Short circuit in discharge 0 = Inactive 1 = detected Bit 11: SCDL Short circuit in discharge latch 0 = Inactive 1 = detected Bit 12: OTC Over temperature in charge 0 = Inactive 1 = detected Bit 13: OTD Over temperature in discharge 0 = Inactive 1 = detected Bit 14: CUVC I*R compensated CUV 0 = Inactive 1 = detected Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Safety Status 0–15	H2	0x0000	0xFFFF	0	SafetyStatus() bit 0 to bit 15 Bit 0: CUV Cell Undervoltage 0 = Inactive 1 = detected Bit 1: COV Cell Overvoltage 0 = Inactive 1 = detected Bit 2: OCC1 Overcurrent in Charge 1st Tier 0 = Inactive 1 = detected Bit 3: OCC2 Overcurrent in Charge 2nd Tier 0 = Inactive 1 = detected Bit 4: OCD1 Overcurrent in Discharge 1st Tier 0 = Inactive 1 = detected Bit 5: OCD2 Overcurrent in Discharge 2nd Tier 0 = Inactive 1 = detected Bit 6: OLD Overload in discharge 0 = Inactive 1 = detected Bit 7: OLDL Overload in discharge latch 0 = Inactive 1 = detected Bit 8: SCC Short circuit in charge 0 = Inactive 1 = detected Bit 9: SCCL Short circuit in charge latch 0 = Inactive 1 = detected Bit 10: SCD Short circuit in discharge 0 = Inactive 1 = detected Bit 11: SCDL Short circuit in discharge latch 0 = Inactive 1 = detected Bit 12: OTC Over temperature in charge 0 = Inactive 1 = detected Bit 13: OTD Over temperature in discharge 0 = Inactive 1 = detected Bit 14: CUVC I*R compensated CUV 0 = Inactive 1 = detected Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	PF Alert 0–15	H2	0x0000	0xFFFF	0	PFAlert() bit 0 to bit 15 Bit 0: CUV Cell undervoltage 0 = Inactive 1 = detected Bit 1: COV Cell overvoltage 0 = Inactive 1 = detected Bit 2: CUDEP 0 = Inactive 1 = Detected Bit 3: Reserved Bit 4: OTCE Overtemperature 0 = Inactive 1 = detected Bit 5: Reserved Bit 6: OTF Overtemperature FET 0 = Inactive 1 = detected Bit 7: QIM QMax Imbalance 0 = Inactive 1 = detected Bit 8: CB Cell balancing 0 = Inactive 1 = detected Bit 9: IMP Cell impedance 0 = Inactive 1 = detected Bit 10: CD Capacity Deterioration 0 = Inactive 1 = detected Bit 11: VIMR Voltage imbalance at Rest 0 = Inactive 1 = detected Bit 12: VIMA Voltage imbalance at Rest 0 = Inactive 1 = detected Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	PF Status 0–15	H2	0x0000	0xFFFF	0	PFStatus() bit 0 to bit 15 Bit 0: CUV Cell undervoltage 0 = Inactive 1 = Active Bit 1: COV Cell overvoltage 0 = Inactive 1 = Active Bit 2: Reserved Bit 3: Reserved Bit 4: OTCE Overtemperature 0 = Inactive 1 = Active Bit 5: Reserved Bit 6: OTF Overtemperature FET 0 = Inactive 1 = Active Bit 7: QIM QMax Imbalance 0 = Inactive 1 = Active Bit 8: CB Cell balancing 0 = Inactive 1 = Active Bit 9: IMP Cell impedance 0 = Inactive 1 = Active Bit 10: CD Capacity Deterioration 0 = Inactive 1 = Active Bit 11: VIMR Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 12: VIMA Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Safety Alert 16–31	H2	0x0000	0xFFFF	0	SafetyAlert() bit 16 to bit 31 Bit 16: OTF FET over temperature 0 = Inactive 1 = detected Bit 17: HWD SBS Host watchdog timeout 0 = Inactive 1 = detected Bit 18: PTO Pre-charging timeout 0 = Inactive 1 = detected Bit 19: PTOS Pre-charging timeout suspend 0 = Inactive 1 = detected Bit 20: CTO Charging timeout 0 = Inactive 1 = detected Bit 21: CTOS Charging timeout suspend 0 = Inactive 1 = detected Bit 22: OC Overcharge 0 = Inactive 1 = detected Bit 23: CHGC Charging Current higher than requested 0 = Inactive 1 = detected Bit 24: CHGV Charging Voltage higher than requested 0 = Inactive 1 = detected Bit 25: Reserved Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Safety Status 16–31	H2	0x0000	0xFFFF	0	SafetyStatus() bit 16 to bit 31 Bit 16: OTF FET over temperature 0 = Inactive 1 = detected Bit 17: HWD SBS Host watchdog timeout 0 = Inactive 1 = detected Bit 18: PTO Pre-charging timeout 0 = Inactive 1 = detected Bit 19: PTOS Pre-charging timeout suspend 0 = Inactive 1 = detected Bit 20: CTO Charging timeout 0 = Inactive 1 = detected Bit 21: CTOS Charging timeout suspend 0 = Inactive 1 = detected Bit 22: OC Overcharge 0 = Inactive 1 = detected Bit 23: CHGC ChargingCurrent higher than requested 0 = Inactive 1 = detected Bit 24: CHGV Charging Voltage higher than requested 0 = Inactive 1 = detected Bit 25: Reserved Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	PF Alert 16–31	H2	0x0000	0xFFFF	0	PFAlert() bit 16 to bit 31 Bit 16: CFET Charge FET 0 = Inactive 1 = detected Bit 17: DFET Discharge FET 0 = Inactive 1 = detected Bit 18: TH Thermistor 0 = Inactive 1 = detected Bit 19: FUSE Fuse 0 = Inactive 1 = detected Bit 20: AFER AFE Register 0 = n/a 1 = Detected Bit 21: AFEC AFE Communication 0 = Inactive 1 = detected Bit 22: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Inactive 1 = detected Bit 23: Reserved Bit 24: Reserved Bit 25: OCECO Open VCx 0 = n/a 1 = detected Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	PF Status 16–31	H2	0x0000	0xFFFF	0	PFStatus() bit 16 to bit 31 Bit 16: CFET Charge FET 0 = Inactive 1 = Active Bit 17: DFET Discharge FET 0 = Inactive 1 = Active Bit 18: TH Thermistor 0 = Inactive 1 = Active Bit 19: FUSE Fuse 0 = Inactive 1 = Active Bit 20: AFER AFE Register 0 = n/a 1 = Active Bit 21: AFEC AFE Communication 0 = Inactive 1 = Active Bit 22: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Inactive 1 = Active Bit 23:PTC PTC by AFE 0 = Inactive 1 = Active Bit 24: IFC Instruction Flash Checksum 0 = n/a 1 = IF checksum failure Bit 25: OCECO Open VCx 0 = n/a 1 = Active Bit 26: DFW DF wearout 0 = n/a 1 = Active Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	PF Status 16–31	H2	0x0000	0xFFFF	0	Bit 16: SDM Shutdown activated by ManufacturerAccess() 0 = Inactive 1 = Active Bit 17: SHIPM Ship Mode activated with ManufacturerAccess() 0 = Inactive 1 = Active Bit 18: AUTH Authentication ongoing 0 = Inactive 1 = Active Bit 19: AWD AFE Watchdog failure 0 = Inactive 1 = Active Bit 20: FVS Fast Voltage Sampling 0 = Inactive 1 = Active Bit 21: CALO Raw ADC/CC offset output 0 = Inactive 1 = Active Bit 22: SDV Shutdown activated by voltage 0 = Inactive 1 = Active Bit 23: SLEEPM Sleep mode active by ManufacturerAccess() 0 = Inactive 1 = Active Bit 24: INIT Initialization after full reset, cleared when SBS data calculated and available 0 = Inactive 1 = Active Bit 25: SMBLCAL CC auto offset calibration ongoing after SBS line goes low 0 = Inactive 1 = Active Bit 26: SLEEPQMAX QMAX update in sleepmode 0 = Inactive 1 = Active Bit 27: SLEEPCC checking current in Sleep Mode 0 = Inactive 1 = Active Bit 28: GPOD GPOD pin status 0 = Inactive (high) 1 = Active (low) Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Operation Status 0–15	H2	0x0000	0xFFFF	0	OperationStatus() bit 0 to bit 15 Bit 0: $\overline{\text{PRES}}$ PRES input state 0 = PRES pin high 1 = PRES pin low detected Bit 1: DSG DSG FET Status 0 = Disabled 1 = Enabled Bit 2: CHG CHG FET Status 0 = Disabled 1 = Enabled Bit 3: PCHG PCHG FET Status 0 = Disabled 1 = Enabled Bit 4: GPOD PPOD FET Status 0 = Disabled 1 = Enabled Bit 5: FUSE FUSE input 0 = FUSE pin low 1 = FUSE pin high detected Bit 6: CB Cell Balancing 0 = Inactive 1 = Active Bit 7: LED LED Display 0 = Inactive 1 = Active Bit 8:9: SEC0,SEC1 Security Mode 0,0 = Reserved 0,1 = Unsealed 1,0 = Full Access 1,1 = Sealed Bit 10: CALCal Raw ADC/CC output active 0 = Inactive 1 = Active Bit 11: SS SafetyStatus 0 = Inactive 1 = Active Bit 12: PF Permanent Failure 0 = Inactive 1 = Active Bit 13: XDSG Discharging Disabled 0 = Inactive 1 = Active Bit 14: XCHG Charging Disabled 0 = Inactive 1 = Active Bit 15: SLEEP Sleep condition met 0 = Disabled 1 = Enabled

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Operation Status 16–31	H2	0x0000	0xFFFF	0	OperationStatus() bit 16 to bit 31 Bit 16: SDM Shutdown activated by ManufacturerAccess() 0 = Inactive 1 = Active Bit 17: SHIPM Ship Mode activated with ManufacturerAccess() 0 = Inactive 1 = Active Bit 18: AUTH Authentication ongoing 0 = Inactive 1 = Active Bit 19: AWD AFE Watchdog failure 0 = Inactive 1 = Active Bit 20: FVS Fast Voltage Sampling 0 = Inactive 1 = Active Bit 21: CALO Raw ADC/CC offset output 0 = Inactive 1 = Active Bit 22: SDV Shutdown activated by voltage 0 = Inactive 1 = Active Bit 23: SLEEPM Sleep mode active by ManufacturerAccess() 0 = Inactive 1 = Active Bit 24: INIT Initialization after full reset, cleared when SBS data calculated and available 0 = Inactive 1 = Active Bit 25: SMBL CALCC auto offset calibration ongoing after SBS line goes low 0 = Inactive 1 = Active Bit 26: SLEEPQMAX QMAX update in sleepmode 0 = Inactive 1 = Active Bit 27: SLEEPCC checking current in Sleep Mode 0 = Inactive 1 = Active Bit 28: XLSBS Fast Mode 0 = Inactive 1 = Active Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Charging Status 0–15	H2	0x0000	0xFFFF	0	ChargingStatus() bit 0 to bit 15 Bit 0: UT Under Temperature Range 0 = Inactive 1 = Active Bit 1: LT Low Temperature Range 0 = Inactive 1 = Active Bit 2: ST Standard Temperature Range 0 = Inactive 1 = Active Bit 3: HT High Temperature Range 0 = Inactive 1 = Active Bit 4: RT Recommended Temperature Range 0 = Inactive 1 = Active Bit 5: OT Over Temperature Range 0 = Inactive 1 = Active Bit 6: PV Precharge Voltage Range 0 = Inactive 1 = Active Bit 7: LV Low Voltage Range 0 = Inactive 1 = Active Bit 8: MV Medium Voltage Range 0 = Inactive 1 = Active Bit 9: HV High Voltage Range 0 = Inactive 1 = Active Bit 10: IN Charge Inhibit 0 = Inactive 1 = Active Bit 11: SU Charge Suspend 0 = Inactive 1 = Active Bit 12: CCR ChargingVoltage() Rate 0 = Inactive 1 = Active Bit 13: CVR ChargingCurrent() Rate 0 = Inactive 1 = Active Bit 14: CCC ChargingCurrent() Compensation 0 = Inactive 1 = Active Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	Device Status Data	Charging Status 16–23	H2	0x0000	0xFFFF	0	ChargingStatus() bit 16 to bit 31 Bit 16: VCT Valid Charge Termination. This flag toggles every time valid charge termination is detected. Bit 17: Reserved Bit 18: Reserved Bit 19: Reserved Bit 20: Reserved Bit 21: Reserved Bit 22: Reserved Bit 23: Reserved Bit 24: Reserved
PF Status	Device Status Data	Gauging Status	H2	0x0000	0xFFFF	0	GaugingStatus() bit 0 to bit 15 Bit 0: REST Device at rest 0 = Inactive 1 = Active Bit 1: DSG Discharge detected 0 = Charging 1 = Discharging Bit 2: RU Resistance update 0 = Disabled 1 = Enabled Bit 3: VOK Cell Voltage OK for QMAX update 0 = Inactive 1 = Active Bit 4: QEN QMax updates 0 = Disabled 1 = Enabled Bit 5: FD Fully Discharged detected by gauge algorithm 0 = Disabled 1 = Enabled Bit 6: FC Fully Charged detected by gauge algorithm 0 = Disabled 1 = Enabled

Class	Subclass	Name	Type	Min	Max	Default	Description
	PF Status	Device Status Data	Gauging Status	H2	0x0000	0xFFFF	Bit 7: NSFM negative scale factor mode 0 = Disabled 1 = Enabled Bit 8: VDQ Discharge qualified for learning 0 = Disabled 1 = Enabled Bit 9: QMAX QMAX updated. This flag toggles every time QMAX is updated Bit 10: RX Resistance update This flag toggles every time Resistance is updated Bit 11: LDMD Load Mode 0 = Constant current mode 1 = Constant power mode Bit 12: OCVFR OCV in flat region 0 = OCV outside flat region 1 = OCV in flat region Bit 13: TDA Terminate Discharge Alarm set by gauging algorithm 0 = Disabled 1 = Enabled Bit 14: TCA Terminate Charge Alarm set by gauging algorithm 0 = Disabled 1 = Enabled Bit 15: LPF Relax LiPh Relax Mode, only active with Chem ID 0x400 0 = Disabled 1 = Enabled

11.13.2 Device Voltage Data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
PF Status	Device Voltage Data	Cell Voltage 0	I2	0	32767	0	mV	Cell 0 voltage
PF Status	Device Voltage Data	Cell Voltage 1	I2	0	32767	0	mV	Cell 1 voltage
PF Status	Device Voltage Data	Cell Voltage 2	I2	0	32767	0	mV	Cell 2 voltage
PF Status	Device Voltage Data	Cell Voltage 3	I2	0	32767	0	mV	Cell 3 voltage
PF Status	Device Voltage Data	Bat Direct Voltage	I2	0	32767	0	mV	Cell stack voltage
PF Status	Device Voltage Data	Pack Voltage	I2	0	32767	0	mV	Pack pin voltage

11.13.3 Device Current Data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
PF Status	Device Current Data	Current	I2	–32768	32767	0	mV	Current()

11.13.4 Device Temperature Data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
PF Status	Device Temperature Data	Internal Temperature	I2	0	9999	0	0.1°K	Internal temperature sensor temperature
PF Status	Device Temperature Data	External 1 Temperature	I2	0	9999	0	0.1°K	External TS1 temperature
PF Status	Device Temperature Data	External 2 Temperature	I2	0	9999	0	0.1°K	External TS2 temperature
PF Status	Device Temperature Data	External 3 Temperature	I2	0	9999	0	0.1°K	External TS3 temperature
PF Status	Device Temperature Data	External 4 Temperature	I2	0	9999	0	0.1°K	External TS4 temperature

11.13.5 Device Gauging Data

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
PF Status	Device Gauging Data	Cell 0 DOD0	I2	0	32767	0		Cell 0 depth of discharge
PF Status	Device Gauging Data	Cell 1 DOD0	I2	0	32767	0		Cell 1 depth of discharge
PF Status	Device Gauging Data	Cell 2 DOD0	I2	0	32767	0		Cell 2 depth of discharge
PF Status	Device Gauging Data	Cell 3 DOD0	I2	0	32767	0		Cell 3 depth of discharge
PF Status	Device Gauging Data	Passed Charge	I2	0	32767	0	mAh	Passed charge since last QMax update

11.13.6 AFE Regs

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	AFE Regs	AFE Status	H1	0x00	0xFF	0	Bit 0: SCD1 SCD1 0 = Inactive 1 = Active Bit 1: SCD2 SCD2 0 = Inactive 1 = Active Bit 2: SCC SCC 0 = Inactive 1 = Active Bit 3: OCD SCD1 0 = Inactive 1 = Active Bit 4: WDF WDF 0 = Inactive 1 = Active Bit 5: Reserved Bit 6: PTC PTC 0 = Inactive 1 = Active Bit 7: FUSE FUSE 0 = Inactive 1 = Active
PF Status	AFE Regs	AFE State Control	H1	0x00	0xFF	0	Bit 0: Reserved Bit 1: SHUTDOWN Enables device shutdown when voltage on PACK pins is removed 0 = Disabled 1 = Enabled Bit 2: WDDIS Enables device watchdog timer 0 = Enabled 1 = Disabled Bit 3: WDRST Enables device reset when watchdog timer times out 0 = Disabled 1 = Enabled Bit 4: RSNS Divide OCD, SCC, SDC1 and SCD2 voltage thresholds by 2 0 = Disabled 1 = Enabled Bit 5: SCDDx2 Double SCD1 and SCD2 Delay thresholds 0 = Disabled 1 = Enabled Bit 6: CTM_ENA Enable customer test mode 0 = Disabled 1 = Enabled Bit 7: FUSE Apart one of FUSE activation sequence 0 = Disabled 1 = Enabled

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	AFE Regs	AFE Control	H1	0x00	0xFF	0	Bit 0: LTCLR LTCLR 0 = Inactive 1 = Active Bit 1: DSG DSG 0 = Inactive 1 = Active Bit 2: CHG CHG 0 = Inactive 1 = Active Bit 3: PCHG CHG 0 = Inactive 1 = Active Bit 4: GPOD CHG 0 = Inactive 1 = Active Bit 5: PMS_CHG PMS_CHG 0 = Inactive 1 = Active Bit 6: CTM_ENB CTM_ENB 0 = Inactive 1 = Active Bit 7: FUSEB FUSEB 0 = Inactive 1 = Active
PF Status	AFE Regs	AFE Output Status	H1	0x00	0xFF	0	Bit 0: Reserved Bit 1: DSG DSG 0 = Inactive 1 = Active Bit 2: CHG CHG 0 = Inactive 1 = Active Bit 3: PCHG CHG 0 = Inactive 1 = Active Bit 4: GPOD CHG 0 = Inactive 1 = Active Bit 5: PMS_CHG PMS_CHG 0 = Inactive 1 = Active Bit 6: CTM CTM 0 = Inactive 1 = Active Bit 7: PMS PMS 0 = Inactive 1 = Active

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	AFE Regs	AFE Function Control	H1	0x00	0xFF	0	Bit 0: VMEN VMEN 0 = Inactive 1 = Active Bit 1: PACK PACK 0 = Inactive 1 = Active Bit 2: BATDSG 0 = Inactive 1 = Active Bit 3: SC_REC SC_REC 0 = Inactive 1 = Active Bit 5:4: RV1,RV0:RV Bit 6: Reserved Bit 7: Reserved
PF Status	AFE Regs	AFE Cell Select	H1	0x00	0xFF	0	Bit 1:0: CELL1, CELL0 Cell Select Bit 2: CALCAL 0 = Inactive 1 = Active Bit 3: Reserved Bit 4: CB0 CB0 0 = Inactive 1 = Active Bit 5: CB1 CB1 0 = Inactive 1 = Active Bit 6: CB2 CB2 0 = Inactive 1 = Active Bit 4: CB3 CB3 0 = Inactive 1 = Active
PF Status	AFE Regs	AFE OCDV	H1	0x00	0xFF	0	Bit 3:0: Over Load Trip Threshold between SRP and SRN 0x00 to 0x0F = 0.050 V to 0.200 V in 10 mV steps when RSNS = 00x00 to 0x0F = 0.025 V to 0.100 V in 5 mV steps when RSNS = 10x00 = 0.050 V or 0.025 V 0x01 = 0.060 V or 0.030 V 0x02 = 0.070 V or 0.035 V 0x03 = 0.080 V or 0.040 V 0x04 = 0.090 V or 0.045 V 0x05 = 0.100 V or 0.050 V 0x06 = 0.110 V or 0.055 V 0x07 = 0.120 V or 0.060 V 0x08 = 0.130 V or 0.065 V 0x09 = 0.140 V or 0.070 V 0x0A = 0.150 V or 0.075 V 0x0B = 0.160 V or 0.080 V 0x0C = 0.170 V or 0.085 V 0x0D = 0.180 V or 0.090 V 0x0E = 0.190 V or 0.095 V 0x0F = 0.200 V or 0.100 V

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	AFE Regs	AFE OCDT	H1	0x00	0xFF	0	Bit 3:0: Over Load Trip Delay 0x00 to 0x0F = 1 ms to 31 ms in 2 ms steps 0x00 = 1 ms 0x01 = 3 ms 0x02 = 5 ms 0x03 = 7 ms 0x04 = 9 ms 0x05 = 11 ms 0x06 = 13 ms 0x07 = 15 ms 0x08 = 17 ms 0x09 = 19 ms 0x0A = 21 ms 0x0B = 23 ms 0x0C = 25 ms 0x0D = 27 ms 0x0E = 29 ms
PF Status	AFE Regs	AFE SCC	H1	0x00	0xFF	0	Bit 2:0: Short Circuit in Charge Threshold between SRP and SRN 0x00 to 0x04 = –0.100 V to –0.300 V in 50 mV steps when RSNS = 00x00 to 0x04 = –0.050 V to –0.150 V in 25 mV steps when RSNS = 1 0x00 = –0.100 V or –0.050 V 0x01 = –0.150 V or –0.075 V 0x02 = –0.200 V or –0.100 V 0x03 = –0.250 V or –0.125 V 0x04 = –0.300 V or –0.150 V 0x05 = reserved 0x06 = reserved 0x07 = reserved Bit 3: Reserved Bit 7:4: Short Circuit in Charge Delay Time 0x00 to 0x0F = 0 µs to 915 µs in 61 µs steps 0x00 = 0 µs 0x01 = 61 µs 0x02 = 122 µs 0x03 = 183 µs 0x04 = 244 µs 0x05 = 305 µs 0x06 = 366 µs 0x07 = 427 µs 0x08 = 488 µs 0x09 = 549 µs 0x0A = 610 µs 0x0B = 671 µs 0x0C = 732 µs 0x0D = 793 µs 0x0E = 854 µs 0x0F = 915 µs
PF Status	AFE Regs	AFE SCD1	H1	0x00	0xFF	0	Bit 2:0: Short Circuit in Discharge 1 Threshold between SRP and SRN 0x00 to 0x07 = 0.100 V to 0.300 V in 50 mV steps when RSNS = 00x00 to 0x07 = 0.050 V to 0.150 V in 25 mV steps when RSNS = 1 0x00 = 0.100 V or 0.050 V 0x01 = 0.150 V or 0.075 V 0x02 = 0.200 V or 0.100 V 0x03 = 0.250 V or 0.125 V 0x04 = 0.300 V or 0.150 V 0x05 = 0.350 V or 0.175 V 0x06 = 0.400 V or 0.200 V 0x07 = 0.450 V or 0.225 V Bit 3: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
PF Status	AFE Regs	AFE SCD1	H1	0x00	0xFF	0	Bit 7:4: Short Circuit in Discharge 1 Delay Time 0x00 to 0x0F = 0 µs to 915 µs in 61 µs steps when SCDDx2 = 00x00 to 0x0F = 0 µs to 1830 µs in 122 µs steps when SCDDx2 = 1 0x00 = 0 µs 0x01 = 61 µs or 122 µs 0x02 = 122 µs or 244 µs 0x03 = 183 µs or 366 µs 0x04 = 244 µs or 488 µs 0x05 = 305 µs or 610 µs 0x06 = 366 µs or 732 µs 0x07 = 427 µs or 854 µs 0x08 = 488 µs or 976 µs 0x09 = 549 µs or 1098 µs 0x0A = 610 µs or 1220 µs 0x0B = 671 µs or 1342 µs 0x0C = 732 µs or 1464 µs 0x0D = 793 µs or 1586 µs 0x0E = 854 µs or 1708 µs 0x0F = 915 µs or 1830 µs
PF Status	AFE Regs	AFE SCD2	H1	0x00	0xFF	0	Bit 2:0: Short Circuit in Discharge 2 Threshold between SRP and SRN 0x00 to 0x07 = 0.100 V to 0.300 V in 50 mV steps when RSNS = 00x00 to 0x07 = 0.050 V to 0.150 V in 25 mV steps when RSNS = 10x00 = 0.100 V or 0.050 V 0x01 = 0.150 V or 0.075 V 0x02 = 0.200 V or 0.100 V 0x03 = 0.250 V or 0.125 V 0x04 = 0.300 V or 0.150 V 0x05 = 0.350 V or 0.175 V 0x06 = 0.400 V or 0.200 V 0x07 = 0.450 V or 0.225 V Bit 3: Reserved Bit 7:4: Short Circuit in Discharge 2 Delay Time 0x00 to 0x0F = 0 µs to 915 µs in 61 µs steps when SCDDx2 = 00x00 to 0x0F = 0 µs to 1830 µs in 122 µs steps when SCDDx2 = 10x00 = 0 µs 0x01 = 30 µs or 61 µs 0x02 = 61 µs or 122 µs 0x03 = 91 µs or 183 µs 0x04 = 122 µs or 244 µs 0x05 = 152 µs or 305 µs 0x06 = 183 µs or 366 µs 0x07 = 213 µs or 427 µs 0x08 = 244 µs or 488 µs 0x09 = 275 µs or 549 µs 0x0A = 305 µs or 610 µs 0x0B = 335 µs or 671 µs 0x0C = 366 µs or 732 µs 0x0D = 396 µs or 793 µs 0x0E = 426 µs or 854 µs 0x0F = 458 µs or 915 µs

11.14 Black Box

11.14.1 Safety Status

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	Safety Status	1st Safety Status 0–15	H2	0x0000	0xFFFF	0	SafetyStatus() bit 0 to bit 15 Bit 0: CUV Cell Undervoltage 0 = Inactive 1 = detected Bit 1: COV Cell Overvoltage 0 = Inactive 1 = detected Bit 2: OCC1 Overcurrent in Charge 1st Tier 0 = Inactive 1 = detected Bit 3: OCC2 Overcurrent in Charge 2nd Tier 0 = Inactive 1 = detected Bit 4: OCD1 Overcurrent in Discharge 1st Tier 0 = Inactive 1 = detected Bit 5: OCD2 Overcurrent in Discharge 2nd Tier 0 = Inactive 1 = detected Bit 6: OLD Overload in discharge 0 = Inactive 1 = detected Bit 7: OLDL Overload in discharge latch 0 = Inactive 1 = detected Bit 8: SCC Short circuit in charge 0 = Inactive 1 = detected
Black Box	Safety Status	1st Safety Status 0–15	H2	0x0000	0xFFFF	0	Bit 9: SCCL Short circuit in charge latch 0 = Inactive 1 = detected Bit 10: SCD Short circuit in discharge 0 = Inactive 1 = detected Bit 11: SCDL Short circuit in discharge latch 0 = Inactive 1 = detected Bit 12: OTC Over temperature in charge 0 = Inactive 1 = detected Bit 13: OTD Over temperature in discharge 0 = Inactive 1 = detected Bit 14: CUVC I*R compensated CUV 0 = Inactive 1 = detected Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	Safety Status	1st Safety Status 16–31	H2	0x0000	0xFFFF	0	SafetyStatus() bit 16 to bit 31 Bit 16: OTF FET over temperature 0 = Inactive 1 = detected Bit 17: HWD SBS Host watchdog timeout 0 = Inactive 1 = detected Bit 18: PTO Pre-charging timeout 0 = Inactive 1 = detected Bit 19: PTOS Pre-charging timeout suspend 0 = Inactive 1 = detected Bit 20: CTO Charging timeout 0 = Inactive 1 = detected
Black Box	Safety Status	1st Safety Status 16–31	H2	0x0000	0xFFFF	0	Bit 21: CTOS Charging timeout suspend 0 = Inactive 1 = detected Bit 22: OC Overcharge 0 = Inactive 1 = detected Bit 23: CHGC ChargingCurrent higher than requested 0 = Inactive 1 = detected Bit 24: CHGV ChargingVoltage higher than requested 0 = Inactive 1 = detected Bit 25: Reserved Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved
Black Box	Safety Status	1st Time to Next Event	U1	0	255	0	Time from 1st event to 2nd event

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	Safety Status	2nd Safety Status 0–15	H2	0x0000	0xFFFF	0	SafetyStatus() bit 0 to bit 15 Bit 0: CUV Cell Undervoltage 0 = Inactive 1 = detected Bit 1: COV Cell Overvoltage 0 = Inactive 1 = detected Bit 2: OCC1 Overcurrent in Charge 1st Tier 0 = Inactive 1 = detected Bit 3: OCC2 Overcurrent in Charge 2nd Tier 0 = Inactive 1 = detected Bit 4: OCD1 Overcurrent in Discharge 1st Tier 0 = Inactive 1 = detected Bit 5: OCD2 Overcurrent in Discharge 2nd Tier 0 = Inactive 1 = detected Bit 6: OLD Overload in discharge 0 = Inactive 1 = detected
Black Box	Safety Status	2nd Safety Status 0–15	H2	0x0000	0xFFFF	0	Bit 7: OLDL Overload in discharge latch 0 = Inactive 1 = detected Bit 8: SCC Short circuit in charge 0 = Inactive 1 = detected Bit 9: SCCL Short circuit in charge latch 0 = Inactive 1 = detected Bit 10: SCD Short circuit in discharge 0 = Inactive 1 = detected Bit 11: SCDL Short circuit in discharge latch 0 = Inactive 1 = detected Bit 12: OTC Over temperature in charge 0 = Inactive 1 = detected Bit 13: OTD Over temperature in discharge 0 = Inactive 1 = detected Bit 14: CUVC I*R compensated CUV 0 = Inactive 1 = detected Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	Safety Status	2nd Safety Status 16–31	H2	0x0000	0xFFFF	0	SafetyStatus() bit 16 to bit 31 Bit 16: OTF FET over temperature 0 = Inactive 1 = detected Bit 17: HWD SBS Host watchdog timeout 0 = Inactive 1 = detected Bit 18: PTO Pre-charging timeout 0 = Inactive 1 = detected Bit 19: PTOS Pre-charging timeout suspend 0 = Inactive 1 = detected Bit 20: CTO Charging timeout 0 = Inactive 1 = detected
Black Box	Safety Status	2nd Safety Status 16–31	H2	0x0000	0xFFFF	0	Bit 21: CTOS Charging timeout suspend 0 = Inactive 1 = detected Bit 22: OC Overcharge 0 = Inactive 1 = detected Bit 23: CHGC ChargingCurrent higher than requested 0 = Inactive 1 = detected Bit 24: CHGV Charging Voltage higher than requested 0 = Inactive 1 = detected Bit 25: Reserved Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved
Black Box	Safety Status	2nd Time to Next Event	U1	0	255	0	Time from 2nd event to 3rd event

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	Safety Status	3rd Safety Status 0–15	H2	0x0000	0xFFFF	0	SafetyStatus() bit 0 to bit 15 Bit 0: CUV Cell Undervoltage 0 = Inactive 1 = detected Bit 1: COV Cell Overvoltage 0 = Inactive 1 = detected Bit 2: OCC1 Overcurrent in Charge 1st Tier 0 = Inactive 1 = detected Bit 3: OCC2 Overcurrent in Charge 2nd Tier 0 = Inactive 1 = detected Bit 4: OCD1 Overcurrent in Discharge 1st Tie r0 = inactive 1 = detected Bit 5: OCD2 Overcurrent in Discharge 2nd Tier 0 = inactive 1 = detected Bit 6: OLD Overload in discharge 0 = inactive 1 = detected Bit 7: OLDL Overload in discharge latch 0 = inactive 1 = detected
Black Box	Safety Status	3rd Safety Status 0–15	H2	0x0000	0xFFFF	0	Bit 8: SCC Short circuit in charge 0 = inactive 1 = detected Bit 9: SCCL Short circuit in charge latch 0 = inactive 1 = detected Bit 10: SCD Short circuit in discharge 0 = inactive 1 = detected Bit 11: SCDL Short circuit in discharge latch 0 = inactive 1 = detected Bit 12: OTC Over temperature in charge 0 = inactive 1 = detected Bit 13: OTD Over temperature in discharge 0 = inactive 1 = detected Bit 14: CUVC I*R compensated CUV 0 = inactive 1 = detected Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	Safety Status	3rd Safety Status 16–31	H2	0x0000	0xFFFF	0	SafetyStatus() bit 16 to bit 31 Bit 16: OTF FET over temperature 0 = inactive 1 = detected Bit 17: HWDSBS Host watchdog timeout 0 = inactive 1 = detected Bit 18: PTO Pre-charging timeout 0 = inactive 1 = detected Bit 19: PTOS Pre-charging timeout suspend 0 = inactive 1 = detected Bit 20: CTO Charging timeout 0 = inactive 1 = detected
Black Box	Safety Status	3rd Safety Status 16–31	H2	0x0000	0xFFFF	0	Bit 21: CTOS Charging timeout suspend 0 = inactive 1 = detected Bit 22: OC Overcharge 0 = inactive 1 = detected Bit 23: CHGC ChargingCurrent higher than requested 0 = inactive 1 = detected Bit 24: CHGV Charging Voltage higher than requested 0 = inactive 1 = detected Bit 25: Reserved Bit 26: Reserved Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved
Black Box	Safety Status	3rd Time to Next Event	U1	0	255		Time since 3rd event

11.14.2 PF Status

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	1st PF Status 0–15	H2	0x0000	0xFFFF	0	PFStatus() bit 0 to bit 15 Bit 0: CUV Cell undervoltage 0 = Inactive 1 = Active Bit 1: COV Cell overvoltage 0 = Inactive 1 = Active Bit 2: CUDEP 0 = Inactive 1 = Active Bit 3: Reserved Bit 4: OTCE Overtemperature 0 = Inactive 1 = Active Bit 5: Reserved Bit 6: OTF Overtemperature FET 0 = Inactive 1 = Active Bit 7: QIM QMax Imbalance 0 = Inactive 1 = Active
Black Box	PF Status	1st PF Status 0–15	H2	0x0000	0xFFFF	0	Bit 8: CB Cell balancing 0 = Inactive 1 = Active Bit 9: IMP Cell impedance 0 = Inactive 1 = Active Bit 10: CD Capacity Deterioration 0 = Inactive 1 = Active Bit 11: VIMR Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 12: VIMA Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	1st PF Status 16–32	H2	0x0000	0xFFFF	0	PFStatus() bit 16 to bit 31 Bit 16: CFET Charge FET 0 = Inactive 1 = Active Bit 17: DFET Discharge FET 0 = Inactive 1 = Active Bit 18: TH Thermistor 0 = Inactive 1 = Active Bit 19: FUSE Fuse 0 = Inactive 1 = Active Bit 20: AFER AFE Register 0 = n/a 1 = Active Bit 21: AFEC AFE Communication 0 = Inactive 1 = Active Bit 22: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Inactive 1 = Active Bit 23:PTC PTC by AFE 0 = Inactive 1 = Active Bit 24: IFC Instruction Flash Checksum 0 = n/a 1 = IF checksum failure Bit 25: OCECO Open VCx 0 = n/a 1 = Active Bit 26: DFW DF wearout 0 = n/a 1 = Active Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	1st PF Status 16–32	H2	0x0000	0xFFFF	0	Bit 16: SDM Shutdown activated by ManufacturerAccess() 0 = inactive 1 = Active Bit 17: SHIPM Ship Mode activated with ManufacturerAccess() 0 = inactive 1 = Active Bit 18: AUTH Authentication ongoing 0 = inactive 1 = Active Bit 19: AWD AFE Watchdog failure 0 = inactive 1 = Active Bit 20: FVS Fast Voltage Sampling 0 = inactive 1 = Active Bit 21: CALO Raw ADC/CC offset output 0 = inactive 1 = Active Bit 22: SDV Shutdown activated by voltage 0 = inactive 1 = Active Bit 23: SLEEPM Sleep mode active by ManufacturerAccess() 0 = inactive 1 = Active Bit 24: INIT Initialization after full reset, cleared when SBS data calculated and available 0 = inactive 1 = Active Bit 25: SMBLCAL CC auto offset calibration ongoing after SBS line goes low 0 = inactive 1 = Active Bit 26: SLEEPQMAX QMAX update in sleepmode 0 = inactive 1 = Active Bit 27: SLEEPCC checking current in Sleep Mode 0 = inactive 1 = Active Bit 28: GPOD GPOD pin status 0 = inactive (high) 1 = Active (low) Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved: Reserved
Black Box	PF Status	1st Time to Next Event	U1	0	255	0	Time from 1st event to 2nd event

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	2nd PF Status 0–15	H2	0x0000	0xFFFF	0	PFStatus() bit 0 to bit 15 Bit 0: CUV Cell undervoltage 0 = Inactive 1 = Active Bit 1: COV Cell overvoltage 0 = Inactive 1 = Active Bit 2: CUDEP Copper Deposition 0 = Inactive 1 = Active Bit 3: Reserved Bit 4: OTCE Overtemperature 0 = Inactive 1 = Active Bit 5: Reserved Bit 6: OTF Overtemperature FET 0 = Inactive 1 = Active Bit 7: QIM QMax Imbalance 0 = Inactive 1 = Active Bit 8: CB Cell balancing 0 = Inactive 1 = Active Bit 9: IMP Cell impedance 0 = Inactive 1 = Active Bit 10: CD Capacity Deterioration 0 = Inactive 1 = Active Bit 11: VIMR Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 12: VIMA Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	2nd PF Status 16–32	H2	0x0000	0xFFFF	0	PFStatus() bit 16 to bit 31 Bit 16: CFET Charge FET 0 = Inactive 1 = Active Bit 17: DFET Discharge FET 0 = Inactive 1 = Active Bit 18: TH Thermistor 0 = Inactive 1 = Active Bit 19: FUSE Fuse 0 = Inactive 1 = Active Bit 20: AFER AFE Register 0 = n/a 1 = Active Bit 21: AFEC AFE Communication 0 = Inactive 1 = Active Bit 22: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Inactive 1 = Active Bit 23:PTC PTC by AFE 0 = Inactive 1 = Active Bit 24: IFC Instruction Flash Checksum 0 = n/a 1 = IF checksum failure Bit 25: OCECO Open VCx 0 = n/a 1 = Active Bit 26: DFW DF wearout 0 = n/a 1 = Active Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	2nd PF Status 16–32	H2	0x0000	0xFFFF	0	Bit 16: SDM Shutdown activated by ManufacturerAccess() 0 = inactive 1 = Active Bit 17: SHIPM Ship Mode activated with ManufacturerAccess() 0 = inactive 1 = Active Bit 18: AUTH Authentication ongoing 0 = inactive 1 = Active Bit 19: AWD AFE Watchdog failure 0 = inactive 1 = Active Bit 20: FVS Fast Voltage Sampling 0 = inactive 1 = Active Bit 21: CALO Raw ADC/CC offset output 0 = inactive 1 = Active Bit 22: SDV Shutdown activated by voltage 0 = inactive 1 = Active Bit 23: SLEEPM Sleep mode active by ManufacturerAccess() 0 = inactive 1 = Active Bit 24: INIT Initialization after full reset, cleared when SBS data calculated and available 0 = inactive 1 = Active Bit 25: SMBLCAL CC auto offset calibration ongoing after SBS line goes low 0 = inactive 1 = Active Bit 26: SLEEPQMAX QMAX update in sleepmode 0 = inactive 1 = Active Bit 27: SLEEPCC checking current in Sleep Mode 0 = inactive 1 = Active Bit 28: GPOD GPOD pin status 0 = inactive (high) 1 = Active (low) Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved: Reserved
Black Box	PF Status	2nd Time to Next Event	U1	0	255	0	Time from 2nd event to 3rd event

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	3rd PF Status 0–15	H2	0x0000	0xFFFF	0	PFStatus() bit 0 to bit 15 Bit 0: CUV Cell undervoltage 0 = Inactive 1 = Active Bit 1: COV Cell overvoltage 0 = Inactive 1 = Active Bit 2: CUDEP Copper Deposition 0 = Inactive 1 = Active Bit 3: Reserved Bit 4: OTCE Overtemperature 0 = Inactive 1 = Active Bit 5: Reserved Bit 6: OTF Overtemperature FET 0 = Inactive 1 = Active Bit 7: QIM QMax Imbalance 0 = Inactive 1 = Active Bit 8: CB Cell balancing 0 = Inactive 1 = Active Bit 9: IMP Cell impedance 0 = Inactive 1 = Active Bit 10: CD Capacity Deterioration 0 = Inactive 1 = Active Bit 11: VIMR Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 12: VIMA Voltage imbalance at Rest 0 = Inactive 1 = Active Bit 13: Reserved Bit 14: Reserved Bit 15: Reserved

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	3rd PF Status 16–32	H2	0x0000	0xFFFF	0	PFStatus() bit 16 to bit 31 Bit 16: CFET Charge FET 0 = Inactive 1 = Active Bit 17: DFET Discharge FET 0 = Inactive 1 = Active Bit 18: TH Thermistor 0 = Inactive 1 = Active Bit 19: FUSE Fuse 0 = Inactive 1 = Active Bit 20: AFER AFE Register 0 = n/a 1 = Active Bit 21: AFEC AFE Communication 0 = Inactive 1 = Active Bit 22: 2LVL FUSE input indicating fuse trigger by external 2nd level protection 0 = Inactive 1 = Active Bit 23:PTC PTC by AFE 0 = Inactive 1 = Active Bit 24: IFC Instruction Flash Checksum 0 = n/a 1 = IF checksum failure Bit 25: OCECO Open VCx 0 = n/a 1 = Active Bit 26: DFW DF wearout 0 = n/a 1 = Active Bit 27: Reserved Bit 28: Reserved Bit 29: Reserved Bit 30: Reserved Bit 31

Class	Subclass	Name	Type	Min	Max	Default	Description
Black Box	PF Status	3rd PF Status 16–32	H2	0x0000	0xFFFF	0	Bit 16: SDM Shutdown activated by ManufacturerAccess() 0 = inactive 1 = Active Bit 17: SHIPM Ship Mode activated with ManufacturerAccess() 0 = inactive 1 = Active Bit 18: AUTH Authentication ongoing 0 = inactive 1 = Active Bit 19: AWD AFE Watchdog failure 0 = inactive 1 = Active Bit 20: FVS Fast Voltage Sampling 0 = inactive 1 = Active Bit 21: CALO Raw ADC/CC offset output 0 = inactive 1 = Active Bit 22: SDV Shutdown activated by voltage 0 = inactive 1 = Active Bit 23: SLEEPM Sleep mode active by ManufacturerAccess() 0 = inactive 1 = Active Bit 24: INIT Initialization after full reset, cleared when SBS data calculated and available 0 = inactive 1 = Active Bit 25: SMBLCAL CC auto offset calibration ongoing after SBS line goes low 0 = inactive 1 = Active Bit 26: SLEEPQMAX QMAX update in sleepmode 0 = inactive 1 = Active Bit 27: SLEEPCC Checking current in Sleep Mode 0 = inactive 1 = Active Bit 28: GPOD GPOD pin status 0 = inactive (high) 1 = Active (low) Bit 29: Reserved Bit 30: Reserved Bit 31: Reserved: Reserved
Black Box	PF Status	3rd Time to Next Event	U1	0	255	0	Time since 3rd event

11.15 Calibration

11.15.1 Voltage

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Voltage	Cell Scale 0	I2	–32768	32767	20451	VC1–VSS Cell 0 gain
Calibration	Voltage	Cell Scale 1	I2	–32768	32767	20468	VC2–VC1 Cell 1 gain
Calibration	Voltage	Cell Scale 2	I2	–32768	32767	20520	VC3–VC2 Cell 2 gain
Calibration	Voltage	Cell Scale 3	I2	–32768	32767	20517	VC4–VC3 Cell 3 gain
Calibration	Voltage	Pack Gain	I2	–32768	32767	44100	PACK–VSS gain
Calibration	Voltage	Battery Gain	I2	–32768	32767	44100	VC4–VSS gain

11.15.2 Current

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Current	CC Gain	F4	1.00E–001	4.00E+000	0.9419	Coulomb Counter Gain
Calibration	Current	Capacity Gain	F4	2.98E+004	1.19E+006	280932.625	Capacity Gain

11.15.3 Current Offset

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Current Offset	CC Offset	I2	–32768	32767	–7204	Coulomb Counter Offset
Calibration	Current Offset	Coulomb Counter Offset Samples	U2	0	65535	64	Coulomb Counter Offset Samples used for averaging
Calibration	Current Offset	Board Offset	I2	–32768	32767	0	PCB board offset

11.15.4 Temperature

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Calibration	Temperature	Internal Temp Offset	I1	–128	127	0	0.1°C	Internal temperature sensor reading offset
Calibration	Temperature	External 1 Temp Offset	I1	–128	127	0	0.1°C	TS1 temperature sensor reading offset
Calibration	Temperature	External 2 Temp Offset	I1	–128	127	0	0.1°C	TS2 temperature sensor reading offset
Calibration	Temperature	External 3 Temp Offset	I1	–128	127	0	0.1°C	TS3 temperature sensor reading offset
Calibration	Temperature	External 4 Temp Offset	I1	–128	127	0	0.1°C	TS4 temperature sensor reading offset

11.15.5 Internal Temp Model

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Internal Temp Model	Int Coeff 1	I2	–32768	32768	0	Internal temperature calculation polynomial value 1
Calibration	Internal Temp Model	Int Coeff 2	I2	–32768	32768	0	Internal temperature calculation polynomial value 2
Calibration	Internal Temp Model	Int Coeff 3	I2	–32768	32768	–11136	Internal temperature calculation polynomial value 3
Calibration	Internal Temp Model	Int Coeff 4	I2	–32768	32768	5754	Internal temperature calculation polynomial value 4
Calibration	Internal Temp Model	Int Minimum AD	I2	–32768	32768	0	Minimum AD count used for calculation
Calibration	Internal Temp Model	Int Maximum Temp	I2	–32768	32768	5754	Maximum Temperature boundary

11.15.6 Cell Temp Model

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Cell Temp Model	Coefficient a1	I2	–32768	32768	–14520	Cell Temperature calculation polynomial a1
Calibration	Cell Temp Model	Coefficient a2	I2	–32768	32768	23696	Cell Temperature calculation polynomial a2
Calibration	Cell Temp Model	Coefficient a3	I2	–32768	32768	–20298	Cell Temperature calculation polynomial a3
Calibration	Cell Temp Model	Coefficient a4	I2	–32768	32768	28073	Cell Temperature calculation polynomial a4
Calibration	Cell Temp Model	Coefficient a5	I2	–32768	32768	865	Cell Temperature calculation polynomial a5
Calibration	Cell Temp Model	Coefficient b1	I2	–32768	32768	–694	Cell Temperature calculation polynomial b1
Calibration	Cell Temp Model	Coefficient b2	I2	–32768	32768	1326	Cell Temperature calculation polynomial b2
Calibration	Cell Temp Model	Coefficient b3	I2	–32768	32768	–3880	Cell Temperature calculation polynomial b3
Calibration	Cell Temp Model	Coefficient b4	I2	–32768	32768	5127	Cell Temperature calculation polynomial b4
Calibration	Cell Temp Model	Rc0	I2	–32768	32768	11703	Resistance at 25°C
Calibration	Cell Temp Model	Adc0	I2	–32768	32768	11703	ADC reading at 25°C
Calibration	Cell Temp Model	Rpad	I2	–32768	32768	0	Pad Resistance
Calibration	Cell Temp Model	Rint	I2	–32768	32768	0	Pull up resistor resistance

11.15.7 FET Temp Model

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	FET Temp Model	Coefficient a1	I2	–32768	32768	–14520	FET Temperature calculation polynomial a1
Calibration	FET Temp Model	Coefficient a2	I2	–32768	32768	23696	FET Temperature calculation polynomial a2

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	FET Temp Model	Coefficient a3	I2	–32768	32768	–20298	FET Temperature calculation polynomial a3
Calibration	FET Temp Model	Coefficient a4	I2	–32768	32768	28073	FET Temperature calculation polynomial a4
Calibration	FET Temp Model	Coefficient a5	I2	–32768	32768	865	FET Temperature calculation polynomial a5
Calibration	FET Temp Model	Coefficient b1	I2	–32768	32768	–694	FET Temperature calculation polynomial b1
Calibration	FET Temp Model	Coefficient b2	I2	–32768	32768	1326	FET Temperature calculation polynomial b2
Calibration	FET Temp Model	Coefficient b3	I2	–32768	32768	–3880	FET Temperature calculation polynomial b3
Calibration	FET Temp Model	Coefficient b4	I2	–32768	32768	5127	FET Temperature calculation polynomial b4
Calibration	FET Temp Model	Rc0	I2	–32768	32768	11703	Resistance at 25°C
Calibration	FET Temp Model	Adc0	I2	–32768	32768	11703	ADC reading at 25°C
Calibration	FET Temp Model	Rpad	I2	–32768	32768	0	Pad Resistance
Calibration	FET Temp Model	Rint	I2	–32768	32768	0	Pull up resistor resistance

11.15.8 Filter

Class	Subclass	Name	Type	Min	Max	Default	Description
Calibration	Filter	Cell Voltage 1	U1	0	255	145	Low pass filter settings for averaging, sample setting values and associated low-pass filter time constants are in Table C-2.
Calibration	Filter	Cell Voltage 2	U1	0	255	145	
Calibration	Filter	Cell Voltage 3	U1	0	255	145	
Calibration	Filter	Cell Voltage 4	U1	0	255	145	
Calibration	Filter	Pack Voltage Out	U1	0	255	10	
Calibration	Filter	Direct Battery Voltage	U1	0	255	10	
Calibration	Filter	Summed Battery Voltage	U1	0	255	145	
Calibration	Filter	Cell Temperature	U1	0	255	145	
Calibration	Filter	Fet Temperature	U1	0	255	145	

11.15.9 Current Deadband

Class	Subclass	Name	Type	Min	Max	Unit	Description
Calibration	Current Deadband	Deadband	U1	0	255	3 mA	Deadband to report 0 mA
Calibration	Current Deadband	Coulomb Counter Deadband	U1	0	255	34 µV	Coulomb counter deadband to report 0 charge

AFE Threshold and Delay Settings

A.1 Overload in Discharge Protection (OLD)

Table A-1. Overload in Discharge Protection Threshold (Settings:AFE State Control [RSNS] = 0)

OLD Threshold ([RSNS] = 0)			
Setting	**Threshold**	**Setting**	**Threshold**
0x00	0.050 V	0x08	0.130 V
0x01	0.060 V	0x09	0.140 V
0x02	0.070 V	0x0a	0.150 V
0x03	0.080 V	0x0b	0.160 V
0x04	0.090 V	0x0c	0.170 V
0x05	0.100 V	0x0d	0.180 V
0x06	0.110 V	0x0e	0.190 V
0x07	0.120 V	0x0f	0.200 V

Table A-2. Overload in Discharge Protection Threshold (Settings:AFE State Control [RSNS] = 1)

OLD Threshold ([RSNS] = 1)			
Setting	**Threshold**	**Setting**	**Threshold**
0x00	0.025 V	0x08	0.065 V
0x01	0.030 V	0x09	0.070 V
0x02	0.035 V	0x0a	0.075 V
0x03	0.040 V	0x0b	0.080 V
0x04	0.045 V	0x0c	0.085 V
0x05	0.050 V	0x0d	0.090 V
0x06	0.055 V	0x0e	0.095 V
0x07	0.060 V	0x0f	0.100 V

Table A-3. Overload in Discharge Protection Delay

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	1 ms	0x04	9 ms	0x08	17 ms	0x0c	25 ms
0x01	3 ms	0x05	11 ms	0x09	19 ms	0x0d	27 ms
0x02	5 ms	0x06	13 ms	0x0a	21 ms	0x0e	29 ms
0x03	7 ms	0x07	15 ms	0x0b	23 ms	0x0f	31 ms

A.2 Short Circuit in Charge (SCC)

Table A-4. Short Circuit in Charge Threshold (Settings:AFE State Control [RSNS] = 0)(1)

Setting	Threshold	Setting	Threshold
0x00	–0.100 V	0x04	–0.300 V
0x01	–0.150 V	0x05	N/A
0x02	–0.200 V	0x06	N/A
0x03	–0.250 V	0x07	N/A

(1) Data flash setting Protection:*SCC Threshold*[2:0] sets the voltage threshold.

Table A-5. Short Circuit in Charge Threshold (Settings:AFE State Control [RSNS] = 1)(1)

Setting	Threshold	Setting	Threshold
0x00	–0.050 V	0x04	–0.150 V
0x01	–0.075 V	0x05	–0.175 V
0x02	–0.100 V	0x06	–0.200 V
0x03	–0.125 V	0x07	–0.225 V

(1) Data flash setting Protection:*SCC Threshold*[2:0] sets the voltage threshold.

Table A-6. Short Circuit in Charge Delay(1)

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	244 µs	0x08	488 µs	0x0c	732 µs
0x01	61 µs	0x05	305 µs	0x09	549 µs	0x0d	793 µs
0x02	122 µs	0x06	366 µs	0x0a	610 µs	0x0e	854 µs
0x03	183 µs	0x07	427 µs	0x0b	671 µs	0x0f	915 µs

(1) Data flash setting Protection:*SCC Threshold*[7:4] sets the delay time.

A.3 Short Circuit in Discharge (SCD1 and SCD2)

Table A-7. Short Circuit in Discharge Threshold (Settings:AFE State Control [RSNS] = 0)(1)

Setting	Threshold	Setting	Threshold
0x00	0.100 V	0x04	0.300 V
0x01	0.150 V	0x05	0.350 V
0x02	0.200 V	0x06	0.400 V
0x03	0.250 V	0x07	0.450 V

(1) Data flash setting Protection:*SCD1 and SCD2 Threshold*[2:0] sets the voltage threshold.

Table A-8. Short Circuit in Discharge Threshold (Settings:AFE State Control[RSNS] = 1)(1)

Setting	Threshold	Setting	Threshold
0x00	0.050 V	0x04	0.150 V
0x01	0.075 V	0x05	0.175 V
0x02	0.100 V	0x06	0.200 V

(1) Data flash setting Protection:*SCD1 and SCD2 Threshold*[2:0] sets the voltage threshold

Table A-9. Short Circuit in Discharge 1 Delay (Settings:AFE State Control[SCDDx2] = 0)(1)

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	244 µs	0x08	488 µs	0x0c	732 µs

(1) Data flash setting Protection:*SCD1 and SCD2 Threshold*[7:4] sets the delay time.

Table A-9. Short Circuit in Discharge 1 Delay (Settings:AFE State Control[SCDDx2] = 0)[(1)] (continued)

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x01	61 µs	0x05	305 µs	0x09	549 µs	0x0d	793 µs
0x02	122 µs	0x06	366 µs	0x0a	610 µs	0x0e	854 µs
0x03	183 µs	0x07	427 µs	0x0b	671 µs	0x0f	915 µs

Table A-10. Short Circuit in Discharge 1 Delay (Settings:AFE State Control[SCDDx2] = 1)[(1)]

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	488 µs	0x08	976 µs	0x0c	1464 µs
0x01	122 µs	0x05	610 µs	0x09	1098 µs	0x0d	1586 µs
0x02	244 µs	0x06	732 µs	0x0a	1220 µs	0x0e	1708 µs
0x03	366 µs	0x07	854 µs	0x0b	1342 µs	0x0f	1830 µs

(1) Data flash setting Protection:SCD1 Threshold[7:4] sets the delay time.

Table A-11. Short Circuit in Discharge 2 Delay (Settings:AFE State Control[SCDDx2] = 0)[(1)]

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	122 µs	0x08	244 µs	0x0c	366 µs
0x01	30 µs	0x05	152 µs	0x09	275 µs	0x0d	396 µs
0x02	61 µs	0x06	183 µs	0x0a	305 µs	0x0e	426 µs
0x03	91 µs	0x07	213 µs	0x0b	335 µs	0x0f	458 µs

(1) Data flash setting Protection: *SCD2 Threshold*[7:4] sets the delay time.

Table A-12. Short Circuit in Discharge 2 Delay (Settings:AFE State Control[SCDDx2] = 1)[(1)]

Setting	Time	Setting	Time	Setting	Time	Setting	Time
0x00	0 µs	0x04	244 µs	0x08	488 µs	0x0c	732 µs
0x01	61 µs	0x05	305 µs	0x09	549 µs	0x0d	793 µs
0x02	122 µs	0x06	366 µs	0x0a	610 µs	0x0e	854 µs
0x03	183µs	0x07	427 µs	0x0b	671 µs	0x0f	915 µs

(1) Data flash setting Protection: SCD2 Threshold[7:4] sets the delay time.

Reading and Writing to Data Flash

Use ManufacturerAccess() 0x01yy and ManufacturerInput() 0x2f to read and right to data flash, which is a 32-byte operation. First, determine the physical address of the target data flash parameter. This information is reflected by the subclass ID and offset, available in and .

Below is an example of updating data flash setting Protections:*CUV Recovery*

Subclass ID of Protections:*CUV Recovery* = 235

Offset of Protections:*CUV Recovery* = 3.

Data Type = I2.

1. Identify the data flash row number and byte index:
   (a) Identify the physical address of the target parameter.
   The physical address of Protections:*CUV Recovery* = Subclass ID + Offset = 238.
   (b) Find the row number of Protections:*CUV Recovery*.
   Each data flash row is 32-byte long.
   Row number of Protections:*CUV Recovery* = 238\32 = 7.
   (c) Find out which byte(s) the target parameter is resided at with the row.
   Byte Index = Physical location—(row number * row length).
   Byte Index for Protections:*CUV Recovery* = 238—(7*32) = 14.
   Since the data type of Protections:*CUV Recovery* is I2, this means the target parameter is resided at row 7, byte index 14 and 15.
2. Read data flash parameter:
   (a) Send the data flash row number to bq30z50/55 using MAC command 0x1yy.
   From step A2, the row number of *CUV Recovery* is 7.
   Issue SMBus write word. cmd = 0x00, word = 0x107.
   Note: the row number issue through command 0x1yy must be in Hex.
   (b) Use ManufacturerInput() 0x2f to read the data flash row where the target parameter is located.
   Issue SMBus block read, cmd = 0x2f, length = 32.
   Note: Store the read data into a memory array, e.g. yRowDataArray(0 to 31).
   (c) Data flash parameter Protections:CUV Recovery is located at yRowDataArrray(14) and yRowDataArrray(15).
3. Update data flash parameter.
   (a) From step B3, update the desire value of the target data flash parameter.
   (b) Follow step B1 to set up the row number.
   (c) Use ManufacturerInput() 0x2f to write the updated yRowDataArray(0 to 31) back to the device data flash.
   Issue SMBus block write, cmd = 0x2f, length = 32.
   (d) A read verify (repeat step B1 to B3) is recommend to ensure correct data is written to the data flash.

Sample Filter Settings

Table C-1. Sample Remcap Filter Settings and Associated Low-Pass Filter Time Constants

Remcap Smoothing Filter	Effective Low-Pass Time Constant
200	11 seconds
230	22 seconds
240	36 seconds
245	54 seconds
250	100 seconds
252	146 seconds
253	3.2 minutes
254	4.8 minutes
255 (max)	9.6 minutes

Table C-2. Sample V/I/T Filter Settings and Associated Low-Pass Filter Time Constants

V/I/T Smoothing Filter	Effective Low-Pass Time Constant
10	0.25 seconds
50	0.5 seconds
145	1 second
200	3 seconds

IMPORTANT NOTICE

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