# *bq20z90-V1.50 + bq29330, bq20z95*

# *Technical Reference*

Literature Number: SLUU264A
November 2006–Revised August 2007

TEXAS INSTRUMENTS

# Contents

# Preface

## 1.1 Read this First

This manual discusses modules and peripherals of the bq20z90/bq20z95 and the use with the bq29330 device to build a complete battery pack gas gauge and protection solution.

## 1.2 Notational Conventions

Following notation is used, if SBS commands and Data Flash values are mentioned within a text block:

- SBS commands are set in italic, e.g.: *Voltage*
- SBS bits and flags are capitalized, set in italic and enclosed with square brackets, e.g.: *[LED1]*
- Data Flash values are set in bold italic e.g.: **COV Threshold**
- All Data Flash bits and flags are capitalized, set in bold italic and enclosed with square brackets, e.g.: **[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:ManufacterAccess(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(0):COV Threshold(0), or

DF:Configuration:Registers(64):Operation A Cfg(0)[LED1].

# Detailed Description

## 2.1 1st Level Protection Features

The bq20z90/bq20z95 supports a wide range of battery and system protection features that are easily configured or enabled via the integrated data flash.

### *2.1.1 Cell Overvoltage and Cell Undervoltage*

The bq20z90/bq20z95 can detect cell overvoltage/undervoltage and protect battery cells from damage from battery cell overvoltage/undervoltage. If the over/under voltage remains over an adjustable time period, the bq20z90/bq20z95 goes into pack overvoltage/undervoltage condition and switches off the CHG/DSG FET. The bq20z90/bq20z95 recovers from a cell overvoltage condition if all the cell voltages drops below the cell overvoltage recovery threshold. The bq20z90/bq20z95 recovers from cell undervoltage condition if all the cell voltages rise above the cell undervoltage recovery threshold.

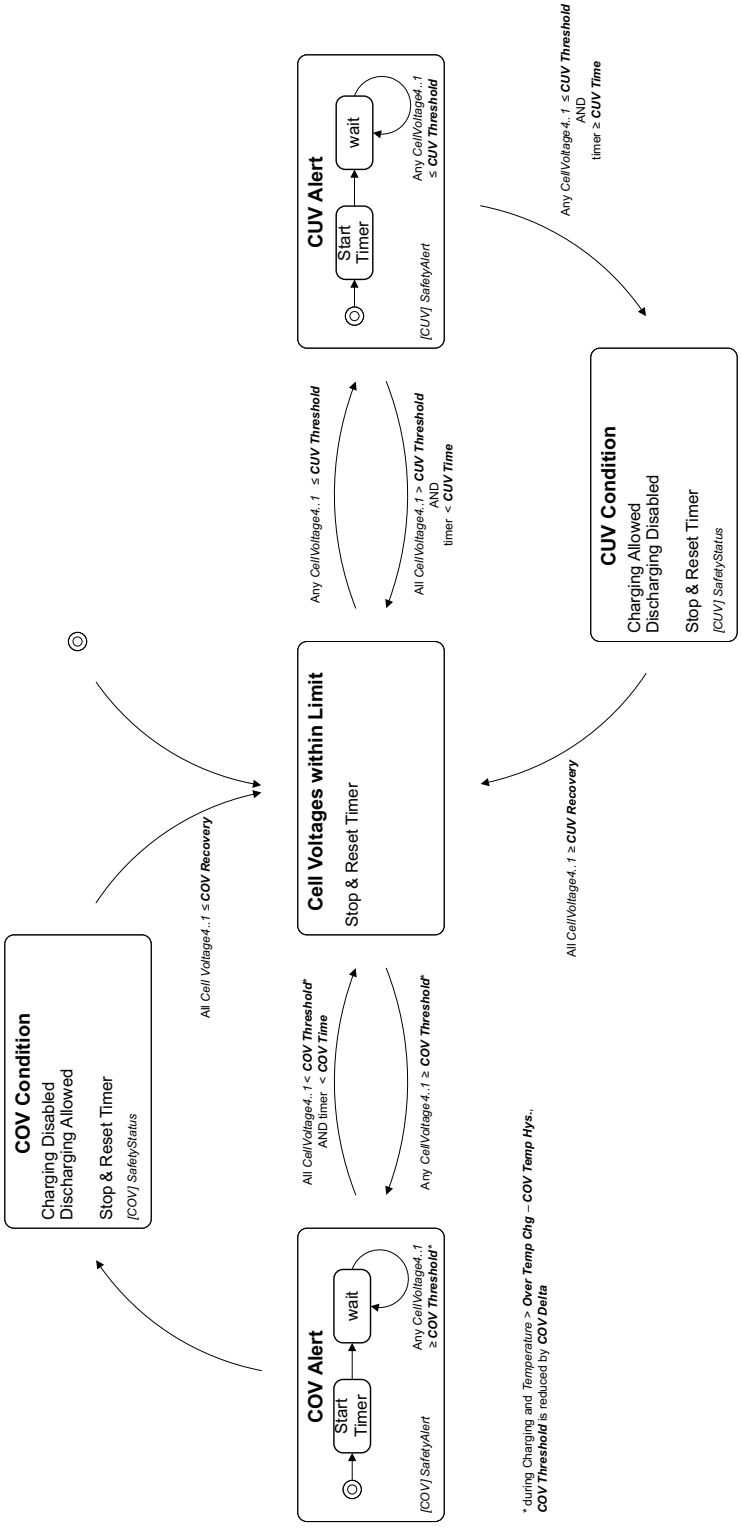


**Figure 2-1. COV and CUV**

**Table 2-1. COV and CUV**

| Condition: | | COV Condition | COV Alert | Normal | CUV Alert | CUV Condition |
|---|---|---|---|---|---|---|
| **Flags:** | *BatteryStatus* | *[TCA]* | | | | *[TDA], [FD]* |
| | *SafetyAlert* | | *[COV]* | | *[CUV]* | |
| | *SafetyStatus* | *[COV]* | | | | *[CUV]* |
| | *OperationStatus* | | | | | *[XDSG]* |
| **FET:** | | CHG FET disabled, enabled during discharge | normal | normal | normal | DSG FET disabled, enabled during charge |
| **SBS Command:** | *ChargingCurrent* | 0 | charging algorithm | charging algorithm | charging algorithm | `Pre-chg Current` |
| | *ChargingVoltage* | 0 | charging algorithm | charging algorithm | charging algorithm | charging algorithm |

The bq20z90/bq20z95 indicates cell over voltage by setting the *[COV]* flag in *SafetyAlert* if any *CellVoltage4..1* reaches or surpasses the `COV Threshold` limit during charging. The bq20z90/bq20z95 goes into cell over voltage condition and changes the *[COV]* flag in *SafetyAlert* to the *[COV]* flag in *SafetyStatus* if any of *CellVoltage4..1* stays above `COV Threshold` limit for a minimum time period of `COV Time`. This function is disabled if `COV Time` is set to zero.

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

The bq20z90/bq20z95 recovers from cell over voltage condition if all *CellVoltages4..1* are equal to or lower than `COV Recovery` limit. On recovery the *[COV]* flag in *SafetyStatus* is reset, *[TCA]* flag is reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate value per charging algorithm.

In cell over voltage condition the CHG FET is turned on during discharging to prevent overheating of the CHG FET body diode.

The bq20z90/bq20z95 indicates cell under voltage by setting the *[CUV]* flag in *SafetyAlert* if any *CellVoltage4..1* reaches or drops below the `CUV Threshold` limit during discharging. The bq20z90/bq20z95 goes into cell under voltage condition and changes the *[CUV]* flag in *SafetyAlert* to the *[CUV]* flag in *SafetyStatus* if any of *CellVoltage4..1* stays below `CUV Threshold` limit for a minimum time period of `CUV Time`. This function is disabled if `CUV Time` is set to zero.

In cell under voltage condition, discharging is disabled and DSG FET is turned off, *ChargingCurrent* is set to `Pre-chg Current`,the *[CUV]* flag in *SafetyAlert* is reset, the *[TDA]* and *[FD]* flags in *BatteryStatus* and the *[CUV]* flag in *SafetyStatus* are set.

The bq20z90/bq20z95 recovers from cell under voltage condition if all *CellVoltages4..1* are equal to or higher than `CUV Recovery` limit. On recovery the *[CUV]* flag in *SafetyStatus* is reset, *[XDSG]* flag is reset, the *[TDA]* and *[FD]* flags are reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate value per charging algorithm.

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

**Related Variables:**

- DF:1st Level Safety:Voltage(0):COV Threshold(0)
- DF:1st Level Safety:Voltage(0):COV Time(2)
- DF:1st Level Safety:Voltage(0):COV Recovery(3)
- DF:1st Level Safety:Voltage(0):CUV Threshold(12)
- DF:1st Level Safety:Voltage(0):CUV Time(14)
- DF:1st Level Safety:Voltage(0):CUV Recovery(15)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)

- SBS:BatteryStatus(0x16)[TCA],[TDA],[FD],[DSG]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[CUV],[COV]
- SBS:SafetyStatus(0x51)[CUV],[COV]
- SBS:OperationStatus(0x54)[XDSG]

### 2.1.2 Cell Overvoltage Threshold Compensation

In charging mode, the actual threshold for cell-overvoltage detection may be reduced, based on the SBS *Temperature* function. If `COV Delta` is set to zero, the compensation is disabled.

**Table 2-2. Cell Overvoltage Threshold Compensation**

| Temperature: | COV Threshold used: |
|---|---|
| ≤ `Over Temp Chg` - `COV Temp. Hys` | `COV Threshold` |
| > `Over Temp Chg` - `COV Temp. Hys` | `COV Threshold` - `COV Delta` |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):COV Threshold(0)
- DF:1st Level Safety:Voltage(0):COV Delta(5)
- DF:1st Level Safety:Voltage(0):COV Temp. Hys(6)
- DF:1st Level Safety:Temperature(2):Over Temp Chg(0)
- SBS:Temperature(0x08)

### 2.1.3 Pack Overvoltage and Undervoltage

The bq20z90/bq20z95 can detect battery pack overvoltage/undervoltage and protect the battery pack from damage from battery pack overvoltage/undervoltage. If the overvoltage/undervoltage remains over an adjustable time period, the bq20z90/bq20z95 goes into pack overvoltage/undervoltage condition and switches off the CHG/DSG FET. The bq20z90/bq20z95 recovers from a pack overvoltage condition if the pack voltage drops below the pack overvoltage recovery threshold and recovers from a pack undervoltage condition if the pack voltage rises above the pack undervoltage recovery threshold.

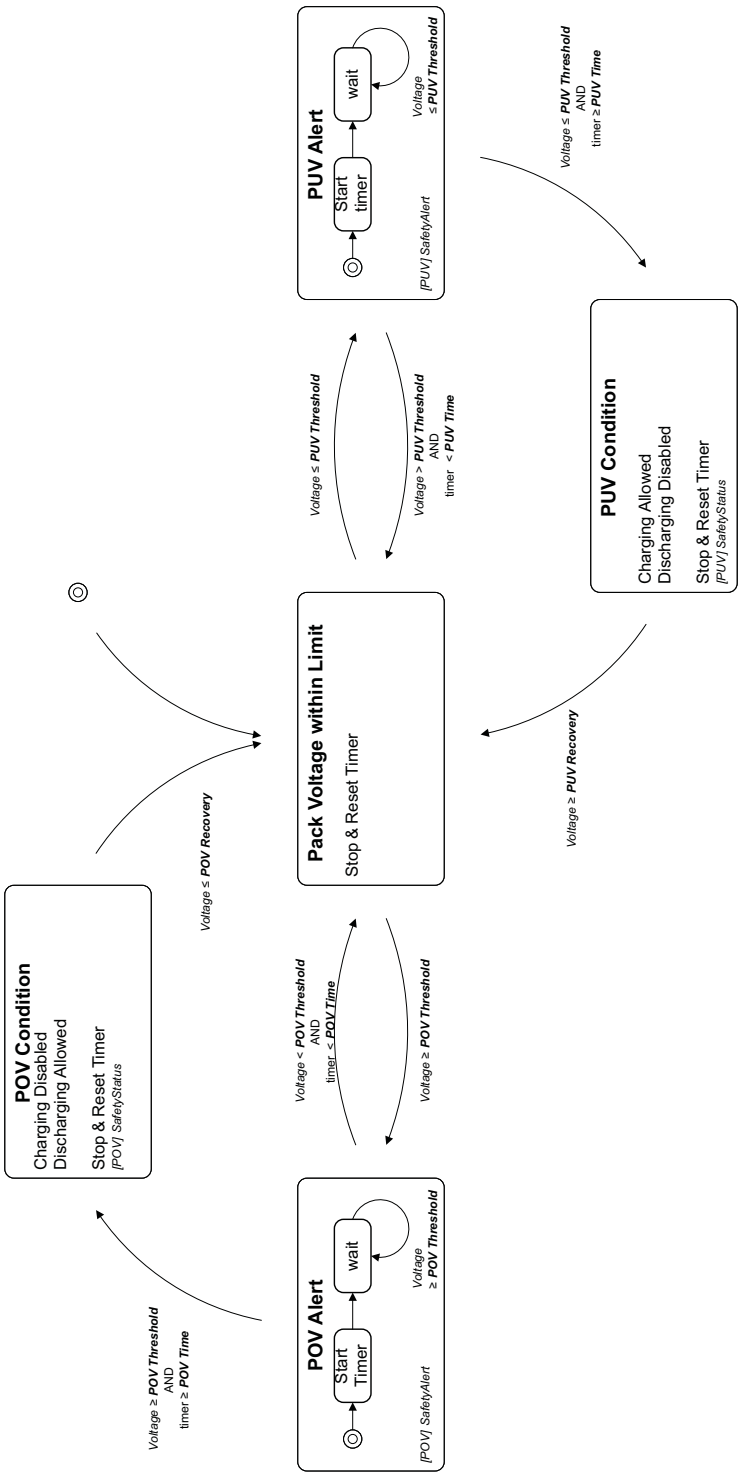


**Figure 2-2. POV and PUV**

**Table 2-3. POV and PUV**

| Condition: | | POV Condition | POV Alert | Normal | PUV Alert | PUV Condition |
|---|---|---|---|---|---|---|
| **Flags:** | *BatteryStatus* | *[TCA]* | | | | *[TDA], [FD]* |
| | *SafetyAlert* | | *[POV]* | | *[PUV]* | |
| | *SafetyStatus* | *[POV]* | | | | *[PUV]* |
| | *OperationStatus* | | | | | *[XDSG]* |
| **FET:** | | CHG FET disabled, enabled during discharge | normal | normal | normal | DSG FET disabled, enabled during charge |
| **SBS Command:** | *ChargingCurrent* | 0 | charging algorithm | charging algorithm | charging algorithm | `Pre-chg Current` |
| | *ChargingVoltage* | 0 | charging algorithm | charging algorithm | charging algorithm | charging algorithm |

The bq20z90/bq20z95 sets the pack over voltage *[POV]* flag in *SafetyAlert* if pack *Voltage* reaches or surpasses `POV Threshold` limit during charging. The bq20z90/bq20z95 changes *[POV]* in *SafetyAlert* to *[POV]* in *SafetyStatus*, if the pack *Voltage* stays above `POV Threshold` limit for a time period of `POV Time`. This function is disabled if `POV Time` is set to zero.

In pack overvoltage condition, charging is disabled and CHG FET is turned off, *ChargingCurrent* and *ChargingVoltage* are set to zero, *[POV]* flag in *SafetyAlert* is reset, *[TCA]* flag in *BatteryStatus* and *[POV]* flag in *SafetyStatus* are set.

The bq20z90/bq20z95 recovers from pack over voltage condition, if pack *Voltage* is equal to or below `POV Recovery` limit. On recovery *[POV]* flag in *SafetyStatus* is reset, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set back to appropriate value per charging algorithm.

In pack over voltage condition, the CHG FET is turned on during discharging to prevent overheating of the CHG FET body diode.

The bq20z90/bq20z95 sets the pack under voltage *[PUV]* flag in *SafetyAlert* if pack *Voltage* reaches or drops below `PUV Threshold` limit during discharging. The bq20z90/bq20z95 changes pack under voltage alert to pack undervoltage condition if pack voltage stays below `PUV Threshold` limit for a time period of `PUV Time`. This function is disabled if `PUV Time` is set to zero.

In pack under voltage condition, the discharging is disabled and the DSG FET is turned off, the ZVCHG FET is turned on (if configured), *ChargingCurrent* is set to ***Pre-chg Current***, *[PUV]* flag in *SafetyAlert* is reset, *[TDA]* and *[FD]* flags are set, *[XDSG]* flag is set, and *[PUV]* flag in *SafetyStatus* is set.

The bq20z90/bq20z95 recovers from pack under voltage condition, if the pack *Voltage* is equal to or above ***PUV Recovery*** limit. On recovery *[PUV]* flag in *SafetyStatus* is reset, *[XDSG]* flag is reset, *[TDA]* and [FD] flags are reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate value per charging algorithm.

In pack under voltage condition, the DSG FET is turned on during charging to prevent overheating of the DSG FET body diode.

**Related Variables:**

- DF:1st Level Safety:Voltage(0):POV Threshold(7)
- DF:1st Level Safety:Voltage(0):POV Time(9)
- DF:1st Level Safety:Voltage(0):POV Recovery(10)
- DF:1st Level Safety:Voltage(0):PUV Threshold(17)
- DF:1st Level Safety:Voltage(0):PUV Time(19)
- DF:1st Level Safety:Voltage(0):PUV Recovery(20)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- DF:Power:Power(68):Shutdown Voltage(2)
- DF:Power:Power(68):Shutdown Time(4)
- SBS:Voltage(0x09)
- SBS:ChargingCurrent(0x14)

- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA], [TDA], [FD], [DSG]
- SBS:SafetyAlert(0x50)[PUV], [POV]
- SBS:SafetyStatus(0x51)[PUV], [POV]
- SBS:OperationStatus(0x54)[XDSG]

### 2.1.4 Charge and Discharge Overcurrent

The bq20z90/bq20z95 has two independent tiers (levels) of overcurrent protection for charge and discharge. These two tiers require the *Current* value to be greater than or equal to a programmed OC Threshold in either charge or discharge current for a period greater than OC Time Limit. If the OC Time Limit for any of the overcurrent protections is set to 0, that specific feature is disabled.

**Table 2-4. Charge and Discharge Overcurrent**

| Protection | OC Threshold | OC Time Limit | OC Recovery Threshold | *SafetyAlert* Flag | *SafetyStatus* Flag |
|---|---|---|---|---|---|
| Tier-1 Charge | ***OC (1st Tier)Chg*** | ***OC(1st Tier) Chg Time*** | ***OC Chg Recovery*** | *[OCC]* | *[OCC]* |
| Tier-2 Charge | ***OC (2nd Tier) Chg*** | ***OC (2nd Tier) Chg Time*** | | *[OCC2]* | *[OCC2]* |
| Tier-1 Discharge | ***OC (1st Tier) Dsg*** | ***OC (1st Tier) Dsg Time*** | ***OC Dsg Recovery*** | *[OCD]* | *[OCD]* |
| Tier-2 Discharge | ***OC (2nd Tier) Dsg*** | ***OC (2nd Tier Dsg Time*** | | *[OCD2]* | *[OCD2]* |
| Tier-3 Discharge | ***AFE OC Dsg*** | ***AFE OC Dsg Time*** | ***AFE OC DsgRecovery*** for ***Current Recovery Time*** | - | *[AOCD]* |

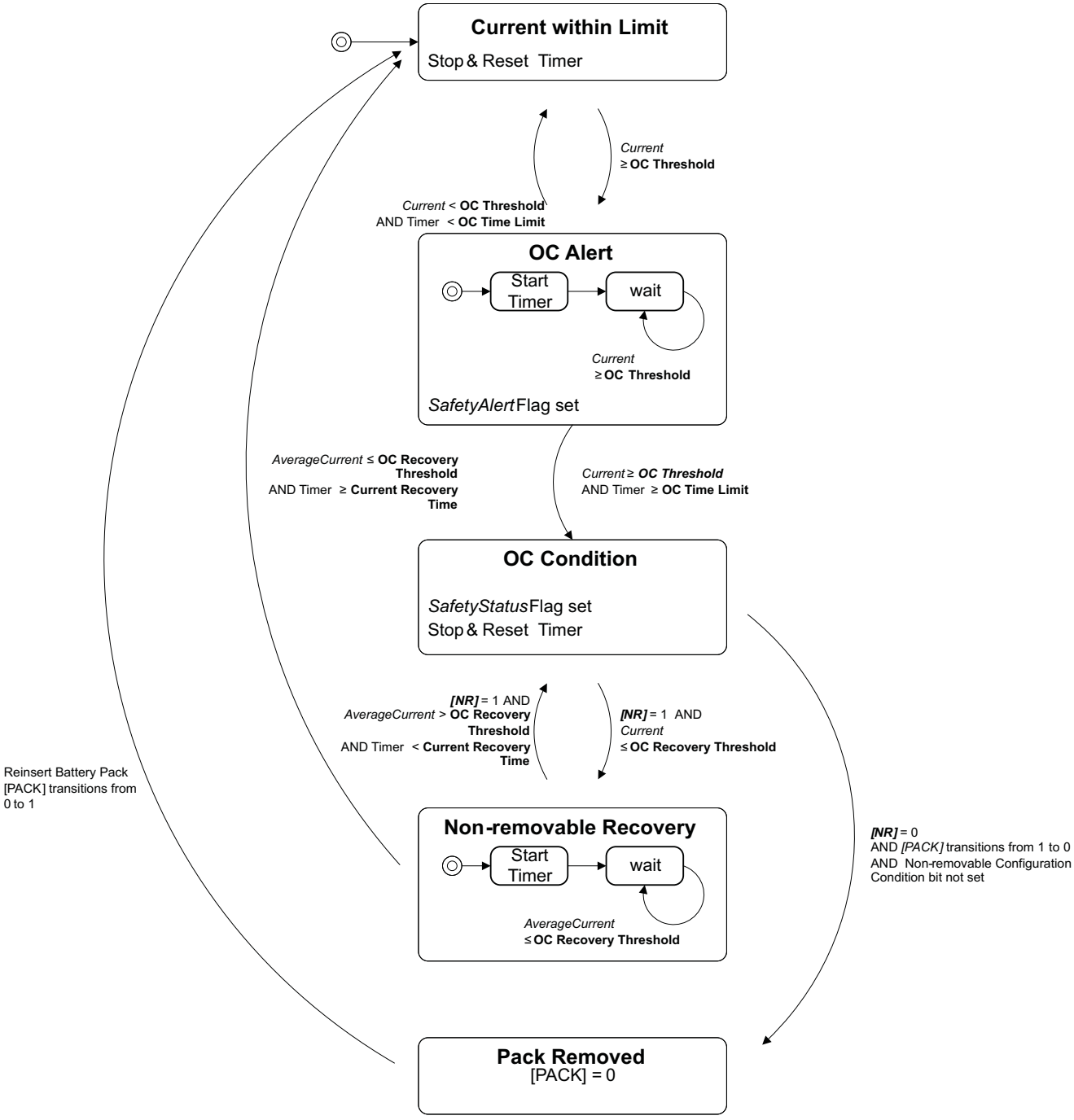


**Figure 2-3. OC Protection**

For the first two tiers of overcurrent protection, the specific flag in *SafetyAlert* is set if *Current* exceeds the OC Threshold. The bq20z90/bq20z95 changes the specific flag in *SafetyAlert* to the specific flag in *SafetyStatus* if the *Current* stays above the OC Threshold limit for at least OC Time Limit period. This function is disabled if the OC Time Limit is set to zero. The *SafetyStatus* flag is reset if the *Current* falls below the OC Recovery Threshold.

If the timer of any tier expires during charging, the CHG FET is turned off. When this occurs, the internal *AFE_Current_Fault* timer is started from 0, *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* flag is set and the appropriate *SafetyStatus* tier flag is set.

However, when the bq20z90/bq20z95 has either of *[OCC]* or *[OCC2]* flags in *SafetyStatus* set, the CHG FET is turned on again during discharge (*Current* ≤ (-) ***Dsg Current Threshold***). This prevents overheating of the CHG FET body diode during discharge. No other flags change state until full recovery is reached. This action is not affected by the setting of ***[NR]*** bit.

If the timer of either of the first two tiers expires during discharging, the DSG FET is turned off and the ZVCHG FET is turned on if used. When this occurs the *AFE_Current_Fault* timer is started from 0, *ChargingCurrent* is set to `Pre-chg Current`, *[XDSGI]* flag is set, *[TDA]* flag is set, and the correct tier flag is set in *SafetyStatus*.

When the bq29330 detects a discharge-overcurrent fault, the charge and discharge FETs are turned off, the XALERT pin of the bq20z90/bq20z95 is driven low by the XALERT pin of the bq29330, and the bq29330 is interrogated. When the bq20z90/bq20z95 identifies the overcurrent condition, the *AFE_Current_Fault* timer is started from 0, *[TDA]* flag is set, *ChargingCurrent* is set to 0, and *[AOCD]* is set.

However, when the bq20z90/bq20z95 has any of *[OCD]*, *[OCD2]*, *[AOCD]* set, the FETs are turned on again during charging (*Current* ≥ `Chg Current Threshold`). This prevents overheating of the discharge-FET body diode during charge. No other flags change state until full recovery is reached. This action is not affected by the state of ***[NR]*** bit.

**Table 2-5. Overcurrent Conditions**

| **Protection** | **Condition** | **Flags** | | | | **FET** | **Charging Current** | **Charging Voltage** |
|---|---|---|---|---|---|---|---|---|
| | | *SafetyAlert* | *SafetyStatus* | *BatteryStatus* | *OperationStatus* | | | |
| Tier-1 Charge | OC Alert | *[OCC]* | | | | normal | charging algorithm | charging algorithm |
| | OC Cond-ition | | *[OCC]* | *[TCA]* | | CHG FET disabled, enabled during discharge | 0 | 0 |
| Tier-2 Charge | OC Alert | *[OCC2]* | | | | normal | charging algorithm | charging algorithm |
| | OC Cond-ition | | *[OCC2]* | *[TCA]* | | CHG FET disabled, enabled during discharge | 0 | 0 |
| Tier-1 Dis-charge | OC Alert | *[OCD]* | | | | normal | charging algorithm | charging algorithm |
| | OC Cond-ition | | *[OCD]* | *[TDA]* | *[XDSGI]* | DSG FET disabled, enabled during charge | ***Pre-chg Current*** | charging algorithm |
| Tier-2 Dis-charge | OC Alert | *[OCD2]* | | | | normal | charging algorithm | charging algorithm |
| | OC Cond-ition | | *[OCD2]* | *[TDA]* | *[XDSGI]* | DSG FET disabled, enabled during charge | ***Pre-chg Current*** | charging algorithm |
| Tier-3 Dis-charge | OC Cond-ition | | *[AOCD]* | *[TDA]* | *[XDSGI]* | CHG FET and DSG FET disabled | 0 | charging algorithm |

The bq20z90/bq20z95 can individually configure each overcurrent-protection feature to recover via two different methods based on ***[NR]*** bit.

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

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

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

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

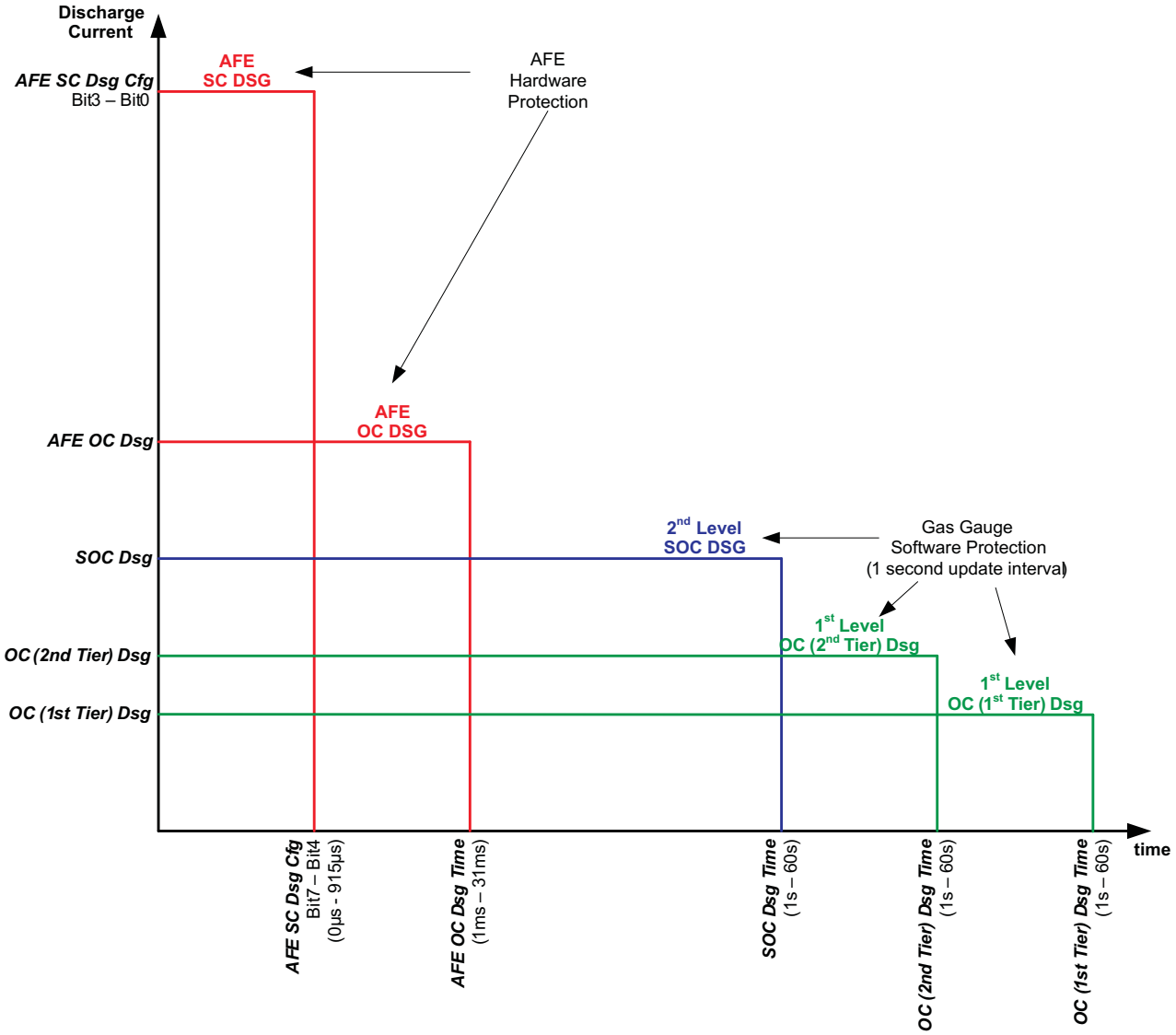


**Figure 2-4. Overcurrent Protection Levels**

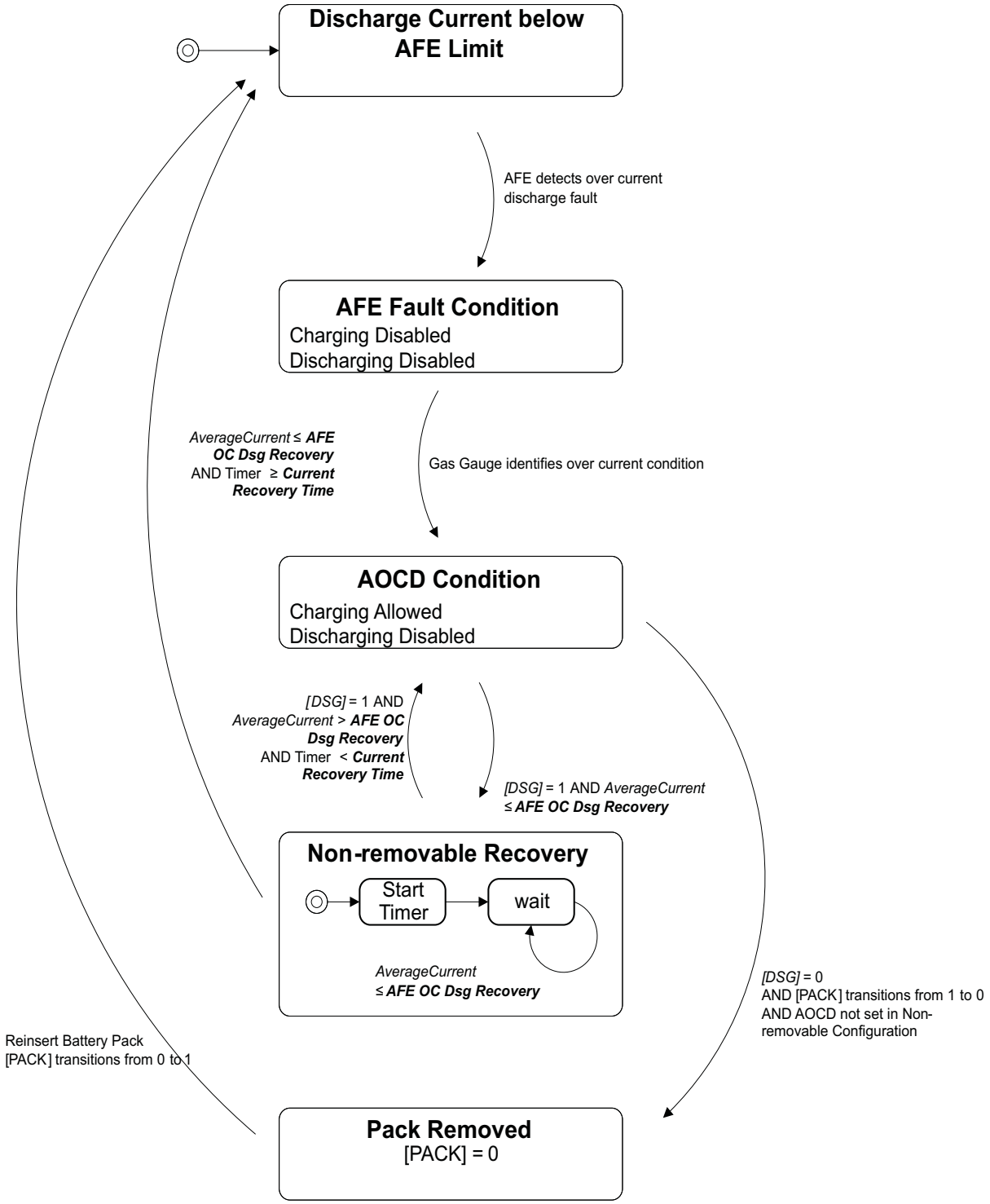


**Figure 2-5. AFE Discharge Over Current Protection**

**Related Variables:**

- DF:1st Level Safety:Current(1):OC(1st Tier) Chg(0)
- DF:1st Level Safety:Current(1):OC(1st Tier) Chg Time(2)
- DF:1st Level Safety:Current(1):OC Chg Recovery(3)
- DF:1st Level Safety:Current(1):OC(1st Tier) Dsg(5)

- DF:1st Level Safety:Current(1):OC(1st Tier) Dsg Time(7)
- DF:1st Level Safety:Current(1):OC Dsg Recovery(8)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Chg(10)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Chg Time(12)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Dsg(13)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Dsg Time(15)
- DF:1st Level Safety:Current(1):Current Recovery Time(16)
- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- DF:1st Level Safety:Current(1):AFE OC Dsg Time(18)
- DF:1st Level Safety:Current(1):AFE OC Dsg Recovery(19)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- DF:Configuration:Registers(64):Non-Removable Cfg(8)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyAlert(0x50)
- SBS:SafetyStatus(0x51)
- SBS:OperationStatus(0x54)[XDSGI]

### *2.1.5 Short-Circuit Protection*

The bq20z90/bq20z95 short-circuit protection is controlled by the bq29330, but is recovered by the bq20z90/bq20z95. This allows different recovery methods to accommodate various applications.

The bq29330 charge short-circuit and discharge short-circuit protection are configured by the bq20z90/bq20z95 data flash ***AFE SC Chg Cfg*** and ***AFE SC Dsg Cfg*** registers, respectively.

When the bq29330 detects a short circuit in charge or short circuit in discharge fault, the charge and discharge FETs are turned off, the XALERT pin of the bq20z90/bq20z95 is driven low by the XALERT pin of the bq29330 and the bq29330 is interrogated. When the bq20z90/bq20z95 identifies the short-circuit condition (charge or discharge current direction), the internal *AFE_Current_Fault* timer is started from 0, either *[TCA]* or *[TDA]* battery status is set, *ChargingCurrent* and *ChargingVoltage* is set to 0 and either *[SCC]* or *[SCD]* is set. If the short-circuit condition is in discharge, then *[XDSG]* flag is also set.

Each bq20z90/bq20z95 short-circuit protection feature can be individually configured to recover via two different methods, based on ***[NR]*** bit.

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

**Non-removable Battery Mode Recovery** is where ***[NR]*** = 1. The state of ***Non-Removable Cfg*** has no consequence when ***[NR]*** bit is set to 1. This recovery requires *AverageCurrent* to be $\leq$ ***AFE SC Recovery*** threshold and for the internal *AFE_Current_Fault* timer to be $\geq$ ***Current Recovery Time***.

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

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

**Table 2-6. Short Circuit Protection**

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

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE SC Chg Cfg(21)
- DF:1st Level Safety:Current(1):AFE SC Dsg Cfg(22)
- DF:1st Level Safety:Current(1):AFE SC Recovery(23)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- DF:Configuration:Registers(64):Non-Removable Cfg(8)
- SBS:AverageCurrent(0x0b)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyStatus(0x51)[SCC],[SCD]
- SBS:OperationStatus(0x54)[XDSG]

### *2.1.6 Overtemperature Protection*

The bq20z90/bq20z95 has overtemperature protection for both charge and discharge conditions.

The bq20z90/bq20z95 sets the over temperature charging *[OTC] SafetyAlert* flag, if pack temperature reaches or surpasses ***Over Temp Chg*** limit during charging. The bq20z90/bq20z95 changes *[OTC] SafetyAlert* to over temperature condition, if pack temperature stays above ***Over Temp Chg*** limit for a time period of ***OT Chg Time***. This function is disabled if ***OT Chg Time*** is set to zero.

If *[OTFET]* is set and bq20z90/bq20z95 is in *[OTC]* condition, charging is disabled and CHG FET is turned off, ZVCHG FET is turned off if configured for use, *ChargingCurrent* and *ChargingVoltage* are set to zero, the *[OTC]* flag in *SafetyAlert* is reset, *[TCA]* and *[OTC]* in *SafetyStatus* are set.

The bq20z90/bq20z95 recovers from an *[OTC]* condition if *Temperature* is equal to or below ***OTC Chg Recovery*** limit. On recovery the *[OTC]* flag in *SafetyStatus* is reset, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set back to their appropriate value per the charging algorithm, and the CHG FET returns to previous state.

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

The bq20z90/bq20z95 sets the over temperature discharging *[OTD] SafetyAlert* flag, if pack temperature reaches or surpasses ***Over Temp Dsg*** limit during discharging. The bq20z90/bq20z95 changes *[OTD] SafetyAlert* to over temperature condition, if pack temperature stays above ***Over Temp Dsg*** limit for a time period of ***OT Dsg Time***. This function is disabled if ***OT Dsg Time*** is set to zero.

If *[OTFET]* is set and bq20z90/bq20z95 is in *[OTD]* condition, discharging is disabled and DSG FET is turned off, *ChargingCurrent* is set to zero, the *[OTD] SafetyAlert* flag is reset, *[TDA]* is set, *[XDSG]* flag is set and the *[OTD]* flag in *SafetyStatus* is set.

The bq20z90/bq20z95 recovers from an *[OTD]* condition if pack temperature is equal to or below ***OTD Chg Recovery*** limit. On recovery *[OTD]* in *SafetyStatus* is reset, *[TDA]* is reset, *ChargingCurrent* is set back to the appropriate value per the charging algorithm, and the DSG FET is allowed to switch on again.

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

**Table 2-7. Overtemperature Protection**

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

**Related Variables:**

- DF:1st Level Safety:Temperature(2):Over Temp Chg(0)
- DF:1st Level Safety:Temperature(2):OT Chg Time(2)
- DF:1st Level Safety:Temperature(2):OT Chg Recovery(3)
- DF:1st Level Safety:Temperature(2):Over Temp Dsg(5)
- DF:1st Level Safety:Temperature(2):OT Dsg Time(7)
- DF:1st Level Safety:Temperature(2):OT Dsg Recovery(8)
- DF:Configuration:Registers(64):Operation Cfg B(2)[OTFET]
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyAlert(0x50)[OTC],[OTD]
- SBS:SafetyStatus(0x51)[OTC],[OTD]
- SBS:OperationStatus(0x54)[XDSG]

### *2.1.7 Host Watchdog*

The bq20z90/bq20z95 can be configured to require the host system to communicate with the battery periodically, else the battery disables charging and discharging. The Host Watchdog function is only active in Normal Power mode and is disabled if ***Host Watchdog Timeout*** is set to 0.

If the bq20z90/bq20z95 does not receive any valid SMBus communications for ***Host Watchdog Timeout*** period of time, the FETs are turned off, *ChargingVoltage* and *ChargingCurrent* are set to 0, *[TCA]* and *[TDA]* in *BatteryStatus*, *[XDSG]* in *OperationStatus*, and *[HWDG]* in *SafetyStatus* are all set.

For normal recovery to be achieved, normal SMBus communication must be resumed. When this occurs, the FETs are returned to the normal operating state, *[TCA]* and *[TDA]* in *BatteryStatus* are cleared, *ChargingCurrent* and *ChargingVoltage* are set to the appropriate value per the charging algorithm, and *[XDSG]* and *[HWDG]* are cleared.

**Related Variables:**

- DF:1st Level Safety:Host Comm(3):Host Watchdog Timeout(0)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyStatus(0x51)[HWDG]
- SBS:OperationStatus(0x54)[XDSG]

### 2.1.8 AFE Watchdog

The bq29330 automatically turns off the CHG FET, DSG FET and ZVCHG FET (if used), if the bq29330 does not receive the appropriate frequency on the WDI pin from bq20z90/bq20z95. The bq20z90/bq20z95 has no warning that this is about to happen, but it can report the occurrence once the bq20z90/bq20z95 is able to interrogate the bq29330.

When the XALERT input of the bq20z90/bq20z95 is triggered by the XALERT pin of the bq29330, the bq20z90/bq20z95 reads the STATUS register of the bq29330. If *[WDF]* is set, the bq20z90/bq20z95 also sets *[WDF]* in *SafetyStatus* and periodic verification of the bq29330 RAM is undertaken. If verification of the bq29330 RAM fails then the FETs will turn off. Verification of the bq29330 RAM will continue once every second. If the periodic verification passes, then *[WDF]* in *SafetyStatus* is cleared and the FETs return to normal operation.

**Related Variables:**

- SBS:SafetyStatus(0x51)[WDF]

## 2.2 2nd Level Protection Features

The bq20z90/bq20z95 provides features that can be used to indicate a more serious fault via the SAFE output. These outputs can be used to blow an in-line fuse to permanently disable the battery pack from charge or discharge activity.

If any PF Threshold condition is met, the appropriate flag is set in *PFAlert*. If the PF Threshold condition is cleared within the PF time limit, the appropriate PFAlert flag is cleared in *PFAlert*. But if the PF Threshold condition continues over the PF Time Limit or Alert Limit, then the bq20z90/bq20z95 goes into permanent failure condition and the appropriate flag is set in *PFStatus* and reset in *PFAlert*.

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

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

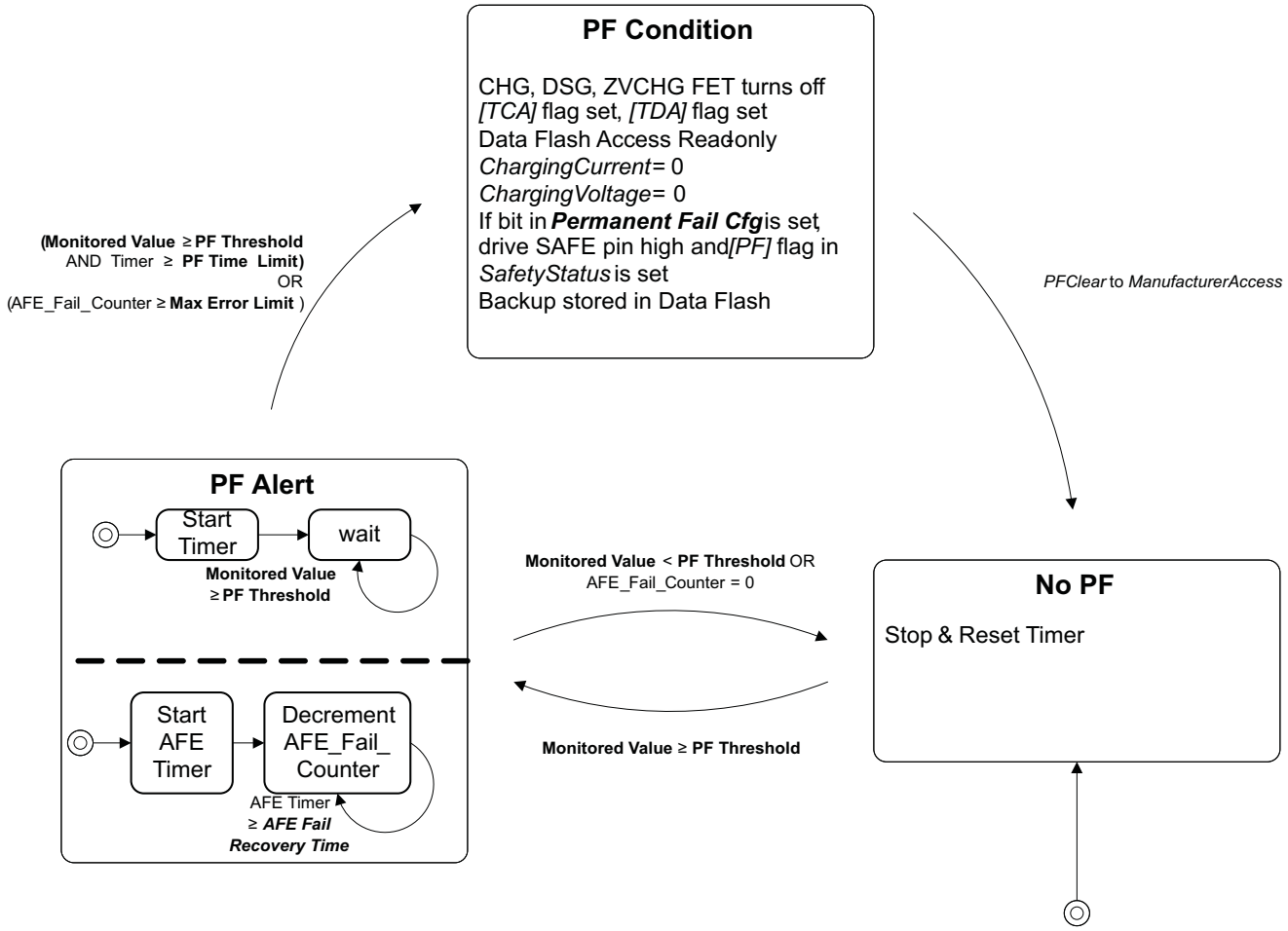


**Figure 2-6. 2nd Level Protection**

### 2.2.1 2nd Level (Permanent) Failure Actions

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

- CHG, DSG, and ZVCHG FETs are turned OFF.
- *[TCA], [TDA]* flags in *BatteryStatus* are set.
- A backup of SBS data and the complete memory map of the bq29330 is stored to data flash.
- Data Flash write access is then disabled, but the data flash can be read.
- *ChargingCurrent* and *ChargingVoltage* are set to 0.
- The appropriate bit in *PF Flags 1* is set.
- If the appropriate bit in ***Permanent Fail Cfg*** is set, then 0x3672 is programmed to ***Fuse Flag***, and the SAFE pin is driven and latched high. The*[PF]* flag in *SafetyStatus* is also set.

**Table 2-8. Permanent Fail Backup**

| SBS Value | Data Flash Backup |
|---|---|
| SBS:Voltage(0x09) | DF:PF Status:Device Status Data(96):PF Voltage(4) |
| SBS:CellVoltage4(0x3c) | DF:PF Status:Device Status Data(96):PF C4 Voltage(6) |
| SBS:CellVoltage3(0x3d) | DF:PF Status:Device Status Data(96):PF C3 Voltage(8) |
| SBS:CellVoltage2(0x3e) | DF:PF Status:Device Status Data(96):PF C2 Voltage(10) |

**Table 2-8. Permanent Fail Backup (continued)**

| SBS Value | Data Flash Backup |
|---|---|
| SBS:CellVoltage1(0x3f) | DF:PF Status:Device Status Data(96):PF C1 Voltage(12) |
| SBS:Current(0x0a) | DF:PF Status:Device Status Data(96):PF Current(14) |
| SBS:Temperature(0x08) | DF:PF Status:Device Status Data(96):PF Temperature(16) |
| SBS:BatteryStatus(0x16) | DF:PF Status:Device Status Data(96):PF Batt Stat(18) |
| SBS:RemainingCapacity(0x0f) | DF:PF Status:Device Status Data(96):PF RC-mAh(20) |
| | DF:PF Status:Device Status Data(96):PF RC-10mWh(22) |
| SBS:ChargingStatus(0x55) | DF:PF Status:Device Status Data(96):PF Chg Status(24) |
| SBS:SafetyStatus(0x51) | DF:PF Status:Device Status Data(96):PF Safety Status(26) |
| **bq29330 Memory Map** | |
| | DF:PF Status:AFE Regs(97):AFE Status(0) |
| | DF:PF Status:AFE Regs(97):AFE Output(1) |
| | DF:PF Status:AFE Regs(97):AFE State(2) |
| | DF:PF Status:AFE Regs(97):AFE Function(3) |
| | DF:PF Status:AFE Regs(97):AFE Cell Select(4) |
| | DF:PF Status:AFE Regs(97):AFE OLV(5) |
| | DF:PF Status:AFE Regs(97):AFE OLT(6) |
| | DF:PF Status:AFE Regs(97):AFE SCC(7) |
| | DF:PF Status:AFE Regs(97):AFE SCD(8) |

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)
- DF:PF Status:Device Status Data(96):PF Flags 2(28)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyStatus(0x51)[PF]
- SBS:PFStatus(0x53)

### 2.2.2 Time Limit Based Protection

bq20z90/bq20z95 reports a 2nd level protection alert by setting the appropriate flag in the *PFAlert* function if the monitored value reaches or rises above the Protection Threshold. If the monitored value stays above the Protection Threshold over the Max Alert duration, the bq20z90/bq20z95 reports a 2nd level permanent failure, clears the appropriate *PFAlert* flag, and sets the appropriate *PFStatus* flag. See the table for all Protection Thresholds and Max Alert durations.

**Safety Overvoltage Protection—**The bq20z90/bq20z95 monitors the pack voltage for extreme values.

**Cell Imbalance Fault—**The bq20z90/bq20z95 starts cell imbalance fault detection when *Current* is lesser or equal to ***Cell Imbalance Current*** for ***Battery Rest Time*** period AND All (*CellVoltage4..1*) > ***Min CIM-check voltage***. The difference between highest cell voltage and lowest cell voltage is monitored. If ***Battery Rest Time*** is set to zero or ***Cell Imbalance Time*** is set to zero, this function is disabled.

**2nd Level Protection IC Input—**The $\overline{\text{PFIN}}$ input of the bq20z90/bq20z95 can be used to determine the state of an external protection device such as the bq294xx. The bq20z90/bq20z95 watches for $\overline{\text{PFIN}}$ pin being driven low by an external device.

**Safety Overcurrent Protection—** The bq20z90/bq20z95 monitors the current during charging and discharging. The overcurrent thresholds and time limits can be set independently for charging and discharging.

**Safety Overtemperature Protection—** The bq20z90/bq20z95 monitors the pack temperature during charging and discharging. The overtemperature thresholds and time limits can be set independently for charging and discharging.

**Open Thermistor—** The bq20z90/bq20z95 can detect an open thermistor condition if the temperature function reports extreme temperature values.

**Charge and Zero-Volt Charge FET Fault Protection—** The bq20z90/bq20z95 monitors if there is, at any time, an attempt to turn off the CHG FET or ZVCHG FET or the CHG bit in the bq29330 OUTPUT register is set and the current still continues to flow.

**Discharge FET Fault Protection—** The bq20z90/bq20z95 monitors if there is, at any time, an attempt to turn off the DSG FET or the DSG bit in the bq29330 OUTPUT register is set and the current still continues to flow.

**Fuse State Detection—** The bq20z90/bq20z95 can detect if an attempt has been made to blow the fuse, but this has failed. The bq20z90/bq20z95 monitors if the ***Fuse Flag*** is set to 0x3672 and current is still flowing.

**Table 2-9. Time Limit Based 2nd Level Protection**

| Protection | Monitored Value | Requirement | PF Threshold | PF Time Limit (set to 0 to disable Protection) | *PFAlert* Flag, *PFStatus* Flag, | *Permanent Fail Cfg* Flag |
|---|---|---|---|---|---|---|
| Safety Overvoltage | *Voltage* | - | ***SOV Threshold*** | ***SOV Time*** | *[SOV]* | *[XSOV]* |
| Cell Imbalance Fault | Difference of highest and lowest of *CellVoltage4..1* | *Current* ≤ ***Cell Imbalance Current*** for ***Battery Rest Time*** AND All (*CellVoltage4..1*) > ***Min CIM-check voltage*** | ***Cell Imbalance Fail Voltage*** | ***Cell Imbalance Time*** | *[CIM]* | *[XCIM]* |
| 2nd Level Protection IC Input | $\overline{\text{PFIN}}$ pin | - | $\overline{\text{PFIN}}$ pin low | ***PFIN Detect Time*** | *[PFIN]* | *[XPFIN]* |
| Safety Overcurrent Charge | *Current* | *Current* > 0 | ***SOC Chg*** | ***SOC Chg Time*** | *[SOCC]* | *[XSOCC]* |
| Safety Overcurrent Discharge | (-)*Current* | *Current* < 0 | ***SOC Dsg*** | ***SOC Dsg Time*** | *[SOCD]* | *[XSOCD]* |
| Safety Overtemperature Chg | *Temperature* | *Current* > 0 | ***SOT Chg*** | ***SOT Chg Time*** | *[SOTC]* | *[XSOTC]* |
| Safety Overtemperature Dsg | *Temperature* | *Current* < 0 | ***SOT Dsg*** | ***SOT Dsg Time*** | *[SOTD]* | *[XSOTD]* |
| Open Thermistor | *Temperature* | - | ***Open Thermistor*** | ***Open Time*** | *[OTS]* | *[XOTS]* |
| Charge and Zero-Volt Charge FET Fault | *Current* | (CHG FET or ZVCHG FET turn off attempt or CHG Flag in bq29330 OUTPUT register set) and *Current* >0 | ***FET Fail Limit*** | ***FET Fail Time*** | *[CFETF]* | *[XCFETF]* |
| Discharge FET Fault | (-)*Current* | (DSG FET turn off attempt or DSG Flag in bq29330 OUTPUT register set) and *Current* < 0 | ***FET Fail Limit*** | ***FET Fail Time*** | *[DFETF]* | *[XDFETF]* |
| Fuse State | \|*Current*\| | ***Fuse Flag*** = 0x3672 | ***Fuse Fail Limit*** | ***Fuse Fail Time*** | *[FBF]* | *[XFBF]* |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SOV Threshold(0)
- DF:2nd Level Safety:Voltage(16):SOV Time(2)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(4)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(6)

- DF:2nd Level Safety:Voltage(16):Battery Rest Time(7)
- DF:2nd Level Safety:Voltage(16):Min CIM-check voltage(9)
- DF:2nd Level Safety:Voltage(16):PFIN Detect Time(11)
- DF:2nd Level Safety:Current(17):SOC Chg(0)
- DF:2nd Level Safety:Current(17):SOC Chg Time(2)
- DF:2nd Level Safety:Current(17):SOC Dsg(3)
- DF:2nd Level Safety:Current(17):SOC Dsg Time(5)
- DF:2nd Level Safety:Temperature(18):SOT Chg(0)
- DF:2nd Level Safety:Temperature(18):SOT Chg Time(2)
- DF:2nd Level Safety:Temperature(18):SOT Dsg(3)
- DF:2nd Level Safety:Temperature(18):SOT Dsg Time(5)
- DF:2nd Level Safety:Temperature(18):Open Thermistor(6)
- DF:2nd Level Safety:Temperature(18):Open Time(8)
- DF:2nd Level Safety:FET Verification(19):FET Fail Limit(0)
- DF:2nd Level Safety:FET Verification(19):FET Fail Time(2)
- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Limit(0)
- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Time(2)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- SBS:Temperature(0x08)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:PFStatus(0x53)

### *2.2.3 Limit Based Protection*

The bq20z90/bq20z95 reports a 2nd level permanent failure and sets the appropriate *PFStatus* flag if the internal error counter reaches the max error limit. The internal error counter is incremented by one if the error happens and decremented by one each fail recovery period.

**bq29330 AFE Communication Fault Protection—** The bq20z90/bq20z95 periodically validates its read and write communications with the bq29330. If either a read or write verify fails, an internal AFE_Fail_Counter is incremented. If the AFE_Fail_Counter reaches ***AFE Fail Limit***, the bq20z90/bq20z95 reports a *[AFE_C]* permanent failure. If the ***AFE Fail Limit*** is set to 0, this feature is disabled. An *[AFE_C]* fault can also be declared if, after a full reset, the initial gain and offset values read from the AFE cannot be verified. These values are A/D readings of the bq29330 VCELL output. The bq29330 offset values are verified by reading the values twice and confirming that the readings are within acceptable limits. The max difference between 2 readings is set with ***AFE Init Limit***. The maximum number of read retries, if offset and gain value verification fails and *[AFE_C]* fault is declared, is set in ***AFE Fail Limit***.

**Periodic bq29330 AFE Verification—** The bq20z90/bq20z95 periodically (***AFE Check Time***) compares certain RAM content of the bq29330 AFE with that of the bq20z90/bq20z95 data flash and the expected control-bit states. This function is disabled if ***AFE Check Time*** is set to 0. If an error is detected, the internal AFE_Fail_Counter is incremented. If the internal AFE_Fail_Counter reaches the ***AFE Fail Limit***, the bq20z90/bq20z95 reports a permanent failure.

**bq29330 AFE Init Verification—** After a full reset the bq20z90/bq20z95 and the AFE offset and gain values are read twice and compared. The ***AFE Init Limit*** sets the maximum difference in A/D counts of two successful readings of offset and gain, which the bq20z90/bq20z95 still considers as the same value. If the gain and offset values are still not considered the same after ***AFE Init Retry Limit*** comparison retries, the bq20z90/bq20z95 reports a permanent failure error.

**Data Flash Failure—** The bq20z90/bq20z95 can detect if the data flash is not operating correctly. A permanent failure is reported when either: (i) After a full reset the instruction flash checksum does not verify; (ii) if any data flash write does not verify; or (iii) if any data flash erase does not verify.

**Table 2-10. Error Based 2nd Level Protection**

| Protection | Monitored Value | Fail Recovery | Max Error Limit (set to 0 to disable Protection) | *PFAlert* Flag, *PFStatus* Flag, | *Permanent Fail Cfg* Flag |
|---|---|---|---|---|---|
| AFE Communication Fault | Periodic Communication with bq29330 | decrement of internal AFE_Fail_Counter by one per ***AFE Fail Recovery Time*** period | ***AFE Fail Limit*** | *[AFE_C]* | ***[XAFE_C]*** |
| Periodic AFE Verification | Check RAM of bq29330 with ***AFE Check Time*** period | decrement of internal AFE_Fail_Counter by one per ***AFE Fail Recovery Time*** period | ***AFE Fail Limit*** | *[AFE_P]* | ***[XAFE_P]*** |
| AFE Initialization | Initial gain and offset values from bq29330 after full reset | - | ***AFE Init Retry Limit*** | *[AFE_C]* | ***[XAFE_C]*** |
| Data Flash Failure | Data Flash | - | false flash checksum after reset, data flash write not verified, data flash erase not verified | *[DFF]* | ***[XDFF]*** |

**Related Variables:**

- DF:2nd Level Safety:FET Verification(19):FET Fail Limit(0)
- DF:2nd Level Safety:FET Verification(19):FET Fail Time(2)
- DF:2nd Level Safety:AFE Verification(20):AFE Check Time(0)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Recovery Time(2)
- DF:2nd Level Safety:AFE Verification(20):AFE Init Retry Limit(3)
- DF:2nd Level Safety:AFE Verification(20):AFE Init Limit (4)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- SBS:PFStatus(0x53)

### *2.2.4 Clearing Permanent Failure*

The bq20z90/bq20z95 permanent failure can be cleared by sending two *ManufacturerAccess* commands in sequence: the first word of the *PFKey* followed by the second word of the *PFKey*. After sending these two commands in sequence, *PFStatus* flags are cleared. Refer to Permanent Fail Clear (*PFKey*) Manufacturer access for further details.

**Related Variables:**

- SBS:ManufacturerAccess(0x00)
- SBS:PFStatus(0x53)

## 2.3 Gas Gauging

The bq20z90/bq20z95 measures individual cell voltages, pack voltage, temperature, and current using features of the bq29330 AFE device. The bq20z90/bq20z95 determines battery state of charge by analyzing individual cell voltages when a time exceeding 35 minutes has passed since the batteries last charge or discharge activity. The bq20z90/bq20z95 measures charge and discharge activity by monitoring the voltage across a small-value series sense resistor (10 mΩ typ.) between the cell stack negative terminal and the negative terminal of the battery pack. The battery state of charge is subsequently adjusted during load or charger application using the integrated charge passed through the battery.

### 2.3.1 Impedance Track Configuration

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

**Load Select—** In order to compensate for the I x R drop near the end of discharge, the bq20z90/bq20z95 needs to be configured for whatever current (or power) will flow in the future. While it can not be exactly known, the bq20z90/bq20z95 can use load history such as the average current of the present discharge to make a sufficiently accurate prediction. The bq20z90/bq20z95 can be configured to use several methods of this prediction by setting the ***Load Select*** value. Because this estimate has only a second-order effect on remaining capacity accuracy, different measurement based methods (0x00 to 0x03) result in only minor differences in accuracy. However, methods 0x04 - 0x06, where an estimate is arbitrarily assigned by the user, can result in significant error if a fixed estimate is far from the actual load.

| | **Constant Current** (***Load Mode*** = 0) | **Constant Power** (***Load Mode*** = 1) |
|---|---|---|
| 0 = | ***Avg I Last Run*** | ***Avg P Last Run*** |
| 1 = | present average discharge current | present average discharge power |
| 2 = | *Current* | *Current* x *Voltage* |
| 3 = | *AverageCurrent* (default) | *AverageCurrent* x average *Voltage* |
| 4 = | ***Design Capacity*** / 5 | ***Design Energy*** / 5 |
| 5 = | *AtRate* (mA) | *AtRate* (10 mW) |
| 6 = | ***User Rate-mA*** | ***User Rate-mW*** |

**Pulsed Load Compensation and Termination Voltage—** In order to take into account pulsed loads, while calculating remaining capacity until ***Term Voltage*** threshold is reached, the bq20z90/bq20z95 monitors not only average load but also short load spikes. The maximum voltage deviation during a load spike is continuously updated during discharge and stored in ***Delta Voltage***.

**Reserve Battery Capacity—** The bq20z90/bq20z95 allows an amount of capacity to be reserved in either mAh (***Reserve Cap-mAh***, ***Load Mode*** = 0) or 10 mWh (***Reserve Cap-mWh***, ***Load Mode*** = 1) units between the point where *RemainingCapacity* function reports zero capacity, and the absolute minimum pack voltage, ***Term Voltage***. This enables a system to report zero energy, but still have enough reserve energy to perform a controlled shutdown, or to provide an extended sleep period for the host system.

Also, if ***[RESCAP]*** bit is set to 0, the reserve capacity is compensated at a no-load condition. However, if ***[RESCAP]*** bit is set to 1, then the reserve capacity is compensated at the present discharge rate as selected by ***Load Select***.

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- DF:Configuration:Operation Cfg B(2)[RESCAP]
- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- DF:Gas Gauging:IT Cfg(80):Term Voltage(45)
- DF:Gas Gauging:IT Cfg(80):User Rate-mA(60)
- DF:Gas Gauging:IT Cfg(80):User Rate-mW(62)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(64)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(66)
- DF:Gas Gauging:State(82):Avg I Last Run(21)
- DF:Gas Gauging:State(82):Avg P Last Run(23)

- DF:Gas Gauging:State(82):Delta Voltage(25)
- SBS:BatteryMode(0x03)[CapM]
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:OperationStatus(0x54)[LDMD]

### 2.3.2 Gas Gauge Modes

Resistance updates take place only in discharge mode, while OCV and Qmax updates only take place in relaxation mode. Entry and exit of each mode is controlled by data flash parameters in the subclass 'Gas Gauging: Current Thresholds' section. In Relaxation Mode or Discharge Mode, the DSG flag in *BatteryStatus* is set.

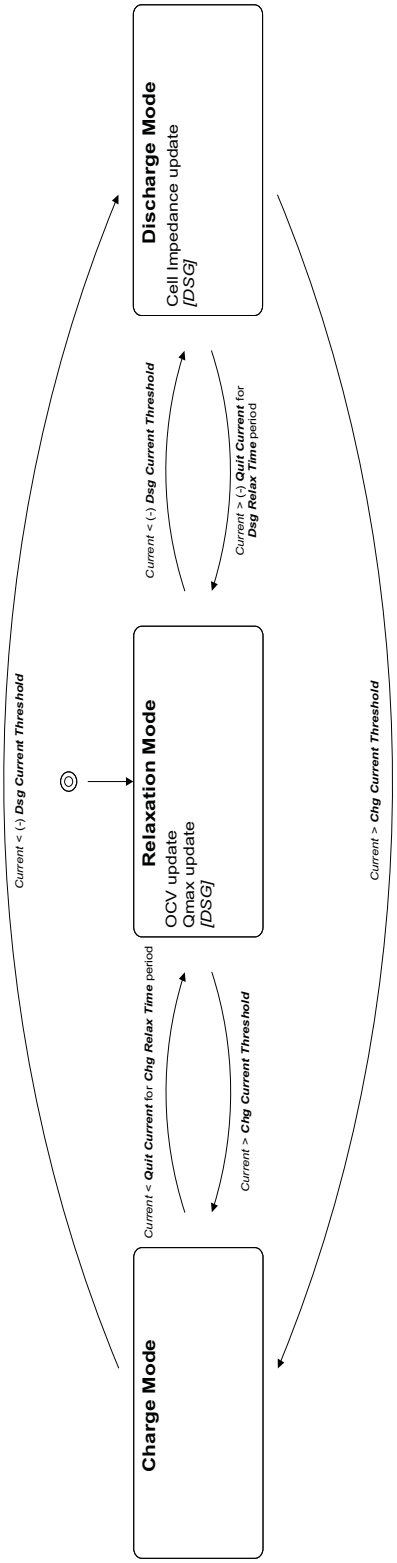


**Figure 2-7. Gas Gauge Operating Modes**

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

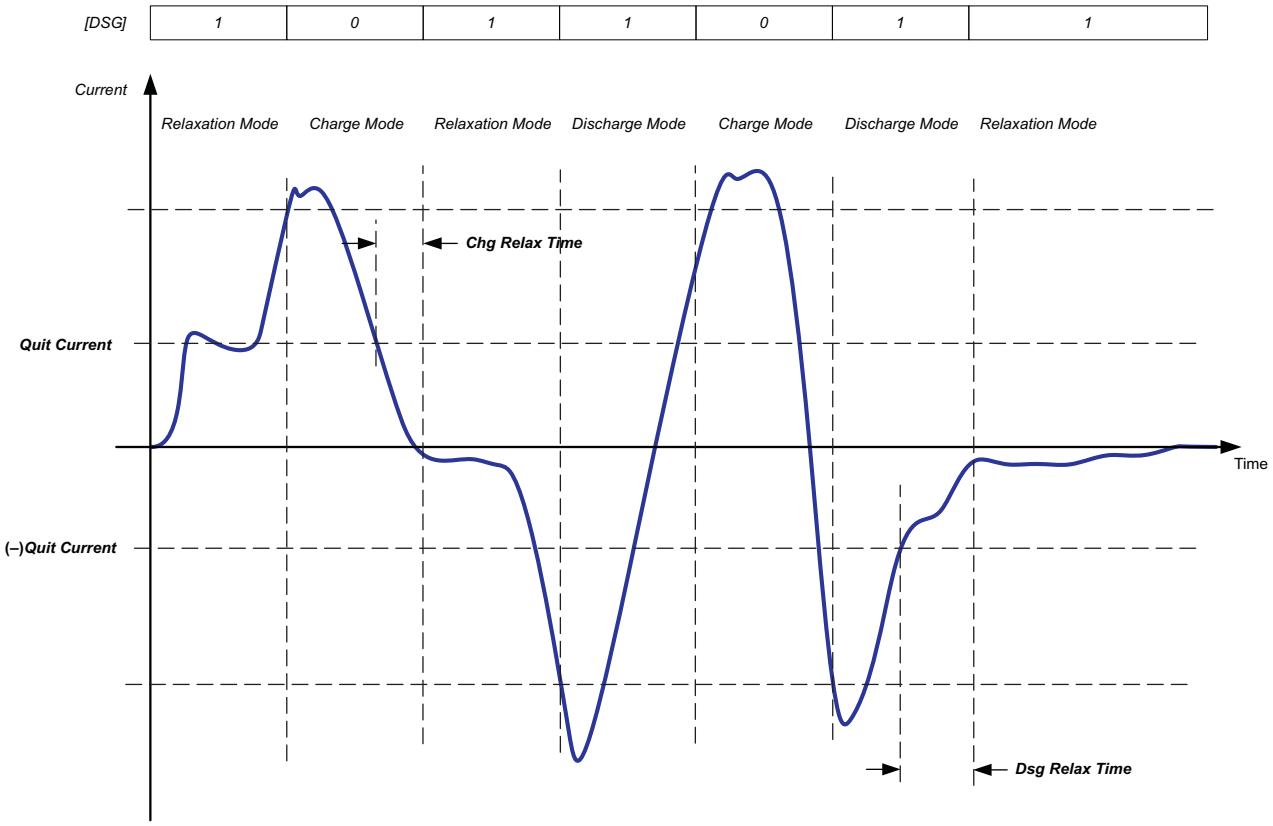


**Figure 2-8. Gas Gauge Operating Mode Example**

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Dsg Current Threshold(0)
- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- DF:Gas Gauging:Current Thresholds(81):Quit Current(4)
- DF:Gas Gauging:Current Thresholds(81):Dsg Relax Time(6)
- DF:Gas Gauging:Current Thresholds(81):Chg Relax Time(7)
- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:OperationStatus(0x54)[VOK],[R_DIS],[QEN]

### *2.3.3 Qmax*

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

Measurements of OCV and charge integration determine chemical state of charge and Chemical Capacity (*Qmax*).

The bq20z90/bq20z95 acquires and updates the battery-impedance profile during normal battery usage. It uses this profile, along with state-of-charge and the *Qmax* values, to determine *FullChargeCapacity* and *RelativeStateOfCharge* specifically for the present load and temperature. *FullChargeCapacity* reports a capacity or energy available from a fully charged battery reduced by ***Reserve Cap-mAh*** or ***Reserve Cap-mWh*** under the present load and present temperature until *Voltage* reaches the ***Term Voltage*** .

**Related Variables:**

- DF:Gas Gauging:IT Config(80):Term Voltage(45)
- SBS:Voltage(0x09)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:FullChargeCapacity(0x10)

#### 2.3.3.1 Qmax initial Values

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

See "Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm" application note (SLUA364) for further details.

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:Gas Gauging:State(82):Qmax Cell 0(0)
- DF:Gas Gauging:State(82):Qmax Cell 1(2)
- DF:Gas Gauging:State(82):Qmax Cell 2(4)
- DF:Gas Gauging:State(82):Qmax Cell 3(6)
- DF:Gas Gauging:State(82):Qmax Pack(8)
- SBS:DesignCapacity(0x18)

#### 2.3.3.2 Qmax Update Conditions

The bq20z90/bq20z95 updates the no-load full capacity (QMAX) when two open circuit voltage (OCV) readings are taken. These OCV readings are taken when the battery is in a relaxed state before and after charge or discharge activity. A relaxed state is achieved if the battery voltage has a dV/dt of < 4 µV/s. Typically it takes 2 hrs in a charged state and 5 hrs in a discharged state to ensure that the dV/dt condition is satisfied. If 5 hrs is exceeded, a reading will be taken even if the dV/dt condition was not satisfied. A QMAX update is disqualified under the following conditions:

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

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

**Voltage—** If *CellVoltage4..1* is within the range of 3737mV and 3800mV for the default LION chemistry. (Refer to "Support of Multiple Li-Ion Chemistries w/Impedance Track(TM) Gas Gauges", application note, (SLUA372) for the voltage ranges of other chemistries.)

**Related Variables:**

- SBS:Temperature(0x08)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:OperationStatus(0x54)[VOK],[QEN]

## 2.4 Charge Control

The bq20z90/bq20z95 can report the appropriate charging current needed for the constant charging current and the charging voltage needed for constant voltage charging per charging algorithm to a smart charger using the *ChargingCurrent* and the *ChargingVoltage* functions. The actual charging status of bq20z90/bq20z95 is indicated with flags and can be read out with the *ChargingStatus* function.

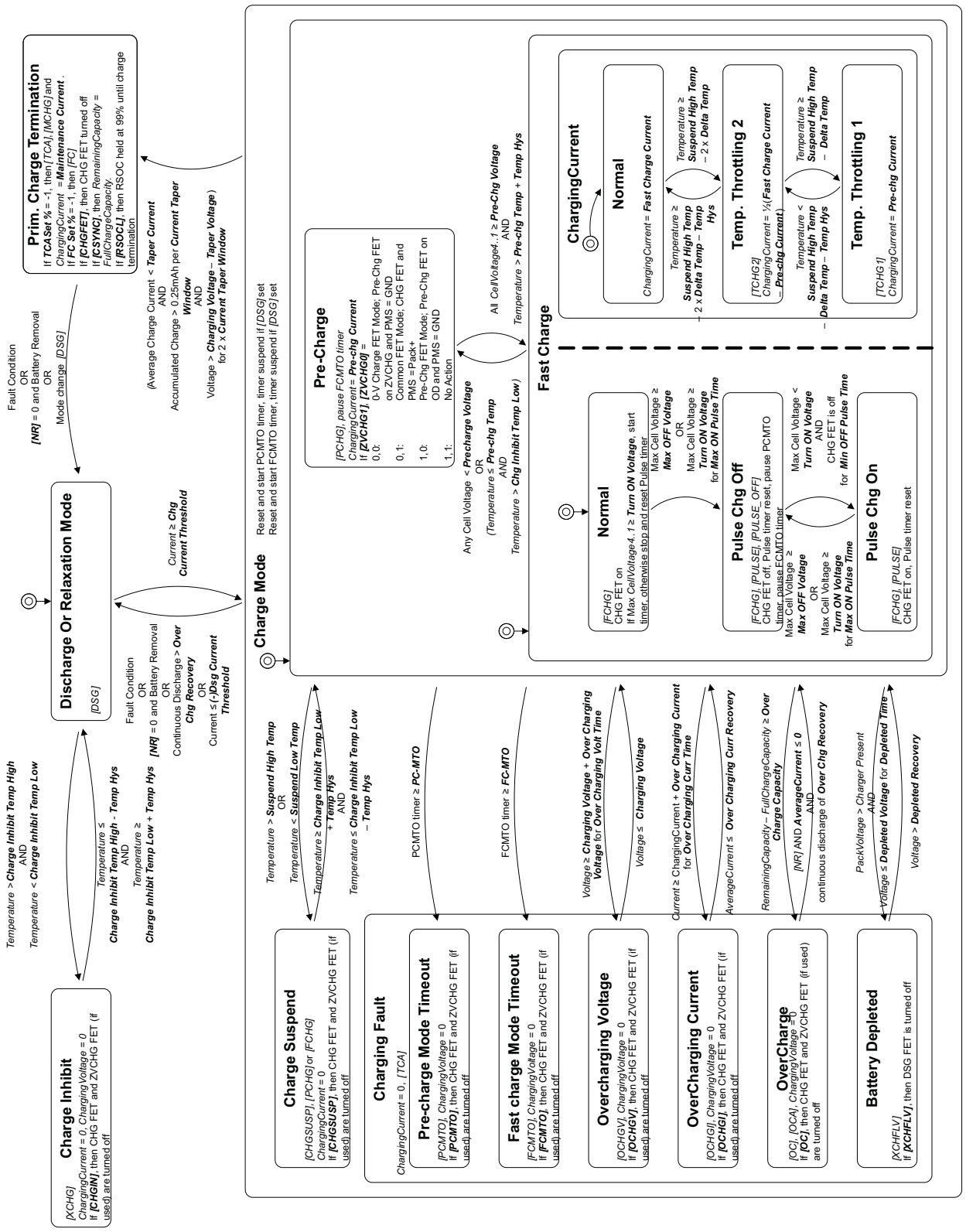


**Figure 2-9. Charging**

- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)

- SBS:ChargingStatus(0x55)

### 2.4.1 Charge Control SMBus Broadcasts

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

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[CPE],[HPE],[BCAST]
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OCA],[TCA],[OTA],[TDA],[RCA],[RTA]

### 2.4.2 Cell Balancing

The bq20z90/bq20z95 can determine the chemical state of charge of each cell using the Impedance Track™ algorithm. The cell balancing algorithm used in the bq20z90/bq20z95 decreases the differences in imbalanced cells in a fully charged state gradually, which prevents fully charged cells from becoming overcharged causing excessive degradation. This increases overall pack energy by preventing premature charge termination. More Information can be found in the "Cell Balancing Using the bq20z90" Application Report (SLUA340).

The algorithm determines the amount of charge needed to fully charge each cell. There is a bypass FET in parallel with each cell connected to the bq29330. The FET is enabled for each cell with charge greater than the lowest charged cell to reduce charge current through those cells. Each FET is enabled for a precalculated time as calculated by the cell balancing algorithm. When any bypass FET is turned on, then the *[CB]* charging status flag is set, otherwise the *[CB]* flag is cleared.

If ***Min Cell Deviation*** is set to 0 cell balancing is disabled and all bypass FETs stay OFF.

The bypass time needed for each cell is calculated as:

***Min Cell Deviation*** = R / (duty_cycle * V_avg) * 3.6 s/mAh

Where:

R = internal bypass FET resistance of 500Ω (typ.) of bq29330 + 2 series input filter resistors, Rχ. For example: if input filter Rχ value is 100 Ω, R = 500 + 2 x Rχ = 700 Ω.

V_avg = 3.6V

duty_cycle = 0.4 typ.

Using default values, the formula calculates the default value for ***Min Cell Deviation***:

***Min Cell Deviation*** = (500Ω + (2 x Rχ) ) / (0.4 * 3.6V) * 3.6 s/mAh = 1750 s/mAh,

**Related Variables:**

- DF:Charge Control:Cell Balancing Cfg(37):Min Cell Deviation(0)
- SBS:ChargingStatus(0x55)[CB]

### *2.4.3 Charge Inhibit Mode*

If the bq20z90/bq20z95 is in discharge mode or relaxation mode (*[DSG]* = 1) the bq20z90/bq20z95 goes into charge inhibit mode and sets the *ChargingCurrent* and *ChargingVoltage* values to 0 to inhibit charging if:

- *Temperature* < ***Charge Inhibit Temp Low*** limit OR
- *Temperature* > ***Charge Inhibit Temp High*** limit

In charge inhibit mode the *[XCHG]* flag in *ChargingStatus* is set. If ***[CHGIN]*** bit in ***Operation Cfg B*** is set, the CHG FET and ZVCHG FET (if used) are also turned off when the bq20z90/bq20z95 is in charge-inhibit mode.

The bq20z90/bq20z95 allows charging to resume when:

- *Temperature* ≥ ***Charge Inhibit Temp Low*** + ***Temp Hys*** AND
- *Temperature* ≤ ***Charge Inhibit Temp High*** - ***Temp Hys***

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

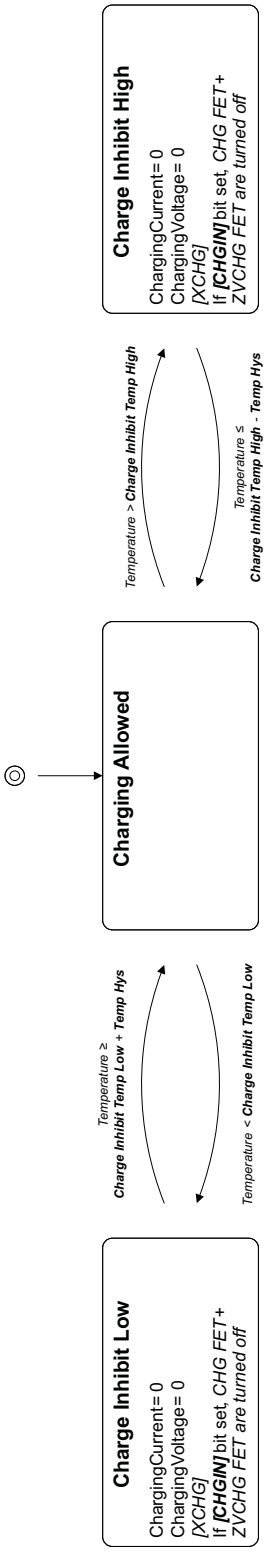


**Figure 2-10. Charge Inhibit**

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)
- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGIN],[NR]
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[XCHG]

### *2.4.4 Charge Suspend Mode*

The bq20z90/bq20z95 suspends charging when:

- *Temperature* < ***Suspend Low Temp***, OR
- *Temperature* > ***Suspend High Temp***

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

The bq20z90/bq20z95 resumes charging if:

- *Temperature* ≥ ***Charge Inhibit Temp Low*** + ***Temp Hys***, AND
- *Temperature* ≤ ***Charge Inhibit Temp High*** – ***Temp Hys***.

Upon resuming, the bq20z90/bq20z95 clears the *[CHGSUSP]* status flag, sets *ChargingCurrent* according to the appropriate charging mode entered and the CHG and ZVCHG FETs (if used) return to their previous state.

The bq20z90/bq20z95 also leaves charge suspend mode and clears the *[CHGSUSP]* flag when a protection condition is detected or when the battery is removed in removable battery mode (***[NR]*** = 0)

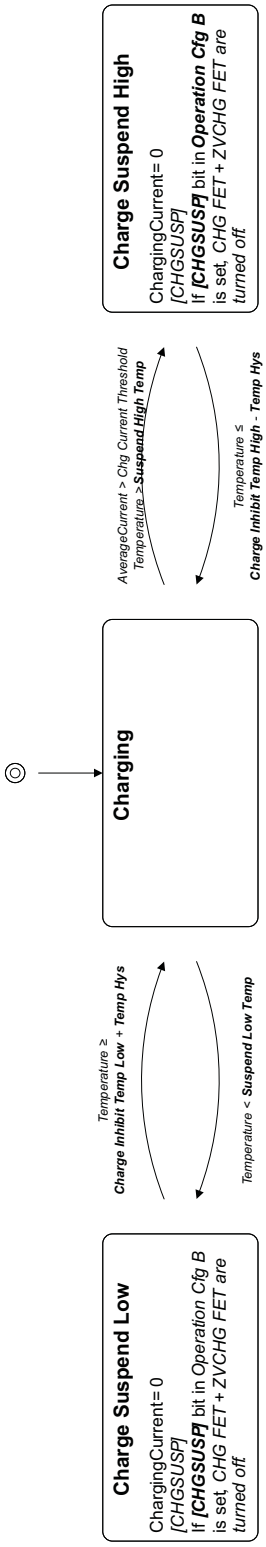


**Figure 2-11. Charge Suspend**

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)

- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Charge Control:Fast Charge Cfg(34):Suspend Low Temp(6)
- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(8)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGSUSP],[NR]
- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- SBS:Temperature(0x08)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[CHGSUSP]

### *2.4.5 Precharge*

The bq20z90/bq20z95 enters precharge mode during charging if the *Temperature* function reports a temperature between ***Charge Inhibit Temp Low*** limit and ***Pre-chg Temp*** limit or any cell voltages are below ***Pre-chg Voltage*** limit. Precharge mode is also entered if any of the *SafetyStatus* flags *[CUV], [PUV], [OCD]* or *[OCD2]* are set.

Depending on the setting of the ***[ZVCHG1]*** and ***[ZVCHG0]*** bits, different FETs can be used in pre-charge mode.

**Table 2-11. Precharge FET**

| ZVCHG1 | ZVCHG0 | FET used |
|---|---|---|
| 0 | 0 | ZVCHG FET |
| 0 | 1 | CHG FET |
| 1 | 0 | GPOD Pin on bq29330 |
| 1 | 1 | No Action |

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

The bq20z90/bq20z95 leaves Pre-charge mode and clears the *[PCHG]* flag if all cell voltages reach or rise above ***Recovery Voltage*** and the reported *Temperature* is equal to or greater than ***Pre-chg Temp*** + ***Temp Hys***. Pre-charge mode is also exited if charge suspend mode is entered, any fault condition is detected, or the pack is removed in removable mode.

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Temp(2)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Voltage(4)
- DF:Charge Control:Pre-Charge Cfg(33):Recovery Voltage(6)
- DF:Configuration:Registers(64):Operation Cfg A(0)[ZVCHG1],[ZVCHG0]
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:SafetyStatus(0x51)[CUV],[PUV],[OCD],[OCD2]
- SBS:ChargingStatus(0x55)[PCHG]

### *2.4.6 Fast Charge*

The bq20z90/bq20z95 enters fast charge mode and sets *ChargingCurrent* to ***Fast Charge Current*** and *ChargingVoltage* to ***Charging Voltage*** when all of the following conditions are met.

- *Temperature* ≥ ***Pre-chg Temp***
- *Temperature* ≤ ***Charge Suspend Temp High*** - (2 x ***Delta Temp***)
- *CellVoltage4..1* ≥ ***Pre-chg Voltage***
- *Voltage* ≤ ***Charging Voltage*** + ***Over Charging Voltage***

During fast charge, *[FCHG] ChargingStatus* flag is set and the CHG FET is turned on if no protection conditions are detected.

**Related Variables:**

- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Temp(2)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Voltage(4)
- DF:Charge Control:Fast Charge Cfg(34):Fast Charge Current(0)
- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Fast Charge Cfg(34):Delta Temp(4)
- DF:Charge Control:Fast Charge Cfg(34):Suspend Temp High(8)
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:ChargingStatus(0x55)[FCHG]

### 2.4.7 Fast Charge Temperature Throttling

The bq20z90/bq20z95 alters *ChargingCurrent* and sets *ChargingStatus[TCHG2], [TCHG1]* flags during fast charge in response to changing temperature conditions.

*ChargingStatus [TCHG2], [TCHG1]* are also cleared when another charging mode is entered, a protection condition is detected, or the battery is removed while ***[NR]*** flag is set.

However, if ***Delta Temp*** is set to 0, *ChargingCurrent* remains ***Fast Charge Current*** during fast charge.

**Table 2-12. Fast Charge Temperature Throttling**

| ***Temperature*** | ***ChargingCurrent*** | ***ChargingStatus* Flag** |
|---|---|---|
| ≤ ***Charge Suspend Temp High*** AND ≥ ( ***Charge Suspend Temp High*** - ***Delta Temp***) | ***Pre-chg Current*** | *[TCHG1]* |
| < ( ***Charge Suspend Temp High*** - ***Delta Temp***) AND ≥ ( ***Charge Suspend Temp High*** – (2 x ***Delta Temp***)), | ( ***Charging Current*** –***Pre-chg Current***) / 2 | *[TCHG2]* |
| < ***(Charge Suspend Temp High*** – (2 x ***Delta Temp***)) AND ≥ ***Pre-Chg Temp*** | ***Charging Current*** | *[FCHG]* |

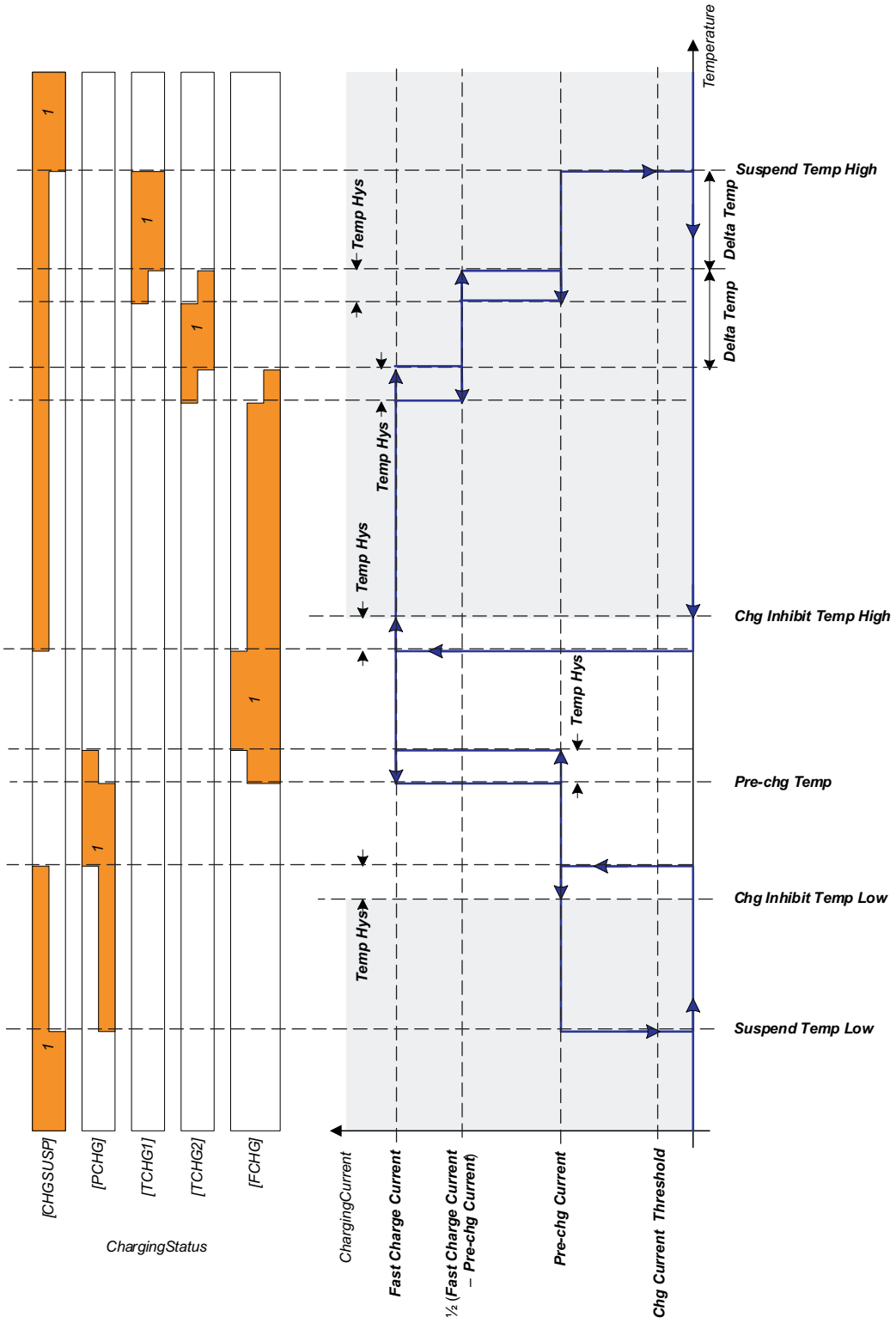


**Figure 2-12. Fast Charge Temperature Throttling**

**Related Variables:**

- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Temp(2)

- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Voltage(4)
- DF:Charge Control:Fast Charge Cfg(34):Fast Charge Current(0)
- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Fast Charge Cfg(34):Delta Temp(4)
- DF:Charge Control:Fast Charge Cfg(34):Suspend Low Temp(6)
- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(8)
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingStatus(0x55)[FCHG],[TCHG1],[TCHG2]

### 2.4.8 Fast Charge Pulse Charging

Pulse charging is part of the fast charging mode and is a loop. During the loop, the measured cell voltages are calculated every 250 ms. This data is not reported via the *CellVoltage4..1* commands.

The pulse charging loop is entered when:

- maximum *CellVoltage4..1* ≥ ***Max OFF Voltage*** OR
- maximum *CellVoltage4..1* ≥ ***Turn OFF Voltage*** for ***Max ON Pulse Time***

When these conditions are met, the CHG FET is turned off, and the *[PULSE]* and *[PLSOFF]* flags in *ChargingStatus* are set.

If the maximum *CellVoltage4..1* is < ***Turn ON Voltage*** AND the CHG FET is off for ***Min OFF Pulse Time***, the CHG FET is turned on and *[PLSOFF]* flag is cleared.

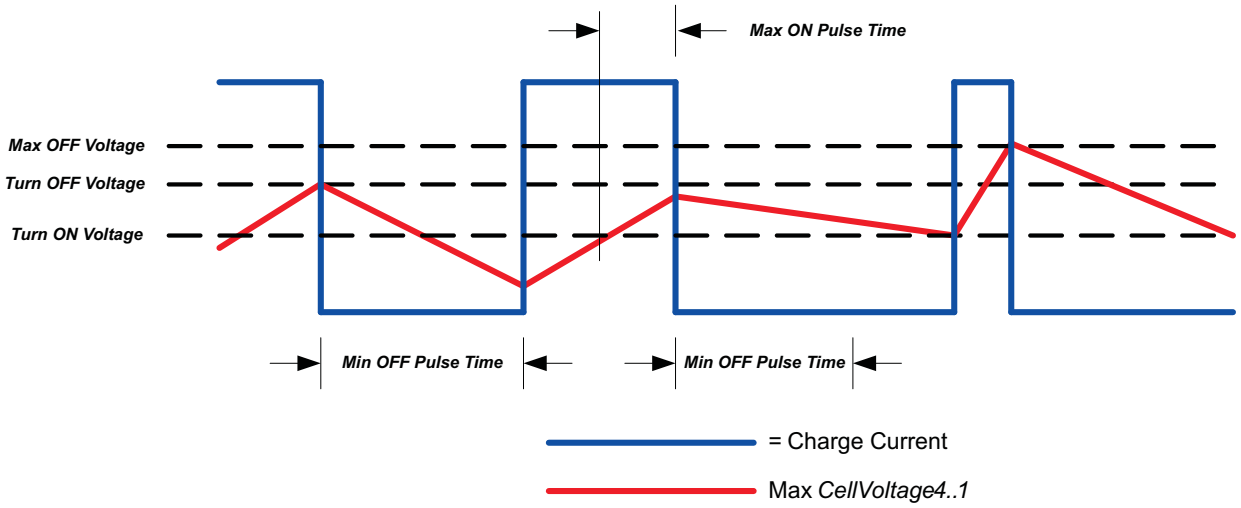


**Figure 2-13. Pulse Charging Example**

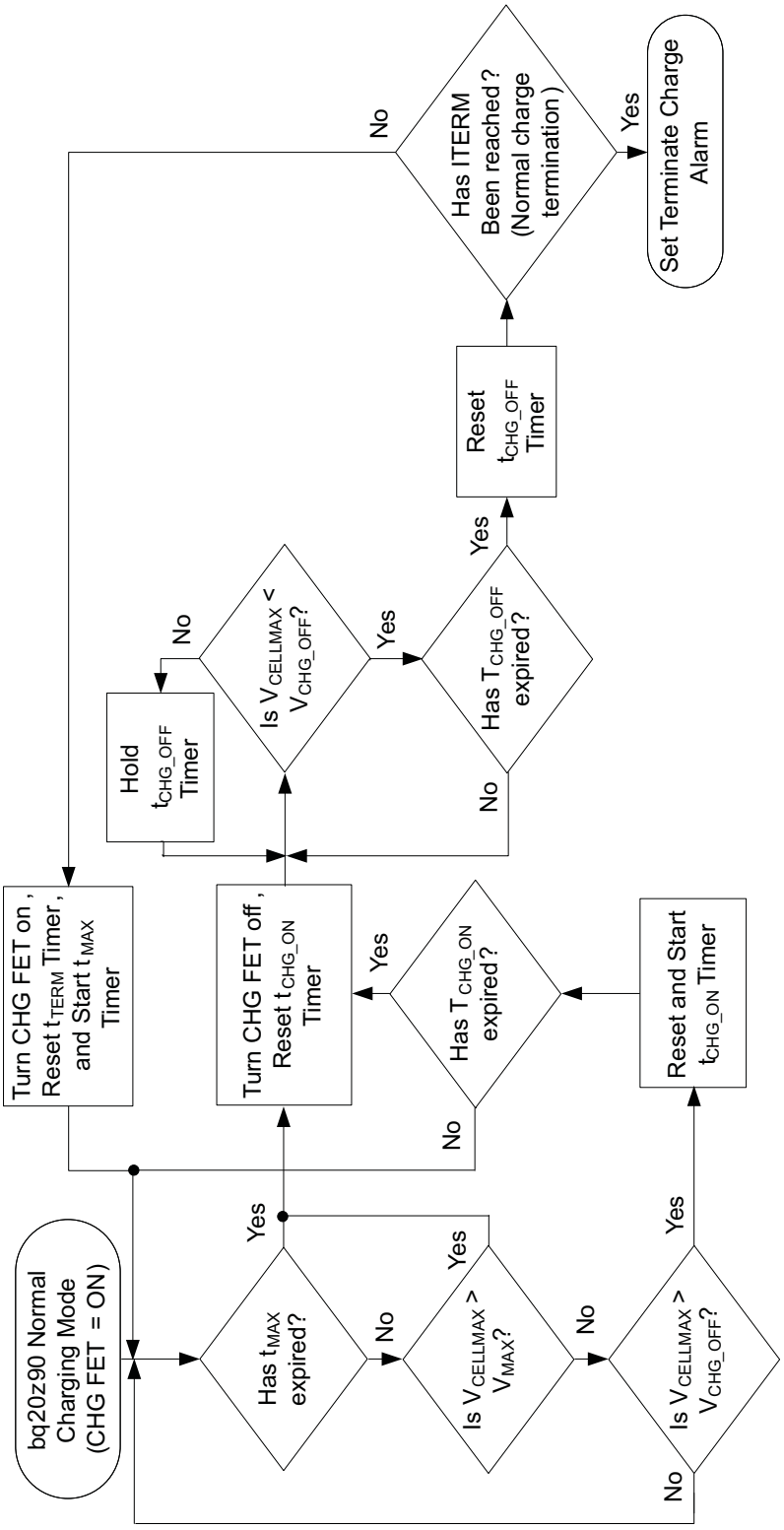


**Figure 2-14. Pulse Charging**

The pulse-charging loop is exited and *[PULSE]* is cleared if another charging mode is entered, a protection condition is detected, or the battery is removed when ***[NR]*** = 0.

**Related Variables:**

- DF:Charge Control:Pulse Charge Cfg(35):Turn ON Voltage(0)
- DF:Charge Control:Pulse Charge Cfg(35):Turn OFF Voltage(2)
- DF:Charge Control:Pulse Charge Cfg(35):Max ON Pulse Time(4)
- DF:Charge Control:Pulse Charge Cfg(35):Max OFF Pulse Time(5)
- DF:Charge Control:Pulse Charge Cfg(35):Max OFF Voltage(6)
- SBS:CellVoltage4..1(0x3c..0xef)
- SBS:ChargingStatus(0x55)[FCHG],[PULSE],[PLSOFF]

### 2.4.9 Primary Charge Termination

The bq20z90/bq20z95 determines charge termination if:

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

**Note:** To ensure proper charge termination, it is recommend that ***Taper Current*** be set to a value greater than ***Quit Current***.

The following parameters change the behavior of bq20z90/bq20z95 on charge termination:

**Table 2-13. Primary Charge Termination**

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

**Related Variables:**

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Termination Cfg.(36):Maintenance Current(0)
- DF:Charge Control:Termination Cfg.(36):Taper Current(2)
- DF:Charge Control:Termination Cfg.(36):Taper Voltage(6)
- DF:Charge Control:Termination Cfg.(36):Current Taper Window(8)
- DF:Charge Control:Termination Cfg.(36):TCA Set %(9)
- DF:Charge Control:Termination Cfg.(36):FC Set %(11)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGFET],[CSYNC]
- DF:Configuration:Registers(64):Operation Cfg C(4)[RSOCL]
- DF:Gas Gauging:Current Thresholds(81):Quit Current(4)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA],[FC]

- SBS:ChargingStatus(0x55)[MCHG]

### 2.4.10 Charging Faults

The bq20z90/bq20z95 can report charging faults in the *ChargingStatus* register. When the ***[OCHGI]*** bit in ***Charge Fault Cfg*** is set, the CHG FET is turned OFF and the ZVCHG FET is turned ON if the ***[ZVCHG1, ZVCHG0]*** bits in ***Operation Cfg A*** are set appropriately. If the ZVCHG FET is not used the CHG FET remains ON, regardless of the bits set in ***Charge Fault Cfg***, because it acts as the ZVCHG FET.

On occurrence of a charging fault the bq20z90/bq20z95 sets:

- The appropriate *ChargingStatus* flag
- If the flag in *Charge Fault Cfg* and *ChargingStatus* matches, CHG FET is turned off and ZVCHG FET (if used) is turned on. The DSG FET is also turned off if charging fault is a Battery Depleted fault.
- *ChargingCurrent* = 0, *ChargingVoltage* = 0; *ChargingVoltage* is not set to zero if it is a Battery Depeted fault.
- *[TCA]* flag in *BatteryStatus*
- *[OC]* flag in *BatteryStatus* if it's an Overcharge fault

On Recovery the bq20z90/bq20z95:

- Resets the appropriate *ChargingStatus* flags
- CHG FET and ZVCHG FET (if used) return to previous states. (DSG FET is also allowed to turn on again on recovery from Battery Depleted fault).
- Sets *ChargingCurrent* and *ChargingVoltage* back to previous state according to charging algorithm.
- Resets *[TCA]BatteryStatus* flag

**Precharge Mode Timeout**

When *Current* is ≥ ***Chg Current Threshold*** the bq20z90/bq20z95 starts the Precharge Timer. The Precharge Timer is suspended during off the phase in pulse charging (*[PLSOFF]* = 1) and when precharge mode is not active (*[PCHG]* = 0). Set ***PC-MTO*** to zero to disable this feature.

The bq20z90/bq20z95 goes into precharge mode charging timeout if:

- Precharge timer ≥ ***PC-MTO***

The bq20z90/bq20z95 recovers if:

- *Current* ≤ ***(-)Dsg Current Threshold***, OR
- Pack is removed and reinserted, if ***[NR]*** = 0

**Fast Charge Mode Timeout**

When *Current* is ≥ ***Chg Current Threshold***, the bq20z90/bq20z95 starts the Fast Charge timer. The Fast Charge Timer is suspended during the off phase in pulse charge mode (*[PLSOFF]*= 1), fast charge is not active (*[FCHG]* = 0), or when *[DSG]* = 1. The Fast Charge Timer is reset when an amount of discharge greater than ***Over Charge Recovery*** is detected or the pack is removed and reinserted when NR = 0. Set ***FC-MTO*** to 0 to disable this feature.

The bq20z90/bq20z95 goes into fast charge mode charging timeout if:

- Fast charge timer ≥ ***FC-MTO***

The bq20z90/bq20z95 recovers if:

- *Current* ≤ ***(-)Dsg Current Threshold*** OR
- Pack is removed and reinserted if ***[NR]*** = 0

**Overcharging Voltage**

The bq20z90/bq20z95 goes into overcharging voltage mode if:

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

The bq20z90/bq20z95 recovers, if:

- *Voltage* ≤ ***Charging Voltage***

**Overcharging Current**

The bq20z90/bq20z95 goes into overcharging current mode if:

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

The bq20z90/bq20z95 recovers, if:

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

**Overcharge**

The bq20z90/bq20z95 goes into overcharge mode if the battery pack is charged in excess of *FullChargeCapacity* by ***Over Charge Capacity***:

The bq20z90/bq20z95 recovers if any of the following conditions are met:

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

### Battery Depleted

The bq20z90/bq20z95 goes into battery depleted mode if:

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

The bq20z90/bq20z95 recovers, if:

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

**Table 2-14. Charging Faults**

| Charge Fault | Fault Condition | Recovery Condition | *ChargingStatus* Flag, *Charge Fault Configuration* Flag |
|---|---|---|---|
| Precharge Timeout | Precharge Timer ≥ ***PC-MTO*** | *Current* ≤ ***(-)Dsg Current Threshold***, OR Pack removed and reinserted if ***[NR]*** = 0 | *[PCMTO]* |
| Fast charge Timeout | Fast charge Timer ≥ ***FC-MTO*** | | *[FCMTO]* |
| Overcharging Voltage | *Voltage* ≥ ***Charging Voltage*** + ***Over Charging Voltage*** for min. ***Over Charging Volt Time*** | *Voltage* ≤ ***Charging Voltage*** | *[OCHGV]* |
| Overcharging Current | *Current* ≥ *ChargingCurrent* + ***Over Charging Current*** for min. ***Over Charging Curr Time*** | *AverageCurrent* ≤ ***Over Charging Curr Recov*** | *[OCHGI]* |
| Overcharge | *RemainingCapacity* - *FullChargeCapacity* ≥ ***Over Charge Capacity*** | Pack removed and reinserted if ***[NR]*** = 0, OR continuous amount of discharge of ***Over Charge Recovery*** if ***[NR]*** = 1, OR *RemainingCapacity* ≤ ***FC Clear %*** | *[OC]* |
| Battery Depleted | *Voltage* ≤ ***Depleted Voltage*** for min ***Depleted Voltage Time*** | *Voltage* > ***Depleted Voltage Recovery*** | *[XCHGLV]* |

### Related Variables:

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Termination Cfg.(36):FC Clear %(12)
- DF:Charge Control:Charging Faults(38):Over Charging Voltage(0)
- DF:Charge Control:Charging Faults(38):Over Charging Volt Time(2)
- DF:Charge Control:Charging Faults(38):Over Charging Current(3)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Recov(6)
- DF:Charge Control:Charging Faults(38):Depleted Voltage(8)
- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- DF:Charge Control:Charging Faults(38):Depleted Recovery(11)
- DF:Charge Control:Charging Faults(38):Over Charge Capacity(13)
- DF:Charge Control:Charging Faults(38):Over Charge Recovery(15)
- DF:Charge Control:Charging Faults(38):FC-MTO(17)
- DF:Charge Control:Charging Faults(38):PC-MTO(19)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TDA],[TCA],[OCA]
- SBS:ChargingStatus(0x55)[FCHG],[PLSOFF],[PULSE]

### 2.4.11 Discharge and Charge Alarms

The bq20z90/bq20z95 enables *[TDA], [FD], [TCA] and [FC]* flags in *BatteryStatus* to be set or cleared on the following thresholds based on *RelativeStateOfCharge*. All thresholds can be disabled by setting them to -1. ***FC Clear %*** should not be disabled by setting to -1.

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

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

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

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):TCA Set %(9)
- DF:Charge Control:Termination Cfg.(36):TCA Clear %(10)
- DF:Charge Control:Termination Cfg.(36):FC Set %(11)
- DF:Charge Control:Termination Cfg.(36):FC Clear %(12)
- DF:SBS Configuration:Configuration(49):TDA Set %(0)
- DF:SBS Configuration:Configuration(49):TDA Clear %(1)
- DF:SBS Configuration:Configuration(49):FD Set %(2)
- DF:SBS Configuration:Configuration(49):FD Clear %(3)
- DF:SBS Configuration:Configuration(49):TDA Set Volt Threshold(4)
- DF:SBS Configuration:Configuration(49):TDA Set Volt Time(6)
- DF:SBS Configuration:Configuration(49):TDA Clear Volt(7)
- DF:SBS Configuration:Configuration(49):FD Set Volt Threshold(9)
- DF:SBS Configuration:Configuration(49):FD Volt Time(11)
- DF:SBS Configuration:Configuration(49):FD Clear Volt(12)
- SBS:Voltage(0x09)
- SBS:RelativeStateOfCharge(0x0d)

## 2.5 LED Display

### 2.5.1 Display Activation

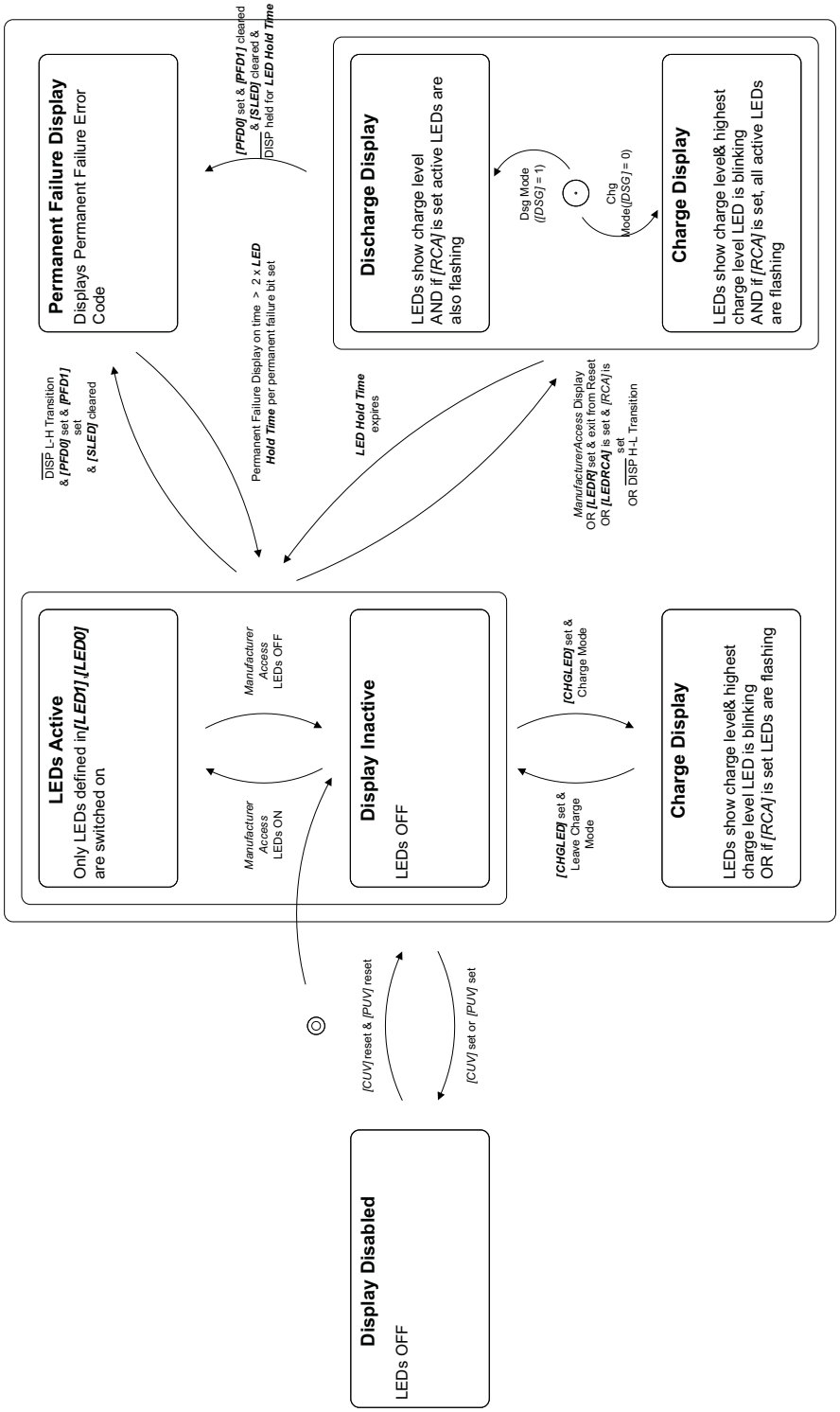


**Figure 2-15. Display Activation**

The LED display is activated with a H-L transition at the $\overline{\text{DISP}}$ pin. The following flags configure additional display activation settings.

If *[CUV]* or *[PUV]* flags are set, the display is disabled.

**LEDR —** Set this flag to activate the display on exit from reset of bq20z90/bq20z95.

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

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

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

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[LEDR],[LEDRCA],[CHGLED]
- DF:Configuration:Registers(64):Operation Cfg B(2)[PFD1],[PFD0]
- DF:LED Support:LED Cfg(67):LED Hold Time(6)
- SBS:ManufacturerAccess(0x00):LEDs ON(0x0032)
- SBS:ManufacturerAccess(0x00):LEDs OFF(0x0033)
- SBS:ManufacturerAccess(0x00):Display ON(0x0034)
- SBS:BatteryStatus(0x16)[RCA]
- SBS:SafetyStatus(0x51)[CUV],[PUV]
- SBS:PFStatus(0x53)

### *2.5.2 Display Configuration*

The following parameters configures the display in various ways.

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

**LED1, LED0 —** These bits configure the number of LEDs and the charge threshold levels used in the LED display. The bq20z90/bq20z95 can use predefined charge levels for 3,4, or 5 LEDs or user defined levels.

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

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

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

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

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0],[SLED],[LEDRCA]
- DF:LED Support:LED Cfg(67):LED Flash Rate(0)
- DF:LED Support:LED Cfg(67):LED Blink Rate(2)
- DF:LED Support:LED Cfg(67):LED Delay(4)
- DF:LED Support:LED Cfg(67):LED Hold Time(6)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)

### 2.5.3 Display Format

The bq20z90/bq20z95 can show state of charge using the LED display. Predefined levels for 3, 4 or 5 LEDs or user configurable levels can be selected. State of charge levels can be configured for charging and discharging.

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

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

**Table 2-15. Display Charge Level Threshold**

| **LED1, LED0 Setting:** | **3 LED** | **4 LED** | **5 LED** | **USER** | |
|---|---|---|---|---|---|
| **Threshold Level:** | **charge + discharge level** | | | **charging level** | **discharging level** |
| Flash Alarm active | 0% - 10% | 0% - 10% | 0% - 10% | 0% - ***CHG Flash Alarm*** | 0% - ***DSG Flash Alarm*** |
| LED 1 active | 0% - 100% | 0% - 100% | 0% - 100% | ***CHG Thresh 1*** - 100% | ***DSG Thresh 1*** - 100% |
| LED 2 active | 34% - 100% | 25% - 100% | 20% - 100% | ***CHG Thresh 2*** - 100% | ***DSG Thresh 2*** - 100% |
| LED 3 active | 67% - 100% | 50% - 100% | 40% - 100% | ***CHG Thresh 3*** - 100% | ***DSG Thresh 3*** - 100% |
| LED 4 active | - | 75% - 100% | 60% - 100% | ***CHG Thresh 4*** - 100% | ***DSG Thresh 4*** - 100% |
| LED 5 active | - | - | 80% - 100% | ***CHG Thresh 5*** - 100% | ***DSG Thresh 5*** - 100% |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0],[LEDRCA]
- DF:LED Support:LED Cfg(67):LED Flash Rate(0)
- DF:LED Support:LED Cfg(67):LED Blink Rate(2)
- DF:LED Support:LED Cfg(67):CHG Flash Alarm(7)
- DF:LED Support:LED Cfg(67):CHG Thresh 1(8)
- DF:LED Support:LED Cfg(67):CHG Thresh 2(9)
- DF:LED Support:LED Cfg(67):CHG Thresh 3(10)
- DF:LED Support:LED Cfg(67):CHG Thresh 4(11)
- DF:LED Support:LED Cfg(67):CHG Thresh 5(12)
- DF:LED Support:LED Cfg(67):DSG Flash Alarm(13)
- DF:LED Support:LED Cfg(67):DSG Thresh 1(14)
- DF:LED Support:LED Cfg(67):DSG Thresh 2(15)
- DF:LED Support:LED Cfg(67):DSG Thresh 3(16)
- DF:LED Support:LED Cfg(67):DSG Thresh 4(17)
- DF:LED Support:LED Cfg(67):DSG Thresh 5(18)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### *2.5.4 Permanent Failure Error Codes*

When a permanent failure occurs, the type of permanent failure error can be shown on the display. The table below shows available error codes. The permanent failure display requires proper setting of ***[PFD1]*** and ***[PFD0]*** bits. The permanent failure code display is disabled if ***[SLED]*** bit is set.

| ***PFStatus*** | **LED3** | **LED2** | **LED1** |
|---|---|---|---|
| No PF Fault | Flashing with ***LED Blink Rate*** | Off | Off |
| *[FBF]* | On | Flashing with ***LED Blink Rate*** | Flashing with ***LED Flash Rate*** |
| *[PFVSHUT]* | Off | Flashing with ***LED Blink Rate*** | Flashing with ***LED Flash Rate*** |
| Reserved | Flashing with ***LED Flash Rate*** | Flashing with ***LED Blink Rate*** | On |
| *[SOPT]* | On | Flashing with ***LED Blink Rate*** | On |
| *[SOCD]* | Off | Flashing with ***LED Blink Rate*** | On |
| *[SOCC]* | Flashing with ***LED Flash Rate*** | Flashing with ***LED Blink Rate*** | Off |
| *[AFE_P]* | On | Flashing with ***LED Blink Rate*** | Off |
| *[AFE_C]* | Off | Flashing with ***LED Blink Rate*** | Off |
| *[DFF]* | Flashing with ***LED Blink Rate*** | Flashing with ***LED Flash Rate*** | Flashing with ***LED Flash Rate*** |
| *[DFETF]* | Flashing with ***LED Blink Rate*** | On | Flashing with ***LED Flash Rate*** |
| *[CFETF]* | Flashing with ***LED Blink Rate*** | Off | Flashing with ***LED Flash Rate*** |
| *[CIM]* | Flashing with ***LED Blink Rate*** | Flashing with ***LED Flash Rate*** | On |

| *PFStatus* | LED3 | LED2 | LED1 |
|---|---|---|---|
| *[SOTD]* | Flashing with ***LED Blink Rate*** | On | On |
| *[SOTC]* | Flashing with ***LED Blink Rate*** | Off | On |
| *[SOV]* | Flashing with ***LED Blink Rate*** | Flashing with ***LED Flash Rate*** | Off |
| *[PFIN]* | Flashing with ***LED Blink Rate*** | On | Off |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[PFD1],[PFD0]
- DF:LED Support:LED Cfg(67):LED Flash Rate(0)
- DF:LED Support:LED Cfg(67):LED Blink Rate(2)

### *2.5.5 LED Current Configuration*

The sink current setting of the LED inputs to the bq20z90/bq20z95 can be programmed with the following settings. All of the LEDs are programmed with the same current level.

**Table 2-16. LED Current Configuration**

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

**Related Variables:**

- DF:LED Support:LED Cfg(67):Sink Current(19)

## 2.6 Device Operating Mode

The bq20z90/bq20z95 has several device power modes. During these modes, the bq20z90/bq20z95 modifies its operation to minimize power consumption from the battery.

### *2.6.1 Normal Mode*

During normal operation, the bq20z90/bq20z95 takes *Current*, *Voltage*, and *Temperature* measurements, performs calculations, updates SBS data, and makes protection and status decisions at one-second intervals. Between these periods of activity, the bq20z90/bq20z95 is in a reduced power state.

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

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:OperationStatus(0x54)[PRES]

### *2.6.2 Battery Pack Removed Mode/System Present Detection*

#### 2.6.2.1 Battery Pack Removed

The bq20z90/bq20z95 detects the Battery Pack Removed state if ***[NR]*** bit is set to 0 AND the $\overline{\text{PRES}}$ input is high (*[PRES]* = 0).

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

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

The bq20z90/bq20z95 exits the Battery Pack Removed state if ***[NR]*** flag is set to 0, AND the $\overline{\text{PRES}}$ input is low (*[PRES]* = 1). When this occurs, *[TCA]* and *[TDA]* flags are reset.

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:OperationStatus(0x54)[PRES]

#### 2.6.2.2 System Present

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:OperationStatus(0x54)[PRES]

### *2.6.3 Sleep Mode*

In Sleep mode the bq20z90/bq20z95 measures Voltage and Temperature in ***Sleep Voltage Time*** intervals and *Current* at ***Sleep Current Time*** intervals. At each interval the bq20z90/bq20z95 performs calculations, updates SBS data, and makes protection and status decisions. Between these periods of activity, the bq20z90/bq20z95 is in a reduced-power state.

The bq20z90/bq20z95 enters Sleep mode when the following conditions exist:

- If ***[NR]*** bit is set to 0, *[PRES]* must also be set to 0, for the bq20z90/bq20z95 to enter sleep.

AND one of the following conditions:

- (|*Current*| ≤ ***Sleep Current***) AND (SMBus is low for ***Bus Low Time)*** AND (***[SLEEP]*** bit is set)
  OR
- (|*Current*| ≤ ***Sleep Current***) AND *(ManufacturerAccess* Sleep command is received) AND (***[SLEEP]*** is set).

Entry to Sleep mode is blocked if any of the *PFStatus* flags are set. If ***Sleep Voltage Time*** = 0 or ***Sleep Current Time*** = 0, sleep mode is not entered, and the bq20z90/bq20z95 remains in Normal mode.

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

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

The bq20z90/bq20z95 exits Sleep mode when one or more of the following conditions exist:

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

The bq20z90/bq20z95 exits Sleep mode if absolute value of *Current* is greater than ***Sleep Current***, OR the SMBC or SMBD inputs transition high, OR any *OperationStatus*, *ChargingStatus*, or *SafetyStatus* flags change state.

In addition, if ***[NR]*** is cleared, the bq20z90/bq20z95 exits Sleep mode when *[PRES]* = 1.

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR],[NRCHG]
- DF:Power:Power(68):Sleep Current(10)
- DF:Power:Power(68):Bus Low Time(12)
- DF:Power:Power(68):Cal Inhibit Temp Low(13)
- DF:Power:Power(68):Cal Inhibit Temp Low(15)
- DF:Power:Power(68):Sleep Voltage Time(17)
- DF:Power:Power(68):Sleep Current Time(18)
- DF:Power:Power(68):Wake Current Reg(19)
- SBS:ManufacturerAccess(0x00):Sleep(0x0011)
- SBS:Current(0x0a)
- SBS:SafetyStatus(0x51)
- SBS:OperationStatus(0x54)[PRES]

### 2.6.4 Wake Function

The bq20z90/bq20z95 can exit sleep mode, if enabled, by the presence of a voltage across SRP and SRN. The level of the current signal needed is programmed in ***Wake Current Reg***.

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

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

**Figure 2-16. Wake Current Reg**

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

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

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

**Table 2-17. Wake Current Reg**

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Power:Power(68):Wake Current Reg(19)
- SBS:Current(0x0a)

### *2.6.5 Shutdown Mode*

The bq20z90/bq20z95 enters Shutdown mode if the following conditions are met:

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

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

  OR
- (*ManufacturerAccess* shutdown command received AND *Current* = 0) AND *PackVoltage* < ***Charger Present*** threshold.

When the bq20z90/bq20z95 meets these conditions, the CHG, DSG, and ZVCHG FETs are turned off, and the bq29330 is commanded to shut down. In Shutdown mode, the bq20z90/bq20z95 is completely powered down because its supply is removed.

To exit Shutdown mode the voltage at the PACK pin of the bq29330 must be greater than its minimum operating voltage. When this occurs, the bq29330 returns power to the bq20z90/bq20z95 , the *[WAKE]* flag is set, and the bq29330 is configured. The *[INIT]* and *[WAKE]* flags are cleared after approximately 1 s when all SBS parameters have been measured and updated.

**Related Variables:**

- DF:Power:Power(68):Shutdown Voltage(2)
- DF:Power:Power(68):Shutdown Time(4)
- DF:Power:Power(68):Cell Shutdown Voltage(5)
- DF:Power:Power(68):Cell Shutdown Time(7)
- DF:Power:Power(68):Charger Present(8)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- DF:Configuration:Registers(64):Operation Cfg C(4)[SHUTV]
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[INIT]
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:OperationStatus(0x54)[PRES],[WAKE]
- SBS:PackVoltage(0x5a)

## 2.7 Security (Enables and Disables Features)

There are three levels of secured operation within the bq20z90/bq20z95. To switch between the levels, different operations are needed with different codes. The three levels are Sealed, Unsealed, and Full Access.

1. **Full Access or Unsealed to Sealed —** The use of the *Seal Device* command instructs the bq20z90/bq20z95 to limit access to the SBS functions and data flash space and sets the *[SS]* flag. In sealed mode, standard SBS functions have access per the Smart Battery Data Specification - Appendix A. Extended SBS Functions and data flash are not accessible. Once in sealed mode, the part can never permanently return to Unsealed or Full Access modes.

2. **Sealed to Unsealed —** Instructs the bq20z90/bq20z95 to extend access to the SBS and data flash space and clears the *[SS]* flag. In unsealed mode, all data, SBS, and DF have read/write access. Unsealing is a 2 step command performed by writing the 1st word of the *UnSealKey* to *ManufacturerAccess* followed by the second word of the *UnSealKey* to *ManufacturerAccess*. The unseal key can be read and changed via the extended SBS block command *UnSealKey* when in Full Access Mode. To return to the Sealed mode, either a hardware reset is needed, or the *ManufacturerAccess* seal device command is needed to transit from Full Access or Unsealed to Sealed.

3. **Unsealed to Full Access —** Instructs the bq20z90/bq20z95 to allow Full Access to all SBS commands and data flash. The bq20z90/bq20z95 is shipped from TI in this mode. The keys for Unsealed to Full Access can be read and changed via the extended SBS block command *FullAccessKey* when in Full Access mode. Changing from Unsealed to Full Access is performed by using the *ManufacturerAccess* command, by writing the 1st word of the *FullAccessKey* to *ManufacturerAccess* followed by the second word of the *FullAccessKey* to *ManufacturerAccess*. The full access key can be read and changed via the extended SBS block command *FullAccessKey* when in Full Access Mode. In Full Access mode, the command to go to Boot ROM can be sent.

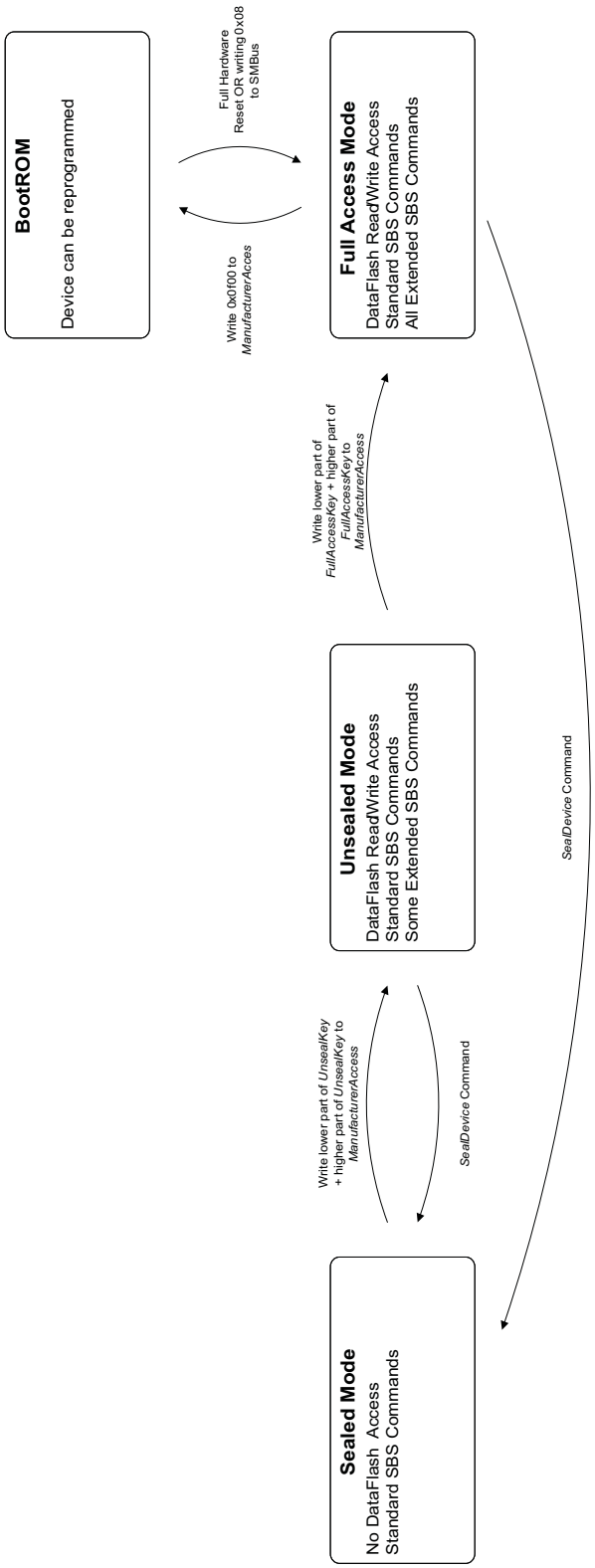


**Figure 2-17. Security**

**Related Variables:**

- SBS:ManufacturerAccess(0x00):Seal Device(0x0020)

- SBS:OperationStatus(0x54)[SS],[FAS]
- SBS:UnSealKey(0x60)
- SBS:FullAccessKey(0x61)

## 2.8 Calibration

### *2.8.1 Coulomb Counter Dead Band*

The bq20z90/bq20z95 does not accumulate charge or discharge for gas gauging when the current input is below the dead-band current threshold. The threshold is programmed in ***CC Deadband*** (Coulomb Counter Deadband) and should be set sufficiently high to prevent false signal detection with no charge or discharge flowing through the sense resistor.

**Related Variables:**

- DF:Calibration:Current(107):CC Deadband(1)

### *2.8.2 Auto Calibration*

The bq20z90/bq20z95 provides an auto-calibration feature to cancel the voltage offset error across SRP and SRN for maximum charge measurement accuracy. The bq20z90/bq20z95 performs auto-calibration when the SMBus lines stay low continuously for a minimum of 5 s and *Temperature* is within bounds of ***Cal Inhibit Temp Low*** and ***Cal Inhibit Temp High***.

**Related Variables:**

- DF:Power:Power(68):Cal Inhibit Temp Low(13)
- DF:Power:Power(68):Cal Inhibit Temp High(15)
- SBS:Temperature(0x08)

## 2.9 Communications

The bq20z90/bq20z95 uses SMBus v1.1 with Master Mode and packet error checking (PEC) options per the SBS specification.

### *2.9.1 SMBus On and Off State*

The bq20z90/bq20z95 detects an SMBus off state when SMBC and SMBD are logic-low for $\geq$ 2 seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

### *2.9.2 Packet Error Checking*

The bq20z90/bq20z95 can receive or transmit data with or without PEC.

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

In the write-word protocol, the bq20z90/bq20z95 receives the PEC after the last byte of data from the host. If the host does not support PEC, the last byte of data is followed by a stop condition. After receipt of the PEC, the bq20z90/bq20z95 compares the value to its calculation. If the PEC is correct, the bq20z90/bq20z95 responds with an ACKNOWLEDGE. If it is not correct, the bq20z90/bq20z95 responds with a NOT ACKNOWLEDGE and sets an error code. If the host supports PEC, the ***[HPE]*** bit should be set to 1.

In the read-word and block-read in master mode, the host generates an ACKNOWLEDGE after the last byte of data sent by the bq20z90/bq20z95. The bq20z90/bq20z95 then sends the PEC, and the host, acting as a master-receiver, generates a NOT ACKNOWLEDGE and a stop condition.

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[HPE]

### *2.9.3 bq20z90/bq20z95 Slave Address*

The bq20z90/bq20z95 uses the address 0x16 on SMB for communication.

### *2.9.4 Broadcasts to Smart Charger and Smart Battery Host*

The bq20z90/bq20z95 can broadcast messages to the smart battery charger and smart battery host. This can be enabled with the ***[BCAST]*** bit.

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

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[CPE],[HPE],[BCAST]

# Standard SBS Commands

The bq20z90/bq20z95 SBS command set meets the SBD v1.1 specification. All SBS Values are updated in 1-second intervals.

## A.1 ManufacturerAccess(0x00)

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

**Table A-1. ManufacturerAccess**

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

### *A.1.1 System Data*

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

#### A.1.1.1 Device Type(0x0001)

Returns the IC part number.

**Table A-2. Device Type**

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

#### A.1.1.2 Firmware Version(0x0002)

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

**Table A-3. Firmware Version**

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

#### A.1.1.3 Hardware Version(0x0003)

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

**Table A-4. Hardware Version**

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

### A.1.1.4 DF Checksum(0x0004)

This function is only available when the bq20z90/bq20z95 is in unsealed mode or full access mode, indicated by the *[SS]* and *[FAS]* flag. A write to this command forces the bq20z90/bq20z95 to generate a checksum of the full Data Flash (DF) array. The generated checksum is then returned within 45 ms.

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

**Table A-5. DF Checksum**

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

### A.1.1.5 Manufacturer Status(0x0006)

This function is available while the bq20z90/bq20z95 is in normal operation. This 16-bit word reports the battery status.

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | FET1 | FET0 | PF1 | PF0 | STATE3 | STATE2 | STATE1 | STATE0 |
| **Low Byte** | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

LEGEND: All bits are read only

**Figure A-1. Manufacturer Status**

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

0,0 = Both charge and discharge FETs are on.

0,1 = CHG FET is off, DSG FET is on.

1,0 = Both charge and discharge FETs are off.

1,1 = CHG FET is on, DSG FET is off.

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

0,0 = Fuse is blown if enabled via DF:Configuration:Register(64):Permanent Fail Cfg(6)

0,1 = Cell imbalance failure

1,0 = Safety voltage failure

1,1 = FET failure

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

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

#### A.1.1.6 Chemistry ID(0x0008)

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

**Table A-6. Chemistry ID**

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

### *A.1.2 System Control*

The commands in this section cause the bq20z90/bq20z95 to take actions when written. No data is returned.

#### A.1.2.1 Shutdown(0x0010)

Instructs the bq20z90/bq20z95 to verify and enter shutdown mode. This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode. Shutdown will not be entered unless the *PackVoltage* < ***Charger Present*** and *Current* ≤ 0.

**Related Variables:**

- DF:Power:Power(68):Charger Present(8)
- SBS:Current(0x0a)
- SBS:OperationStatus(0x54)[SS],[FAS]
- SBS:PackVoltage(0x5a)

#### A.1.2.2 Sleep(0x0011)

Instructs the bq20z90/bq20z95 to verify and enter sleep mode if no other command is sent after the *Sleep* command. Any SMB transition will wake up the bq20z90/bq20z95. It takes about 1 min. before the device will go to sleep. This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.3 Seal Device(0x0020)

Instructs the bq20z90/bq20z95 to limit access to the extended SBS functions and data flash space, sets the *[SS]* flag, and clears the *[FAS]* flag.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

See "Security" chapter in this document for detailed information.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.4 IT Enable(0x0021)

This command forces the bq20z90/bq20z95 to begin the Impedance Track™ algorithm, changes ***Update Status***, and sets the *[QEN]* flag.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:OperationStatus(0x54)[VOK],[QEN],[SS],[FAS]

#### A.1.2.5 SAFE Activation(0x0030)

This command drives the SAFE pin high.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.6 SAFE Clear(0x0031)

This command sets the SAFE pin back to low.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.7 LEDs ON(0x0032)

Activates all configured LEDs to stay on.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- DF:Configuration:Registers(64)Operation Cfg A(0)[LED1],[LED0]
- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.8 LEDs OFF(0x0033)

Deactivates all configured LEDs.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- DF:Configuration:Registers(64)Operation Cfg A(0)[LED1],[LED0]
- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.9 Display ON(0x0034)

Simulates a H-L transition at $\overline{\text{DISP}}$ pin and activates the LED display to show charge level.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.10 Calibration Mode(0x0040)

Places the bq20z90/bq20z95 into calibration mode. See "Data Flash Programming/Calibrating the bq20z80 Gas Gauges (Rev. A) " application note (SLUA355A) for further details.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.11 Reset(0x0041)

The bq20z90/bq20z95 undergoes a full reset. The bq20z90/bq20z95 holds the clock line down for a few milli-seconds to complete the reset

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS],[FAS]

#### A.1.2.12 BootRom(0x0f00)

The bq20z90/bq20z95 goes into BootRom mode.

This command is only available when the bq20z90/bq20z95 is in Full Access mode.

**Related Variables:**

- SBS:OperationStatus(0x54)[FAS]

#### A.1.2.13 Permanent Fail Clear(*PFKey*)

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

It instructs the bq20z90/bq20z95 to clear the *PFStatus*, clear the *[PF]* flag, clear the ***Fuse Flag***, reset the SAFE pin, and unlock the data flash for writes.

This command is only available when the bq20z90/bq20z95 is in Unsealed or Full Access mode.

**Related Variables:**

- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)
- SBS:SafetyStatus(0x51)[PF]
- SBS:PFStatus(0x53)
- SBS:OperationStatus(0x54)[SS],[FAS]
- SBS:PFKey(0x62)

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

#### A.1.2.14 Unseal Device (*UnsealKey*)

Instructs the bq20z90/bq20z95 to enable access to the SBS functions and data flash space and clear the *[SS]* flag. This 2 step command needs to be written to *ManufacturerAccess* in the following order: 1st word of the *UnSealKey* first followed by the 2nd word of the *UnSealKey*. If the command fails 4 seconds must pass before the command can be reissued.

This command is only available when the bq20z90/bq20z95 is in Sealed mode.

See "*Security*" chapter in this document for detailed information.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS]
- SBS:UnSealKey(0x60)

#### A.1.2.15 Full Access Device (*FullAccessKey*)

Instructs the bq20z90/bq20z95 to enable full access to all SBS functions and data flash space and set the *[FAS]* flag. This 2 step command needs to be written to *ManufacturerAccess* in the following order: 1st word of the *FullAccessKey* first followed by the 2nd word of the *FullAccessKey*.

This command is only available when the bq20z90/bq20z95 is in Unsealed mode.

See "*Security*" chapter in this document for detailed information.

**Related Variables:**

- SBS:OperationStatus(0x54)[SS],[FAS]
- SBS:FullAccessKey(0x61)

### *A.1.3 Extended SBS Commands*

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

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

0x0050 = SBS:SafetyAlert(0x50)

0x0051 = SBS:SafetyStatus(0x51)

0x0052 = SBS:PFAlert(0x52)

0x0053 = SBS:PFStatus(0x53)

0x0054 = SBS:OperationStatus(0x54)

0x0055 = SBS:ChargingStatus(0x55)

0x0057 = SBS:ResetData(0x57)

0x0058 = SBS:WDResetData(0x58)

0x005a = SBS:PackVoltage(0x5a)

0x005d = SBS:AverageVoltage(0x5d)

## A.2 RemainingCapacityAlarm(0x01)

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

If *RemainingCapacity* < *RemainingCapacityAlarm*, the *[RCA]* flag is set and the bq20z90/bq20z95 sends an *AlarmWarning* message to the SMBUS host.

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

0 = Remaining capacity alarm is disabled

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

**Table A-7. RemainingCapacityAlarm**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Rem Cap Alarm(0)
- SBS:BatteryMode(0x03)[CapM]
- SBS:RemainingCapacity(0x0f)
- SBS:BatteryStatus(0x16)[RCA],[DSG]

## A.3 RemainingTimeAlarm(0x02)

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

If *AverageTimeToEmpty* < *RemainingTimeAlarm*, the *[RTA]* flag is set and the bq20z90/bq20z95 sends an *AlarmWarning* message to the SMBus host.

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

0 = Remaining time alarm is disabled

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

**Table A-8. RemainingTimeAlarm**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Rem Time Alarm(4)
- SBS:AverageTimeToEmpty(0x12)
- SBS:BatteryStatus(0x16)[RTA]

## A.4 BatteryMode(0x03)

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

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

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

**Figure A-2. BatteryMode**

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

0 = Reports in mA or mAh (default)

1 = Reports in 10mW or 10mWh

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

SBS:RemainingCapacityAlarm(0x01)

SBS:AtRate(0x04)

SBS:RemainingCapacity(0x0f)

SBS:FullChargeCapacity(0x10)

SBS:DesignCapacity(0x18)

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

SBS:RemainingTimeAlarm(0x02)

SBS:AtRateTimeToEmpty(0x06)

SBS:AtRateOK(0x07)

SBS:RunTimeToEmpty(0x11)

SBS:AverageTimeToEmpty(0x12)

SBS:BatteryStatus(0x16)

**ChgM: —** Enables or disables the bq20z90/bq20z95 's transmission of *ChargingCurrent* and *ChargingVoltage* messages to the Smart Battery Charger.

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

1 = Disable *ChargingVoltage* and *ChargingCurrent* broadcasts to the Smart Battery Charger. (default)

**Related Variables:**

DF:Configuration:Registers(64):Operation Cfg B(2)[BCAST]

SBS:ChargingCurrent(0x14)

SBS:ChargingVoltage(0x15)

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

0 = Enable *AlarmWarning* broadcast to host and Smart Battery Charger by setting the ***[BCAST]*** bit in ***Operation Cfg B*** (default). The bq20z90/bq20z95 sends the *AlarmWarning* messages to the SMBus Host and the Smart Battery Charger any time an alarm condition is detected

1 = Disable *AlarmWarning* broadcast to host and Smart BatteryCharger. The bq20z90/bq20z95 does not master the SMBus, and *AlarmWarning* messages are not sent to the SMBus Host and the Smart Battery Charger for a period of no more than 65 seconds and no less than 45 seconds. *[AM]* is automatically cleared by the bq20z90/bq20z95 60 seconds after being set to 1, independent of the ***[BCAST]*** bit.

**Related Variables:**

DF:Configuration:Registers(64):Operation Cfg B(2)[BCAST]

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

**PB: —** Sets the role of the battery pack. This flag is not used by bq20z90/bq20z95 and should be set to 0.

**CC: —** Enable or disable internal charge controller. This flag is not used by bq20z90/bq20z95 and should be set to 0.

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

0 = Battery OK

1 = Condition cycle requested

**Related Variables:**

DF:SBS Configuration:Data(48):CF MaxError Limit(21)

SBS:MaxError(0x0c)

**PBS: —** Primary battery support is not supported by bq20z90/bq20z95 and is fixed to 0.

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

## A.5 AtRate(0x04)

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

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

The default value for *AtRate* is zero.

**Table A-9. AtRate**

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

**Related Variables:**

- SBS:AtRateTimeToFull(0x05)
- SBS:AtRateTimeToEmpty(0x06)
- SBS:AtRateOK(0x07)
- SBS:BatteryMode(0x03)[CapM]

## A.6 AtRateTimeToFull(0x05)

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

*AtRateTimeToFull* can report time based on constant current (*[CapM]* = 0) or constant power (*[CapM]* = 1), and updates within one second after the SMBus host sets the *AtRate* value. The bq20z90/bq20z95 automatically updates *AtRateTimeToFull* based on the *AtRate* function at one-second intervals.

0..65534 = predicted time to full charge, based on *AtRate*

65535 = no charge or discharge (*AtRate* is 0)

**Table A-10. AtRateTimeToFull**

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

**Related Variables:**

- SBS:AtRate(0x04)
- SBS:BatteryMode(0x03)[CapM]

## A.7 AtRateTimeToEmpty(0x06)

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

*AtRateTimeToEmpty* can report time based on constant current (*[LDMD]* = 0), or constant power (*[LDMD]* = 1), and is updated within one second after the SMBus host sets the *AtRate* value. The bq20z90/bq20z95 updates *AtRateTimeToEmpty* at one-second intervals.

0..65534 = predicted remaining operating time, based on *AtRate*

65535 = no charge or discharge (*AtRate* is 0)

**Table A-11. AtRateTimeToEmpty**

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

**Related Variables:**

- SBS:AtRate(0x04)
- SBS:OperationStatus(0x54)[LDMD]

## A.8 AtRateOK(0x07)

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

The bq20z90/bq20z95 updates this value within one second after the SMBus host sets the *AtRate* function value. The bq20z90/bq20z95 updates *AtRateOK* at one-second intervals.

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

0 = FALSE bq20z90/bq20z95 can **not** deliver energy for 10 seconds based on discharge rate indicated in *AtRate*

1..65535 = TRUE bq20z90/bq20z95 deliver can energy for 10 seconds based on discharge rate indicated in *AtRate*

**Table A-12. AtRateOK**

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

**Related Variables:**

- SBS:AtRate(0x04)

## A.9 Temperature(0x08)

This read-word function returns an unsigned integer value of the temperature in units of 0.1°K, as measured by the bq20z90/bq20z95. It has a range of 0 to 6553.5°K.

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

**Table A-13. Temperature**

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

**Related Variables:**

- DF:Configuration:Register(64):Operation Cfg A(0)

## A.10 Voltage(0x09)

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

**Table A-14. Voltage**

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

## A.11 Current(0x0a)

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

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

**Table A-15. Current**

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

**Related Variables:**

- DF:Calibration:Current(107):Deadband(1)

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

## A.12 AverageCurrent(0x0b)

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

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

**Table A-16. AverageCurrent**

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

**Related Variables:**

- DF:Calibration:Current(107):Filter(0)
- SBS:Current(0x0a)

## A.13 MaxError(0x0c)

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

Max error is incremented internally by 0.05% for every increment of *CylceCount* after the last QMAX update. *MaxError* is incremented in the display by 1% for increment of *CycleCount*.

| Event | ***MaxError* Setting** |
|---|---|
| Full Reset | set to 100% |
| QMAX and Ra table update | set to 1% |
| QMAX update | set to 3% |
| Ra table update | set to 5% |

**Table A-17. MaxError**

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

**Related Variables:**

- SBS:CycleCount(0x17)

## A.14 RelativeStateOfCharge(0x0d)

This read-word function returns an unsigned integer value of the predicted remaining battery capacity expressed as a percentage of *FullChargeCapacity* with a range of 0 to 100%, with fractions of % rounded up.

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

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

**Table A-18. RelativeStateOfCharge**

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg C(4)[RSOCL]
- SBS:FullChargeCapacity(0x10)

## A.15 AbsoluteStateOfCharge(0x0e)

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

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

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

**Table A-19. AbsoluteStateOfCharge**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- SBS:BatteryMode(0x03)[CapM]
- SBS:RemainingCapacity(0x0f)

## A.16 RemainingCapacity(0x0f)

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

**Table A-20. RemainingCapacity**

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

**Related Variables:**

- SBS:BatteryMode(0x03)[CapM]

## A.17 FullChargeCapacity(0x10)

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

**Table A-21. FullChargeCapacity**

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

**Related Variables:**

- SBS:BatteryMode(0x03)[CapM]

## A.18 RunTimeToEmpty(0x11)

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

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

0..65534 = predicted remaining battery life, based on *Current*

65535 = battery is not being discharged

**Table A-22. RunTimeToEmpty**

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

**Related Variables:**

- SBS:BatteryMode(0x03)[CapM]

## A.19 AverageTimeToEmpty(0x12)

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

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

0..65534 = predicted remaining battery life, based on *AverageCurrent*

65535 = battery is not being discharged

**Table A-23. AverageTimeToEmpty**

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

**Related Variables:**

- SBS:BatteryMode(0x03)[CapM]
- SBS:AverageCurrent(0x0b)

## A.20 AverageTimeToFull(0x13)

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

0..65534 = predicted remaining time until full charge

65535 = battery is not being charged

**Table A-24. AverageTimeToFull**

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

**Related Variables:**

- SBS:AverageCurrent(0x0b)

## A.21 ChargingCurrent(0x14)

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

0..65534 = desired charging current in mA

65535 = charger should operate as voltage source outside it's maximum regulated current range

**Table A-25. ChargingCurrent**

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

## A.22 ChargingVoltage(0x15)

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

0..65534 = desired charging voltage in mV

65535 = charger should operate as current source outside it's maximum regulated voltage range

**Table A-26. ChargingVoltage**

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

## A.23 BatteryStatus(0x16)

This read-word function returns the status of the bq20z90/bq20z95 -based battery.

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

LEGEND: All Values Read Only; RSVD = Reserved

**Figure A-3. BatteryStatus**

**OCA —** 1 = Over Charged Alarm

**TCA —** 1 = Terminate Charge Alarm

**OTA —** 1 = Over Temperature Alarm

**TDA —** 1 = Terminate Discharge Alarm

**RCA —** Remaining Capacity Alarm

1 = Remaining Capacity Alarm is set

see:

SBS:RemainingCapacityAlarm(0x01)

**RTA —** Remaining Time Alarm

1 = Remaining Time Alarm is set

see:

SBS:RemainingTimeAlarm(0x02)

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

**DSG —** Discharging

0 = bq20z90/bq20z95 is in charging mode

1 = bq20z90/bq20z95 is in discharging mode, relaxation mode, or valid charge termination has occurred

see:

"Gas Gauging" chapter in this document

**FC—** 1 = Fully Charged

**FD—** 1 = Fully Discharged

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

| | | |
|---|---|---|
| 0,0,0,0 = | OK | bq20z90/bq20z95 processed the function code with no errors detected. |
| 0,0,0,1 = | BUSY | bq20z90/bq20z95 is unable to process the function code at this time. |
| 0,0,1,0 = | Reserved | bq20z90/bq20z95 detected an attempt to read or write to a function code reserved by this version of the specification or bq20z90/bq20z95 detected an attempt to access an unsupported optional manufacturer function code. |

| | | |
|---|---|---|
| 0,0,1,1 = | Unsupported | bq20z90/bq20z95 does not support this function code as defined in this version of the specification. |
| 0,1,0,0 = | AccessDenied | bq20z90/bq20z95 detected an attempt to write to a read-only function code. |
| 0,1,0,1 = | Over/Underflow | bq20z90/bq20z95 detected a data overflow or underflow. |
| 0,1,1,0 = | BadSize | bq20z90/bq20z95 detected an attempt to write to a function code with an incorrect data block. |
| 0,1,1,1 = | UnknownError | bq20z90/bq20z95 detected an unidentifiable error. |

## A.24 CycleCount(0x17)

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

| CCT | Cycle Count Calculation |
|---|---|
| 0 = | one cycle count is the accumulated discharge of ***CC Threshold*** |
| 1 = | one cycle count is the accumulated discharge of ***CC %*** x *FullChargeCapacity*. If ***CC Threshold*** is greater than ***CC %*** x *FullChargeCapacity*, ***CC Threshold*** is used for the calculation |

**Table A-27. CycleCount**

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

**Related Variables:**

- DF:SBS Configuration:Data(48)Cycle Count(16)
- DF:SBS Configuration:Data(48)CC Threshold(18)
- DF:SBS Configuration:Data(48)CC %(20)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CCT]
- SBS:FullChargeCapacity(0x10)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.25 DesignCapacity(0x18)

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

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

When the bq20z90/bq20z95 is in unsealed or higher security mode, this block is R/W.

**Table A-28. DesignCapacity**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- SBS:BatteryMode(0x03)[CapM]
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.26 DesignVoltage(0x19)

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-29. DesignVoltage**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Voltage(8)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.27 SpecificationInfo(0x1a)

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

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

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

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-30. SpecificationInfo**

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

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

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

**Figure A-4. SpecificationInfo**

**Related Variables:**

- DF:SBS Configuration:Data(48):Spec Info(10)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.28 ManufactureDate(0x1b)

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

(year-1980) x 512 + month x 32 + day

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-31. ManufactureDate**

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

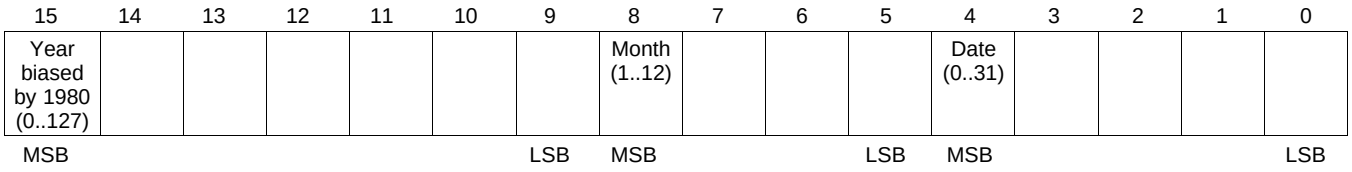


**Figure A-5. ManufacturerDate**

**Related Variables:**

- DF:SBS Configuration:Data(48):Manuf Date(12)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.29 SerialNumber(0x1c)

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-32. SerialNumber**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Ser. Num.(14)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.30 ManufacturerName(0x20)

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

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-33. ManufacturerName**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Manuf Name(26)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.31 DeviceName(0x21)

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

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-34. DeviceName**

| SBS Cmd. | Mode | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|
| 0x21 | R/W | DeviceName | String | 7+1 | - | - | bq20z90/bq20z95 | ASCII |

**Related Variables:**

- DF:SBS Configuration:Data(48):Device Name(38)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.32 DeviceChemistry(0x22)

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

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

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-35. DeviceChemistry**

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Device Chemistry(46)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.33 ManufacturerData(0x23)

This read-block function returns several configuration data flash elements with an absolute maximum length of 14 Data + 1 length byte (stored in Manufacturer Data Length). The Manufacturing data elements shown below are stored in the Manufacturer Data subclass.

When the bq20z90/bq20z95 is in Unsealed or higher security mode, this block is R/W.

**Table A-36. ManufacturerData**

| Data | Byte | Name | Format |
|---|---|---|---|
| Manufacturer Data | 0 | Pack Lot Code | hex |
| | 1 | | |
| | 2 | PCB Lot Code | |
| | 3 | | |
| | 4 | Firmware Version | |
| | 5 | | |
| | 6 | Hardware Revision | |
| | 7 | | |
| | 8 | Cell Revision | |
| | 9 | | |
| bq20z90/bq20z95 Counter | 10 | Partial Reset Counter | |
| | 11 | Full Reset Counter | |
| | 12 | Watchdog Reset Counter | |
| | 13 | Check Sum | |
| | 14 | String Length Byte | |

**Related Variables:**

- DF:System Data:Manufacturer Data(56):Pack Lot Code(0)
- DF:System Data:Manufacturer Data(56):PCB Lot Code(2)
- DF:System Data:Manufacturer Data(56):Firmware Version(4)
- DF:System Data:Manufacturer Data(56):Hardware Revision(6)
- DF:System Data:Manufacturer Data(56):Cell Revision(8)
- SBS:OperationStatus(0x54)[SS],[FAS]

## A.34 Authenticate(0x2f)

This read- or write-block function allows the host to authenticate the bq20z90/bq20z95 -based battery using a SHA-1 authentication transform with a length of 20 data bytes + 1 length byte. See *SHA-1 Authentication* chapter and *Using SHA-1 in bq20zxx Family of Gas Gauges* application report (SLUA359) for detailed information.

**Table A-37. Authenticate**

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

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

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

**Table A-38. CellVoltage4..1**

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

## A.36 SBS Command Values

**Table A-39. SBS COMMANDS**

| SBS Cmd | Mode | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|
| 0x00 | R/W | ManufacturerAccess | hex | 2 | 0x0000 | 0xffff | — | |
| 0x01 | R/W | RemainingCapacityAlarm | unsigned int | 2 | 0 | 65535 | 300 | mAh or 10mWh |
| 0x02 | R/W | RemainingTimeAlarm | unsigned int | 2 | 0 | 65535 | 10 | min |
| 0x03 | R/W | BatteryMode | hex | 2 | 0x0000 | 0xe383 | — | |
| 0x04 | R/W | AtRate | signed int | 2 | -32768 | 32767 | — | mA or 10mW |
| 0x05 | R | AtRateTimeToFull | unsigned int | 2 | 0 | 65534 | — | min |
| 0x06 | R | AtRateTimeToEmpty | unsigned int | 2 | 0 | 65534 | — | min |
| 0x07 | R | AtRateOK | unsigned int | 2 | 0 | 65535 | — | |
| 0x08 | R | Temperature | unsigned int | 2 | 0 | 65535 | — | 0.1°K |
| 0x09 | R | Voltage | unsigned int | 2 | 0 | 65535 | — | mV |
| 0x0a | R | Current | signed int | 2 | -32768 | 32767 | — | mA |
| 0x0b | R | AverageCurrent | signed int | 2 | -32768 | 32767 | — | mA |
| 0x0c | R | MaxError | unsigned int | 1 | 0 | 100 | — | % |
| 0x0d | R | RelativeStateOfCharge | unsigned int | 1 | 0 | 100 | — | % |
| 0x0e | R | AbsoluteStateOfCharge | unsigned int | 1 | 0 | 100+ | — | % |
| 0x0f | R/W | RemainingCapacity | unsigned int | 2 | 0 | 65535 | — | mAh or 10mWh |
| 0x10 | R | FullChargeCapacity | unsigned int | 2 | 0 | 65535 | — | mAh or 10mWh |
| 0x11 | R | RunTimeToEmpty | unsigned int | 2 | 0 | 65534 | — | min |
| 0x12 | R | AverageTimeToEmpty | unsigned int | 2 | 0 | 65534 | — | min |
| 0x13 | R | AverageTimeToFull | unsigned int | 2 | 0 | 65534 | — | min |
| 0x14 | R | ChargingCurrent | unsigned int | 2 | 0 | 65534 | — | mA |
| 0x15 | R | ChargingVoltage | unsigned int | 2 | 0 | 65534 | — | mV |
| 0x16 | R | BatteryStatus | unsigned int | 2 | 0x0000 | 0xdbff | — | |
| 0x17 | R/W | CycleCount | unsigned int | 2 | 0 | 65535 | — | |
| 0x18 | R/W | DesignCapacity | unsigned int | 2 | 0 | 65535 | 4400 | mAh or 10mWh |
| 0x19 | R/W | DesignVoltage | unsigned int | 2 | 0 | 65535 | 14400 | mV |
| 0x1a | R/W | SpecificationInfo | hex | 2 | 0x0000 | 0xffff | 0x0031 | |
| 0x1b | R/W | ManufactureDate | unsigned int | 2 | — | — | 01-Jan-1980 | ASCII |
| 0x1c | R/W | SerialNumber | hex | 2 | 0x0000 | 0xffff | 0x0001 | |
| 0x20 | R/W | ManufacturerName | String | 11+1 | — | — | Texas Inst. | ASCII |
| 0x21 | R/W | DeviceName | String | 7+1 | — | — | bq20z90/bq20z95 | ASCII |
| 0x22 | R/W | DeviceChemistry | String | 4+1 | — | — | LION | ASCII |
| 0x23 | R/W | ManufacturerData | String | 14+1 | — | — | — | ASCII |
| 0x2f | R/W | Authenticate | String | 20+1 | — | — | — | ASCII |
| 0x3c | R | CellVoltage4 | unsigned int | 2 | 0 | 65535 | — | mV |
| 0x3d | R | CellVoltage3 | unsigned int | 2 | 0 | 65535 | — | mV |
| 0x3e | R | CellVoltage2 | unsigned int | 2 | 0 | 65535 | — | mV |
| 0x3f | R | CellVoltage1 | unsigned int | 2 | 0 | 65535 | — | mV |

# Extended SBS Commands

The extended SBS commands are only available when the bq20z90/bq20z95 device is in unsealed or full access mode.

**Related Variables:**

- SBS:ManufacturerAccess(0x00):Seal Access(0x0020)
- SBS:OperationStatus(0x54)[SS],[FAS]
- SBS:UnSealKey(0x60)
- SBS:FullAccessKey(0x61)

## B.1 AFEData(0x45)

This read-block function returns a string of 11 data bytes + 1 length byte. The first 9 bytes are the bq29330 memory map followed by 2 bytes of the internal bq20z90/bq20z95 AFE_Fail_Counter.

**Table B-1. AFEData**

| Data | Byte | Name | Format |
|---|---|---|---|
| bq29330 | 0 | AFE Status | hex |
| | 1 | AFE Output | |
| | 2 | AFE State | |
| | 3 | AFE Function | |
| | 4 | AFE Cell Select | |
| | 5 | AFE OLV | |
| | 6 | AFE OLT | |
| | 7 | AFE SCC | |
| | 8 | AFE SCD | |
| bq20z90/bq20z95 | 9 | internal AFE_Fail_Counter high byte | |
| | 10 | internal AFE_Fail_Counter low byte | |
| | 11 | String Length Byte | |

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)
- DF:PF Status:AFE Regs(97)

## B.2 FETControl(0x46)

This read- or write-word function allows direct control of the FETs for test purposes.

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **FETControl** | RSVD | RSVD | RSVD | OD | ZVCHG | CHG | DSG | RSVD |

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

**Figure B-1. FETControl**

**OD —** bq29330 GPOD pin control.

0 = disable GPOD pin (high-Z)

1 = enable GPOD pin (open drain)

**ZVCHG —** Zero-Volt (Pre-Charge) charge FET Control

0 = turn OFF pre-charge FET

1 = turn ON pre-charge FET

**CHG —** Charge FET Control

0 = turn OFF CHG FET. CHG FET doesn't turn off in discharge mode to protect the FET body diode.

1 = turn ON CHG FET

**DSG —** Discharge FET Control

0 = turn OFF DSG FET. DSG FET doesn't turn of in charge mode to protect the FET body diode.

1 = turn ON DSG FET

## B.3 StateOfHealth(0x4f)

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

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

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- SBS:FullChargeCapacity(0x10)
- SBS:BatteryMode(0x03)[CapM]

## B.4 SafetyAlert(0x50)

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

See the "1st Level Protection Features" chapter for further details.

**Related Variables:**

- SBS:SafetyStatus(0x51)

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | OTD | OTC | OCD | OCC | OCD2 | OCC2 | PUV | POV |
| **Low Byte** | CUV | COV | PF | HWDG | WDF | AOCD | SCC | SCD |

LEGEND: All Values Read-Only

**Figure B-2. SafetyAlert**

**OTD—** 1 = Discharge overtemperature alert

**OTC—** 1 = Charge overtemperature alert

**OCD—** 1 = Discharge overcurrent alert

**OCC—** 1 = Charge overcurrent alert

**OCD2—** 1 = Tier-2 discharge overcurrent alert

**OCC2—** 1 = Tier-2 charge overcurrent alert

**PUV—** 1 = Pack undervoltage alert

**POV—** 1 = Pack overvoltage alert

**CUV—** 1 = Cell undervoltage alert

**PF—** 1 = Permanent failure alert

**COV—** 1 = Cell overvoltage alert

**HWDG—** 1 = Host watchdog alert

**WDF—** 1 = AFE watchdog alert

**AOCD—** 1 = AFE discharge overcurrent alert

**SCC—** 1 = Charge short-circuit alert

**SCD—** 1 = Discharge short-circuit alert

## B.5 SafetyStatus(0x51)

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

See the "1st Level Protection Features" chapter for further details.

**Related Variables:**

- SBS:SafetyAlert(0x50)

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | OTD | OTC | OCD | OCC | OCD2 | OCC2 | PUV | POV |
| **Low Byte** | CUV | COV | PF | HWDG | WDF | AOCD | SCC | SCD |

LEGEND: All Values Read-Only

**Figure B-3. SafetyStatus**

**OTD—** 1 = Discharge overtemperature condition

**OTC—** 1 = Charge overtemperature condition

**OCD—** 1 = Discharge overcurrent condition

**OCC—** 1 = Charge overcurrent condition

**OCD2—** 1 = Tier-2 discharge overcurrent condition

**OCC2—** 1 = Tier-2 charge overcurrent condition

**PUV—** 1 = Pack undervoltage condition

**POV—** 1 = Pack overvoltage condition

**CUV—** 1 = Cell undervoltage condition

**COV—** 1 = Cell overvoltage condition

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

**HWDG—** 1 = Host watchdog condition

**WDF—** 1 = AFE watchdog condition

**AOCD—** 1 = AFE discharge overcurrent condition

**SCC—** 1 = Charge short-circuit condition

**SCD—** 1 = Discharge short-circuit condition

## B.6 PFAlert(0x52)

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

See the "2nd Level Protection Features" chapter for further details.

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)
- DF:PF Status:Device Status Data(96):PF Flags 2(28)
- SBS:Current(0x0a)
- SBS:Voltage(0x09)
- SBS:PFStatus(0x53)

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

LEGEND: All Values Read-Only; RSVD = Reserved

**Figure B-4. PFAlert**

**FBF—** = 1: Fuse Blow Failure alert

**SOPT—** = 1: Open Thermistor permanent failure alert

**SOCD—** = 1: Discharge Safety Overcurrent permanent failure alert

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

**AFE_P—** = 1: Periodic AFE Communications permanent failure alert

**AFE_C—** = 1: Permanent AFE Communications failure alert

**DFF—** 1 = Data Flash Fault permanent failure alert

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

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

**CIM—** = 1: Cell-Imbalance permanent failure alert

**SOTD—** = 1: Discharge Safety Overtemperature permanent failure alert

**SOTC—** = 1: Charge Safety Overtemperature permanent failure alert

**SOV—** = 1: Safety-Overvoltage permanent failure alert

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

## B.7 PFStatus(0x53)

The permanent failure status register indicates the source of the bq20z90/bq20z95 permanent-failure condition.

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

See the "2nd Level Protection Features" chapter for further details.

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)
- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- DF:PF Status:Device Status Data(96):PF Flags 2(28)
- SBS:PFAlert(0x52)

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

LEGEND: All Values Read-Only; RSVD = Reserved

**Figure B-5. PFStatus**

**FBF—** 1 = Fuse Blow Failure

**SOPT—** 1 = Open Thermistor permanent failure

**SOCD—** 1 = Discharge Safety Overcurrent permanent failure

**SOCC—** 1 = Charge Safety-Overcurrent permanent failure

**AFE_P—** 1 = Periodic AFE Communications permanent failure

**AFE_C—** 1 = Permanent AFE Communications failure

**DFF—** 1 = Data Flash Fault permanent failure

**DFETF—** 1 = Discharge-FET-Failure permanent failure

**CFETF—** 1 = Charge-FET-Failure permanent failure

**CIM—** 1 = Cell-Imbalance permanent failure

**SOTD—** 1 = Discharge Safety Overtemperature permanent failure

**SOTC—** 1 = Charge Safety Overtemperature permanent failure

**SOV—** 1 = Safety-Overvoltage permanent failure

**PFIN—** 1 = External Input Indication of permanent failure

## B.8 OperationStatus(0x54)

This read-word function returns the current operation status of the bq20z90/bq20z95.

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | PRES | FAS | SS | CSV | RSVD | LDMD | RSVD | RSVD |
| **Low Byte** | WAKE | DSG | XDSG | XDSGI | RSVD | R_DIS | VOK | QEN |

LEGEND: All Values Read-Only; RSVD = Reserved

**Figure B-6. OperationStatus**

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

**FAS—** 0 = Full access security mode

**SS—** 1 = Sealed security mode

**CSV—** 1 = Data Flash checksum value has been generated

**LDMD—** Load mode for Impedance Track modeling. 0 = constant current, 1 = constant power

**WAKE—** 1 = bq20z90/bq20z95 WAKE mode

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

**XDSG—** 1 = Discharge fault

**XDSGI—** 1 = Discharge disabled due to a current issue

**R_DIS—** 1 = Ra Table resistance updates are disabled

**VOK—** 1 = Voltages are OK for a QMAX update

**QEN—** 1 = QMAX updates are enabled

## B.9 ChargingStatus(0x55)

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

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | XCHG | CHGSUSP | PCHG | MCHG | TCHG1 | TCHG2 | FCHG | PULSE |
| **Low Byte** | PLSOFF | CB | PCMTO | FCMTO | OCHGV | OCHGI | OC | XCHGLV |

LEGEND: All Values Read-Only

**Figure B-7. ChargingStatus**

**XCHG—** 1 = Charging disabled

**CHGSUSP—** 1 = Charging suspend conditions exist

**PCHG—** 1 = Precharging conditions exist

**MCHG—** 1 = Maintenance charging conditions exist

**TCHG1, TCHG2—**1 = Temperature-based throttling of charging current conditions exist

**FCHG—** 1 = Fast charging conditions exist

**PULSE—** 1 = Pulse charging in progress

**PLSOFF—** 1 = Pulse charging has turned CHG FET OFF

**CB—** 1 = Cell balancing in progress

**PCMTO—** 1 = Precharge timeout fault

**FCMTO—** 1 = Fast-charge timeout fault

**OCHGV—** 1 = Overcharge voltage fault

**OCHGI—** 1 = Overcharge current fault

**OC—** 1 = Overcharge fault

**XCHGLV—** 1 = Battery is depleted

## B.10 ResetData(0x57)

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

**Table B-2. ResetData**

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

## B.11 WDResetData(0x58)

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

**Table B-3. WDResetData**

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

## B.12 PackVoltage(0x5a)

This read-word function returns an unsigned integer value representing the measure voltage from the AFE PACK pin, in mV, with a range of 0 to 65535.

**Table B-4. PackVoltage**

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

## B.13 AverageVoltage(0x5d)

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

**Table B-5. AverageVoltage**

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

**Related Variables:**

- SBS:Voltage(0x09)

## B.14 UnSealKey(0x60)

This read- or write-block command allows the user to change the Unseal key for the Sealed-to-Unsealed security-state transition. This function is only available when the bq20z90/bq20z95 is in the Full-Access mode, indicated by a cleared *[FAS]* flag.

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

**Table B-6. UnSealKey**

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

**Related Variables:**

- SBS:OperationStatus(0x54)[FAS]

## B.15 FullAccessKey(0x61)

This read- or write-block command allows the user to change the Full-Access security key for the Unsealed-to-Full-Access security-state transition. This function is only available when the bq20z90/bq20z95 is in the Full-Access mode, indicated by a cleared *[FAS]* flag.

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

**Table B-7. FullAccessKey**

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

**Related Variables:**

- SBS:OperationStatus(0x54)[FAS]

## B.16 PFKey(0x62)

This read- or write-block command allows the user to change the Permanent-Failure-Clear key. This function is only available when the bq20z90/bq20z95 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

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

**Table B-8. PFKey**

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

**Related Variables:**

- SBS:OperationStatus(0x54)[FAS]

## B.17 AuthenKey3(0x63)

This read- or write-block command stores Byte 12 - Byte 15 of the 16 Byte long authentication key. This function is only available when the bq20z90/bq20z95 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

**Table B-9. AuthenKey3**

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

**Related Variables:**

- SBS:AuthenKey2(0x64)
- SBS:AuthenKey1(0x65)
- SBS:AuthenKey0(0x66)

## B.18 AuthenKey2(0x64)

This read- or write-block command stores Byte 8 - Byte 11 of the 16 Byte long authentication key. This function is only available when the bq20z90/bq20z95 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

**Table B-10. AuthenKey2**

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

**Related Variables:**

- SBS:AuthenKey3(0x63)
- SBS:AuthenKey1(0x65)
- SBS:AuthenKey0(0x66)

## B.19 AuthenKey1(0x65)

This read- or write-block command stores Byte 4 - Byte 7 of the 16 Byte long authentication key. This function is only available when the bq20z90/bq20z95 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

**Table B-11. AuthenKey1**

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

**Related Variables:**

- SBS:AuthenKey3(0x63)
- SBS:AuthenKey2(0x64)
- SBS:AuthenKey0(0x66)

## B.20 AuthenKey0(0x66)

This read- or write-block command stores Byte 0 - Byte 3 of the 16 Byte long authentication key. This function is only available when the bq20z90/bq20z95 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

**Table B-12. AuthenKey0**

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

**Related Variables:**

- SBS:AuthenKey3(0x63)
- SBS:AuthenKey2(0x64)
- SBS:AuthenKey1(0x65)

## B.21 ManufacturerInfo(0x70)

This read/write block function returns the data stored in ***Manuf. Info*** where byte 0 is the MSB with a maximum length of 31 data + 1 length byte. When the bq20z90/bq20z95 is in Unsealed or Full Access mode, this block is read/write. When the bq20z90/bq20z95 is in Sealed mode, this block is read only.

**Table B-13. ManfacturerInfo**

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

**Related Variables:**

- DF:System Data:Manufactuer Info(58):Manuf. Info(0)
- SBS:OperationStatus(0x54)[SS],[FAS]

## B.22 SenseResistor(0x71)

This read- or write-word command allows the user to change the sense resistor value used in µΩ. The bq20z90/bq20z95 automatically updates the respective calibration data on receipt of a new sense resistor value.

**Table B-14. SenseResistor**

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

## B.23 DataFlashSubClassID(0x77)

This write word function sets the bq20z90/bq20z95 data flash subclass, where data can be accessed by following the *DataFlashSubClass1..8* commands.

See "Accessing Data Flash" chapter for further information.

A *NACK* is returned to this command if the value of the class is outside of the allowed range. The subclasses are defined in the Data Flash.

**Table B-15. DataFlashSubClassID**

| SBS Cmd. | Mode | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|
| 0x77 | W | DataFlashSubClassID | hex | 2 | 0x0000 | 0xffff | - | |

**Related Variables:**

- SBS:DataFlashSubClassPage1..8(0x78..0x7f)

## B.24 DataFlashSubClassPage1..8(0x78..0x7f)

These commands are used to access the consecutive 32-byte pages of each subclass. *DataFlashSubClassPage1* gets bytes 0 to 31 of the subclass, *DataFlashSubClassPage2* gets bytes 32 to 63, and so on.

**Note:** Any DF location deemed Reserved responds with a *NACK* unless the bq20z90/bq20z95 is in the correct security state to allow access.

**Table B-16. DataFlashSubClass1..8**

| SBS Cmd. | Mode | Name | Format | Size in Bytes | Subclass Offset | Subclass Offset | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|
| 0x78 | R/W | DataFlashSubClassPage1 | hex | 32 | 0 | 31 | - | |
| 0x79 | R/W | DataFlashSubClassPage2 | hex | 32 | 32 | 63 | - | |
| 0x7a | R/W | DataFlashSubClassPage3 | hex | 32 | 64 | 95 | - | |
| 0x7b | R/W | DataFlashSubClassPage4 | hex | 32 | 96 | 127 | - | |
| 0x7c | R/W | DataFlashSubClassPage5 | hex | 32 | 128 | 159 | - | |
| 0x7d | R/W | DataFlashSubClassPage6 | hex | 32 | 160 | 191 | - | |
| 0x7e | R/W | DataFlashSubClassPage7 | hex | 32 | 192 | 223 | - | |
| 0x7f | R/W | DataFlashSubClassPage8 | hex | 32 | 224 | 255 | - | |

**Related Variables:**

- SBS:DataFlashSubClassID(0x77)

## B.25 Extended SBS Command Values

**Table B-17. EXTENDED SBS COMMANDS**

| SBS Cmd | Mode | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|
| 0x45 | R | AFEData | String | 11+1 | — | — | — | ASCII |
| 0x46 | R/W | FETControl | hex | 1 | 0x00 | 0x1e | — | |
| 0x4f | R | StateOfHealth | unsigned int | 1 | 0 | 100 | — | % |
| 0x50 | R | SafetyAlert | hex | 2 | 0x0000 | 0xffff | — | |
| 0x51 | R | SafetyStatus | hex | 2 | 0x0000 | 0xffff | — | |
| 0x52 | R | PFAlert | hex | 2 | 0x0000 | 0x9fff | — | |
| 0x53 | R | PFStatus | hex | 2 | 0x0000 | 0x9fff | — | |
| 0x54 | R | OperationStatus | hex | 2 | 0x0000 | 0xf7f7 | — | |
| 0x55 | R | ChargingStatus | hex | 2 | 0x0000 | 0xffff | — | |
| 0x57 | R | ResetData | hex | 2 | 0x0000 | 0xffff | — | |
| 0x58 | R | WDResetData | unsigned int | 2 | 0 | 65535 | — | |
| 0x5a | R | PackVoltage | unsigned int | 2 | 0 | 65535 | --- | mV |
| 0x5d | R | AverageVoltage | unsigned int | 2 | 0 | 65535 | — | mV |
| 0x60 | R/W | UnSealKey | hex | 4 | 0x00000000 | 0xffffffff | — | |
| 0x61 | R/W | FullAccessKey | hex | 4 | 0x00000000 | 0xffffffff | — | |
| 0x62 | R/W | PFKey | hex | 4 | 0x00000000 | 0xffffffff | — | |
| 0x63 | R/W | AuthenKey3 | hex | 4 | 0x00000000 | 0xffffffff | — | |
| 0x64 | R/W | AuthenKey2 | hex | 4 | 0x00000000 | 0xffffffff | — | |
| 0x65 | R/W | AuthenKey1 | hex | 4 | 0x00000000 | 0xffffffff | — | |
| 0x66 | R/W | AuthenKey0 | hex | 4 | 0x00000000 | 0xffffffff | — | |
| 0x70 | R/W | ManufacturerInfo | String | 8+1 | — | — | — | ASCII |

**Table B-17. EXTENDED SBS COMMANDS (continued)**

| SBS Cmd | Mode | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|
| 0x71 | R/W | SenseResistor | unsigned int | 2 | 0 | 65535 | — | µΩ |
| 0x77 | R/W | DataFlashSubClassID | hex | 2 | 0x0000 | 0xffff | — | |
| 0x78 | R/W | DataFlashSubClassPage1 | hex | 32 | — | — | — | |
| 0x79 | R/W | DataFlashSubClassPage2 | hex | 32 | — | — | — | |
| 0x7a | R/W | DataFlashSubClassPage3 | hex | 32 | — | — | — | |
| 0x7b | R/W | DataFlashSubClassPage4 | hex | 32 | — | — | — | |
| 0x7c | R/W | DataFlashSubClassPage5 | hex | 32 | — | — | — | |
| 0x7d | R/W | DataFlashSubClassPage6 | hex | 32 | — | — | — | |
| 0x7e | R/W | DataFlashSubClassPage7 | hex | 32 | — | — | — | |
| 0x7f | R/W | DataFlashSubClassPage8 | hex | 32 | — | — | — | |

# Data Flash

**CAUTION**

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

Data Flash can only be updated if *Voltage* ≥ ***Flash Update OK Voltage*** or *PackVoltage* ≥ ***Charger Present***. Data flash reads and writes are verified according to the method detailed in the "2nd Level Protection Features" section of this data sheet.

Note: Data Flash updates are disabled when the *[PF] SafetyStatus* flag is set.

## C.1 Accessing Data Flash

In different security modes, the data flash access conditions change. See *ManufacturerAccess* and "Security" chapter for further details.

| SECURITY MODE | NORMAL DATA FLASH ACCESS |
|---|---|
| BootROM | N/A |
| Full Access | R/W |
| Unsealed | R/W |
| Sealed | N/A |

### *C.1.1 Data Flash Interface*

The bq20z90/bq20z95 data flash is organized into subclasses where each data flash variable is assigned an offset within its numbered subclass. For example: the ***Pre-chg Temp*** threshold location is defined as:

- Class = Charge Control
- SubClass = Pre-Charge Cfg = 33
- Offset = 2

Note: Data Flash commands are NACK'ed if the bq20z90/bq20z95 is in sealed mode (*[SS]* flag is set).

Each subclass can be addressed individually by using the *DataFlashSubClassID* command and the data within each subclass is accessed by using the *DataFlashSubClassPage1..8* commands.

Reading and Writing subclass data are block operations which are each 32 Bytes long. Data can be written in shorter block sizes, however. The final block in one subclass can be shorter than 32 bytes so care must be taken not to write over the subclass boundary. None of the values written are bounded by the bq20z90/bq20z95 and the values are not rejected by the gas gauge. Writing an incorrect value may result in hardware failure due to firmware program interpretation of the invalid data. The data written is persistent, so a Power On Reset does resolve the fault.

**Related Variables:**

- SBS:DataFlashSubClassID(0x77)
- SBS:DataFlashSubClassPage1..8(0x78..0x7f)

### C.1.2 Reading a SubClass

Information required:

- SubClassID
- Number of bytes in the subclass
- Variable Offset

Procedure:

1. Write the SubClassID to bq20z90/bq20z95 using *DataFlashSubClassID* command.
2. Read a block of data using *DataFlashSubClassPage1..8* command. A subclass can hold up to 256 bytes of data, but subclass data can only be read in 32 byte long data blocks. The *DataFlashSubClassPage1* command reads only the first 32 bytes in a subclass, the *DataFlashSubClassPage2* command reads the second 32 bytes in a subclass, and so on. For example if the subclass has 40 bytes, *DataFlashSubClassPage1* + *DataFlashSubClassPage2* is needed to read the whole subclass.

### C.1.3 Writing a SubClass

Information required:

- SubClassID
- Number of bytes in the subclass
- 32 bytes of initialized data to be written. Less than 32 bytes is acceptable if a subclass contains less than 32 bytes in the last block.

Procedure:

1. Write the SubClassID to bq20z90/bq20z95 using *DataFlashSubClassID* command.
2. Write a block of data using *DataFlashSubClassPage1..8* command. A subclass can hold up to 256 bytes of data, but subclass data can only be write in 32 byte long data blocks. The *DataFlashSubClassPage1* command writes only the first 32 bytes in a subclass, the *DataFlashSubClassPage2* command writes the second 32 bytes in a subclass, and so on. For example, if the subclass has 40 bytes and data in offset 34 of the subclass needs to be changed, use *DataFlashSubClassPage2* to write data from byte 32 - 40 of the subclass.

### C.1.4 Example

To write the value of ***Term Voltage*** to a value of 8.7 V the following sequence is used.

Read complete Gas Gauging-IT Config subclass (SubclassID = 80) into RAM:

- Write Subclass ID
  - SMB Slave Address (0x16)
  - SMB CMD 0x77 with 0x0050 as data (=80 decimal)
- Read Subclass (2 blocks are needed as its over 32 bytes long)
  - SMBSlave Address (0x16)
  - SMB CMD 0x78 receiving 32 bytes of data
  - SMB CMD 0x79 receiving 32 bytes of data

Overwrite offset 45 of received data with 8.7 V:

- Update offset 45 of second block with 0x21fc (=8700 decimal)

Write the complete subclass back to the bq20z90/bq20z95:

- Write Subclass ID
  - SMB Slave Address (0x16)
  - SMB CMD 0x77 with 0x0050 as data
- Write Subclass
  - SMB Slave Address (0x17)
  - SMB CMD 0x78 with 32 bytes of data
  - SMB CMD 0x79 with 32 bytes of data

Alternatively, only the required block rather than the full subclass can be accessed.

Read required block of Gas Gauging-IT Config subclass (SubclassID = 80) into RAM:

- Write Subclass ID
  - SMB Slave Address (0x17)
  - SMB CMD 0x77 with 0x0050 as data (=80 decimal)
- Read Subclass (2nd block is needed as its offset 45)
  - SMB Slave Address (0x16)
  - SMB CMD 0x79 receiving 32 bytes of data

Overwrite offset (45 - 32 = 13) of received data with 8.7 V:

- Update offset 45 with 0x21fc (= 8700 decimal)

Write the updated block back to the bq20z90/bq20z95:

- Write Subclass ID
  - SMB Slave Address (0x17) SMB CMD 0x77 with 0x0050 as data
- Write Subclass
  - SMB Slave Address (0x17)
  - SMB CMD 0x79 with 32 bytes of data

## C.2 1st Level Safety Class

### *C.2.1 Voltage (Subclass 0)*

#### C.2.1.1 COV Threshold (Offset 0)

The bq20z90/bq20z95 sets the *[COV]* flag in *SafefyAlert* if any *CellVoltage4..1* is equal to or higher than the ***COV Threshold***.

**Table C-1. COV Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 0 | COV Threshold | unsigned integer | 2 | 3700 | 5000 | 4300 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):COV Time(2)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[COV]

#### C.2.1.2 COV Time (Offset 2)

If the *[COV] SafetyAlert* time period exceeds ***COV Time*** the bq20z90/bq20z95 goes into a cell over voltage condition. This function is disabled if ***COV Time*** is set to 0.

In a cell over voltage condition the CHG FET is turned off, the *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* is set, the *[COV] SafetyAlert* flag is reset, and the *[COV] SafetyStatus* flag is set.

**Table C-2. COV Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 2 | COV Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):COV Threshold(0)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[COV]
- SBS:SafetyStatus(0x51)[COV]

### C.2.1.3 COV Recovery (Offset 3)

The bq20z90/bq20z95 recovers from a cell over voltage condition if all cell voltages are lower than the ***COV Recovery*** threshold level. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, *[TCA]* is cleared, and the *[COV]* in *SafetyStatus* is reset.

**Table C-3. COV Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 3 | COV Recovery | unsigned integer | 2 | 0 | 4400 | 3900 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):COV Threshold(0)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyStatus(0x51)[COV]

### C.2.1.4 COV Delta (Offset 5)

The ***COV Delta*** reduces the ***COV Threshold*** limit when charging takes place above the over temperature limit. ***COV Threshold*** compensation is disabled when ***COV Delta*** is set to 0. The temperature limit is defined by the following formula:

*Temperature* > ***Over Temp Chg*** - ***COV Temp Hys***

**Table C-4. COV Delta**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 5 | COV Delta | unsigned integer | 1 | 0 | 200 | 20 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):COV Threshold(0)
- DF:1st Level Safety:Voltage(0):COV Temp. Hys(6)
- DF:1st Level Safety:Temperature(2):Over Temp Chg(0)
- SBS:Temperature(0x08)
- SBS:BatteryStatus(0x16)[DSG]

### C.2.1.5 COV Temp. Hys (Offset 6)

The ***COV Temp. Hys*** reduces the ***Over Temp Chg*** threshold used by COV threshold compensation.

**Table C-5. COV Temp. Hys**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 6 | COV Temp. Hys | unsigned integer | 1 | 0 | 250 | 100 | 0.1°C |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):COV Threshold(0)
- DF:1st Level Safety:Voltage(0):COV Delta(5)
- DF:1st Level Safety:Temperature(2):Over Temp Chg(0)
- SBS:Temperature(0x08)
- SBS:BatteryStatus(0x16)[DSG]

### C.2.1.6 POV Threshold (Offset 7)

The bq20z90/bq20z95 sets the *[POV]* in *SafetyAlert* if *Voltage* is equal to or higher than ***POV Threshold***.

**Table C-6. POV Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 7 | POV Threshold | unsigned integer | 2 | 0 | 18000 | 17500 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):POV Time(9)
- SBS:Voltage(0x09)
- SBS:SafetyAlert(0x50)[POV]

### C.2.1.7 POV Time (Offset 9)

If the *[POV]* in *SafetyAlert* time period exceeds ***POV Time*** the bq20z90/bq20z95 goes into a pack over voltage condition. This function is disabled if ***POV Time*** is set to 0.

In a pack over voltage condition the CHG FET is turned off, the *ChargingCurrent* is set to 0, the *ChargingVoltage* is set to 0, *[TCA]* is set, the *[POV] SafetyAlert* is reset, and the *[POV]* in *SafetyStatus* is set.

**Table C-7. POV Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 9 | POV Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):POV Threshold(7)
- DF:1st Level Safety:Voltage(0):POV Recovery(10)
- SBS:Voltage(0x09)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyAlert(0x50)[POV]
- SBS:SafetyStatus(0x51)[POV]

### C.2.1.8 POV Recovery (Offset 10)

The bq20z90/bq20z95 recovers from a pack over voltage condition if the *Voltage* is lower than the ***POV Recovery*** threshold level. On recovery the *ChargingCurrent* and *ChargingVoltage* are set to appropriate values per the charging algorithm, *[TCA]* is reset, and the *[POV]* in *SafetyStatus* is reset.

**Table C-8. POV Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 10 | POV Recovery | unsigned integer | 2 | 0 | 17000 | 16000 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):POV Threshold(7)
- SBS:Voltage(0x09)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyStatus(0x51)[POV]

### C.2.1.9 CUV Threshold (Offset 12)

The bq20z90/bq20z95 sets the *[CUV] SafetyAlert* if any *CellVoltage4..1* is equal to or lower than the ***CUV Threshold***.

**Table C-9. CUV Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 12 | CUV Threshold | unsigned integer | 2 | 0 | 3500 | 2200 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):CUV Time(14)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[CUV]

### C.2.1.10 CUV Time (Offset 14)

If *[CUV]* in *SafetyAlert* time period exceeds ***CUV Time*** the bq20z90/bq20z95 goes into a cell under voltage condition. This function is disabled if ***CUV Time*** is set to 0.

**Table C-10. CUV Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 14 | CUV Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):CUV Threshold(12)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- SBS:Charging Current(0x14)
- SBS:BatteryStatus(0x16)[TDA],[FD]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[CUV]
- SBS:SafetyStatus(0x51)[CUV]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.1.11 CUV Recovery (Offset 15)

The bq20z90/bq20z95 recovers from a cell under voltage condition, if all *CellVoltage4..1* are higher than the ***CUV Recovery*** threshold. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriates value per the charging algorithm, the *[TDA]* and *[FD]* flags are reset, the *[CUV]* in *SafetyStatus* is reset, and the *[XDSG]* flag in *OperationStatus* is reset.

**Table C-11. CUV Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 15 | CUV Recovery | unsigned integer | 2 | 0 | 3600 | 3000 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):CUV Threshold(12)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TDA],[FD]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyStatus(0x51)[CUV]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.1.12 PUV Threshold (Offset 17)

The bq20z90/bq20z95 sets the *[PUV]* in *SafetyAlert* if *Voltage* is equal to or lower than ***PUV Threshold***.

**Table C-12. PUV Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 17 | PUV Threshold | unsigned integer | 2 | 0 | 16000 | 11000 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):PUV Time(19)
- SBS:Voltage(0x09)
- SBS:SafetyAlert(0x50)[PUV]

### C.2.1.13 PUV Time (Offset 19)

If the *[PUV]* in *SafetyAlert* time period exceeds ***PUV Time*** the bq20z90/bq20z95 goes into a pack under voltage condition. This function is disabled if ***PUV Time*** is set to 0.

In a pack under voltage condition the DSG FET is turned off, the *ChargingCurrent* is set to the ***Pre-chg Current*** value, the *[TDA]* and *[FD]* flags are set, the *[PUV]* in *SafetyAlert* is cleared, the *[PUV]* in *SafetyStatus* is set, and the *[XDSG]* flag is set.

**Table C-13. PUV Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 19 | PUV Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):PUV Threshold(17)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- SBS:Voltage(0x09)
- SBS:Charging Current(0x14)
- SBS:BatteryStatus(0x16)[TDA],[FD]
- SBS:SafetyAlert(0x50)[PUV]
- SBS:SafetyStatus(0x51)[PUV]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.1.14 PUV Recovery (Offset 20)

The bq20z90/bq20z95 recovers from a pack under voltage condition if the pack voltage is higher than the ***PUV Recovery*** threshold level. On recovery, the *[TDA]* and *[FD]* flags are reset, the *[PUV] SafetyStatus* is reset, and the *[XDSG]* flag is reset.

**Table C-14. PUV Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Voltage | 20 | PUV Recovery | unsigned integer | 2 | 0 | 16000 | 12000 | mV |

**Related Variables:**

- DF:1st Level Safety:Voltage(0):PUV Threshold(17)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[PUV]
- SBS:OperationStatus(0x54)[XDSG]

## C.2.2 Current (Subclass 1)

### C.2.2.1 OC (1st Tier) Chg (Offset 0)

The bq20z90/bq20z95 sets the *[OCC] SafetyAlert* if charge *Current* is equal to or higher than the ***OC (1st Tier) Chg*** threshold.

**Table C-15. OC (1st Tier) Chg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 0 | OC (1st Tier) Chg | unsigned integer | 2 | 0 | 20000 | 6000 | mA |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg Time(2)
- SBS:Current(0x0a)
- SBS:SafetyAlert(0x50)[OCC]

### C.2.2.2 OC (1st Tier) Chg Time (Offset 2)

If the *[OCC]* in *SafetyAlert* time period exceeds the ***OC (1st Tier) Chg Time*** time the bq20z90/bq20z95 goes into an overcurrent charge condition. This function is disabled if ***OC (1st Tier) Chg Time*** is set to 0.

In an overcurrent while charging condition the CHG FET is turned off, the *ChargeCurrent* and *ChargeVoltage* are set to 0, the *[TCA]* flag is set, the *[OCC]* flag in *SafetyAlert* is cleared, and the *[OCC]* flag in *SafetyStatus* is set.

**Table C-16. OC (1st Tier) Chg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 2 | OC (1st Tier) Chg Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg(0)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyAlert(0x50)[OCC]
- SBS:SafetyStatus(0x51)[OCC]

### C.2.2.3 OC Chg Recovery (Offset 3)

The bq20z90/bq20z95 recovers from an over current charge condition in non-removable battery mode if the *AverageCurrent* is equal to or lower than the ***OC Chg Recovery*** threshold for a length of ***Current Recovery Time***. The bq20z90/bq20z95 recovers in removable battery mode by removing and reinserting the battery pack. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to appropriate their values per the charging algorithm, *[TCA]* is reset, and the *[OCC]* flag in *SafetyStatus* is reset.

**Table C-17. OC Chg Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 3 | OC Chg Recovery | signed integer | 2 | -1000 | 1000 | 200 | mA |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg(0)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x0b)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyStatus(0x51)[OCC]

### C.2.2.4 OC (1st Tier) Dsg (Offset 5)

The bq20z90/bq20z95 sets the *[OCD] SafetyAlert* if the discharge *Current* is equal to or higher than the ***OC (1st Tier) Dsg*** threshold.

**Table C-18. OC (1st Tier) Dsg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 5 | OC (1st Tier) Dsg | unsigned integer | 2 | 0 | 20000 | 6000 | mA |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Dsg Time(7)
- SBS:Current(0x0a)
- SBS:SafetyAlert(0x50)[OCD]

### C.2.2.5 OC (1st Tier) Dsg Time (Offset 7)

If the *[OCD]* in *SafetyAlert* time period exceeds the ***OC (1st Tier) Dsg Time*** bq20z90/bq20z95 goes into an overcurrent discharge condition. This function is disabled if ***OC (1st Tier) Dsg Time*** is set to 0.

In an overcurrent discharge condition the DSG FET is turned off, the *ChargeCurrent* is set to ***Pre-chg Current***, the *[TDA]* flag is set, the *[OCD]* flag in *SafetyAlert* is reset, the *[OCD]* flag in *SafetyStatus* is set, and the *[XDSG]* flag is set.

**Table C-19. OC (1st Tier) Dsg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 7 | OC (1st Tier) Dsg Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Dsg(5)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyAlert(0x50)[OCD]
- SBS:SafetyStatus(0x51)[OCD]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.2.6 OC Dsg Recovery (Offset 8)

The bq20z90/bq20z95 recovers from an over current discharge condition in non-removable battery mode if the *AverageCurrent* is equal to or lower than the ***OC Dsg Recovery*** current level for a length of ***Current Recovery Time***. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, *[TDA]* is reset, the *[OCD] SafetyStatus* flag is reset, and the *[XDSG]* flag is reset

**Table C-20. OC Dsg Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 8 | OC Dsg Recovery | signed integer | 2 | 0 | 1000 | 200 | mA |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Dsg(5)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[OCD]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.2.7 OC (2nd Tier) Chg (Offset 10)

The bq20z90/bq20z95 sets *[OCC2] SafetyAlert* if charge *Current* is equal to or higher than the ***OC (2nd Tier) Chg*** threshold.

**Table C-21. OC (2nd Tier) Chg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 10 | OC (2nd Tier) Chg | unsigned integer | 2 | 0 | 20000 | 8000 | mA |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Chg Time(12)
- SBS:Current(0x0a)
- SBS:SafetyAlert(0x50)[OCC2]

### C.2.2.8 OC (2nd Tier) Chg Time (Offset 12)

If the *[OCC2] SafetyAlert* time period exceeds the ***OC (2nd Tier) Chg Time*** the bq20z90/bq20z95 goes into an overcurrent charge condition. This function is disabled if ***OC (2nd Tier) Chg Time*** is set to 0.

In an overcharge condition the CHG FET is turned off, the *ChargingCurrent* and *ChargingVoltage* are set to 0, the *[TCA]* flag is set, the *[OCC2] SafetyAlert* flag is reset. and the *[OCC2] SafetyStatus* flag is set.

**Table C-22. OC (2nd Tier) Chg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 12 | OC (2nd Tier) Chg Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Chg(10)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyAlert(0x50)[OCC2]
- SBS:SafetyStatus(0x51)[OCC2]

### C.2.2.9 OC (2nd Tier) Dsg (Offset 13)

The bq20z90/bq20z95 sets *[OCD2]* in *SafetyAlert* if the discharge *Current* is equal to or higher than the ***OC (2nd Tier) Dsg*** overcurrent threshold.

**Table C-23. OC (2nd Tier) Dsg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 13 | OC (2nd Tier) Dsg | unsigned integer | 2 | 0 | 22000 | 8000 | mA |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Dsg Time(15)
- SBS:Current(0x0a)
- SBS:SafetyAlert(0x50)[OCD2]

### C.2.2.10 OC (2nd Tier) Dsg Time (Offset 15)

If the *[OCD2]* in *SafetyAlert* time period exceeds the ***OC (2nd Tier) Dsg Time*** the bq20z90/bq20z95 goes into an overcurrent discharge condition. This function is disabled if ***OC (2nd Tier) Dsg Time*** is set to 0.

In an overcurrent discharge condition the DSG FET is turned off, the *ChargingCurrent* is set to *Pre-chg Current*, *[TDA]* is set, the *[OCD2]* flag in *SafetyAlert* is reset, the *[OCD2]* flag in *SafetyStatus* is set, and the *[XDSG]* flag is set.

**Table C-24. OC (2nd Tier) Dsg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 15 | OC (2nd Tier) Dsg Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Dsg(13)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyAlert(0x50)[OCD]
- SBS:SafetyStatus(0x51)[OCD]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.2.11 Current Recovery Time (Offset 16)

The ***Current Recovery Time*** sets the minimum time period where the *AverageCurrent* need to be below the over current charge/discharge recovery threshold to recover from an over current charge/discharge condition.

**Table C-25. Current Recovery Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 16 | Current Recovery Time | unsigned integer | 1 | 0 | 240 | 8 | Sec |

**Related Variables:**

- DF:1st Level Safety:Current(1):OC Chg Recovery(3)
- DF:1st Level Safety:Current(1):OC Dsg Recovery(8)
- SBS:AverageCurrent(0x0b)

### C.2.2.12 AFE OC Dsg (Offset 17)

The ***AFE OC Dsg*** threshold sets the OLV register of the bq29330 AFE device. See the overload threshold register of the bq29330 datasheet for more details and appropriate values to use.

**Table C-26. AFE OC Dsg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 17 | AFE OC Dsg | hex | 1 | 0x00 | 0x1f | 0x12 | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **Low Byte** | RSVD | RSVD | RSVD | OLV4 | OLV3 | OLV2 | OLV1 | OLV0 |

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

**Figure C-1. OLV Register**

**OLV4, OLV3, OLV2, OLV1, OLV0 —** Sets the overload voltage threshold of the bq29330

0x00 - 0x1f = sets the voltage threshold between 50mV and 205mV in 5mV steps.

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE OC Dsg Time(18)

### C.2.2.13 AFE OC Dsg Time (Offset 18)

The ***AFE OC Discharge Time*** is programmed into the OLT register of the bq29330 AFE device. If an overcurrent discharge condition is reported by the bq29330 *ChargingCurrent* is set to 0, *[TDA]* in ***BatteryStatus*** is set, and *[AOCD]* in *SafetyStatus* is set.

**Table C-27. AFE OC Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 18 | AFE OC Dsg Time | hex | 1 | 0x00 | 0x0f | 0x0f | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **Low Byte** | RSVD | RSVD | RSVD | RSVD | OLT3 | OLT2 | OLT1 | OLT0 |

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

**Figure C-2. OLT Register**

**OLT3, OLT2, OLT1, OLT0 —** Sets the overload voltage delay of bq29330

0x00 - 0x0f = sets the overvoltage trip delay between 1ms - 31ms in 1ms steps

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[AOCD]

### C.2.2.14 AFE OC Dsg Recovery (Offset 19)

The bq20z90/bq20z95 recovers from an over current discharge condition in non-removable battery mode if the *AverageCurrent* is equal to or lower than the ***(-)AFE OC Dsg Recovery*** current level for the length of ***Current Recovery Time***. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, *[TDA]* is reset, the *[AOCD]* flag in *SafetyStatus* is reset, and *[XDSG]* is reset

**Table C-28. AFE OC Dsg Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 19 | AFE OC Dsg Recovery | signed integer | 2 | 10 | 1000 | 5 | mA |

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x0b)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyStatus(0x51)[AOCD]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.2.15 AFE SC Chg Cfg (Offset 21)

The ***AFE SC Charge Cfg*** is programmed into the SCC register of the bq29330 AFE device.
***AFE SC Charge Cfg*** sets the short circuit in charging voltage threshold and the short circuit in charging delay of the bq29330.

If the bq20z90/bq20z95 identifies a charge in short circuit situation from the bq29330 *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* in *BatteryStatus* is set, and *[SCC]* in *SafetyStatus* is set.

**Table C-29. AFE SC Chg Cfg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 21 | AFE SC Chg Cfg | hex | 1 | 0x00 | 0xff | 0x77 | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **Low Byte** | SCCT3 | SCCT2 | SCCT1 | SCCT0 | SCCV3 | SCCV2 | SCCV1 | SCCV0 |

**Figure C-3. SCC Register**

**SCCT3, SCCT2, SCCT1, SCCT0 —** Sets the short circuit delay in charging of the bq29330

0x0 - 0xf = sets the short circuit in charging delay between 0µs - 915µs in 61µs steps

**SCCV3, SCCV2, SCCV1, SCCV0 —** Sets the short circuit voltage threshold in charging of the bq29330

0x0 - 0xf = sets the short circuit voltage threshold between 0.1V and 0.475V in 25mV steps

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE SC Recovery(23)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyStatus(0x51)[SCC]

### C.2.2.16 AFE SC Dsg Cfg (Offset 22)

The ***AFE SC Dsg Cfg*** is programmed into the SCD register of the bq29330 AFE device. The ***AFE SC Dsg Cfg*** sets the short circuit in discharging voltage threshold and the short circuit in discharging delay of the bq29330.

If the bq20z90/bq20z95 identifies a discharge in short circuit situation from the bq29330 *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TDA]* in *BatteryStatus* is set, *[SCD]* in *SafetyStatus* is set, and *[XDSG]* in *OperationStatus* is set.

**Table C-30. AFE SC Dsg Cfg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 22 | AFE SC Dsg Cfg | hex | 1 | 0x00 | 0xff | 0x77 | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **Low Byte** | SCDT3 | SCDT2 | SCDT1 | SCDT0 | SCDV3 | SCDV2 | SCDV1 | SCDV0 |

**Figure C-4. SCD Register**

**SCDT3, SCDT2, SCDT1, SCDT0 —** Sets the short circuit delay in discharging of the bq29330

0x0 - 0xf = sets the short circuit in discharging delay between 0µs - 915µs in 61µs steps

**SCDV3, SCDV2, SCDV1, SCDV0 —** Sets the short circuit voltage threshold in discharging of the bq29330

0x0 - 0xf = sets the short circuit voltage threshold between 0.1V and 0.475V in 25mV steps

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE SC Recovery(23)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[SCD]
- SBS:OperationStatus(0x54)[XDSG]

#### C.2.2.17 AFE SC Recovery (Offset 23)

The bq20z90/bq20z95 recovers from a short circuit in charging or discharging condition in non-removable battery mode if the absolute value of *AverageCurrent* is equal to or lower than the ***AFE SC Recovery*** current level for the length of ***Current Recovery Time***. On recovery, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, *[TDA]* and *[TCA]* in *BatteryStatus* are reset, *[SCC]* and *[SCD]* in *SafetyStatus* are reset, and *[XDSG]* is reset

**Table C-31. AFE SC Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Current | 23 | AFE SC Recovery | unsigned integer | 2 | 0 | 200 | 1 | mA |

**Related Variables:**

- DF:1st Level Safety:Current Recovery Time(16)
- DF:1st Level Safety:Current(1):AFE SC Chg Cfg(21)
- DF:1st Level Safety:Current(1):AFE SC Dsg Cfg(22)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x0b)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyStatus(0x51)[SCC],[SCD]
- SBS:OperationStatus(0x54)[XDSG]

### *C.2.3 Temperature (Subclass 2)*

#### C.2.3.1 Over Temp Chg (Offset 0)

The bq20z90/bq20z95 sets the *[OTC]* flag in *SafetyAlert* if the pack *Temperature* is equal to or higher than the ***Over Temp Chg*** threshold.

**Table C-32. Over Temp Chg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Temperature | 0 | Over Temp Chg | unsigned integer | 2 | 0 | 1200 | 550 | 0.1°C |

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT Chg Time(2)
- SBS:Temperature(0x08)
- SBS:SafetyAlert(0x50)[OTC]

#### C.2.3.2 OT Chg Time (Offset 2)

If the *[OTC]* in *SafetyAlert* time period exceeds the ***OT Chg Time*** period the bq20z90/bq20z95 goes into an over temperature charge condition. This function is disabled if ***OT Chg Time*** is set to 0.

In and over temperature charge condition the *ChargingVoltage* and *ChargingCurrent* are set to 0, the *[OTA]* flag in *BatteryStatus* is set, *[TCA]* is set, the *[OTC]* flag in *SafetyAlert* is reset, and the *[OTC]* flag in *SafetyStatus* is set. If the *[OTFET]* bit is enabled the CHG FET also turns off.

**Table C-33. OT Chg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Temperature | 2 | OT Chg Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Temperature(2):Over Temp Chg (0)
- DF:Configuration:Registers(64):Operation Cfg B(2)[OTFET]
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA],[TCA]
- SBS:SafetyAlert(0x50)[OTC]
- SBS:SafetyStatus(0x51)[OTC]

### C.2.3.3 OT Chg Recovery (Offset 3)

The bq20z90/bq20z95 recovers from an over temperature charge condition if the *Temperature* is equal to or lower than the ***OT Chg Recovery*** level. On recovery, the CHG FET returns to it's normal operating state, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, the *[OTA]* flag is reset, and the *[OTC]* flag in *SafetyStatus* is reset.

**Table C-34. OT Chg Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Temperature | 3 | OT Chg Recovery | unsigned integer | 2 | 0 | 1200 | 500 | 0.1°C |

**Related Variables:**

- DF:1st Level Safety:Temperature(2):Over Temp Chg (0)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA]
- SBS:SafetyStatus(0x51)[OTC]

### C.2.3.4 Over Temp Dsg (Offset 5)

The bq20z90/bq20z95 sets the *[OTD]* in *SafetyAlert* if the pack *Temperature* is equal to or higher than the ***Over Temp Dsg*** threshold.

**Table C-35. Over Temp Dsg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Temperature | 5 | Over Temp Dsg | unsigned integer | 2 | 0 | 1200 | 600 | 0.1°C |

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT Dsg Time(7)
- SBS:Temperature(0x08)
- SBS:SafetyAlert(0x50)[OTD]

### C.2.3.5 OT Dsg Time (Offset 7)

If the *[OTD]* in *SafetyAlert* time period exceeds the ***OT Dsg Time*** the bq20z90/bq20z95 goes into an over temperature discharge condition. This function is disabled if ***OT Dsg Time*** is set to 0.

In an over temperature discharge condition the *ChargingCurrent* is set to 0, *[OTA]* is set, the *[OTD]* flag in *SafetyAlert* is reset, and the *[OTD] SafetyStatus* flag is set. If the *[OTFET]* bit is enabled, the DSG FET also turns off and *[XDSG]* in *OperationStatus* is set.

**Table C-36. OT Dsg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Temperature | 7 | OT Dsg Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:1st Level Safety:Temperature(2):Over Temp Dsg (5)
- DF:Configuration:Registers(64):Operation Cfg B(2)[OTFET]
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA]
- SBS:SafetyAlert(0x50)[OTD]
- SBS:SafetyStatus(0x51)[OTD]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.3.6 OT Dsg Recovery (Offset 8)

The bq20z90/bq20z95 recovers from an over temperature discharge condition if the *Temperature* is equal to or lower than the ***OT Dsg Recovery*** level. On recovery, the DSG FET returns to it's normal operating state, the *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm, the *[OTA]* flag is reset, the *[OTD] SafetyStatus* flag is reset, and the *[XDSG]* flag in *OperationStatus* is reset.

**Table C-37. OT Dsg Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 2 | Temperature | 8 | OT Dsg Recovery | unsigned integer | 2 | 0 | 1200 | 550 | 0.1°C |

**Related Variables:**

- DF:1st Level Safety:Temperature(2):Over Temp Dsg 5)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA]
- SBS:SafetyStatus(0x51)[OTD]
- SBS:OperationStatus(0x54)[XDSG]

## *C.2.4 Host Comm (Subclass 3)*

### C.2.4.1 Host Watchdog Timeout (Offset 0)

If the bq20z90/bq20z95 receives no valid SMBus communication for a time period greater than ***Host Watchdog Timeout*** the FETs are turned off, *ChargingVoltage* and *ChargingCurrent* are set to 0, *[TCA]* and *[TDA]* in *BatteryStatus* are set, *[HWDG]* in *SafetyStatus* is set, and *[XDSG]* in *OperationStatus* is set.

The bq20z90/bq20z95 recovers if valid SMBus communication resumes. On recovery, the FETs returns to their normal operating state, *ChargingVoltage* and *ChargingCurrent* are set to their appropriate values per the charging algorithm, *[TCA]* and *[TDA]* in *BatteryStatus* is cleared, *[HWDG]* in *SafetyStatus* is reset, and *[XDSG]* in *OperationStatus* is reset.

**Table C-38. Host Watchdog Timeout**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 3 | Host Comm | 0 | Host Watchdog Timeout | unsigned integer | 1 | 0 | 255 | 0 | Sec |

**Related Variables:**

- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyStatus(0x51)[HWDG]
- SBS:OperationStatus(0x54)[XDSG]

## C.3 2nd Level Safety

### *C.3.1 Voltage (Subclass 16)*

#### C.3.1.1 SOV Threshold (Offset 0)

The bq20z90/bq20z95 sets the *[SOV]* flag in *PFAlert* if the *Voltage* reports a value equal to or higher than the ***SOV Threshold***.

**Table C-39. SOV Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 0 | SOV Threshold | unsigned integer | 2 | 0 | 20000 | 18000 | mV |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SOV Time(2)
- SBS:Voltage(0x09)
- SBS:PFAlert(0x52)[SOV]

#### C.3.1.2 SOV Time (Offset 2)

If the *[SOV] PFAlert* time period exceeds the ***SOV Time*** limit the bq20z90/bq20z95 goes into a safety over voltage condition, *[SOV]* in *PFAlert* is cleared, *[SOV]* in *PFStatus* is set and, if the ***[XSOV]*** bit in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***SOV Time*** is set to 0.

**Table C-40. SOV Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 2 | POV Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SOV Threshold(0)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOV]
- SBS:Voltage(0x09)

- SBS:PFAlert(0x52)[SOV]
- SBS:PFStatus(0x53)[SOV]

### C.3.1.3 Cell Imbalance Current (Offset 3)

The battery pack *Current* must be below the ***Cell Imbalance Current*** limit for ***Cell Imbalance Time*** before the bq20z90/bq20z95 starts detecting cell imbalance.

**Table C-41. Cell Imbalance Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 3 | Cell Imbalance Current | unsigned integer | 1 | 0 | 200 | 5 | mA |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(4)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(6)
- DF:2nd Level Safety:Voltage(16):Battery Rest Time(7)
- SBS:Current(0x0a)

### C.3.1.4 Cell Imbalance Fail Voltage (Offset 4)

If the *Current* goes below ***Cell Imbalance Current*** for ***Battery Rest Time*** the bq20z90/bq20z95 starts cell imbalance measurements. The bq20z90/bq20z95 sets the *[CIM]* flag in *PFAlert* if the bq20z90/bq20z95 measures a difference between any *CellVoltage4..1* equal to or higher than the ***Cell Imbalance Fail Voltage*** threshold.

**Table C-42. Cell Imbalance Fail Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 4 | Cell Imbalance Fail Voltage | unsigned integer | 2 | 0 | 5000 | 1000 | mV |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(6)
- DF:2nd Level Safety:Voltage(16):Battery Rest Time(7)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAlert(0x52)[CIM]

### C.3.1.5 Cell Imbalance Time (Offset 6)

If the *[CIM] PFAlert* time period exceeds the ***Cell Imbalance Time*** limit the bq20z90/bq20z95 goes into a cell imbalance condition, *[CIM]* in *PFAlert* is cleared, *[CIM]* in *PFStatus* is set and, if ***[XCIM]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is also driven high. This function is disabled if ***Cell Imbalance Time*** is set to 0.

**Table C-43. Cell Imbalance Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 6 | Cell Imbalance Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(4)
- DF:2nd Level Safety:Voltage(16):Battery Rest Time(7)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOV]
- SBS:PFAlert(0x52)[CIM]
- SBS:PFStatus(0x53)[CIM]

### C.3.1.6 Battery Rest Time (Offset 7)

The battery *Current* must be below ***Cell Imbalance Current*** limit for at least ***Battery Rest Time*** period before the bq20z90/bq20z95 starts detecting a cell imbalance. Cell imbalance detection is disabled if ***Battery Rest Time*** is set to 0.

**Table C-44. Battery Rest Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 7 | Battery Rest Time | unsigned integer | 2 | 0 | 65535 | 1800 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(4)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(6)
- SBS:Current(0x0a)

### C.3.1.7 Min CIM-check voltage (Offset 9)

The battery *Current* must be below ***Cell Imbalance Current*** limit for at least ***Battery Rest Time*** period AND All (*CellVoltage4..1*) must be greater than ***Min CIM-check voltage*** before bq20z70/bq20z75 starts detecing cell imbalance.

**Table C-45. Min CIM-check voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 9 | Min CIM-check voltage | unsigned integer | 2 | 0 | 65535 | 3000 | mV |

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(4)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(6)
- DF:2nd Level Safety:Voltage(16):Battery Rest Time(7)
- SBS:Current(0x0a)
- SBS:CellVoltage4..1(0x3c..0x3f)

#### C.3.1.8 PFIN Detect Time (Offset 11)

If the $\overline{\text{PFIN}}$ pin is logic low then *[PFIN]* in *PFAlert* is set. If the *[PFIN]* PF alert time period exceeds ***PFIN Detect Time****[PFIN]* in *PFAlert* is reset, *[PFIN]* in *PFStatus* is set and, if ***[XPFIN]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is also driven high. This function is disabled if ***PFIN Detect Time*** is set to 0.

**Table C-46. PFIN Detect Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 16 | Voltage | 11 | PFIN Detect Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XPFIN]
- SBS:PFAlert(0x52)[PFIN]
- SBS:PFStatus(0x53)[PFIN]

### *C.3.2 Current (Subclass 17)*

#### C.3.2.1 SOC Chg (Offset 0)

The bq20z90/bq20z95 sets the *[SOCC]* in *PFAlert* if *Current* is equal to or higher than the ***SOC Chg*** threshold.

**Table C-47. SOC Chg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 17 | Current | 0 | SOC Chg | unsigned integer | 2 | 0 | 30000 | 10000 | mA |

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Chg Time(2)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOCC]
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[SOCC]

#### C.3.2.2 SOC Chg Time (Offset 2)

If the *[SOCC]* in *PFAlert* time period exceeds the ***SOC Chg Time*** the bq20z90/bq20z95 goes into a SOCC condition *[SOCC]* in *PFAlert* is cleared, *[SOCC]* in *PFStatus* is set and, if ***[XSOCC]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***SOC Chg Time*** is set to 0.

**Table C-48. SOC Chg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 17 | Current | 2 | SOC Chg Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Chg(0)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOCC]
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[SOCC]
- SBS:PFStatus(0x53)[SOCC]

### C.3.2.3 SOC Dsg (Offset 3)

The bq20z90/bq20z95 sets the *[SOCD] PFAlert* if discharge *Current* is equal to or higher than the ***(-)SOC Dsg*** threshold.

**Table C-49. SOC Dsg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 17 | Current | 3 | SOC Dsg | unsigned integer | 2 | 0 | 30000 | 10000 | mA |

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Dsg Time(5)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOCC]
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[SOCD]

### C.3.2.4 SOC Dsg Time (Offset 5)

If the *[SOCD] PFAlert* time period exceeds the safety over current charge time the bq20z90/bq20z95 goes into a SOCD condition, *[SOCD]* in *PFAlert* is cleared, *[SOCD]* in *PFStatus* is set and, if the ***[XSOCD]*** bit in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***SOCD Dsg Time*** is set to 0.

**Table C-50. SOC Dsg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 17 | Current | 5 | SOC Dsg Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Dsg(3)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOCD]
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[SOCD]
- SBS:PFStatus(0x53)[SOCD]

## *C.3.3 Temperature (Subclass 18)*

### C.3.3.1 SOT Chg (Offset 0)

The bq20z90/bq20z95 sets the *[SOTC] PFAlert* if *Temperature* is equal to or higher than the ***SOT Chg*** threshold during charging (*[DSG]* = 0).

**Table C-51. SOT Chg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 18 | Temperature | 0 | SOT Chg | unsigned integer | 2 | 0 | 1200 | 650 | 0.1°C |

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT Chg Time(2)
- SBS:Temperature(0x08)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFAlert(0x52)[SOTC]

### C.3.3.2 SOT Chg Time (Offset 2)

If the *[SOT]* flag in *PFAlert* time period exceeds ***SOT Chg Time*** the bq20z90/bq20z95 goes into a SOTC condition, *[SOTC]* in *PFAlert* is cleared, *[SOTC]* in *PFStatus* is set and, if ***[XSOTC]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***SOT Chg Time*** is set to 0.

**Table C-52. SOT Chg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 18 | Temperature | 2 | SOT Chg Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT Chg(0)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOTC]
- SBS:Temperature(0x08)
- SBS:PFAlert(0x52)[SOTC]
- SBS:PFStatus(0x53)[SOTC]

### C.3.3.3 SOT Dsg (Offset 3)

The bq20z90/bq20z95 sets the *[SOTD] PFAlert* if *Temperature* is equal to or higher than the *SOT Dsg* threshold during discharging (*[DSG]* = 1).

**Table C-53. SOT Dsg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 18 | Temperature | 3 | SOT Dsg | unsigned integer | 2 | 0 | 1200 | 750 | 0.1°C |

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT Dsg Time(5)
- SBS:Temperature(0x08)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFAlert(0x52)[SOTD]

### C.3.3.4 SOT Dsg Time (Offset 5)

If the *[SOTD]* in *PFAlert* time period exceeds ***SOT Dsg Time*** the bq20z90/bq20z95 goes into a *SOTD* condition, *[SOTD]* in *PFAlert* is reset, *[SOTD]* in *PFStatus* is set and, if ***[XSOTD]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***SOT Dsg Time*** is set to 0.

**Table C-54. SOT Dsg Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 18 | Temperature | 5 | SOT Dsg Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT Dsg(3)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOTD]
- SBS:Temperature(0x08)
- SBS:PFAlert(0x52)[SOTD]
- SBS:PFStatus(0x53)[SOTD]

#### C.3.3.5 Open Thermistor (Offset 6)

The bq20z90/bq20z95 sets the *[SOPT]* flag in *PFAlert* if the thermistor *Temperature* is equal to or lower than the ***Open Thermistor*** threshold.

**Table C-55. Open Thermistor**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 18 | Temperature | 6 | Open Thermistor | signed integer | 2 | -1000 | 1200 | -333 | 0.1°C |

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):Open Time(7)
- SBS:Temperature(0x08)
- SBS:PFAlert(0x52)[SOPT]

#### C.3.3.6 Open Time (Offset 7)

If the *[SOPT] PFAlert* time period exceeds ***Open Time*** period the bq20z90/bq20z95 goes into a safety open thermistor condition, *[SOPT]* in *PFAlert* is reset, *[SOPT]* in *PFStatus* is set and, if ***[XSOPT]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***Open Time*** is set to 0.

**Table C-56. Open Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 18 | Temperature | 8 | Open Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):Open Thermistor(6)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOPT]
- SBS:Temperature(0x08)
- SBS:PFAlert(0x52)[SOPT]
- SBS:PFStatus(0x53)[SOPT]

### *C.3.4 FET Verification (Subclass 19)*

#### C.3.4.1 FET Fail Limit (Offset 0)

The bq20z90/bq20z95 sets the *[CFETF] PFAlert* if the bq20z90/bq20z95 detects charge *Current* equal to or higher than the ***FET Fail Limit*** threshold when the CHG FET is supposed to be off.

The bq20z90/bq20z95 sets the *[DFETF] PFAlert* if the bq20z90/bq20z95 detects discharge *Current* equal to or lower than the ***(-)FET Fail Limit*** threshold when the DSG FET is supposed to be off.

**Table C-57. FET Fail Limit**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 19 | FET Verification | 0 | FET Fail Limit | unsigned integer | 2 | 0 | 500 | 20 | mA |

**Related Variables:**

- DF:2nd Level Safety:FET Verification(19):FET Fail Time(2)
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[CFETF],[DFETF]

### C.3.4.2 FET Fail Time (Offset 2)

If the *[CFETF]* alert time period exceeds ***FET Fail Time*** the bq20z90/bq20z95 goes into a charge FET failure condition, *[CFETF]* in *PFAlert* is reset, *[CFETF]* in *PFStatus* is set and, if ***[XCFETF]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***FET Fail Time*** is set to 0.

If the *[DFETF]* alert time period exceeds ***FET Fail Time*** the bq20z90/bq20z95 goes into a discharge FET failure condition, *[DFETF]* in *PFAlert* is reset, *[DFETF]* in *PFStatus* is set and, if ***[XDFETF]*** in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***FET Fail Time*** is set to 0.

**Table C-58. FET Fail Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 19 | AFE Verification | 2 | FET Fail Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:FET Verification(19):FET Fail Limit(0)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XCFETF],[XDFETF]
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[CFETF],[DFETF]
- SBS:PFStatus(0x53)[CFETF],[DFETF]

## *C.3.5 AFE Verification (Subclass 20)*

### C.3.5.1 AFE Check Time (Offset 0)

The bq20z90/bq20z95 compares periodically, with a period of ***AFE Check Time***, certain RAM content and expected control bit states of the bq29330 AFE with the values stored in data flash. If an error is detected, the internal AFE fail counter is incremented. Set to 0 to disable *[AFE_P]* faults

**Table C-59. AFE Check Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 20 | FET Verification | 0 | AFE Check Time | unsigned integer | 1 | 0 | 255 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Recovery Time(2)
- SBS:SafetyStatus(0x51)[WDF]
- SBS:PFStatus(0x53)[AFE_P]

### C.3.5.2 AFE Fail Limit (Offset 1)

If the internal AFE fail counter reaches the ***AFE Fail Limit*** the bq20z90/bq20z95 reports a *[AFE_C]* permanent failure and, if *[XAFE_C]* in ***Permanent Fail Cfg*** is set, the SAFE pin is driven high. This function is disabled if ***AFE Fail Limit*** is set to zero.

**Table C-60. AFE Fail Limit**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 20 | AFE Verification | 1 | AFE Fail Limit | unsigned integer | 1 | 0 | 255 | 10 | |

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Check Time(0)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Recovery Time(2)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XAFE_C]
- SBS:AFEData(0x45)
- SBS:PFStatus(0x53)[AFE_C]

### C.3.5.3 AFE Fail Recovery Time (Offset 2)

The bq20z90/bq20z95 decrements the internal AFE fail counter by one each ***AFE Fail Recovery Time*** period to a minimum of zero.

**Table C-61. AFE Fail Recovery Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 20 | AFE Verification | 2 | AFE Fail Recovery Time | unsigned integer | 1 | 0 | 255 | 20 | Sec |

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Check Time(0)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)

### C.3.5.4 AFE Init Retry Limit (Offset 3)

After a full reset the AFE offset and gain values are read twice and then compared. ***AFE Init Retry Limit*** is the maximum number of times that the initial AFE offset and gain values will be read, if they are not considered the same, until the *[AFE_C]* permanent failure occurs.

**Table C-62. AFE Init Retry Limit**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 20 | AFE Verification | 3 | AFE Init Retry Limit | unsigned integer | 1 | 0 | 255 | 6 | |

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Init Limit(4)
- SBS:PFStatus(0x53)[AFE_C]

### C.3.5.5 AFE Init Limit (Offset 4)

***AFE Init Limit*** is the difference in A/D counts that two successive readings of AFE offset and gain can be and still considered the be same value, after a full reset.

**Table C-63. AFE Init Limit**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 20 | AFE Verification | 4 | AFE Init Limit | unsigned integer | 1 | 0 | 255 | 20 | |

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Init Retry Limit(3)
- SBS:PFStatus(0x53)[AFE_C]

### C.3.6 Fuse Verification(Subclass 21)

#### C.3.6.1 Fuse Fail Limit (Offset 0)

The bq20z90/bq20z95 sets the *[FBF]* flag in *PFAlert* if the absolute value of charge or discharge *Current* is equal to or higher than the fuse fail limit threshold after a fuse blow attempt.

**Table C-64. Fuse Fail Limit**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 21 | Fuse Verification | 0 | Fuse Fail Limit | unsigned integer | 2 | 0 | 20 | 2 | mA |

**Related Variables:**

- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Time(2)
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[FBF]

#### C.3.6.2 Fuse Fail Time (Offset 2)

If the [FBF] in *PFAlert* time period exceeds ***Fuse Fail Time*** the bq20z90/bq20z95 reports a fuse blow failure permanent error, *[FBF]* in *PFAlert* is reset, and *[FBF]* in *PFStatus* is set. This function is disabled if ***Fuse Fail Time*** is set to 0.

**Table C-65. Fuse Fail Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 21 | Fuse Verification | 2 | Fuse Fail Time | unsigned integer | 1 | 0 | 240 | 0 | Sec |

**Related Variables:**

- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Limit(0)
- SBS:PFAlert(0x52)[FBF]
- SBS:PFStatus(0x53)[FBF]

## C.4 Charge Control

### C.4.1 Charge Inhibit Cfg (Subclass 32)

#### C.4.1.1 Chg Inhibit Temp Low (Offset 0)

If the *[DSG]* flag is set and the *Temperature* is below the ***Chg Inhibit Temp Low*** threshold *ChargingCurrent* and *ChargingVoltage* are set to 0. If the ***[CHGIN]*** bit is also set the CHG FET and ZVCHG FET (if used) are switched off and *[XCHG]* in *ChargingStatus* is set during charge inhibit mode.

**Table C-66. Chg Inhibit Temp Low**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 32 | Charge Inhibit Cfg | 0 | Chg Inhibit Temp Low | signed integer | 2 | –400 | 1200 | 0 | 0.1°C |

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)
- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGIN]

- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[XCHG]

#### C.4.1.2 Chg Inhibit Temp High (Offset 2)

If the *[DSG]* flag is set and the *Temperature* is above the ***Chg Inhibit Temp High*** threshold *ChargingCurrent* and *ChargingVoltage* are set to 0. If the ***[CHGIN]*** bit is also set the CHG FET and ZVCHG FET (if used) are switched off and *[XCHG]* in *ChargingStatus* is set during charge inhibit mode.

**Table C-67. Chg Inhibit Temp High**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 32 | Charge Inhibit Cfg | 2 | Chg Inhibit Temp High | signed integer | 2 | –400 | 1200 | 450 | 0.1°C |

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGIN]
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[XCHG]

#### C.4.1.3 Temp Hys (Offset 4)

If, in charge inhibit mode, the *Temperature* rises above ***Chg Inhibit Temp Low*** + ***Temp Hys*** or falls below ***Chg Inhibit Temp High*** - ***Temp Hys*** charging is allowed to be resumed and *[XCHG]* in *ChargingStatus* is cleared. If the ***[NR]*** flag is cleared the fault condition can be cleared by removing and reinserting the battery pack.

**Table C-68. Temp Hys**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 32 | Charge Inhibit Cfg | 4 | Temp Hys | signed integer | 2 | 0 | 100 | 10 | 0.1°C |

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR],[CHGIN]
- SBS:Temperature(0x08)
- SBS:ChargingStatus(0x55)[XCHG]

### *C.4.2 Pre-Charge Cfg (Subclass 33)*

#### C.4.2.1 Pre-chg Current (Offset 0)

The bq20z90/bq20z95 sets the *ChargingCurrent* to the ***Pre-chg Current*** value when in pre-charge mode.

**Table C-69. Pre-chg Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 33 | Pre-Charge Cfg | 0 | Pre-chg Current | unsigned integer | 2 | 0 | 2000 | 250 | mA |

**Related Variables:**

- SBS:ChargingCurrent(0x14)

### C.4.2.2 Pre-chg Temp (Offset 2)

If the battery *Temperature* drops below ***Pre-chg Temp*** the bq20z90/bq20z95 enters pre-charge mode and the *[PCHG]* flag in *ChargingStatus* is set. The bq20z90/bq20z95 leaves pre-charge mode if *Temperature* rises above ***Pre-chg Temp*** + ***Temp Hys*** and all *CellVoltage4..1* are above the ***Recovery Voltage*** level. On recovery, *[PCHG]* in *ChargingStatus* is cleared.

**Table C-70. Pre-chg Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 33 | Pre-Charge Cfg | 2 | Pre-chg Temp | signed integer | 2 | -400 | 1200 | 120 | 0.1°C |

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Pre-Charge Cfg(33):Recovery Voltage(6)
- SBS:Temperature(0x08)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:ChargingStatus(0x55)[PCHG]

### C.4.2.3 Pre-chg Voltage (Offset 4)

The bq20z90/bq20z95 enters pre-charge mode and sets the *[PCHG]* flag in *ChargingStatus* if any *CellVoltage4..1* drops below the ***Pre-chg Voltage*** threshold.

**Table C-71. Pre-chg Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 33 | Pre-Charge Cfg | 4 | Pre-chg Voltage | unsigned integer | 2 | 0 | 20000 | 3000 | mV |

**Related Variables:**

- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:ChargingStatus(0x55)[PCHG]

### C.4.2.4 Recovery Voltage (Offset 6)

The bq20z90/bq20z95 enters fast charge mode from pre charge mode and sets the *[FCHG]* flag in *ChargingStatus* if all *CellVoltage4..1* are equal to or higher than the ***Recovery Voltage*** threshold and battery *Temperature* is above ***Pre-chg Temp*** + ***Temp Hys***.

**Table C-72. Recovery Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 33 | Pre-Charge Cfg | 6 | Recovery Voltage | unsigned integer | 2 | 0 | 20000 | 3100 | mV |

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Pre-Charge Cfg(33):Pre-chg Temp(2)
- SBS:Temperature(0x08)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:ChargingStatus(0x55)[FCHG]

## *C.4.3 Fast Charge Cfg (Subclass 34)*

### C.4.3.1 Fast Charge Current (Offset 0)

The bq20z90/bq20z95 sets the *ChargingCurrent* to the ***Fast Charge Current*** value when in fast charge mode.

**Table C-73. Fast Charge Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 34 | Fast Charge Cfg | 0 | Fast Charge Current | unsigned integer | 2 | 0 | 10000 | 4000 | mA |

**Related Variables:**

- SBS:ChargingCurrent(0x14)
- SBS:ChargingStatus(0x55)[FCHG]

### C.4.3.2 Charging Voltage (Offset 2)

The bq20z90/bq20z95 sets the *ChargingVoltage* to the ***Charging Voltage*** value when in fast charge mode..

**Table C-74. Charging Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 34 | Fast Charge Cfg | 2 | Charging Voltage | unsigned integer | 2 | 0 | 20000 | 16800 | mV |

**Related Variables:**

- SBS:ChargingVoltage(0x15)
- SBS:ChargingStatus(0x55)[FCHG]

### C.4.3.3 Delta Temp (Offset 4)

***Delta Temp*** defines the temperature range where the *ChargingCurrent* is adjusted based on *Temperature*. The limits are ***Suspend High Temp*** - ***Delta Temp*** and ***Suspend High Temp*** - (2 x ***Delta Temp***). If ***Delta Temp*** is set to 0, the *ChargingCurrent* is not changed during fast charge.

**Table C-75. Delta Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 34 | Fast Charge Cfg | 4 | Delta Temp | signed integer | 2 | 0 | 500 | 50 | 0.1°C |

**Related Variables:**

- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(8)
- DF:Pre-Charge Cfg(33):Recovery Voltage(6)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingStatus(0x55)[PCHG]

### C.4.3.4 Suspend Low Temp (Offset 6)

If the battery pack *Temperature* drops below ***Suspend Low Temp***, the *AverageCurrent* is above ***Chg Current Threshold***, and the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0), the bq20z90/bq20z95 suspends charging. On suspension, *ChargingCurrent* is set to 0 and the *[CHGSUSP]* flag in *ChargingStatus* is set. The CHG FET and ZVCHG FET (if used) are also disabled if the ***[CHGSUSP]*** bit in ***Operation Cfg B*** is set. The bq20z90/bq20z95 returns to normal charging and clears *[CHGSUSP]* if *Temperature* rises above ***Chg Inhibit Temp Low*** + ***Temp Hys***.

**Table C-76. Suspend Low Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 34 | Fast Charge Cfg | 6 | Suspend Low Temp | signed integer | 2 | -400 | 1200 | -50 | 0.1°C |

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)
- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(8)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGSUSP]
- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- SBS:Temperature(0x08)
- SBS:AverageCurrrent(0x0b)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[CHGSUSP]

### C.4.3.5 Suspend High Temp (Offset 8)

If the battery pack *Temperature* rises above ***Suspend High Temp***, the *AverageCurrent* is above ***Chg Current Threshold***, and the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0), the bq20z90/bq20z95 suspends charging. On suspension, *ChargingCurrent* is set to 0 and the *[CHGSUSP]* flag in *ChargingStatus* is set. The CHG FET and ZVCHG FET (if used) are also disabled if the ***[CHGSUSP]*** bit in ***Operation Cfg B*** is set. The bq20z90/bq20z95 returns to normal charging and clears *[CHGSUSP]* if *Temperature* drops below ***Chg Inhibit Temp High*** - ***Temp Hys***.

**Table C-77. Suspend High Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 34 | Fast Charge Cfg | 10 | Suspend High Temp | signed integer | 2 | -400 | 1200 | 550 | 0.1°C |

**Related Variables:**

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)
- DF:Charge Control:Charge Inhibit Cfg(32):Temp Hys(4)
- DF:Charge Control:Fast Charge Cfg(34):Suspend Low Temp(6)
- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- SBS:Temperature(0x08)
- SBS:AverageCurrrent(0x0b)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[CHGSUSP]

## *C.4.4 Pulse Charge Cfg (Subclass 35)*

### C.4.4.1 Turn ON Voltage (Offset 0)

If any cell voltage drops below ***Turn ON Voltage*** while in pulse charge mode (*[PLSOFF]* = 1) and the CHG FET is off for a least ***Min OFF Pulse Time***, the bq20z90/bq20z95 turns on the CHG FET again, sets *[PULSE]* in *ChargingStatus*, and resets *[PLSOFF]*, also in *ChargingStatus*.

**Table C-78. Turn ON Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Pulse Charge Cfg | 0 | Turn ON Voltage | unsigned integer | 2 | 0 | 5000 | 4150 | mV |

**Related Variables:**

- DF:Charge Control:Pulse Charge Cfg(35):Turn OFF Voltage(2)
- DF:Charge Control:Pulse Charge Cfg(35):Min OFF Pulse Time(5)
- SBS:ChargingStatus(0x55)[PULSE],[PLSOFF]

### C.4.4.2 Turn OFF Voltage (Offset 2)

If any cell voltage during charging is equal to or above ***Max OFF Voltage*** OR ***Turn OFF Voltage*** for ***Max On Pulse Time*** the bq20z90/bq20z95 enters pulse charge mode and sets *[PULSE]* and *[PLSOFF]* in *ChargingStatus*.

**Table C-79. Turn OFF Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Pulse Charge Cfg | 2 | Turn OFF Voltage | unsigned integer | 2 | 0 | 5000 | 4250 | mV |

**Related Variables:**

- DF:Charge Control:Pulse Charge Cfg(35):Max ON Pulse Time(4)
- DF:Charge Control:Pulse Charge Cfg(35):Max OFF Voltage(6)
- SBS:ChargingStatus(0x55)[PULSE],[PLSOFF]

### C.4.4.3 Max ON Pulse Time (Offset 4)

This value sets the maximum time the CHG FET is turned on while in pulse charge mode.

**Table C-80. Max ON Pulse Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Pulse Charge Cfg | 4 | Max ON Pulse Time | unsigned integer | 1 | 0 | 240 | 240 | 0.25 Sec |

**Related Variables:**

- DF:Charge Control:Pulse Charge Cfg(35):Turn OFF Voltage(2)
- SBS:ChargingStatus(0x55)[PULSE],[PLSOFF]

#### C.4.4.4 Min OFF Pulse Time (Offset 5)

This value sets the minimum time the CHG FET stays off in pulse charge mode before it is turned on again

**Table C-81. Min OFF Pulse Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Pulse Charge Cfg | 5 | Min OFF Pulse Time | unsigned integer | 1 | 0 | 240 | 0 | 0.25 Sec |

**Related Variables:**

- DF:Charge Control:Pulse Charge Cfg(35):Turn ON Voltage(0)
- SBS:Charging Status(0x55)[PULSE],[PLSOFF]

#### C.4.4.5 Max OFF Voltage (Offset 6)

The bq20z90/bq20z95 enters pulse charge mode and sets *[PULSE]* and *[PULSE_OFF]* in *ChargingStatus* if the maximum cell voltage is equal to or above ***Max OFF Voltage*** or ***Turn OFF Voltage*** for ***Max ON Pulse Time***.

**Table C-82. Max OFF Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Pulse Charge Cfg | 6 | Max OFF Voltage | unsigned integer | 2 | 0 | 5000 | 4270 | mV |

**Related Variables:**

- DF:Charge Control:Pulse Charge Cfg(35):Turn OFF Voltage(2)
- SBS:Charging Status(0x55)[PULSE],[PLSOFF]

### *C.4.5 Termination Cfg. (Subclass 36)*

#### C.4.5.1 Maintenance Current (Offset 0)

The *ChargingCurrent* is set to ***Maintenance Current*** if a primary charge termination is detected or *RelativeStateOfCharge* > ***TCA Set %***

**Table C-83. Maintenance Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 0 | Maintenance Current | unsigned integer | 2 | 0 | 1000 | 0 | mA |

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):TCA Set %(9)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingStatus(0x55)[MCHG]

### C.4.5.2 Taper Current (Offset 2)

If battery *Current* falls below ***Taper Current*** for 2 consecutive ***Current Taper Window*** time periods during charging and *Voltage* is equal to or higher than ***Charging Voltage*** - ***Taper Voltage*** the bq20z90/bq20z95 recognizes valid primary charge termination.

**Table C-84. Taper Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 2 | Taper Current | unsigned integer | 2 | 0 | 1000 | 250 | mA |

**Related Variables:**

- DF:Charge Control:Fast Charge Cfg(36):Charging Voltage(2)
- DF:Charge Control:Termination Cfg.(36):Taper Voltage(6)
- DF:Charge Control:Termination Cfg.(36):Current Taper Window(8)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)

### C.4.5.3 Taper Voltage (Offset 6)

For valid primary charge termination, pack *Voltage* must be equal to or higher than ***Charging Voltage*** - ***Taper Voltage***.

**Table C-85. Taper Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 6 | Taper Voltage | unsigned integer | 2 | 0 | 1000 | 300 | mV |

**Related Variables:**

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- SBS:Voltage(0x09)

### C.4.5.4 Current Taper Window (Offset 8)

For a valid primary charge termination, *Current* must fall below ***Taper Current*** threshold for 2 consecutive ***Current Taper Window*** time periods.

**Table C-86. Current Taper Window**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 8 | Current Taper Window | unsigned integer | 1 | 0 | 240 | 40 | Sec |

**Related Variables:**

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Termination Cfg.(36):Taper Current(2)
- SBS:Current(0x0a)

### C.4.5.5 TCA Set % (Offset 9)

When set between 0% and 100%, *[TCA]* in *BatteryStatus* is set if *RelativeStateOfCharge* is equal to or above ***TCA Set %***. Set to -1 to disable this function. If set to -1, the *[MCHG]* and *[TCA]* flags are set on primary charge termination and *ChargingCurrent* is set to ***Maintenance Current***.

**Table C-87. TCA Set %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 9 | TCA Set % | signed integer | 1 | -1 | 100 | -1 | % |

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):Maintenance Current(0)
- DF:Charge Control:Termination Cfg.(36):TCA Clear %(10)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[MCHG]

### C.4.5.6 TCA Clear % (Offset 10)

When set between 0% and 100%, *[TCA]* in *BatteryStatus* is cleared if *RelativeStateOfCharge* is below ***TCA Clear %***. Set to -1 to disable this function.

**Table C-88. TCA Clear %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 10 | TCA Clear % | signed integer | 1 | -1 | 100 | 95 | % |

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):TCA Set %(9)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[TCA]

### C.4.5.7 FC Set % (Offset 11)

When set between 0% and 100%, *[FC]* in *BatteryStatus* is set if *RelativeStateOfCharge* is equal to or above ***FC Set %***. Set to -1 to disable this function.

**Table C-89. FC Set %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 11 | FC Set % | signed integer | 1 | -1 | 100 | -1 | % |

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):FC Clear %(12)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[FC]

#### C.4.5.8 FC Clear % (Offset 12)

When set between 0% and 100%, *[FC]* in *BatteryStatus* is cleared if *RelativeStateOfCharge* reaches or falls below ***FC Clear %***. Set to -1 to disable this function. It is recommended, however, not to set ***FC Clear %*** to -1.

**Table C-90. FC Clear %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Termination Cfg. | 12 | FC Clear % | signed integer | 1 | -1 | 100 | 98 | % |

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):FC Set %(11)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[FC]

### *C.4.6 Cell Balancing Cfg (Subclass 37)*

#### C.4.6.1 Min Cell Deviation (Offset 0)

This value defines the conversion factor for calculating cell balancing time per cell in units of balance time per mAh before the bq20z90/bq20z95 starts balancing cell capacity during charging. If ***Min Cell Deviation*** is set to 0 cell balancing is disabled.

**Table C-91. Min Cell Deviation**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 37 | Cell Balancing Cfg | 0 | Min Cell Deviation | unsigned integer | 2 | 0 | 65535 | 1750 | Sec/mAh |

### *C.4.7 Charging Faults (Subclass 38)*

#### C.4.7.1 Over Charging Voltage (Offset 0)

If the battery pack *Voltage* is equal to or greater than *ChargingVoltage* + ***Over Charging Voltage*** for a time period greater than ***Over Charging Volt Time***, the *[OCHGV]* flag is set and the CHG FET and ZVCHG FET (if used) are turned off if ***[OCHGV]*** is also set in ***Charge Fault Cfg***.

**Table C-92. Over Charging Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 0 | Over Charging Voltage | unsigned integer | 2 | 0 | 3000 | 500 | mV |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Volt Time(2)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGV]
- SBS:Voltage(0x09)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGV]

### C.4.7.2 Over Charging Volt Time (Offset 2)

If the battery pack *Voltage* is equal to or greater than *ChargingVoltage* + ***Over Charging Voltage*** for a time period greater than ***Over Charging Volt Time*** the *[OCHGV]* flag is set and the CHG FET and ZVCHG FET (if used) are turned off if ***[OCHGV]*** is also set in ***Charge Fault Cfg***. The bq20z90/bq20z95 recovers if the battery pack *Voltage* is equal to or below ***Charging Voltage***.

**Table C-93. Over Charging Volt Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 2 | Over Charging Volt Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Charging Faults(38):Over Charging Volt Time(2)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGV]
- SBS:Voltage(0x09)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGV]

### C.4.7.3 Over Charging Current (Offset 3)

If the current is equal to or greater than the sum of *ChargingCurrent* and ***Over Charging Current*** for a time period greater than ***Over Charging Curr Time*** the bq20z90/bq20z95 goes into an over charging current error, *[OCHGI]* in *ChargingStatus* set and, if ***[OCHGI]*** in ***Charge Fault Cfg*** is set, the CHG FET turns off and the ZVCHG FET (if used) is turned on. If the ZVCHG FET is not used the CHG FET remains on, regardless of the bits set in ***Charge Fault Cfg***, because it acts as the ZVCHG FET.

**Table C-94. Over Charging Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 3 | Over Charging Current | unsigned integer | 2 | 0 | 2000 | 500 | mA |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGI]
- SBS:Current(0x0a)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGI]

### C.4.7.4 Over Charging Curr Time (Offset 5)

If the *Current* is equal to or greater than the sum of *ChargingCurrent* and ***Over Charging Current*** for a time period greater than ***Over Charging Curr Time*** the bq20z90/bq20z95 goes into over charging current error, *[OCHGI]* in *ChargingStatus* set and, if ***[OCHGI]*** in ***Charge Fault Cfg*** is set, the CHG FET turns off and the ZVCHG FET (if used) is turned on. If the ZVCHG FET is not used the CHG FET remains on, regardless of the bits set in ***Charge Fault Cfg***, because it acts as the ZVCHG FET. The bq20z90/bq20z95 recovers if *AverageCurrent* is equal to or lower than the ***Over Charging Curr Recov*** value.

**Table C-95. Over Charging Curr Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 5 | Over Charging Curr Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Current(3)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Recov(6)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGI]
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGI]

### C.4.7.5 Over Charging Curr Recov (Offset 6)

The bq20z90/bq20z95 recovers from an over charging current fault if *AverageCurrent* is equal to or lower than ***Over Charging Curr Recov***. On recovery, *[OCHGI]* in *ChargingStatus* is reset and the CHG and ZVCHG FETs return to their previous states.

**Table C-96. Over Charging Curr Recov**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 6 | Over Charging Curr Recov | unsigned integer | 2 | 0 | 2000 | 100 | mA |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Current(3)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- SBS:Current(0x0a)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGI]

### C.4.7.6 Depleted Voltage (Offset 8)

The bq20z90/bq20z95 goes into a depleted voltage fault and sets *[XCHGLV]* if the charger is present (*PackVoltage* > ***Charger Present***) and pack *Voltage* is equal to or lower than ***Depleted Voltage*** for a period equal to or greater than ***Depleted Voltage Time***. The DSG FET is turned off and the CHG and ZVCHG FETs are set according to ***[ZVCHG1,ZVCHG0]*** bits if ***[CS_XCHGLV]*** is set in ***Charge Fault Cfg.***

**Table C-97. Depleted Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 8 | Depleted Voltage | unsigned integer | 2 | 0 | 16000 | 8000 | mV |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[CS_XCHGLV]
- DF:Power:Power(68):Charger Present(8)

- SBS:Voltage(0x09)
- SBS:PackVoltage(0x5a)
- SBS:ChargingStatus(0x55)[XCHGLV]

### C.4.7.7 Depleted Voltage Time(Offset 10)

The bq20z90/bq20z95 goes into a depleted voltage fault and sets *[XCHGLV]* if the charger is present and pack *Voltage* is equal to or lower than ***Depleted Voltage*** for a period equal to or greater than ***Depleted Voltage Time***. If ***[CS_XCHGLV]*** is set in ***Charge Fault Cfg*** the DSG FET is turned off and the CHG and ZVCHG FETs are set according to their pre-charge settings.

**Table C-98. Depleted Voltage Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 10 | Depleted Voltage Time | unsigned integer | 1 | 0 | 240 | 2 | Sec |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Depleted Voltage(8)
- DF:Charge Control:Charging Faults(38):Depleted Recovery(11)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[CS_XCHGLV]
- SBS:Voltage(0x09)
- SBS:ChargingStatus(0x55)[XCHGLV]

### C.4.7.8 Depleted Recovery (Offset 11)

The bq20z90/bq20z95 recovers from a depleted voltage fault if pack *Voltage* is equal to or higher than the ***Depleted Recovery*** threshold. On recovery, *[OCHGLV]* is reset and the DSG FET, CHG FET and ZVCHG FET return to their previous states.

**Table C-99. Depleted Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 11 | Depleted Recovery | unsigned integer | 2 | 0 | 16000 | 8500 | mV |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- SBS:Voltage(0x09)
- SBS:ChargingStatus(0x55)[XCHGLV]

### C.4.7.9 Over Charge Capacity (Offset 13)

The bq20z90/bq20z95 goes into an overcharge fault and sets the *[OC]* flag in *ChargingStatus* if the internal counted remaining capacity exceeds *FullChargeCapacity* + ***Over Charge Capacity***. The CHG FET and ZVCHG FET (if used) are also turned of if the ***[OC]*** bit is set in ***Charge Fault Cfg***.

**Table C-100. Over Charge Capacity**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 13 | Over Charge Capacity | unsigned integer | 2 | 0 | 4000 | 300 | mAh |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charge Recovery(15)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OC]
- SBS:FullChargeCapacity(0x10)
- SBS:ChargingStatus(0x55)[OC]

### C.4.7.10 Over Charge Recovery (Offset 15)

The bq20z90/bq20z95 recovers from an over charge in non-removable battery mode(***[NR]*** = 1) if it is continuously discharged by an amount of ***Over Charge Recovery*** charge.

**Table C-101. Over Charge Recovery**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 15 | Over Charge Recovery | unsigned integer | 2 | 0 | 100 | 2 | mAh |

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charge Capacity(13)
- DF:Configuration:Registers(64):Operation B Cfg(2)[NR]
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)
- SBS:ChargingStatus(0x55)[OC]

### C.4.7.11 FC-MTO (Offset 17)

If charge *Current* is equal to or greater than ***Chg Current Threshold*** for ***FC-MTO*** time period the bq20z90/bq20z95 generates a fast charge mode time out fault and sets the *[FCMTO]* flag. The CHG FET and ZVCHG FET (if used) are also turned of if ***[FCMTO]*** is set in ***Charge Fault Cfg***. Set to 0 to disable ***FC-MTO***.

**Table C-102. FC-MTO**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 17 | FC-MTO | unsigned integer | 2 | 0 | 65535 | 10800 | Sec |

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[FCMTO]
- SBS:Current(0x0a)
- SBS:ChargingStatus(0x55)[FCMTO]

### C.4.7.12 PC-MTO (Offset 19)

If charge *Current* is equal to or greater than ***Chg Current Threshold*** for ***PC-MTO*** time period the bq20z90/bq20z95 generates a precharge mode-time out error and sets the *[PCMTO]* flag. The CHG FET and ZVCHG FET (if used) are also turned of if ***[PCMTO]*** is set in ***Charge Fault Cfg***. Set to 0 to disable ***PC-MTO***.

**Table C-103. PC-MTO**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 19 | PC-MTO | unsigned integer | 2 | 0 | 65535 | 3600 | Sec |

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[PCMTO]
- SBS:Current(0x0a)
- SBS:ChargingStatus(0x55)[PCMTO]

### C.4.7.13 Charge Fault Cfg (Offset 21)

This register sets the behavior of the charge, discharge, and zero-volt charge FETs in fault conditions.

**Table C-104. Charge Fault Cfg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 38 | Charging Faults | 21 | Charge Fault Cfg | hex | 1 | 0 | 0x3f | 0x00 | |

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| RSVD | RSVD | PCMTO | FCMTO | OCHGV | OCHGI | OC | CS_XCHGLV |
| R | R | R/W | R/W | R/W | R/W | R/W | R/W |

LEGEND: R/W = Read/Write; R = Read only; - *n* = value after reset; RSVD = Reserved and **must** be programmed to 0

**Figure C-5. Charge Fault Cfg Register**

**PCMTO —** If set, CHG FET and ZVCHG FET (if used) are turned off when pre-charge time out fault occurs.

**FCMTO —** If set, CHG FET and ZVCHG FET (if used) are turned off when fast charge time out fault occurs.

**OCHGV —** If set, CHG FET and ZVCHG FET (if used) are turned off when charge voltage fault occurs.

**OCHGI —** If set, CHG FET is turned off and ZVCHG FET (if used) is turned on when charge current fault occurs. If ZVCHG FET is not used, CHG FET remains on, regardless of this bit, because it acts as ZVCHG FET.

**OC —** If set, CHG FET and ZVCHG FET (if used) are turned off when over charge fault occurs.

**CS_XCHGLV —** If set, DSG FET is turned off when battery depleted fault occurs.

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Volt Time(2)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- DF:Charge Control:Charging Faults(38):Over Charge Capacity(13)
- DF:Charge Control:Charging Faults(38):FC-MTO(17)
- DF:Charge Control:Charging Faults(38):PC-MTO(19)

## C.5 SBS Configuration

## C.5.1 Data (Subclass 48)

### C.5.1.1 Rem Cap Alarm (Offset 0)

When *[CapM]* in *BatteryStatus* is set to 0, the default value of *RemainingCapacityAlarm* is stored in ***Rem Cap Alarm*** and copied to the SBS value upon bq20z90/bq20z95 initialization.

**Table C-105. Rem Cap Alarm**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 0 | Rem Cap Alarm | unsigned integer | 2 | 0 | 700 | 300 | mAh |

**Related Variables:**

- SBS:RemainingCapacityAlarm(0x01)

### C.5.1.2 Rem Energy Alarm (Offset 2)

When *[CapM]* in *BatteryStatus* is set to 1, the default value of *RemainingCapacityAlarm* is stored in ***Rem Energy Alarm*** and copied to the SBS value upon the bq20z90/bq20z95 initialization.

**Table C-106. Rem Energy Alarm**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 2 | Rem Energy Alarm | unsigned integer | 2 | 0 | 1000 | 432 | 10mWh |

**Related Variables:**

- SBS:RemainingCapacityAlarm(0x01)

### C.5.1.3 Rem Time Alarm (Offset 4)

The default value of *RemainingTimeAlarm* is stored in ***Rem Time Alarm*** and copied to the SBS value upon bq20z90/bq20z95 initialization.

**Table C-107. Rem Time Alarm**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 4 | Rem Time Alarm | unsigned integer | 2 | 0 | 30 | 10 | min |

**Related Variables:**

- SBS:RemainingTimeAlarm(0x02)

### C.5.1.4 Init Battery Mode (Offset 6)

The default value of *BatteryMode* is stored in ***Init Battery Mode*** and copied to the SBS value upon bq20z90/bq20z95 initialization.

**Table C-108. Init Battery Mode**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 6 | Init Battery Mode | hex | 2 | 0 | 0xffff | 0x0081 | |

**Related Variables:**

- SBS:BatteryMode(0x03)

### C.5.1.5 Design Voltage (Offset 8)

The default value of *DesignVoltage* is stored in ***Design Voltage*** and copied to the SBS value upon bq20z90/bq20z95 initialization.

**Table C-109. Design Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 8 | Design Voltage | unsigned integer | 2 | 7000 | 18000 | 14400 | mV |

**Related Variables:**

- SBS:DesignVoltage(0x19)

### C.5.1.6 Spec Info (Offset 10)

The default value of *SpecificationInfo* is stored in ***Spec Info*** and copied to the SBS value upon bq20z90/bq20z95 initialization.

**Table C-110. Spec Info**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 10 | Spec Info | hex | 2 | 0x0000 | 0xffff | 0x0031 | |

**Related Variables:**

- SBS:SpecificationInfo(0x1a)

### C.5.1.7 Manuf Date (Offset 12)

The default value of *ManufacturerDate* is stored in ***Manuf Date*** and copied to the SBS value upon bq20z90/bq20z95 initialization.

**Table C-111. Manuf Date**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 12 | Manuf Date | unsigned integer | 2 | 0 | 65535 | 0 | Day + Mo*32 + (Yr -1980)*512 |

**Related Variables:**

- SBS:ManufactureDate(0x1b)

### C.5.1.8 Ser. Num. (Offset 14)

The default value of *SerialNumber* is stored in ***Ser. Num.*** and copied to the SBS value upon bq20z90/bq20z95 initialization.

**Table C-112. Ser. Num.**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 14 | Ser. Num. | hex | 2 | 0x0000 | 0xffff | 0x0001 | |

**Related Variables:**

- SBS:SerialNumber(0x1c)

### C.5.1.9 Cycle Count (Offset 16)

The default value of *CycleCount* is stored in ***Cycle Count*** and copied to the SBS value upon bq20z90/bq20z95 initialization. When the SBS value changes ***Cycle Count*** is also updated.

**Table C-113. Cycle Count**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 16 | Cycle Count | unsigned integer | 2 | 0 | 65535 | 0 | Count |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[CCT]
- DF:SBS Configuration:Data(48):CC Threshold(18)
- DF:SBS Configuration:Data(48):CC %(20)
- SBS:CycleCount(0x17)

### C.5.1.10 CC Threshold (Offset 18)

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

**Table C-114. CC Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 18 | CC Threshold | signed integer | 2 | 100 | 32767 | 4400 | mAh |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[CCT]
- SBS:CycleCount(0x17)

### C.5.1.11 CC % (Offset 20)

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

**Table C-115. CC %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 20 | CC % | unsigned integer | 1 | 0 | 100 | 90 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[CCT]
- DF:SBS Configuration:Data(48):CC Threshold(18)
- SBS:FullChargeCapacity(0x10)
- SBS:CycleCount(0x17)

### C.5.1.12 CF Max Error Limit (Offset 21)

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

**Table C-116. CF Max Error Limit**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 21 | CF Max Error Limit | unsigned integer | 1 | 0 | 100 | 100 | % |

**Related Variables:**

- SBS:BatteryMode(0x03)[CF]
- SBS:MaxError(0x0c)

### C.5.1.13 Design Capacity (Offset 22)

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

**Table C-117. Design Capacity**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 22 | Design Capacity | unsigned integer | 2 | 0 | 65535 | 4400 | mAh |

**Related Variables:**

- DF:Gas Gauging:IT Config(80):Load Select(0)
- SBS:BatteryMode(0x03)[CapM]
- SBS:DesignCapacity(0x18)
- SBS:StateOfHealth(0x4f)

### C.5.1.14 Design Energy (Offset 24)

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

**Related Variables:**

**Table C-118. Design Energy**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 24 | Design Energy | unsigned integer | 2 | 0 | 65535 | 6336 | 0.1Wh |

- DF:Gas Gauging:IT Config(80):Load Select(0)
- SBS:BatteryMode(0x03)[CapM]
- SBS:DesignCapacity(0x18)
- SBS:StateOfHealth(0x4f)

### C.5.1.15 Manuf Name (Offset 26)

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

**Table C-119. Manuf Name**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 26 | Manuf Name | string | 11 + 1 | - | - | Texas Inst. | ASCII |

**Related Variables:**

- SBS:ManufacturerName(0x20)

#### C.5.1.16 Device Name (Offset 38)

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

**Table C-120. Device Name**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 38 | Device Name | string | 7 + 1 | - | - | bq20z90/bq20 z95 | ASCII |

**Related Variables:**

- SBS:DeviceName(0x21)

#### C.5.1.17 Device Chemistry (Offset 46)

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

**Table C-121. Device Chemistry**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Data | 46 | Device Chemistry | string | 4+1 | - | - | LION | ASCII |

**Related Variables:**

- SBS:DeviceChemistry(0x22)

### *C.5.2 Configuration(Subclass 49)*

#### C.5.2.1 TDA Set % (Offset 0)

If set between 0% and 100% the bq20z90/bq20z95 sets the *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below ***TDA Set %***. Set to -1 to disable this function.

**Table C-122. TDA Set %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 0 | TDA Set % | signed integer | 1 | -1 | 100 | 6 | % |

**Related Variables:**

- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[TDA]

### C.5.2.2 TDA Clear % (Offset 1)

If set between 0% and 100% the bq20z90/bq20z95 clears the *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above ***TDA Clear %***. Set to -1\ to disable this function.

**Table C-123. TDA Clear %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 1 | TDA Clear % | signed integer | 1 | -1 | 100 | 8 | % |

**Related Variables:**

- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[TDA]

### C.5.2.3 FD Set % (Offset 2)

If set between 0% and 100%, the bq20z90/bq20z95 sets the *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below ***FD Set %***. Set to -1 to disable this function.

**Table C-124. FD Set %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 2 | FD Set % | signed integer | 1 | -1 | 100 | 2 | % |

**Related Variables:**

- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[FD]

### C.5.2.4 FD Clear % (Offset 3)

If set between 0% and 100% the bq20z90/bq20z95 clears the *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above ***FD Clear %***. Set to -1 to disable this function.

**Table C-125. FD Clear %**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 3 | FC Clear % | signed integer | 1 | -1 | 100 | 5 | % |

**Related Variables:**

- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[FD]

### C.5.2.5 TDA Set Volt Threshold (Offset 4)

The bq20z90/bq20z95 sets the *[TDA]* flag in *BatteryStatus* if *Voltage* is equal to or lower than ***TDA Set Volt Threshold*** for a period equal to or greater than ***TDA Set Volt Time***.

**Table C-126. TDA Set Volt Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 4 | TDA Set Volt Threshold | unsigned integer | 2 | 0 | 16800 | 5000 | mV |

**Related Variables:**

- DF:SBS Configuration:Configuration(49):TDA Set Volt Time(6)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[TDA]

### C.5.2.6 TDA Set Volt Time (Offset 6)

The bq20z90/bq20z95 sets the *[TDA]* flag in *BatteryStatus* if *Voltage* is equal to or lower than ***TDA Set Volt Threshold*** for a period equal to or greater than ***TDA Set Volt Time***. Set to 0 to disable this feature.

**Table C-127. TDA Set Volt Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 6 | TDA Set Volt Time | unsigned integer | 1 | 0 | 240 | 5 | Sec |

**Related Variables:**

- DF:SBS Configuration:Configuration(49):TDA Set Volt Threshold(4)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[TDA]

### C.5.2.7 TDA Clear Volt (Offset 7)

The bq20z90/bq20z95 clears the *[TDA]* flag if *Voltage* is equal to or greater than ***TDA Clear Volt***. ***TDA Clear Volt*** clears *[TDA]* only if *[TDA]* is set by ***TDA Set Volt Threshold***. It will not clear *[TDA]* if *[TDA]* is set by ***TDA Set %*** or any other function.

**Table C-128. TDA Clear Volt**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 7 | TDA Clear Volt | unsigned integer | 2 | 0 | 16800 | 5500 | mV |

**Related Variables:**

- DF:SBS Configuration:Configuration(49):TDA Set Volt Threshold(4)
- DF:SBS Configuration:Configuration(49):TDA Set Volt Time(6)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[TDA]

### C.5.2.8 FD Set Volt Threshold (Offset 9)

The bq20z90/bq20z95 sets the *[FD]* flag if *Voltage* is equal to or lower than ***FD Set Volt Threshold*** for a period equal to or greater than ***FD Volt Time***.

**Table C-129. FD Set Volt Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 9 | FD Set Volt Threshold | unsigned integer | 2 | 0 | 16800 | 5000 | mV |

**Related Variables:**

- DF:SBS Configuration:Configuration(49):FD Volt Time(11)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[FD]

#### C.5.2.9 FD Volt Time (Offset 11)

The bq20z90/bq20z95 sets the *[FD]* flag if *Voltage* is equal to or lower than ***FD Set Volt Threshold*** for a period equal to or greater than ***FD Volt Time***. Set to 0 to disable this feature.

**Table C-130. FD Volt Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 11 | FD Volt Time | unsigned integer | 1 | 0 | 240 | 5 | Sec |

**Related Variables:**

- DF:SBS Configuration:Configuration(49):FD Set Volt Threshold(9)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[FD]

#### C.5.2.10 FD Clear Volt (Offset 12)

The bq20z90/bq20z95 clears the *[FD]* flag if *Voltage* is equal to or greater than ***FD Clear Volt***.

**Table C-131. FD Clear Volt**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Configuration | 12 | FD Clear Volt | unsigned integer | 2 | 0 | 16800 | 5500 | mV |

**Related Variables:**

- DF:SBS Configuration:Configuration(49):FD Set Volt Threshold(9)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[FD]

## C.6 System Data

### *C.6.1 Manufacturer Data (Subclass 56)*

#### C.6.1.1 Pack Lot Code (Offset 0)

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

**Table C-132. Pack Lot Code**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 56 | Manufacturer Data | 0 | Pack Lot Code | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:ManufacturerData(0x23)

### C.6.1.2 PCB Lot Code (Offset 2)

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

**Table C-133. PCB Lot Code**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 56 | Manufacturer Data | 2 | PCB Lot Code | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:ManufacturerData(0x23)

### C.6.1.3 Firmware Version (Offset 4)

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

**Table C-134. Firmware Version**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 56 | Manufacturer Data | 4 | Firmware Version | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:ManufacturerData(0x23)

### C.6.1.4 Hardware Revision (Offset 6)

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

**Table C-135. Hardware Revision**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 56 | Manufacturer Data | 6 | Hardware Revision | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:ManufacturerData(0x23)

### C.6.1.5 Cell Revision (Offset 8)

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

**Table C-136. Cell Revision**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 56 | Manufacturer Data | 8 | Cell Revision | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:ManufacturerData(0x23)

## *C.6.2 Manufacturer Info (Subclass 58)*

### C.6.2.1 Manuf. Info (Offset 0)

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

**Table C-137. Manuf. Info**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 58 | Manufacturer Info | 0 | Manuf. Info | string | 31 + 1 | - | - | 0123456789abcdef0123456789abcde | |

**Related Variables:**

- SBS:ManufacturerInfo(0x70)

## *C.6.3 Lifetime Data (Subclass 59)*

### C.6.3.1 Lifetime Max Temp (Offset 0)

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

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

**Table C-138. Lifetime Max Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 0 | Lifetime Max Temp | signed integer | 2 | 0 | 1400 | 300 | 0.1°C |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.2 Lifetime Min Temp (Offset 2)

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

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

**Table C-139. Lifetime Min Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 2 | Lifetime Min Temp | signed integer | 2 | -600 | 1400 | 200 | 0.1°C |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.3 Lifetime Max Cell Voltage (Offset 4)

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

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

**Table C-140. Lifetime Max Cell Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 4 | Lifetime Max Cell Voltage | signed integer | 2 | -32768 | 32767 | 3500 | mV |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.4 Lifetime Min Cell Voltage (Offset 6)

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

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

**Table C-141. Lifetime Min Cell Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 6 | Lifetime Min Cell Voltage | signed integer | 2 | -32768 | 32767 | 3200 | mV |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.5 Lifetime Max Pack Voltage (Offset 8)

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

- internal measured cell stack voltage - ***Lifetime Max Pack Voltage*** > 100 mV
- internal measured cell stack voltage > ***Lifetime Max Pack Voltage*** for a period > 60 seconds

- internal measured cell stack voltage > ***Lifetime Max Pack Voltage*** AND any other lifetime value is updated.

**Table C-142. Lifetime Max Pack Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 8 | Lifetime Max Pack Voltage | signed integer | 2 | -32768 | 32767 | 14000 | mV |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.6 Lifetime Min Pack Voltage (Offset 10)

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

- ***Lifetime Min Pack Voltage*** - internal measured cell stack voltage > 100 mV
- ***Lifetime Min Pack Voltage*** > internal measured cell stack voltage for a period > 60 seconds
- ***Lifetime Min Pack Voltage*** > internal measured cell stack voltage AND any other lifetime value is updated.

**Table C-143. Lifetime Min Pack Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 10 | Lifetime Min Pack Voltage | signed integer | 2 | -32768 | 32767 | 12800 | mV |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.7 Lifetime Max Chg Current (Offset 12)

If the *[QEN]* flag is set ***Lifetime Max Chg Current*** is updated if one of the following conditions are met:

- internal charge current - ***Lifetime Max Chg Current*** > 100 mA
- internal charge current > ***Lifetime Max Chg Current*** for a period > 60 seconds
- internal charge current > ***Lifetime Max Chg Current*** AND any other lifetime value is updated.

**Table C-144. Lifetime Max Chg Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 12 | Lifetime Max Chg Current | signed integer | 2 | -32768 | 32767 | 1500 | mA |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.8 Lifetime Max Dsg Current (Offset 14)

If the *[QEN]* flag is set ***Lifetime Max Dsg Current*** is updated if one of the following conditions are met:

- ***Lifetime Max Dsg Current*** - internal discharge current < -100 mA
- ***Lifetime Max Dsg Current*** < internal discharge current for a period > 60 seconds
- ***Lifetime Max Dsg Current*** < internal discharge current AND any other lifetime value is updated.

**Table C-145. Lifetime Max Dsg Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 14 | Lifetime Max Dsg Current | signed integer | 2 | -32768 | 32767 | -3000 | mA |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.9 Lifetime Max Chg Power (Offset 16)

If the *[QEN]* flag is set ***Lifetime Max Chg Power*** is updated if one of the following conditions are met:

- ( internal measured voltage × internal measured current) - ***Lifetime Max Chg Power*** > 1000 mW
- ( internal measured voltage × internal measured current) > ***Lifetime Max Chg Power*** for a period > 60 seconds
- ( internal measured voltage × internal measured current) > ***Lifetime Max Chg Power*** AND any other lifetime value is updated.

**Table C-146. Lifetime Max Dsg Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 16 | Lifetime Max Chg Power | signed integer | 2 | -32768 | 32767 | 1500 | 10 mW |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.10 Lifetime Max Dsg Power (Offset 18)

If the *[QEN]* flag is set ***Lifetime Max Dsg Power*** is updated if one of the following conditions are met:

- ***Lifetime Max Dsg Power*** - ( internal measured voltage × internal measured current) > 1000 mW
- ***Lifetime Max Dsg Power*** > ( internal measured voltage × internal measured current) for a period > 60 seconds
- ***Lifetime Max Dsg Power*** > ( internal measured voltage × internal measured current) AND any other lifetime value is updated.

**Table C-147. Lifetime Max Dsg Power**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 18 | Lifetime Max Dsg Power | signed integer | 2 | -32768 | 32767 | -1500 | 10 mW |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.11 Life Max AvgDsg Cur (Offset 22)

If the *[QEN]* flag is set ***Life Max AvgDsg Cur*** is updated if one of the following conditions are met:

- ***Lifetime Max AvgDsg Cur*** - internally measured average discharge current > 100mA
- ***Lifetime Max AvgDsg Cur*** > internally measured average discharge current > 60 seconds
- ***Lifetime Max AvgDsg Cur*** > internally measured average discharge current AND any other lifetime value is updated.

**Table C-148. Life Max AvgDsg Cur**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 22 | Lifetime Max AvgDsg Power | signed integer | 2 | -32768 | 32767 | -1000 | mA |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.12 Life Max AvgDsg Pow (Offset 26)

If the *[QEN]* flag is set ***Life Max AvgDsg Pow*** is updated if one of the following conditions are met:

- ***Life Max AvgDsg Pow*** - averaged (internal measured voltage × internal measured current) > 1000 mW
- ***Life Max AvgDsg Pow*** > averaged (internal measured voltage × internal measured current) for a period > 60 seconds
- ***Life Max AvgDsg Pow*** > averaged (internal measured voltage × internal measured current) AND any other lifetime value is updated.

**Table C-149. Life Max AvgDsg Pow**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 26 | Life Max AvgDsg Pow | signed integer | 2 | -32768 | 32767 | -1500 | 10 mW |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.3.13 Lifetime Avg Temp (Offset 28)

If the *[QEN]* flag is set ***Lifetime Avg Temp*** is updated as follows:

- takes samples of *Temperature* function every 225s, but only updates if any other lifetime value is updated.

**Table C-150. Lifetime Avg Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 59 | Lifetime Data | 28 | Lifetime Avg Temp | signed integer | 2 | 0 | 1400 | 250 | 0.1°C |

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- DF:System Data:Lifetime Temp Samples(60):LT Temp Samples(0)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:Temperature(0x08)
- SBS:OperationStatus(0x54)[QEN]

### *C.6.4 Lifetime Temp Samples (Subclass 60)*

#### C.6.4.1 LT Temp Samples (Offset 0)

This variable indicates the number of temperature samples used for the ***Lifetime Avg Temp*** calculation. Multiply this value by 225 seconds to get the total time that the Impedance Track™ algorithm is active.

**Table C-151. LT Temp Samples**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 60 | Lifetime Temp Samples | 0 | LT Temp Samples | unsigned integer | 4 | 0 | 140000000 | 0 | Count |

**Related Variables:**

- DF:System Data:Lifetime Data(59):Lifetime Avg Temp(28)

## C.7 Configuration

### *C.7.1 Registers (Subclass 64)*

#### C.7.1.1 Operation Cfg A (Offset 0)

This register enables, disables or configures various features of the bq20z90/bq20z95.

**Table C-152. Operation Cfg A**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 64 | Configuration | 0 | Operation Cfg A | hex | 2 | 0x0000 | 0xff3f | 0x0f29 | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | LEDR | LEDRCA | CHGLED | DMODE | LED1 | LED0 | CC1 | CC0 |
| **Low Byte** | RSVD | RSVD | SLEEP | TEMP1 | TEMP0 | SLED | ZVCHG1 | ZVCHG0 |

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

**Figure C-6. Operation Cfg A**

**LEDR —** Enables activation of the LED display on device-reset exit.

0 = LED display is not activated on exit from device reset. (default)

1 = LED display is activated (simulates a $\overline{\text{DISP}}$ transition) on exit from device reset.

**LEDRCA —** Enables flashing of the LED display when the *[RCA]* flag in *BatteryStatus* bit is set.

0 = The LED display is not activated when *[RCA]* is set. (default)

1 = If the LED display is activated when *[RCA]* is set the display flashes with ***LED Flash Rate***

**Related Variables:**

DF:LED Support:LED Cfg(67):LED Flash Rate(0)

SBS:BatteryStatus(0x16)[RCA]

**CHGLED —** Enables the LED display while charging.

0 = Display is not activated by charging; requires push-button event or SMBus command. (default)

1 = Display is active during charging.

**DMODE —** This bit sets the display to show the *RelativeStateOfCharge* or *AbsoluteStateOfCharge* LED representation.

0 = Display reflects RelativeStateOfCharge (default)

1 = Display reflects AbsoluteStateOfCharge

**LED1, LED0 —** These bits configure the number of LEDs and threshold levels used in the LED Display.

0,0 = User defined threshold

0,1 = 3 LEDs used

1,0 = 4 LEDs used

1,1 = 5 LEDs used (default)

**CC1, CC0 —** These bits configure the bq20z90/bq20z95 for the number of series cells in the battery stack.

0,0 = Reserved

0,1 = 2 cell

1,0 = 3 cell

1,1 = 4 cell (default)

**SLEEP —** Enables the bq20z90/bq20z95 to enter Sleep mode if the SMBus lines are low.

0 = The bq20z90/bq20z95 never enters Sleep mode

1 = The bq20z90/bq20z95 enters Sleep mode under normal Sleep entry criteria (default)

**Related Variables:**

SBS:ManufacterAccess(0x00):Sleep(0x0011)

**TEMP1, TEMP0 —** These bits configure the source of the *Temperature* function

0,0 = Internal Temperature Sensor

0,1 = TS1 Input (default)

1,0 = Greater Value of TS1 or TS2 Inputs

1,1 = Average of TS1 and TS2 Inputs

**Related Variables:**

SBS:Temperature(0x08)

**SLED —** Enables the bq20z90/bq20z95 display to be used in serial or parallel mode. The PF error code display doesn't work in serial LED mode

0 = Display is in parallel LED mode (default)

1 = Display is in serial LED mode

**ZVCHG1, ZVCHG0 —** These bits enable or disable the use of the ZVCHG or CHG FET in Zero-Volt/Precharge modes.

0,0 = ZVCHG

0,1 = CHG (default)

1,0 = GPOD of bq29330

1,1 = No Action

### C.7.1.2 Operation Cfg B (Offset 2)

This register enables, disables, or configures various features of the bq20z90/bq20z95.

**Table C-153. Operation Cfg B**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 64 | Configuration | 2 | Operation Cfg B | hex | 2 | 0x0000 | 0xffff | 0x6440 | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | PDF1 | PDF0 | RESCAP | NCSMB | NRCHG | CSYNC | CHGTERM | CCT |
| **Low Byte** | CHGSUSP | OTFET | CHGFET | CHGIN | NR | CPE | HPE | BCAST |

**Figure C-7. Operation Cfg B**

**PDF1, PDF0 —** Configures the Permanent Failure LED display. This function is disabled if the ***[SLED]*** bit in ***Operation Cfg A*** is set.

0,0 = PF Error Code not available

0,1 = PF Error Code is activated after state of charge display if $\overline{\text{DISP}}$ is held low for ***LED Hold Time***. (default)

1,0 = PF Error Code not available

1,1 = PF Error Code is automatically activated after state of charge display

**Related Variables:**

DF:Configuration:Registers(64):Operation Cfg A(0)[SLED]

DF:LED Support:LED Cfg(67):LED Hold Time(6)

**RESCAP —** This bit configures the compensation model of the Impedance Track™ Algorithm for reserve capacity calculation.

0 = Light Load Compensation

1 = Average Load Compensation defined by ***Load Select*** (default)

**Related Variables:**

DF:Gas Gauging:IT Cfg(80):Load Select(0)

DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(64)

DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(68)

**NCSMB —** Disables extended SMBUS $t_{TIMEOUT}$ feature. Use this bit with caution.

0 = Normal SMBUS $t_{TIMEOUT}$ (default)

1 = Extended SMBUS $t_{TIMEOUT}$

**NRCHG —** Enables the CHG FET to remain on during sleep when the bq20z90/bq20z95 is in non-removable battery mode.

0 = CHG FET turns off in Sleep Mode if the ***[NR]*** bit is set (default)

1 = CHG FET remains on in Sleep Mode if the ***[NR]*** bit is set

**Related Variables:**

DF:Configuration:Registers(64):Operation Cfg B(2)[NR]

**CSYNC —** Enables the bq20z90/bq20z95 to write *RemainingCapacity* equal to *FullChargeCapacity* when a valid charge termination is detected.

0 = *RemainingCapacity* is not modified on valid primary charge termination

1 = *RemainingCapacity* is written to equal *FullChargeCapacity* on valid primary charge termination. (default)

**Related Variables:**

SBS:RemainingCapacity(0x0f)

SBS:FullChargeCapacity(0x10)

**CHGTERM —** This bit enables or disables the *[TCA]* and *[FC]* flags in *BatteryStatus* to be cleared after charge termination is confirmed.

0 = *[TCA]* and *[FC]* are not cleared by primary charge termination confirmation, but are cleared by other means. (default)

1 = *[TCA]* and *[FC]* flags are cleared on valid primary charge termination. Note: This does not disable clearing the flags by ***TCA Clear %*** and ***FC Clear %***.

**Related Variables:**

DF:Charge Control:Termination Cfg(36):Taper Current(2)

DF:Charge Control:Termination Cfg(36):Current Taper Window(8)

DF:Charge Control:Termination Cfg(36):TCA Clear %(10)

DF:Charge Control:Termination Cfg(36):FC Clear %(12)

SBS:Current(0x0a)

SBS:BatteryStatus(0x16)[FC],[TCA]

**CCT —** This bit sets the formula for updating *Cycle Count*.

0 = The bq20z90/bq20z95 uses the ***CC Threshold*** value. (default)

1 = The bq20z90/bq20z95 uses ***CC %*** of *FullChargeCapacity*.

**Related Variables:**

DF:SBS Configuration:Data(48):Cycle Count(16)

DF:SBS Configuration:Data(48):CC Threshold(18)

DF:SBS Configuration Data(48):CC %(18\\20)

SBS:FullChargeCapacity(0x10)

**CHGSUSP —** This bit enables the bq20z90/bq20z95 to turn off the CHG FET (and ZVCHG FET) when in charge suspend mode.

0 = No FETs change in Charge Suspend mode. (default)

1 = CHG FET and ZVCHG FET (if used) turn off in Charge Suspend mode.

**OTFET —** This bit enables or disables FET actions from reacting to an overtemperature fault.

0 = There is NO FET action when an overtemperature condition is detected.

1 = When the *[OTC]* flag is set, then the CHG FET is turned off, and when the *[OTD]* flag is set, then the DSG FET is turned off. (default)

**Related Variables:**

SBS:SafetyStatus(0x51)[OTC],[OTD]

**CHGFET —** This bit enables or disables the CHG FET from reacting to a valid charge termination.

0 = CHG FET stays on at charge termination(*[TCA]* is set). (default)

1 = CHG FET turns off at charge termination.

**Related Variables:**

SBS:BatteryStatus(0x16)[TCA]

**CHGIN —** This bit enables the CHG FET and ZVCHG FET (if used) to turn off when the bq20z90/bq20z95 is in charge-inhibit mode.

0 = No FET change in charge-inhibit mode. (default)

1 = CHG and ZVCHG FETs, if used, turn off in charge-inhibit mode.

**Related Variables:**

SBS:ChargingStatus(0x55)[XCHG]

**NR —** This bit configures the bq20z90/bq20z95 to be in removable or non-removable battery mode and determines the recovery method for current based Primary Protection features.

0 = Removable battery mode. (default)

1 = Non-removable battery mode.

**Related Variables:**

DF:Configuration:Registers(64): Non-Removable Cfg(8)

**CPE —** This bit enables or disables PEC transmissions to the smart-battery charger for master-mode alarm messages.

0 = No PEC byte on alarm warning to charger (default)

1 = PEC byte on alarm warning to charger

**HPE —** This bit enables or disables PEC transmissions to the smart-battery host for master-mode alarm messages and prevents receiving communications from all sources in slave mode. If the host uses PEC this bit should be set.

0 = No PEC byte on alarm warning to host and receiving communications from all sources in slave mode (default)

1 = PEC byte on alarm warning to host and receiving communications from all sources in slave mode. If host uses PEC this bit should be set.

**BCAST —** This bit enables or disables SBS broadcasts to the smart-battery charger and host.

0 = Broadcasts to host and charger disabled (default)

1 = Broadcasts to host and charger enabled

### C.7.1.3 Operation Cfg C (Offset 4)

This register enables, disables, or configures various features of the bq20z90/bq20z95.

**Table C-154. Operation Cfg C**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 64 | Configuration | 4 | Operation Cfg C | hex | 2 | 0x0000 | 0x0007 | 0x0000 | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD |
| **Low Byte** | RSVD | RSVD | RSVD | RSVD | RSVD | SHUTV | PRE_ZT_PF_En | RSOCL |

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

**Figure C-8. Operation Cfg C**

**SHUTV —** This bit configures the voltage threshold used when entering Shutdown mode.

0 = Shutdown occurs when *Voltage* ≤ ***Shutdown Voltage*** AND *Current* ≤ 0 for a period greater than ***Shutdown Time***.

1 = Shutdown occurs when Min (*CellVoltage4..1*) ≤ to ***Cell Shutdown Voltage*** and *Current* ≤ 0 for a period greater than ***Cell Shutdown Time***.

**PRE_ZT_PF_En —** This bit enables or disables permanent failures from occurring before Impedance Tracking is enabled.

0 = All PFs (except DFF) are prevented from occurring until Impedance Tracking is enabled. Shutdown is also disabled. Please see note below.

1 = All PFs are allowed regardless of whether Impedance Tracking has been enabled or not.

**RSOCL —** This bit determines the method in which *RelativeStateOfCharge* and *RemainingCapacity* are updated to 100% when charging is complete.

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

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

**Note:** **PRE_ZT_PF_En** - If this bit is set to 0, and a Permanent Failure does occur, *PFStatus* will still report that the failure has occurred. Also, if the FETs have been turned on, they will turn off if a failure occurs. However, dataflash write access is still granted and the Permanent Failure is NOT logged in the PF Status section of dataflash. The *PFStatus* indicator will clear and the FETs will turn on once *ManufacturerAccess*(0x00) has received the *IT Enable* (0x0021) command or the *Reset* (0x0041) command, assuming the Permanent Failure condition no longer exists.

### C.7.1.4 Permanent Fail Cfg (Offset 6)

The ***Permanent Fail Cfg*** register enables or disables the use of the SAFE pin when the corresponding permanent fail error occurs. If the SAFE pin is driven high ***Fuse Flag*** is set to 0x3672.

**Table C-155. Permanent Fail Cfg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 64 | Configuration | 6 | Permanent Fail Cfg | hex | 2 | 0x0000 | 0x5fff | 0x0000 | |

**Related Variables:**

- DF:PF Status:Device Status Data(96):PF Flags1(0)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | RSVD | XPFVSHUT | RSVD | XSOPT | XSOCD | XSOCC | XAFE_P | XAFE_C |
| **Low Byte** | XDFF | XDFETF | XCFETF | XCIM | XSOTD | XSOTC | XSOV | XPFIN |

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

**Figure C-9. Permanent Fail Cfg**

**XPFVSHUT —** If this bit is set AND any permanent failure happens AND the bq20z90/bq20z95 goes into shutdown the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOPT]

**XSOPT —** If this bit is set AND an open thermistor permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOPT]

**XSOCD —** If this bit is set AND a discharge safety overcurrent permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOCD]

**XSOCC —** If this bit is set AND a charge safety overcurrent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOCC]

**XAFE_P —** If this bit is set AND a periodic AFE-communications permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[AFE_P]

**XAFE_C —** If this bit is set AND an AFE-communications permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[AFE_C]

**XDFF —** If this bit is set AND a Data Flash fault permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[DFF]

**XDFETF —** If this bit is set AND a DSG FET permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[DFETF]

**XCFETF —** If this bit is set AND a CHG FET permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[CFETF]

**XCIM —** If this bit is set AND a cell imbalance permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[CIM]

**XSOTD —** If this bit is set AND a discharge overtemperature permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOTD]

**XSOTC —** If this bit is set AND a charge overtemperature permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOTC]

**XSOV —** If this bit is set AND a safety overvoltage permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOV]

**XPFIN —** If this bit is set AND an external input indication permanent failure occurs the SAFE pin is driven high.

**Related Variables:**

DF:PF Status:Device Status Data(96):PF Flags1(0)[PFIN]

### C.7.1.5 Non-Removable Cfg (Offset 8)

If the bq20z90/bq20z95 is in removable battery mode (***[NR]*** = 0) these bits sets the recovery method from 1st level security errors. If the corresponding bit is set it gives an additional recovery option for the particular fault. If ***[NR]*** is set to 1 this register has no effect.

**Table C-156. Non Removable Cfg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 64 | Configuration | 8 | Non-Removable Cfg | hex | 2 | 0x0000 | 0x3b17 | 0x0000 | |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **High Byte** | RSVD | RSVD | OCD | OCC | OCD2 | OCC2 | RSVD | RSVD |
| **Low Byte** | RSVD | RSVD | OC | RSVD | RSVD | AOCD | SCC | SCD |

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

**Figure C-10. Non-Removable Cfg**

**OCD—** Overcurrent in Discharge

**OCC—** Overcurrent in Charge

**OCD2—** Overcurrent in Discharge - Tier 2

**OCC2—** Overcharge

**OC—** Overcurrent in Charge - Tier 2

**AOCD—** AFE Overcurrent in Discharge

**SCC—** Short Circuit in Charge

**SCD—** Short Circuit in Discharge

## C.8 LED Support

### *C.8.1 LED Cfg (Subclass 67)*

#### C.8.1.1 LED Flash Rate (Offset 0)

This value sets the LED flashing time period at a 50% duty cycle for alarm conditions.

**Table C-157. LED Flash Rate**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 0 | LED Flash Rate | unsigned integer | 2 | 0 | 65535 | 512 | 500µSec |

**Related Variables:**

- DF:LED Support:LED Cfg(67):LED Hold Time(6)

#### C.8.1.2 LED Blink Rate (Offset 2)

This value sets the LED blinking time period to a 50% duty cycle for the LED indicating the highest actual charge of the battery.

**Table C-158. LED Blink Rate**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 2 | LED Blink Rate | unsigned integer | 2 | 0 | 65535 | 1024 | 500µSec |

**Related Variables:**

- DF:LED Support:LED Cfg(67):LED Hold Time(6)

#### C.8.1.3 LED Delay (Offset 4)

This value sets the activation delay time from one LED to the next LED after the display is activated.

**Table C-159. LED Delay**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 4 | LED Delay | unsigned integer | 2 | 1 | 65535 | 100 | 500µSec |

**Related Variables:**

- DF:LED Support:LED Cfg(67):LED Hold Time(6)

### C.8.1.4 LED Hold Time (Offset 6)

This value sets the time the LED stays on after all LEDs required to indicate the state of charge are being activated.

**Table C-160. LED Hold Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 6 | LED Hold Time | unsigned integer | 1 | 0 | 255 | 4 | Sec |

**Related Variables:**

- DF:LED Support:LED Cfg(67):LED Delay(4)

### C.8.1.5 CHG Flash Alarm (Offset 7)

If the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0) and the battery charge is below this threshold the remaining enabled LEDs start flashing at ***LED Flash Rate***. Set to -1 to disable this feature.

**Table C-161. CHG Flash Alarm**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 7 | CHG Flash Alarm | signed integer | 1 | -1 | 101 | 10 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- DF:LED Support:LED Cfg(67):LED Flash Rate(0)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.6 CHG Thresh 1 (Offset 8)

If the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0) and the battery charge is below this threshold LED 1 is disabled.

**Table C-162. CHG Thresh 1**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 8 | CHG Thresh 1 | signed integer | 1 | -1 | 101 | 0 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.7 CHG Thresh 2 (Offset 9)

If the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0) and the battery charge is below this threshold LED 2 is disabled.

**Table C-163. CHG Thresh 2**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 9 | CHG Thresh 2 | signed integer | 1 | -1 | 101 | 20 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.8 CHG Thresh 3 (Offset 10)

If the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0) and the battery charge is below this threshold LED 3 is disabled.

**Table C-164. CHG Thresh 3**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 10 | CHG Thresh 3 | signed integer | 1 | -1 | 101 | 40 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.9 CHG Thresh 4 (Offset 11)

If the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0) and the battery charge is below this threshold LED 4 is disabled.

**Table C-165. CHG Thresh 4**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 11 | CHG Thresh 4 | signed integer | 1 | -1 | 101 | 60 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.10 CHG Thresh 5 (Offset 12)

If the bq20z90/bq20z95 is in charge mode (*[DSG]* = 0) and the battery charge is below this threshold LED 5 is disabled.

**Related Variables:**

**Table C-166. CHG Thresh 5**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 12 | CHG Thresh 5 | signed integer | 1 | -1 | 101 | 80 | % |

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.11 DSG Flash Alarm (Offset 13)

If the bq20z90/bq20z95 is in discharge mode (*[DSG]* = 1) and the battery charge is below this threshold the remaining enabled LEDs start flashing with ***LED Flash Rate***. Set to -1% to disable this feature.

**Table C-167. DSG Flash Alarm**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 13 | DSG Flash Alarm | signed integer | 1 | -1 | 101 | 10 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.12 DSG Thresh 1 (Offset 14)

If the bq20z90/bq20z95 is in discharge mode (*[DSG]* = 1) and the battery charge is below this threshold LED 1 is disabled.

**Table C-168. DSG Thresh 1**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 14 | DSG Thresh 1 | signed integer | 1 | -1 | 101 | 0 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.13 DSG Thresh 2 (Offset 15)

If the bq20z90/bq20z95 is in discharge mode (*[DSG]* = 1) and the battery charge is below this threshold LED 2 is disabled.

**Table C-169. DSG Thresh 2**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 15 | DSG Thresh 2 | signed integer | 1 | -1 | 101 | 20 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.14 DSG Thresh 3 (Offset 16)

If the bq20z90/bq20z95 is in discharge mode (*[DSG]* = 1) and the battery charge is below this threshold LED 3 is disabled.

**Table C-170. DSG Thresh 3**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 16 | DSG Thresh 3 | signed integer | 1 | -1 | 101 | 40 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.15 DSG Thresh 4 (Offset 17)

If the bq20z90/bq20z95 is in discharge mode (*[DSG]* = 1) and the battery charge is below this threshold LED 4 is disabled.

**Table C-171. DSG Thresh 4**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 17 | DSG Thresh 4 | signed integer | 1 | -1 | 101 | 60 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.16 DSG Thresh 5 (Offset 18)

If the bq20z90/bq20z95 is in discharge mode (*[DSG]* = 1) and the battery charge is below this threshold LED 5 is disabled.

**Table C-172. DSG Thresh 5**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 18 | DSG Thresh 5 | signed integer | 1 | -1 | 101 | 80 | % |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

#### C.8.1.17 Sink Current (Offset 19)

The sink current setting of the LED inputs to the bq20z90/bq20z95 can be programmed with the following settings. All of the LEDs are programmed with the same current level.

**Table C-173. Sink Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 67 | LED Cfg | 19 | Sink Current | unsigned integer | 1 | 0x00 | 0x03 | 0x03 | |

| | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|---|
| **Low Byte** | RSVD | RSVD | RSVD | RSVD | RSVD | RSVD | ILED1 | ILED0 |

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

**Figure C-11. Sink Current**

**Table C-174. Sink Current Configuration**

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

## C.9 Power

### *C.9.1 Power (Subclass 68)*

#### C.9.1.1 Flash Update OK Voltage (Offset 0)

This value sets the minimum allowed battery pack voltage for a flash update. If the battery pack *Voltage* is below this threshold no flash update will be made. If a charger is detected with ***Charger Present*** then ***Flash Update OK Voltage*** is bypassed and the flash can be updated.

**Table C-175. Flash Update OK Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 0 | Flash Update OK Voltage | unsigned integer | 2 | 6000 | 20000 | 7500 | mV |

**Related Variables:**

- DF:Power:Power(68):Charger Present(8)
- SBS:Voltage(0x09)

### C.9.1.2 Shutdown Voltage (Offset 2)

The bq20z90/bq20z95 goes into shutdown mode if the battery pack *Voltage* is equal to or less than ***Shutdown Voltage*** for ***Shutdown Time*** and has been out of shutdown mode for at least ***Shutdown Time***.

**Table C-176. Shutdown Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 2 | Shutdown Voltage | unsigned integer | 2 | 5000 | 20000 | 7000 | mV |

**Related Variables:**

- DF:Power:Power(68):Shutdown Time(4)
- SBS:Voltage(0x09)

### C.9.1.3 Shutdown Time (Offset 4)

The bq20z90/bq20z95 goes into shutdown mode if the battery pack *Voltage* is equal to or less than ***Shutdown Voltage*** for ***Shutdown Time*** and has been out of shutdown mode for at ***Shutdown Time***.

**Table C-177. Shutdown Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 4 | Shutdown Time | unsigned integer | 1 | 0 | 240 | 10 | Sec |

**Related Variables:**

- DF:Power:Power(68):Shutdown Voltage(2)
- SBS:Voltage(0x09)

### C.9.1.4 Cell Shutdown Voltage (Offset 5)

The bq20z90/bq20z95 goes into shutdown mode if Min (*CellVioltage4..1*) is equal to or less than ***Cell Shutdown Voltage*** for 10s and has been out of shutdown mode for at least ***Cell Shutdown Time***.

**Table C-178. Shutdown Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 5 | Cell Shutdown Voltage | unsigned integer | 2 | 0 | 5000 | 1750 | mV |

**Related Variables:**

- DF:Power:Power(68):Cell Shutdown Time(7)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.9.1.5 Cell Shutdown Time (Offset 7)

The bq20z90/bq20z95 goes into shutdown mode if Min (*CellVioltage4..1*) is equal to or less than ***Cell Shutdown Voltage*** for 10s and has been out of shutdown mode for at least ***Cell Shutdown Time***.

**Table C-179. Shutdown Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 7 | Cell Shutdown Time | unsigned integer | 1 | 0 | 240 | 10 | Sec |

**Related Variables:**

- DF:Power:Power(68):Cell Shutdown Voltage(5)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.9.1.6 Charger Present (Offset 8)

The bq20z90/bq20z95 detects a charger when the voltage at the PACK pin of the q29330 is above the ***Charger Present*** threshold. If a charger is detected it overrides ***Flash Update OK Voltage*** and the flash can be updated.

**Table C-180. Charger Present**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 8 | Charger Present | unsigned integer | 2 | 0 | 23000 | 3000 | mV |

**Related Variables:**

- DF:Power:Power(68):Flash Update OK Voltage(0)
- SBS:PackVoltage(0x5a)

### C.9.1.7 Sleep Current (Offset 10)

The bq20z90/bq20z95 is allowed to go into sleep mode if the charge or discharge current is below ***Sleep Current***. Sleep mode can be enabled with the ***[SLEEP]*** bit. If the absolute value of *Current* is above ***Sleep Current*** the bq20z90/bq20z95 will return to normal mode.

**Table C-181. Sleep Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 10 | Sleep Current | unsigned integer | 2 | 0 | 100 | 10 | mA |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Power:Power(68):Bus Low Time(12)
- SBS:ManufacturerAccess(0x00):Sleep(0x0011)
- SBS:Current(0x0a)

### C.9.1.8 Bus Low Time (Offset 12)

The bq20z90/bq20z95 is allowed to go into sleep mode if it is enabled with the ***[SLEEP]*** bit if the SMBus lines are low for a period greater than ***Bus Low Time***.

**Table C-182. Bus low Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 12 | Bus Low Time | unsigned integer | 1 | 0 | 255 | 5 | Sec |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Power:Power(68):Sleep Current(10)

### C.9.1.9 Cal Inhibit Temp Low (Offset 13)

The bq20z90/bq20z95 does not perform auto-calibration on entry to sleep mode if *Temperature* is below ***Cal Inhibit Temp Low*** or above ***Cal Inhibit Temp High***.

**Table C-183. Cal Inhibit Temp Low**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 13 | Cal Inhibit Temp Low | signed integer | 2 | -400 | 1200 | 50 | 0.1°C |

**Related Variables:**

- DF:Power:Power(68):Cal Inhibit Temp High(15)
- SBS:Temperature(0x08)

### C.9.1.10 Cal Inhibit Temp High (Offset 15)

The bq20z90/bq20z95 does not perform auto-calibration on entry to sleep mode if *Temperature* is below ***Cal Inhibit Temp Low*** or above ***Cal Inhibit Temp High***

**Table C-184. Cal Inhibit Temp High**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 15 | Cal Inhibit Temp High | signed integer | 2 | -400 | 1200 | 450 | 0.1°C |

**Related Variables:**

- DF:Power:Power(68):Cal Inhibit Temp Low(13)
- SBS:Temperature(0x08)

### C.9.1.11 Sleep Voltage Time (Offset 17)

During sleep mode temperature and voltage measurements will be taken in ***Sleep Voltage Time*** intervals.

**Table C-185. Sleep Voltage Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 17 | Sleep Voltage Time | unsigned integer | 1 | 0 | 240 | 5 | Sec |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:Temperature(0x08)
- SBS:Voltage(0x09)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.9.1.12 Sleep Current Time (Offset 18)

During sleep mode current will be measured in ***Sleep Current Time*** intervals.

**Table C-186. Sleep Current Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 18 | Sleep Current Time | unsigned integer | 1 | 0 | 255 | 20 | Sec |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:Current(0x0a)

### C.9.1.13 Wake Current Reg (Offset 19)

***Wake Current Reg*** configures the current threshold required to wake the bq20z90/bq20z95 from sleep mode by detecting voltage across SRP and SRN.

**Table C-187. Wake Current Reg**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 68 | Power | 19 | Wake Current Reg | hex | 1 | 0x00 | 0x07 | 0x00 | |

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

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

**Figure C-12. Wake Current Reg**

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

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

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

**Table C-188. Wake Current Reg**

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

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:Current(0x0a)

## C.10 Gas Gauging

### *C.10.1 IT Cfg (Offset 80)*

### C.10.1.1 Load Select (Offset 0)

This value defines the load compensation model used by the Impedance Track™ algorithm for the *RemainingCapacity* calculation.

| | **Constant Current** (***Load Mode*** = 0) | **Constant Power** (***Load Mode*** = 1) |
|---|---|---|
| 0 = | ***Avg I Last Run*** | ***Avg P Last Run*** |
| 1 = | present average discharge current | present average discharge power |
| 2 = | *Current* | *Current* x *Voltage* |
| 3 = | *AverageCurrent* (default) | *AverageCurrent* x average *Voltage* |
| 4 = | ***Design Capacity*** / 5 | ***Design Energy*** / 5 |
| 5 = | *AtRate* (mA) | *AtRate* (10 mW) |
| 6 = | ***User Rate-mA*** | ***User Rate-10mW*** |

**Table C-189. Load Select**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 80 | IT Cfg | 0 | Load Select | unsigned integer | 1 | 0 | 255 | 3 | |

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- DF:Gas Gauging:IT Cfg(80):User Rate-mA(60)
- DF:Gas Gauging:IT Cfg(80):User Rate-10mW(62)
- DF:Gas Gauging:State(82):Avg I Last Run(21)
- DF:Gas Gauging:State(82):Avg P Last Run(23)
- SBS.BatteryMode(0x03)[CapM]
- SBS:AtRate(0x04)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:RemainingCapacity(0x0f)

### C.10.1.2 Load Mode (Offset 1)

This value defines the load mode used by the Impedance Track™ algorithm for the *RemainingCapacity* calculation.

0 = Constant Current (default)

1 = Constant Power

**Table C-190. Load Mode**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 80 | IT Cfg | 1 | Load Mode | unsigned integer | 1 | 0 | 255 | 0 | |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- SBS:RemainingCapacity(0x0f)

### C.10.1.3 Term Voltage (Offset 45)

This value is the absolute minimum pack voltage used by the Impedance Track™ algorithm for a capacity calculation and should also be set to the absolute minimum pack voltage used by the application. The reserve capacity function also reserves charge where zero *RemainingCapacity* is reported and the ***Term Voltage*** is reached.

**Table C-191. Term Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 80 | IT Cfg | 45 | Term Voltage | signed integer | 2 | -32768 | 32767 | 12000 | mV |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(64)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(66)
- SBS:Voltage(0x09)
- SBS:RemainingCapacity(0x0f)

### C.10.1.4 User Rate-mA (Offset 60)

This value specifies the discharge rate used by the Impedance Track™ algorithm for the *RemainingCapacity* calculation if selected by ***Load Select***.

**Table C-192. User Rate-mA**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 80 | IT Cfg | 60 | User Rate-mA | signed integer | 2 | 2000 | 9000 | 0 | mA |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x0f)

### C.10.1.5 User Rate-10mW (Offset 62)

This value specifies the discharge rate in 10 mW used by the Impedance Track™ algorithm for the *RemainingCapacity* calculation if selected by ***Load Select***.

**Table C-193. User Rate-mW**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 80 | IT Cfg | 62 | User Rate-10mW | signed integer | 2 | 3000 | 14000 | 0 | 10 mW |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x0f)

### C.10.1.6 Reserve Cap-mAh (Offset 64)

This value reserves an amount of charge, in mAh, (*[CapM]* = 0) for the system to react if the *RemainingCapacity* reports zero energy remaining in the battery. The ***Reserve Cap-mAh*** reserves an amount of charge between when the final ***Term Voltage*** is reached and the *RemainingCapacity* reports zero energy. The *FullChargeCapacity* function reports the internal full charge capacity - ***Reserve Cap-mAh***.

**Table C-194. Reserve Cap-mAh**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 80 | IT Cfg | 64 | Reserve Cap-mAh | signed integer | 2 | 0 | 9000 | 0 | mAh |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- DF:Gas Gauging:IT Cfg(80):Term Voltage(45)
- DF:Configuration:Registers(64):Operation Cfg B(2)[RESCAP]
- SBS:BatteryMode(0x03):[CapM]
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)

### C.10.1.7 Reserve Cap-mWh (Offset 66)

This value reserves an amount of charge in, 10 mWh, (*[CapM]* = 1) for the system to react if the *RemainingCapacity* reports zero energy remaining in the battery. The ***Reserve Cap-mWh*** reserves an amount of charge between when the final ***Term Voltage*** is reached and the *RemainingCapacity* reports zero energy. The *FullChargeCapacity* function reports the internal full charge capacity - ***Reserve Cap-mWh***.

**Table C-195. Reserve Cap-mAh**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 80 | IT Cfg | 66 | Reserve Cap-mWh | signed integer | 2 | 0 | 14000 | 0 | 10 mWh |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- DF:Gas Gauging:IT Cfg(80):Term Voltage(45)
- DF:Configuration:Registers(64):Operation Cfg B(2)[RESCAP]
- SBS:BatteryMode(0x03):[CapM]
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)

## *C.10.2 Current Thresholds (Offset 81)*

### C.10.2.1 Dsg Current Threshold (Offset 0)

The bq20z90/bq20z95 enters discharge mode from relaxation mode or charge mode if *Current* < (-) ***Dsg Current Threshold***.

**Table C-196. Dsg Current Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 81 | Current Thresholds | 0 | Dsg Current Threshold | unsigned integer | 2 | 0 | 2000 | 100 | mA |

**Related Variables:**

- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

### C.10.2.2 Chg Current Threshold (Offset 2)

The bq20z90/bq20z95 enters charge mode from relaxation mode or discharge mode if *Current* > ***Chg Current Threshold***.

**Table C-197. Chg Current Threshold**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 81 | Current Thresholds | 2 | Chg Current Threshold | unsigned integer | 2 | 0 | 2000 | 50 | mA |

**Related Variables:**

- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

### C.10.2.3 Quit Current (Offset 4)

The bq20z90/bq20z95 enters relaxation mode from charge mode if *Current* goes below ***Quit Current*** for ***Chg Relax Time***. The bq20z90/bq20z95 enters relaxation mode from discharge mode if *Current* goes above ***(-)Quit Current*** for ***Dsg Relax Time***.

**Table C-198. Quit Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 81 | Current Thresholds | 4 | Quit Current | unsigned integer | 2 | 0 | 1000 | 10 | mA |

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Dsg Relax Time(6)
- DF:Gas Gauging:Current Thresholds(81):Chg Relax Time(7)
- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

### C.10.2.4 Dsg Relax Time (Offset 6)

The bq20z90/bq20z95 enters relaxation mode from discharge mode if *Current* goes above ***(-)Quit Current*** for at least ***Dsg Relax Time***.

**Table C-199. Dsg Relax Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 81 | Current Thresholds | 6 | Dsg Relax Time | unsigned integer | 1 | 0 | 255 | 1 | Sec |

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Quit Current(4)
- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

#### C.10.2.5 Chg Relax Time (Offset 7)

The bq20z90/bq20z95 enters relaxation mode from charge mode if *Current* goes below ***Quit Current*** for at least ***Chg Relax Time.***

**Table C-200. Chg Relax Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 81 | Current Thresholds | 7 | Chg Relax Time | unsigned integer | 1 | 0 | 255 | 60 | Sec |

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Quit Current(4)
- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

### *C.10.3 State (Offset 82)*

#### C.10.3.1 Qmax Cell 0..3 (Offset 0..6)

These values define the maximum chemical capacity for each cell used for the capacity calculation. The value should be taken directly from the battery cell datasheet.

**Table C-201. Qmax Cell 0..3**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 82 | State | 0 | Qmax Cell 0 | unsigned integer | 2 | 0 | 32767 | 4400 | mAh |
| | | 2 | Qmax Cell 1 | | 2 | 0 | 32767 | 4400 | mAh |
| | | 4 | Qmax Cell 2 | | 2 | 0 | 32767 | 4400 | mAh |
| | | 6 | Qmax Cell 3 | | 2 | 0 | 32767 | 4400 | mAh |

**Related Variables:**

- DF:Gas Gauging:State(82):Qmax Pack(8)
- SBS:OperationStatus(0x54)[QEN]

#### C.10.3.2 Qmax Pack (Offset 8)

This value defines the maximum chemical capacity of the battery pack. It usually gets set to the smallest value of ***Qmax Cell 0*** .. ***3***.

**Table C-202. Qmax Pack**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 82 | State | 8 | Qmax Pack | unsigned integer | 2 | 0 | 32767 | 4400 | mAh |

**Related Variables:**

- DF:Gas Gauging:State(82):Qmax Cell 0(0)
- DF:Gas Gauging:State(82):Qmax Cell 1(2)
- DF:Gas Gauging:State(82):Qmax Cell 2(4)

- DF:Gas Gauging:State(82):Qmax Cell 3(6)
- SBS:OperationStatus(0x54)[QEN]

### C.10.3.3 Update Status (Offset 12)

It is recommended to use *ManufacturerAccess* to enable or disable the Impedance Track™ algorithm and lifetime data updating.

0x00 = no Impedance Track™ algorithm and lifetime data updating (default)

0x02 = QMAX updated

0x04 = Impedance Track™ algorithm and lifetime data updating

0x06 = QMAX updated + Impedance Track™ algorithm and lifetime data updating

**Table C-203. Update Status**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 82 | State | 12 | Update Status | hex | 1 | 0x00 | 0x03 | 0x00 | |

**Related Variables:**

- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)

### C.10.3.4 Avg I Last Run (Offset 21)

The bq20z90/bq20z95 calculates and stores the average discharge current from the last discharge cycle in this value. This value is used by the Impedance Track™ algorithm for the *RemainingCapacity* calculation. It is not recommended to change this value.

**Table C-204. Avg I Last Run**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 82 | State | 21 | Avg I Last Run | signed integer | 2 | -32768 | 32767 | -2000 | mA |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x0f)

### C.10.3.5 Avg P Last Run (Offset 23)

The bq20z90/bq20z95 calculates and stores the average discharge power from the last discharge cycle in this value. This value is used by the Impedance Track™ algorithm for the *RemainingCapacity* calculation. It is not recommended to change this value.

**Table C-205. Avg P Last Run**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 82 | State | 23 | Avg P Last Run | signed integer | 2 | -32768 | 32767 | -3022 | 10 mW |

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x0f)

#### C.10.3.6 Delta Voltage (Offset 25)

The bq20z90/bq20z95 stores the maximum difference of *Voltage* during short load spikes and normal loads so the Impedance Track™ algorithm can calculate the *RemainingCapacity* for pulsed loads. It is not recommended to change this value.

**Table C-206. Delta Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 82 | State | 25 | Delta Voltage | signed integer | 2 | -32768 | 32767 | 0 | mV |

**Related Variables:**

- SBS:Voltage(0x09)
- SBS:RemainingCapacity(0x0f)

## C.11 Ra Table

### *C.11.1 R_a0 (Subclass 88)*

#### C.11.1.1 Cell0 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 0. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-207. Cell0 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 88 | R_a0 | 0 | Cell0 R_a flag | hex | 2 | 0x0000 | 0xffff | 0xff55 | |

**Related Variables:**

- DF:Ra Table:R_a0(88):Cell0 R_a 0..14(2..30)

#### C.11.1.2 Cell0 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 0 in this table.

**Table C-208. Cell0 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 88 | R_a0 | 2 | Cell0 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | Cell0 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | Cell0 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | Cell0 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | Cell0 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | Cell0 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | Cell0 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | Cell0 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | Cell0 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | Cell0 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | Cell0 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | Cell0 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | Cell0 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | Cell0 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | Cell0 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a0(88):Cell0 R_a flag(0)

## *C.11.2 R_a1 (Subclass 89)*

### C.11.2.1 Cell1 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 1. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-209. Cell1 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 89 | R_a1 | 0 | Cell1 R_a flag | hex | 2 | 0x0000 | 0xffff | 0xff55 | |

**Related Variables:**

- DF:Ra Table:R_a1(89):Cell1 R_a 0..14(2..30)

### C.11.2.2 Cell1 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 1 in this table.

**Table C-210. Cell1 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 89 | R_a1 | 2 | Cell1 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | Cell1 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | Cell1 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | Cell1 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | Cell1 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | Cell1 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | Cell1 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | Cell1 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | Cell1 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | Cell1 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | Cell1 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | Cell1 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | Cell1 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | Cell1 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | Cell1 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a1(89):Cell1 R_a flag(0)

## *C.11.3 R_a2 (Subclass 90)*

### C.11.3.1 Cell2 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 2. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-211. Cell2 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 90 | R_a2 | 0 | Cell2 R_a flag | hex | 2 | 0x0000 | 0xffff | 0xff55 | |

**Related Variables:**

- DF:Ra Table:R_a2(90):Cell2 R_a 0..14(2..30)

### C.11.3.2 Cell2 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 2 in this table.

**Table C-212. Cell2 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 90 | R_a2 | 2 | Cell2 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | Cell2 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | Cell2 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | Cell2 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | Cell2 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | Cell2 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | Cell2 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | Cell2 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | Cell2 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | Cell2 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | Cell2 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | Cell2 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | Cell2 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | Cell2 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | Cell2 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a2(90):Cell2 R_a flag(0)

## *C.11.4 R_a3 (Subclass 91)*

### C.11.4.1 Cell3 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 3. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-213. Cell3 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 91 | R_a3 | 0 | Cell3 R_a flag | hex | 2 | 0x0000 | 0xffff | 0xff55 | |

**Related Variables:**

- DF:Ra Table:R_a3(91):Cell3 R_a 0..14(2..30)

### C.11.4.2 Cell3 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 3 in this table.

**Table C-214. Cell3 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 91 | R_a3 | 2 | Cell3 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | Cell3 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | Cell3 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | Cell3 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | Cell3 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | Cell3 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | Cell3 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | Cell3 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | Cell3 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | Cell3 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | Cell3 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | Cell3 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | Cell3 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | Cell3 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | Cell3 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a3(91):Cell3 R_a flag(0)

## *C.11.5 R_a0x (Subclass 92)*

### C.11.5.1 xCell0 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 0. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-215. xCell0 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 92 | R_a0x | 0 | xCell0 R_a flag | hex | 2 | 0xffff | 0xffff | 0xffff | |

**Related Variables:**

- DF:Ra Table:R_a0x(92):xCell0 R_a 0..14(2..30)

### C.11.5.2 xCell0 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 0 in this table.

**Table C-216. xCell0 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 92 | R_a0x | 2 | xCell0 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | xCell0 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | xCell0 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | xCell0 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | xCell0 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | xCell0 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | xCell0 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | xCell0 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | xCell0 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | xCell0 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | xCell0 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | xCell0 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | xCell0 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | xCell0 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | xCell0 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a0x(92):xCell0 R_a flag(0)

## *C.11.6 R_a1x (Subclass 93)*

### C.11.6.1 xCell1 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 1. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-217. xCell1 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 93 | R_a1x | 0 | xCell1 R_a flag | hex | 2 | 0xffff | 0xffff | 0xffff | |

**Related Variables:**

- DF:Ra Table:R_a1x(93):xCell1 R_a 0..14(2..30)

### C.11.6.2 xCell1 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 1 in this table.

**Table C-218. xCell1 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 93 | R_a1x | 2 | xCell1 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | xCell1 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | xCell1 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | xCell1 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | xCell1 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | xCell1 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | xCell1 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | xCell1 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | xCell1 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | xCell1 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | xCell1 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | xCell1 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | xCell1 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | xCell1 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | xCell1 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a1x(93):xCell1 R_a flag(0)

## *C.11.7 R_a2x (Subclass 94)*

### C.11.7.1 xCell2 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 2. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-219. xCell2 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 94 | R_a2x | 0 | xCell2 R_a flag | hex | 2 | 0xffff | 0xffff | 0xffff | |

**Related Variables:**

- DF:Ra Table:R_a2x(94):xCell2 R_a 0..14(2..30)

### C.11.7.2 xCell2 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 2 in this table.

**Table C-220. xCell2 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 94 | R_a2x | 2 | xCell2 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | xCell2 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | xCell2 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | xCell2 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | xCell2 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | xCell2 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | xCell2 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | xCell2 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | xCell2 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | xCell2 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | xCell2 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | xCell2 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | xCell2 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | xCell2 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | xCell2 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a2x(94):xCell2 R_a flag(0)

## *C.11.8 R_a3x (Subclass 95)*

### C.11.8.1 xCell3 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 3. It is recommended not to change this value.

| High Byte | | Low Byte | |
|---|---|---|---|
| 0x00 | cell impedance & QMAX updated | 0x00 | table not used & QMAX updated |
| 0x05 | relaxation mode and QMAX update in progress | 0x55 | table being used |
| 0x55 | discharge mode & cell impedance updated | 0xff | table never used, no QMAX or cell impedance update |
| 0xff | cell impedance newer updated | | |

**Table C-221. xCell3 R_a flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 95 | R_a3x | 0 | xCell3 R_a flag | hex | 2 | 0xffff | 0xffff | 0xffff | |

**Related Variables:**

- DF:Ra Table:R_a3x(95):xCell3 R_a 0..14(2..30)

### C.11.8.2 xCell3 R_a 0..14 (Offset 2..30)

The bq20z90/bq20z95 stores and updates the impedance profile for cell 3 in this table.

**Table C-222. xCell3 R_a**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 95 | R_a3x | 2 | xCell3 R_a 0 | signed integer | 2 | 0 | 32767 | 160 | 2^-10 Ω |
| | | 4 | xCell3 R_a 1 | | | 0 | 32767 | 166 | |
| | | 6 | xCell3 R_a 2 | | | 0 | 32767 | 153 | |
| | | 8 | xCell3 R_a 3 | | | 0 | 32767 | 151 | |
| | | 10 | xCell3 R_a 4 | | | 0 | 32767 | 145 | |
| | | 12 | xCell3 R_a 5 | | | 0 | 32767 | 152 | |
| | | 14 | xCell3 R_a 6 | | | 0 | 32767 | 176 | |
| | | 16 | xCell3 R_a 7 | | | 0 | 32767 | 204 | |
| | | 18 | xCell3 R_a 8 | | | 0 | 32767 | 222 | |
| | | 20 | xCell3 R_a 9 | | | 0 | 32767 | 254 | |
| | | 22 | xCell3 R_a 10 | | | 0 | 32767 | 315 | |
| | | 24 | xCell3 R_a 11 | | | 0 | 32767 | 437 | |
| | | 26 | xCell3 R_a 12 | | | 0 | 32767 | 651 | |
| | | 28 | xCell3 R_a 13 | | | 0 | 32767 | 1001 | |
| | | 30 | xCell3 R_a 14 | | | 0 | 32767 | 1458 | |

**Related Variables:**

- DF:Ra Table:R_a3x(95):xCell3 R_a flag(0)

## C.12 PF Status

### *C.12.1 Device Status Data (Subclass 96)*

#### C.12.1.1 PF Flags 1 (Offset 0)

The flags in the ***PF Flags 1*** register indicate the reason that the bq20z90/bq20z95 has entered permanent failure. If the failure flag in ***PF Flags 1*** matches the bit in ***Permanent Fail Cfg*** the SAFE pin is driven high and the ***Fuse Flag*** is set to 0x3672. The SAFE pin can be used to blow an optional fuse in a severe failure condition to prevent more damage of the system.

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

**Table C-223. PF Flags 1**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 0 | PF Flags 1 | hex | 2 | 0x0000 | 0xbfff | 0x0000 | |

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)
- DF:PF Status:Device Status Data(96):PF Flags 2(28)
- SBS:PFAlert(0x52)
- SBS:PFStatus(0x53)

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

LEGEND: All Values Read Only

**Figure C-13. PF Flags 1**

**FBF—** = 1: Fuse Blow Failure. The fuse has not cut off current even though the SAFE pin output has been driven high.

**PFVSHUT—** = 1: Another permanent failure has occurred AND the device went into shutdown after that event

**SOPT—** = 1: Open Thermistor permanent failure

**SOCD—** = 1: Safety Overcurrent in Discharge permanent failure

**SOCC—** = 1: Safety Overcurrent in Charge permanent failure

**AFE_P—** = 1: Periodic AFE-Communications permanent failure

**AFE_C—** =1 AFE-Communications permanent failure

**DFF—** = 1: Data Flash Fault permanent failure

**DFETF—** = 1: Discharge FET permanent failure

**CFETF—** = 1: Charge FET permanent failure

**CIM—** = 1: Cell-Imbalance permanent failure

**SOTD—** = 1: Discharge Safety Overtemperature permanent failure

**SOTC—** = 1: Charge Safety Overtemperature permanent failure

**SOV—** = 1: Safety Overvoltage permanent failure

**PFIN—** = 1: External PFIN Input of bq29330 Indication of a Permanent Failure.

### C.12.1.2 Fuse Flag (Offset 2)

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

0x0000 = No Failure(default)

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

**Table C-224. Fuse Flag**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 2 | Fuse Flag | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):PF Flags 1(0)

### C.12.1.3 PF Voltage (Offset 4)

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

**Table C-225. PF Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 4 | PF Voltage | unsigned integer | 2 | 0 | 32767 | 0 | mV |

**Related Variables:**

- SBS:Voltage(0x09)

### C.12.1.4 PF C4 Voltage (Offset 6)

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

**Table C-226. PF C4 Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 6 | PF C4 Voltage | unsigned integer | 2 | 0 | 9999 | 0 | mV |

**Related Variables:**

- SBS:CellVoltage4(0x3c)

### C.12.1.5 PF C3 Voltage (Offset 8)

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

**Table C-227. PF C3 Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 8 | PF C3 Voltage | unsigned integer | 2 | 0 | 9999 | 0 | mV |

**Related Variables:**

- SBS:CellVoltage3(0x3d)

### C.12.1.6 PF C2 Voltage (Offset 10)

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

**Table C-228. PF C2 Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 10 | PF C2 Voltage | unsigned integer | 2 | 0 | 9999 | 0 | mV |

**Related Variables:**

- SBS:CellVoltage2(0x3e)

### C.12.1.7 PF C1 Voltage (Offset 12)

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

**Table C-229. PF C1 Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 12 | PF C1 Voltage | unsigned integer | 2 | 0 | 9999 | 0 | mV |

**Related Variables:**

- SBS:CellVoltage1(0x3f)

### C.12.1.8 PF Current (Offset 14)

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

**Table C-230. PF Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 14 | PF Current | signed integer | 2 | -32768 | 32767 | 0 | mA |

**Related Variables:**

- SBS:Current(0x0a)

### C.12.1.9 PF Temperature (Offset 16)

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

**Table C-231. PF Temperature**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 16 | PF Temperature | signed integer | 2 | -9999 | 9999 | 0 | 0.1 K |

**Related Variables:**

- SBS:Temperature(0x08)

### C.12.1.10 PF Batt Stat (Offset 18)

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

**Table C-232. PF Batt Stat**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 18 | PF Batt Stat | unsigned integer | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:BatteryStatus(0x16)

### C.12.1.11 PF RC-mAh (Offset 20)

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

**Table C-233. PF RC-mAh**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 20 | PF RC-mAh | unsigned integer | 2 | 0 | 32767 | 0 | mAh |

**Related Variables:**

- SBS:BatteryMode(0x03)[CapM]
- SBS:RemainingCapacity(0x0f)

### C.12.1.12 PF RC-10mWh (Offset 22)

When a permanent failure is detected *RemainingCapacity*, in 10mWh, is captured and stored in ***PF-RC 10mWh***.

**Table C-234. PF RC-10mWh**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 22 | PF RC-10mWh | unsigned integer | 2 | 0 | 32767 | 0 | 10mWh |

**Related Variables:**

- SBS:BatteryMode(0x03)[CapM]
- SBS:RemainingCapacity(0x0f)

### C.12.1.13 PF Chg Status (Offset 24)

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

**Table C-235. PF Chg Status**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 24 | PF Chg Status | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:ChargingStatus(0x55)

### C.12.1.14 PF Safety Status (Offset 26)

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

**Table C-236. PF Safety Status**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 26 | PF Safety Status | hex | 2 | 0x0000 | 0xffff | 0x0000 | |

**Related Variables:**

- SBS:SafetyStatus(0x51)

### C.12.1.15 PF Flags 2 (Offset 28)

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

**Table C-237. PF Flags 2**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 96 | Device Status Data | 28 | PF Flags 2 | hex | 2 | 0x0000 | 0x8000 | 0x0000 | |

**Related Variables:**

- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- SBS:PFStatus(0x53)

### *C.12.2 AFE Regs (Subclass 97)*

When the bq20z90/bq20z95 detects a permanent failure a complete copy of the bq29330 register values is stored ***AFE Regs***.

**Table C-238. AFE Regs**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 97 | AFE Regs | 0 | AFE Status | hex | 1 | 0x00 | 0xff | 0x00 | |
| | | 1 | AFE Output | | | | | | |
| | | 2 | AFE State | | | | | | |
| | | 3 | AFE Function | | | | | | |
| | | 4 | AFE Cell Select | | | | | | |
| | | 5 | AFE OLV | | | | | | |
| | | 6 | AFE OLT | | | | | | |
| | | 7 | AFE SCC | | | | | | |
| | | 8 | AFE SCD | | | | | | |

## C.13 Calibration

### *C.13.1 Data (Subclass 104)*

#### C.13.1.1 CC Gain (Offset 0)

***CC Gain*** sets the mA current scale factor for the coulomb counter. Use calibration routines to set this value.

**Table C-239. CC Gain**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 0 | CC Gain | floating point | 4 | 0.1 | 4 | 0.9419 | |

**Related Variables:**

- SBS:Current(0x0a)

#### C.13.1.2 CC Delta (Offset 4)

***CC Delta*** sets the mAh capacity scale factor for the coulomb counter. Use calibration routines to set this value.

**Table C-240. CC Delta**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 4 | CC Delta | floating point | 4 | 29826 | 1193046 | 280932.6 | |

**Related Variables:**

- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)

### C.13.1.3 Ref Voltage (Offset 8)

This register value stores the AFE reference voltage in units of 50 µV.

**Table C-241. Ref Voltage**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 8 | Ref Voltage | signed integer | 2 | 0 | 32767 | 24500 | 50µV |

### C.13.1.4 AFE Pack Gain (Offset 12)

This register value stores the scale factor for the voltage at the PACK pin of the bq29330 AFE.

**Table C-242. AFE Pack Gain**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 12 | AFE Pack Gain | unsigned integer | 2 | 0 | 32767 | 22500 | µV/cnt |

### C.13.1.5 CC Offset (Offset 14)

This register value stores the coulomb counter offset compensation. It is set by automatic calibration of the bq20z90/bq20z95. It is not recommended to change this value.

**Table C-243. CC Offset**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 14 | CC Offset | signed integer | 2 | -32768 | 32767 | -1667 | |

### C.13.1.6 Board Offset (Offset 16)

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

**Table C-244. Board Offset**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 16 | Board Offset | signed integer | 2 | -32768 | 32767 | 0 | |

**Related Variables:**

- Calibration:Data(104):CC Offset(14)

### C.13.1.7 Int Temp Offset (Offset 18)

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

**Table C-245. Int Temp Offset**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 18 | Int Temp Offset | signed integer | 1 | -128 | 127 | 0 | |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x08)

#### C.13.1.8 Ext1 Temp Offset (Offset 19)

This register value stores the temperature sensor offset compensation for the external temperature sensor 1 connected at the TS1 pin of the bq20z90/bq20z95. Use calibration routines to set this value.

**Table C-246. Ext1 Temp Offset**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 19 | Ext1 Temp Offset | signed integer | 1 | -128 | 127 | 0 | |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x08)

#### C.13.1.9 Ext2 Temp Offset (Offset 20)

This register value stores the temperature sensor offset compensation for the external temperature sensor 2 connected at the TS2 pin of the bq20z90/bq20z95. Use calibration routines to set this value.

**Table C-247. Ext2 Temp Offset**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 104 | Data | 20 | Ext2 Temp Offset | signed integer | 1 | -128 | 127 | 0 | |

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x08)

### *C.13.2 Config (Subclass 105)*

#### C.13.2.1 CC Current (Offset 0)

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

**Table C-248. CC Current**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 0 | CC Current | unsigned integer | 2 | 0 | 32767 | 3000 | mA |

**Related Variables:**

- SBS:Current(0x0a)

### C.13.2.2 Voltage Signal (Offset 2)

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

**Table C-249. Voltage Signal**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 2 | Voltage Signal | unsigned integer | 2 | 0 | 32767 | 16800 | mV |

**Related Variables:**

- SBS:Voltage(0x09)

### C.13.2.3 Temp Signal (Offset 4)

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

**Table C-250. Temp Signal**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 4 | Temp Signal | unsigned integer | 2 | 0 | 32767 | 2980 | 0.1K |

**Related Variables:**

- SBS:Temperature(0x08)

### C.13.2.4 CC Offset Time (Offset 6)

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

**Table C-251. CC Offset Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 6 | CC Offset Time | unsigned integer | 2 | 0 | 65535 | 250 | mSec |

**Related Variables:**

- Calibration:Data(104):CC Offset(14)

### C.13.2.5 ADC Offset Time (Offset 8)

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

**Table C-252. ADC Offset Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 8 | ADC Offset Time | unsigned integer | 2 | 0 | 65535 | 32 | mSec |

### C.13.2.6 CC Gain Time (Offset 10)

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

**Table C-253. CC Gain Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 10 | CC Gain Time | unsigned integer | 2 | 0 | 65535 | 250 | mSec |

**Related Variables:**

- Calibration:Data(104):CC Gain(0)

### C.13.2.7 Voltage Time (Offset 12)

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

**Table C-254. Voltage Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 12 | Voltage Time | unsigned integer | 2 | 0 | 65535 | 1984 | mSec |

**Related Variables:**

- SBS:Voltage(0x09)

### C.13.2.8 Temperature Time (Offset 14)

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

**Table C-255. Temperature Time**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 14 | Temperature Time | unsigned integer | 2 | 0 | 65535 | 32 | mSec |

**Related Variables:**

- Calibration:Data(104):Int Temp Offset(18)
- Calibration:Data(104):Ext1 Temp Offset(19)
- Calibration:Data(104):Ext2 Temp Offset(20)
- SBS:Temperature(0x08)

#### C.13.2.9 Cal Mode Timeout (Offset 17)

The bq20z90/bq20z95 will exit calibration mode automatically after a ***Cal Mode Timeout*** period.

**Table C-256. Cal Mode Timeout**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 105 | Config | 17 | Cal Mode Timeout | unsigned integer | 2 | 0 | 65535 | 38400 | Sec / 128 |

**Related Variables:**

- SBS:ManufacturerAccess(0x00):Calibration Mode(0x0040)

### *C.13.3 Temp Model (Subclass 106)*

#### C.13.3.1 Ext Coef 1..4, Ext Min AD, Ext Max Temp (Offset 0..10)

These values characterize the external thermistor connected to the TS1 pin or the TS2 pin of the bq20z90/bq20z95. The default values characterize the Semitec 103AT NTC thermistor. Do not modify these values without consulting TI.

**Table C-257. Ext Coef 1..4, Ext Min AD, Ext Max Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 106 | Temp Model | 0 | Ext Coef 1 | signed integer | 2 | -32768 | 32767 | -28285 | Sec |
| | | 2 | Ext Coef 2 | | | | | 20848 | |
| | | 4 | Ext Coef 3 | | | | | -7537 | |
| | | 6 | Ext Coef 4 | | | | | 4012 | |
| | | 8 | Ext Min AD | | | | | 0 | |
| | | 10 | Ext Max Temp | | | | | 4012 | |

#### C.13.3.2 Int Coef 1..4, Int Min AD, Int Max Temp (Offset 12..22)

These values characterize the internal thermistor of the bq20z90/bq20z95. Do not modify these values without consulting TI.

**Table C-258. Int Coef 1..4, Int Min AD, Int Max Temp**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 106 | Temp Model | 12 | Int Coef 1 | signed integer | 2 | -32768 | 32767 | 0 | Sec |
| | | 14 | Int Coef 2 | | | | | 0 | |
| | | 16 | Int Coef 3 | | | | | -11136 | |
| | | 18 | Int Coef 4 | | | | | 5754 | |
| | | 20 | Int Min AD | | | | | 0 | |
| | | 22 | Int Max Temp | | | | | 5754 | |

### *C.13.4 Current (Subclass 107)*

#### C.13.4.1 Filter (Offset 0)

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

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

with:

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

**Table C-259. Filter**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 107 | Current | 0 | Filter | unsigned integer | 1 | 0 | 255 | 239 | mA |

**Related Variables:**

- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)

### C.13.4.2 Deadband (Offset 1)

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

**Table C-260. Deadband**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 107 | Current | 1 | Deadband | unsigned integer | 1 | 0 | 255 | 3 | mA |

**Related Variables:**

- SBS:Current(0x0a)

### C.13.4.3 CC Deadband (Offset 2)

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

**Table C-261. CC Deadband**

| Subclass ID | Subclass Name | Offset | Name | Format | Size in Bytes | Min Value | Max Value | Default Value | Unit |
|---|---|---|---|---|---|---|---|---|---|
| 107 | Current | 2 | CC Deadband | unsigned integer | 1 | 0 | 255 | 34 | 294 nV |

**Related Variables:**

- SBS:RemainingCapacity(0x0f)

## C.14 Data Flash Values

**Table C-262. DATA FLASH VALUES**

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| 1st Level Safety | 0 | Voltage | 0 | COV Threshold | I2 | 3700 | 5000 | 4300 | mV |
| 1st Level Safety | 0 | Voltage | 2 | COV Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 0 | Voltage | 3 | COV Recovery | I2 | 0 | 4400 | 3900 | mV |

**Table C-262. DATA FLASH VALUES (continued)**

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| 1st Level Safety | 0 | Voltage | 5 | COV Delta | U1 | 0 | 200 | 20 | mV |
| 1st Level Safety | 0 | Voltage | 6 | COV Temp. Hys | U1 | 0 | 250 | 100 | 0.1°C |
| 1st Level Safety | 0 | Voltage | 7 | POV Threshold | I2 | 0 | 18000 | 17500 | mV |
| 1st Level Safety | 0 | Voltage | 9 | POV Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 0 | Voltage | 10 | POV Recovery | I2 | 0 | 17000 | 16000 | mV |
| 1st Level Safety | 0 | Voltage | 12 | CUV Threshold | I2 | 0 | 3500 | 2200 | mV |
| 1st Level Safety | 0 | Voltage | 14 | CUV Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 0 | Voltage | 15 | CUV Recovery | I2 | 0 | 3600 | 3000 | mV |
| 1st Level Safety | 0 | Voltage | 17 | PUV Threshold | I2 | 0 | 16000 | 11000 | mV |
| 1st Level Safety | 0 | Voltage | 19 | PUV Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 0 | Voltage | 20 | PUV Recovery | I2 | 0 | 16000 | 12000 | mV |
| 1st Level Safety | 1 | Current | 0 | OC (1st Tier) Chg | I2 | 0 | 20000 | 6000 | mA |
| 1st Level Safety | 1 | Current | 2 | OC (1st Tier) Chg Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 1 | Current | 3 | OC Chg Recovery | I2 | -1000 | 1000 | 200 | mA |
| 1st Level Safety | 1 | Current | 5 | OC (1st Tier) Dsg | I2 | 0 | 20000 | 6000 | mA |
| 1st Level Safety | 1 | Current | 7 | OC (1st Tier) Dsg Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 1 | Current | 8 | OC Dsg Recovery | I2 | 0 | 1000 | 200 | mA |
| 1st Level Safety | 1 | Current | 10 | OC (2nd Tier) Chg | I2 | 0 | 20000 | 8000 | mA |
| 1st Level Safety | 1 | Current | 12 | OC (2nd Tier) Chg Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 1 | Current | 13 | OC (2nd Tier) Dsg | I2 | 0 | 22000 | 8000 | mA |
| 1st Level Safety | 1 | Current | 15 | OC (2nd Tier) Dsg Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 1 | Current | 16 | Current Recovery Time | U1 | 0 | 240 | 8 | s |
| 1st Level Safety | 1 | Current | 17 | AFE OC Dsg | H1 | 0x00 | 0x1f | 0x12 | |
| 1st Level Safety | 1 | Current | 18 | AFE OC Dsg Time | H1 | 0x00 | 0x0f | 0x0f | |
| 1st Level Safety | 1 | Current | 19 | AFE OC Dsg Recovery | I2 | 10 | 1000 | 5 | mA |
| 1st Level Safety | 1 | Current | 21 | AFE SC Chg Cfg | H1 | 0x00 | 0xff | 0x77 | |
| 1st Level Safety | 1 | Current | 22 | AFE SC Dsg Cfg | H1 | 0x00 | 0xff | 0x77 | |
| 1st Level Safety | 1 | Current | 23 | AFE SC Recovery | I2 | 0 | 200 | 1 | mA |
| 1st Level Safety | 2 | Temperature | 0 | Over Temp Chg | I2 | 0 | 1200 | 550 | 0.1°C |
| 1st Level Safety | 2 | Temperature | 2 | OT Chg Time | U1 | 0 | 240 | 2 | s |

## Table C-262. DATA FLASH VALUES (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| 1st Level Safety | 2 | Temperature | 3 | OT Chg Recovery | I2 | 0 | 1200 | 500 | 0.1°C |
| 1st Level Safety | 2 | Temperature | 5 | Over Temp Dsg | I2 | 0 | 1200 | 600 | 0.1°C |
| 1st Level Safety | 2 | Temperature | 7 | OT Dsg Time | U1 | 0 | 240 | 2 | s |
| 1st Level Safety | 2 | Temperature | 8 | OT Dsg Recovery | I2 | 0 | 1200 | 550 | 0.1°C |
| 1st Level Safety | 3 | Host Comm | 0 | Host Watchdog Timeout | U1 | 0 | 255 | 0 | s |
| 2nd Level Safety | 16 | Voltage | 0 | SOV Threshold | I2 | 0 | 20000 | 18000 | mV |
| 2nd Level Safety | 16 | Voltage | 2 | SOV Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 16 | Voltage | 3 | Cell Imbalance Current | I1 | 0 | 200 | 5 | mA |
| 2nd Level Safety | 16 | Voltage | 4 | Cell Imbalance Fail Voltage | I2 | 0 | 5000 | 1000 | mV |
| 2nd Level Safety | 16 | Voltage | 6 | Cell Imbalance Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 16 | Voltage | 7 | Battery Rest Time | U2 | 0 | 65535 | 1800 | s |
| 2nd Level Safety | 16 | Voltage | 9 | Min CIM-check voltage | U2 | 0 | 65535 | 3000 | mV |
| 2nd Level Safety | 16 | Voltage | 11 | PFIN Detect Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 17 | Current | 0 | SOC Chg | I2 | 0 | 30000 | 10000 | mA |
| 2nd Level Safety | 17 | Current | 2 | SOC Chg Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 17 | Current | 3 | SOC Dsg | I2 | 0 | 30000 | 10000 | mA |
| 2nd Level Safety | 17 | Current | 5 | SOC Dsg Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 18 | Temperature | 0 | SOT Chg | I2 | 0 | 1200 | 650 | 0.1°C |
| 2nd Level Safety | 18 | Temperature | 2 | SOT Chg Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 18 | Temperature | 3 | SOT Dsg | I2 | 0 | 1200 | 750 | 0.1°C |
| 2nd Level Safety | 18 | Temperature | 5 | SOT Dsg Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 18 | Temperature | 6 | Open Thermistor | I2 | -1000 | 1200 | -333 | 0.1°C |
| 2nd Level Safety | 18 | Temperature | 8 | Open Time | I1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 19 | FET Verification | 0 | FET Fail Limit | I2 | 0 | 500 | 20 | mA |
| 2nd Level Safety | 19 | FET Verification | 2 | FET Fail Time | U1 | 0 | 240 | 0 | s |
| 2nd Level Safety | 20 | AFE Verification | 0 | AFE Check Time | U1 | 0 | 255 | 0 | s |
| 2nd Level Safety | 20 | AFE Verification | 1 | AFE Fail Limit | U1 | 0 | 255 | 10 | |
| 2nd Level Safety | 20 | AFE Verification | 2 | AFE Fail Recovery Time | U1 | 0 | 255 | 20 | s |
| 2nd Level Safety | 20 | AFE Verification | 3 | AFE Init Retry Limit | U1 | 0 | 255 | 6 | |
| 2nd Level Safety | 20 | AFE Verification | 4 | AFE Init Limit | U1 | 0 | 255 | 20 | |

**Table C-262. DATA FLASH VALUES (continued)**

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| 2nd Level Safety | 21 | Fuse Verification | 0 | Fuse Fail Limit | I2 | 0 | 20 | 2 | mA |
| 2nd Level Safety | 21 | Fuse Verification | 2 | Fuse Fail Time | U1 | 0 | 240 | 0 | s |
| Charge Control | 32 | Charge Inhibit Cfg | 0 | Chg Inhibit Temp Low | I2 | -400 | 1200 | 0 | 0.1°C |
| Charge Control | 32 | Charge Inhibit Cfg | 2 | Chg Inhibit Temp High | I2 | -400 | 1200 | 450 | 0.1°C |
| Charge Control | 32 | Charge Inhibit Cfg | 4 | Temp Hys | I2 | 0 | 100 | 10 | 0.1°C |
| Charge Control | 33 | Pre-Charge Cfg | 0 | Pre-chg Current | I2 | 0 | 2000 | 250 | mA |
| Charge Control | 33 | Pre-Charge Cfg | 2 | Pre-chg Temp | I2 | -400 | 1200 | 120 | 0.1°C |
| Charge Control | 33 | Pre-Charge Cfg | 4 | Pre-chg Voltage | I2 | 0 | 20000 | 3000 | mV |
| Charge Control | 33 | Pre-Charge Cfg | 6 | Recovery Voltage | I2 | 0 | 20000 | 3100 | mV |
| Charge Control | 34 | Fast Charge Cfg | 0 | Fast Charge Current | I2 | 0 | 10000 | 4000 | mA |
| Charge Control | 34 | Fast Charge Cfg | 2 | Charging Voltage | I2 | 0 | 20000 | 16800 | mV |
| Charge Control | 34 | Fast Charge Cfg | 4 | Delta Temp | I2 | 0 | 500 | 50 | 0.1°C |
| Charge Control | 34 | Fast Charge Cfg | 6 | Suspend Low Temp | I2 | -400 | 1200 | -50 | 0.1°C |
| Charge Control | 34 | Fast Charge Cfg | 8 | Suspend High Temp | I2 | -400 | 1200 | 550 | 0.1°C |
| Charge Control | 35 | Pulse Charge Cfg | 0 | Turn ON Voltage | I2 | 0 | 5000 | 4150 | mV |
| Charge Control | 35 | Pulse Charge Cfg | 2 | Turn OFF Voltage | I2 | 0 | 5000 | 4250 | mV |
| Charge Control | 35 | Pulse Charge Cfg | 4 | Max ON Pulse Time | U1 | 0 | 240 | 240 | Seconds/4 |
| Charge Control | 35 | Pulse Charge Cfg | 5 | Min OFF Pulse Time | U1 | 0 | 240 | 0 | Seconds/4 |
| Charge Control | 35 | Pulse Charge Cfg | 6 | Max OFF Voltage | I2 | 0 | 5000 | 4270 | mV |
| Charge Control | 36 | Termination Cfg. | 0 | Maintenance Current | I2 | 0 | 1000 | 0 | mA |
| Charge Control | 36 | Termination Cfg. | 2 | Taper Current | I2 | 0 | 1000 | 250 | mA |
| Charge Control | 36 | Termination Cfg. | 6 | Taper Voltage | I2 | 0 | 1000 | 300 | mV |
| Charge Control | 36 | Termination Cfg. | 8 | Current Taper Window | U1 | 0 | 240 | 40 | s |
| Charge Control | 36 | Termination Cfg. | 9 | TCA Set % | I1 | -1 | 100 | -1 | % |
| Charge Control | 36 | Termination Cfg. | 10 | TCA Clear % | I1 | -1 | 100 | 95 | % |
| Charge Control | 36 | Termination Cfg. | 11 | FC Set % | I1 | -1 | 100 | -1 | % |
| Charge Control | 36 | Termination Cfg. | 12 | FC Clear % | I1 | -1 | 100 | 98 | % |
| Charge Control | 37 | Cell Balancing Cfg | 0 | Min Cell Deviation | U2 | 0 | 65535 | 1750 | s/mAh |
| Charge Control | 38 | Charging Faults | 0 | Over Charging Voltage | I2 | 0 | 3000 | 500 | mV |
| Charge Control | 38 | Charging Faults | 2 | Over Charging Volt Time | U1 | 0 | 240 | 2 | s |

## Table C-262. DATA FLASH VALUES (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| Charge Control | 38 | Charging Faults | 3 | Over Charging Current | I2 | 0 | 2000 | 500 | mA |
| Charge Control | 38 | Charging Faults | 5 | Over Charging Curr Time | U1 | 0 | 240 | 2 | s |
| Charge Control | 38 | Charging Faults | 6 | Over Charging Curr Recov | I2 | 0 | 2000 | 100 | mA |
| Charge Control | 38 | Charging Faults | 8 | Depleted Voltage | I2 | 0 | 16000 | 8000 | mV |
| Charge Control | 38 | Charging Faults | 10 | Depleted Voltage Time | U1 | 0 | 240 | 2 | s |
| Charge Control | 38 | Charging Faults | 11 | Depleted Recovery | I2 | 0 | 16000 | 8500 | mV |
| Charge Control | 38 | Charging Faults | 13 | Over Charge Capacity | I2 | 0 | 4000 | 300 | mAh |
| Charge Control | 38 | Charging Faults | 15 | Over Charge Recovery | I2 | 0 | 100 | 2 | mAh |
| Charge Control | 38 | Charging Faults | 17 | FC-MTO | U2 | 0 | 65535 | 10800 | s |
| Charge Control | 38 | Charging Faults | 19 | PC-MTO | U2 | 0 | 65535 | 3600 | s |
| Charge Control | 38 | Charging Faults | 21 | Charge Fault Cfg | H1 | 0x00 | 0x3f | 0x00 | |
| SBS Configuration | 48 | Data | 0 | Rem Cap Alarm | I2 | 0 | 700 | 300 | mAh |
| SBS Configuration | 48 | Data | 2 | Rem Energy Alarm | I2 | 0 | 1000 | 432 | 10mW |
| SBS Configuration | 48 | Data | 4 | Rem Time Alarm | U2 | 0 | 30 | 10 | min |
| SBS Configuration | 48 | Data | 6 | Init Battery Mode | H2 | 0x0000 | 0xffff | 0x0081 | |
| SBS Configuration | 48 | Data | 8 | Design Voltage | I2 | 7000 | 18000 | 14400 | mV |
| SBS Configuration | 48 | Data | 10 | Spec Info | H2 | 0x0000 | 0xffff | 0x0031 | |
| SBS Configuration | 48 | Data | 12 | Manuf Date | U2 | 0 | 65535 | 0 | Day + Mo*32 + (Yr - 1980)*256 |
| SBS Configuration | 48 | Data | 14 | Ser. Num. | H2 | 0x0000 | 0xffff | 0x0001 | |
| SBS Configuration | 48 | Data | 16 | Cycle Count | U2 | 0 | 65535 | 0 | Count |
| SBS Configuration | 48 | Data | 18 | CC Threshold | I2 | 100 | 32767 | 4400 | mAh |
| SBS Configuration | 48 | Data | 20 | CC % | U1 | 0 | 100 | 90 | % |
| SBS Configuration | 48 | Data | 21 | CF MaxError Limit | U1 | 0 | 100 | 100 | % |
| SBS Configuration | 48 | Data | 22 | Design Capacity | I2 | 0 | 65535 | 4400 | mAh |
| SBS Configuration | 48 | Data | 24 | Design Energy | I2 | 0 | 65535 | 6336 | 10mW |
| SBS Configuration | 48 | Data | 26 | Manuf Name | S12 | - | - | Texas Inst. | ASCII |
| SBS Configuration | 48 | Data | 38 | Device Name | S8 | - | - | bq20z90/bq20z95 | ASCII |
| SBS Configuration | 48 | Data | 46 | Device Chemistry | S5 | - | - | LION | ASCII |

**Table C-262. DATA FLASH VALUES (continued)**

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| SBS Configuration | 49 | Configuration | 0 | TDA Set % | I1 | -1 | 100 | 6 | % |
| SBS Configuration | 49 | Configuration | 1 | TDA Clear % | I1 | -1 | 100 | 8 | % |
| SBS Configuration | 49 | Configuration | 2 | FD Set % | I1 | -1 | 100 | 2 | % |
| SBS Configuration | 49 | Configuration | 3 | FD Clear % | I1 | -1 | 100 | 5 | % |
| SBS Configuration | 49 | Configuration | 4 | TDA Set Volt Threshold | I2 | 0 | 16800 | 5000 | mV |
| SBS Configuration | 49 | Configuration | 6 | TDA Set Volt Time | U1 | 0 | 240 | 5 | s |
| SBS Configuration | 49 | Configuration | 7 | TDA Clear Volt | I2 | 0 | 16800 | 5500 | mV |
| SBS Configuration | 49 | Configuration | 9 | FD Set Volt Threshold | I2 | 0 | 16800 | 5000 | mV |
| SBS Configuration | 49 | Configuration | 11 | FD Volt Time | U1 | 0 | 240 | 5 | s |
| SBS Configuration | 49 | Configuration | 12 | FD Clear Volt | I2 | 0 | 16800 | 5500 | mV |
| System Data | 56 | Manufacturer Data | 0 | Pack Lot Code | H2 | 0x0000 | 0xffff | 0x0000 | |
| System Data | 56 | Manufacturer Data | 2 | PCB Lot Code | H2 | 0x0000 | 0xffff | 0x0000 | |
| System Data | 56 | Manufacturer Data | 4 | Firmware Version | H2 | 0x0000 | 0xffff | 0x0000 | |
| System Data | 56 | Manufacturer Data | 6 | Hardware Revision | H2 | 0x0000 | 0xffff | 0x0000 | |
| System Data | 56 | Manufacturer Data | 8 | Cell Revision | H2 | 0x0000 | 0xffff | 0x0000 | |
| System Data | 58 | Manufacturer Info | 0 | Manuf. Info | S32 | - | - | 0123456789abcdef0123456789abcde | |
| System Data | 59 | Lifetime Data | 0 | Lifetime Max Temp | I2 | 0 | 1400 | 300 | 0.1°C |
| System Data | 59 | Lifetime Data | 2 | Lifetime Min Temp | I2 | -600 | 1400 | 200 | 0.1°C |
| System Data | 59 | Lifetime Data | 4 | Lifetime Max Cell Voltage | I2 | 0 | 32767 | 3500 | mV |
| System Data | 59 | Lifetime Data | 6 | Lifetime Min Cell Voltage | I2 | 0 | 32767 | 3200 | mV |
| System Data | 59 | Lifetime Data | 8 | Lifetime Max Pack Voltage | I2 | 0 | 32767 | 14000 | mV |
| System Data | 59 | Lifetime Data | 10 | Lifetime Min Pack Voltage | I2 | 0 | 32767 | 12800 | mV |
| System Data | 59 | Lifetime Data | 12 | Lifetime Max Chg Current | I2 | -32768 | 32767 | 1500 | mA |
| System Data | 59 | Lifetime Data | 14 | Lifetime Max Dsg Current | I2 | -32768 | 32767 | -3000 | mA |
| System Data | 59 | Lifetime Data | 16 | Lifetime Max Chg Power | I2 | -32768 | 32767 | 1500 | cWatt |
| System Data | 59 | Lifetime Data | 18 | Lifetime Max Dsg Power | I2 | -32768 | 32767 | -1500 | cWatt |
| System Data | 59 | Lifetime Data | 22 | Life Max AvgDsg Cur | I2 | -32768 | 32767 | -1000 | mA |
| System Data | 59 | Lifetime Data | 26 | Life Max AvgDsg Pow | I2 | -32768 | 32767 | -1500 | cW |
| System Data | 59 | Lifetime Data | 28 | Lifetime Avg Temp | I2 | -40 | 1400 | 250 | 0.1°C |
| System Data | 60 | Lifetime Temp Samples | 0 | LT Temp Samples | I4 | 0 | 140000000 | 0 | Count |
| Configuration | 64 | Registers | 0 | Operation Cfg A | H2 | 0x0000 | 0xffff | 0x0f29 | |
| Configuration | 64 | Registers | 2 | Operation Cfg B | H2 | 0x0000 | 0xffff | 0x6440 | |
| Configuration | 64 | Registers | 4 | Operation Cfg C | H2 | 0x0000 | 0xffff | 0x0000 | |
| Configuration | 64 | Registers | 6 | Permanent Fail Cfg | H2 | 0x0000 | 0xffff | 0x0000 | |
| Configuration | 64 | Registers | 8 | Non-Removable Cfg | H2 | 0x0000 | 0xffff | 0x0000 | |
| LED Support | 67 | LED Cfg | 0 | LED Flash Rate | U2 | 0 | 65535 | 512 | 500us |
| LED Support | 67 | LED Cfg | 2 | LED Blink Rate | U2 | 0 | 65535 | 1024 | 500us |

## Table C-262. DATA FLASH VALUES (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| LED Support | 67 | LED Cfg | 4 | LED Delay | U2 | 1 | 65535 | 100 | 500us |
| LED Support | 67 | LED Cfg | 6 | LED Hold Time | U1 | 0 | 255 | 4 | sec |
| LED Support | 67 | LED Cfg | 7 | CHG Flash Alarm | I1 | -1 | 101 | 10 | % |
| LED Support | 67 | LED Cfg | 8 | CHG Thresh 1 | I1 | -1 | 101 | 0 | % |
| LED Support | 67 | LED Cfg | 9 | CHG Thresh 2 | I1 | -1 | 101 | 20 | % |
| LED Support | 67 | LED Cfg | 10 | CHG Thresh 3 | I1 | -1 | 101 | 40 | % |
| LED Support | 67 | LED Cfg | 11 | CHG Thresh 4 | I1 | -1 | 101 | 60 | % |
| LED Support | 67 | LED Cfg | 12 | CHG Thresh 5 | I1 | -1 | 101 | 80 | % |
| LED Support | 67 | LED Cfg | 13 | DSG Flash Alarm | I1 | -1 | 101 | 10 | % |
| LED Support | 67 | LED Cfg | 14 | DSG Thresh 1 | I1 | -1 | 101 | 0 | % |
| LED Support | 67 | LED Cfg | 15 | DSG Thresh 2 | I1 | -1 | 101 | 20 | % |
| LED Support | 67 | LED Cfg | 16 | DSG Thresh 3 | I1 | -1 | 101 | 40 | % |
| LED Support | 67 | LED Cfg | 17 | DSG Thresh 4 | I1 | -1 | 101 | 60 | % |
| LED Support | 67 | LED Cfg | 18 | DSG Thresh 5 | I1 | -1 | 101 | 80 | % |
| LED Support | 67 | LED Cfg | 19 | Sink Current | U1 | 0 | 3 | 3 | |
| Power | 68 | Power | 0 | Flash Update OK Voltage | I2 | 6000 | 20000 | 7500 | mV |
| Power | 68 | Power | 2 | Shutdown Voltage | I2 | 5000 | 20000 | 7000 | mV |
| Power | 68 | Power | 4 | Shutdown Time | U1 | 0 | 240 | 10 | s |
| Power | 68 | Power | 5 | Cell Shutdown Voltage | I2 | 0 | 5000 | 1750 | mV |
| Power | 68 | Power | 7 | Cell Shutdown Time | U1 | 0 | 240 | 10 | s |
| Power | 68 | Power | 8 | Charger Present | I2 | 0 | 23000 | 3000 | mV |
| Power | 68 | Power | 10 | Sleep Current | I2 | 0 | 100 | 10 | mA |
| Power | 68 | Power | 12 | Bus Low Time | U1 | 0 | 255 | 5 | s |
| Power | 68 | Power | 13 | Cal Inhibit Temp Low | I2 | -400 | 1200 | 50 | 0.1°C |
| Power | 68 | Power | 15 | Cal Inhibit Temp High | I2 | -400 | 1200 | 450 | 0.1°C |
| Power | 68 | Power | 17 | Sleep Voltage Time | U1 | 0 | 240 | 5 | s |
| Power | 68 | Power | 18 | Sleep Current Time | U1 | 0 | 255 | 20 | s |
| Power | 68 | Power | 19 | Wake Current Reg | H1 | 0x00 | 0x07 | 0x00 | |
| Gas Gauging | 80 | IT Cfg | 0 | Load Select | U1 | 0 | 255 | 3 | |
| Gas Gauging | 80 | IT Cfg | 1 | Load Mode | U1 | 0 | 255 | 0 | |
| Gas Gauging | 80 | IT Cfg | 45 | Term Voltage | I2 | -32768 | 32767 | 12000 | mV |
| Gas Gauging | 80 | IT Cfg | 60 | User Rate-mA | I2 | 2000 | 9000 | 0 | mA |
| Gas Gauging | 80 | IT Cfg | 62 | User Rate-mW | I2 | 3000 | 14000 | 0 | 10mW |
| Gas Gauging | 80 | IT Cfg | 64 | Reserve Cap-mAh | I2 | 0 | 9000 | 0 | mAh |
| Gas Gauging | 80 | IT Cfg | 66 | Reserve Cap-mWh | I2 | 0 | 14000 | 0 | 10mWh |
| Gas Gauging | 81 | Current Thresholds | 0 | Dsg Current Threshold | I2 | 0 | 2000 | 100 | mA |
| Gas Gauging | 81 | Current Thresholds | 2 | Chg Current Threshold | I2 | 0 | 2000 | 50 | mA |
| Gas Gauging | 81 | Current Thresholds | 4 | Quit Current | I2 | 0 | 1000 | 10 | mA |
| Gas Gauging | 81 | Current Thresholds | 6 | Dsg Relax Time | U1 | 0 | 255 | 1 | s |
| Gas Gauging | 81 | Current Thresholds | 7 | Chg Relax Time | U1 | 0 | 255 | 60 | s |
| Gas Gauging | 82 | State | 0 | Qmax Cell 0 | I2 | 0 | 32767 | 4400 | mAh |
| Gas Gauging | 82 | State | 2 | Qmax Cell 1 | I2 | 0 | 32767 | 4400 | mAh |
| Gas Gauging | 82 | State | 4 | Qmax Cell 2 | I2 | 0 | 32767 | 4400 | mAh |
| Gas Gauging | 82 | State | 6 | Qmax Cell 3 | I2 | 0 | 32767 | 4400 | mAh |
| Gas Gauging | 82 | State | 8 | Qmax Pack | I2 | 0 | 32767 | 4400 | mAh |
| Gas Gauging | 82 | State | 12 | Update Status | H1 | 0x00 | 0x03 | 0x00 | |

**Table C-262. DATA FLASH VALUES (continued)**

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| Gas Gauging | 82 | State | 21 | Avg I Last Run | I2 | -32768 | 32767 | -2000 | mA |
| Gas Gauging | 82 | State | 23 | Avg P Last Run | I2 | -32768 | 32767 | -3022 | cWatt |
| Gas Gauging | 82 | State | 25 | Delta Voltage | I2 | -32768 | 32767 | 0 | mV |
| Ra Table | 88 | R_a0 | 0 | Cell0 R_a flag | H2 | 0x0000 | 0x0000 | 0xff55 | |
| Ra Table | 88 | R_a0 | 2 | Cell0 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 4 | Cell0 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 6 | Cell0 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 8 | Cell0 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 10 | Cell0 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 12 | Cell0 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 14 | Cell0 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 16 | Cell0 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 18 | Cell0 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 20 | Cell0 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 22 | Cell0 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 24 | Cell0 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 26 | Cell0 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 28 | Cell0 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |
| Ra Table | 88 | R_a0 | 30 | Cell0 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 0 | Cell1 R_a flag | H2 | 0x0000 | 0x0000 | 0xff55 | |
| Ra Table | 89 | R_a1 | 2 | Cell1 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 4 | Cell1 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 6 | Cell1 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 8 | Cell1 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 10 | Cell1 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 12 | Cell1 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 14 | Cell1 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 16 | Cell1 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 18 | Cell1 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 20 | Cell1 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 22 | Cell1 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 24 | Cell1 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 26 | Cell1 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 28 | Cell1 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |
| Ra Table | 89 | R_a1 | 30 | Cell1 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 0 | Cell2 R_a flag | H2 | 0x0000 | 0x0000 | 0xff55 | |
| Ra Table | 90 | R_a2 | 2 | Cell2 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 4 | Cell2 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 6 | Cell2 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 8 | Cell2 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 10 | Cell2 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 12 | Cell2 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 14 | Cell2 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 16 | Cell2 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 18 | Cell2 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 20 | Cell2 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 22 | Cell2 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 24 | Cell2 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 26 | Cell2 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |

## Table C-262. DATA FLASH VALUES (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| Ra Table | 90 | R_a2 | 28 | Cell2 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |
| Ra Table | 90 | R_a2 | 30 | Cell2 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 0 | Cell3 R_a flag | H2 | 0x0 | 0x0 | 0xff55 | |
| Ra Table | 91 | R_a3 | 2 | Cell3 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 4 | Cell3 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 6 | Cell3 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 8 | Cell3 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 10 | Cell3 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 12 | Cell3 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 14 | Cell3 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 16 | Cell3 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 18 | Cell3 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 20 | Cell3 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 22 | Cell3 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 24 | Cell3 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 26 | Cell3 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 28 | Cell3 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |
| Ra Table | 91 | R_a3 | 30 | Cell3 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 0 | xCell0 R_a flag | H2 | 0xffff | 0xffff | 0xffff | |
| Ra Table | 92 | R_a0x | 2 | xCell0 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 4 | xCell0 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 6 | xCell0 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 8 | xCell0 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 10 | xCell0 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 12 | xCell0 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 14 | xCell0 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 16 | xCell0 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 18 | xCell0 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 20 | xCell0 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 22 | xCell0 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 24 | xCell0 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 26 | xCell0 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 28 | xCell0 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |
| Ra Table | 92 | R_a0x | 30 | xCell0 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 0 | xCell1 R_a flag | H2 | 0xffff | 0xffff | 0xffff | |
| Ra Table | 93 | R_a1x | 2 | xCell1 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 4 | xCell1 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 6 | xCell1 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 8 | xCell1 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 10 | xCell1 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 12 | xCell1 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 14 | xCell1 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 16 | xCell1 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 18 | xCell1 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 20 | xCell1 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 22 | xCell1 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 24 | xCell1 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 26 | xCell1 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |
| Ra Table | 93 | R_a1x | 28 | xCell1 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |

**Table C-262. DATA FLASH VALUES (continued)**

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| Ra Table | 93 | R_a1x | 30 | xCell1 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 0 | xCell2 R_a flag | H2 | 0xffff | 0xffff | 0xffff | |
| Ra Table | 94 | R_a2x | 2 | xCell2 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 4 | xCell2 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 6 | xCell2 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 8 | xCell2 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 10 | xCell2 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 12 | xCell2 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 14 | xCell2 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 16 | xCell2 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 18 | xCell2 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 20 | xCell2 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 22 | xCell2 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 24 | xCell2 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 26 | xCell2 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 28 | xCell2 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |
| Ra Table | 94 | R_a2x | 30 | xCell2 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 0 | xCell3 R_a flag | H2 | 0xffff | 0xffff | 0xffff | |
| Ra Table | 95 | R_a3x | 2 | xCell3 R_a 0 | I2 | 183 | 183 | 160 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 4 | xCell3 R_a 1 | I2 | 181 | 181 | 166 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 6 | xCell3 R_a 2 | I2 | 198 | 198 | 153 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 8 | xCell3 R_a 3 | I2 | 244 | 244 | 151 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 10 | xCell3 R_a 4 | I2 | 254 | 254 | 145 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 12 | xCell3 R_a 5 | I2 | 261 | 261 | 152 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 14 | xCell3 R_a 6 | I2 | 333 | 333 | 176 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 16 | xCell3 R_a 7 | I2 | 338 | 338 | 204 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 18 | xCell3 R_a 8 | I2 | 345 | 345 | 222 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 20 | xCell3 R_a 9 | I2 | 350 | 350 | 254 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 22 | xCell3 R_a 10 | I2 | 382 | 382 | 315 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 24 | xCell3 R_a 11 | I2 | 429 | 429 | 437 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 26 | xCell3 R_a 12 | I2 | 502 | 502 | 651 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 28 | xCell3 R_a 13 | I2 | 545 | 545 | 1001 | 2^-10Ω |
| Ra Table | 95 | R_a3x | 30 | xCell3 R_a 14 | I2 | 366 | 366 | 1458 | 2^-10Ω |
| PF Status | 96 | Device Status Data | 0 | PF Flags 1 | H2 | 0x0000 | 0x6fff | 0x0000 | |
| PF Status | 96 | Device Status Data | 2 | Fuse Flag | H2 | 0x0000 | 0xffff | 0x0000 | |
| PF Status | 96 | Device Status Data | 4 | PF Voltage | I2 | 0 | 32767 | 0 | mV |
| PF Status | 96 | Device Status Data | 6 | PF C4 Voltage | I2 | 0 | 9999 | 0 | mV |
| PF Status | 96 | Device Status Data | 8 | PF C3 Voltage | I2 | 0 | 9999 | 0 | mV |
| PF Status | 96 | Device Status Data | 10 | PF C2 Voltage | I2 | 0 | 9999 | 0 | mV |
| PF Status | 96 | Device Status Data | 12 | PF C1 Voltage | I2 | 0 | 9999 | 0 | mV |
| PF Status | 96 | Device Status Data | 14 | PF Current | I2 | -32768 | 32767 | 0 | mA |
| PF Status | 96 | Device Status Data | 16 | PF Temperature | I2 | -9999 | 9999 | 0 | 0.1 K |
| PF Status | 96 | Device Status Data | 18 | PF Batt Stat | H2 | 0x0000 | 0xffff | 0x0000 | |

## Table C-262. DATA FLASH VALUES (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| PF Status | 96 | Device Status Data | 20 | PF RC-mAh | I2 | 0 | 32767 | 0 | mAh |
| PF Status | 96 | Device Status Data | 22 | PF RC-10mWh | I2 | 0 | 32767 | 0 | cWattHr |
| PF Status | 96 | Device Status Data | 24 | PF Chg Status | H2 | 0x0000 | 0xffff | 0x0000 | |
| PF Status | 96 | Device Status Data | 26 | PF Safety Status | H2 | 0x0000 | 0xffff | 0x0000 | |
| PF Status | 96 | Device Status Data | 28 | PF Flags 2 | H2 | 0x0000 | 0x8000 | 0x0000 | |
| PF Status | 97 | AFE Regs | 0 | AFE Status | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 1 | AFE Output | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 2 | AFE State | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 3 | AFE Function | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 4 | AFE Cell Select | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 5 | AFE OLV | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 6 | AFE OLT | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 7 | AFE SCC | H1 | 0x00 | 0xff | 0x00 | |
| PF Status | 97 | AFE Regs | 8 | AFE SCD | H1 | 0x00 | 0xff | 0x00 | |
| Calibration | 104 | Data | 0 | CC Gain | F4 | 0.1 | 4 | 0.9419 | |
| Calibration | 104 | Data | 4 | CC Delta | F4 | 29826 | 1193046 | 280932.6 | |
| Calibration | 104 | Data | 8 | Ref Voltage | I2 | 0 | 32767 | 24500 | 50µV |
| Calibration | 104 | Data | 12 | AFE Pack Gain | I2 | 0 | 32767 | 22050 | µV/cnt |
| Calibration | 104 | Data | 14 | CC Offset | I2 | -32768 | 32767 | -1667 | |
| Calibration | 104 | Data | 16 | Board Offset | I2 | -32767 | 32767 | 0 | |
| Calibration | 104 | Data | 18 | Int Temp Offset | I1 | -128 | 127 | 0 | |
| Calibration | 104 | Data | 19 | Ext1 Temp Offset | I1 | -128 | 127 | 0 | |
| Calibration | 104 | Data | 20 | Ext2 Temp Offset | I1 | -128 | 127 | 0 | |
| Calibration | 105 | Config | 0 | CC Current | I2 | 0 | 32767 | 3000 | mA |
| Calibration | 105 | Config | 2 | Voltage Signal | I2 | 0 | 32767 | 16800 | mV |
| Calibration | 105 | Config | 4 | Temp Signal | I2 | 0 | 32767 | 2980 | 0.1°C |
| Calibration | 105 | Config | 6 | CC Offset Time | U2 | 0 | 65535 | 250 | ms |
| Calibration | 105 | Config | 8 | ADC Offset Time | U2 | 0 | 65535 | 32 | ms |
| Calibration | 105 | Config | 10 | CC Gain Time | U2 | 0 | 65535 | 250 | ms |
| Calibration | 105 | Config | 12 | Voltage Time | U2 | 0 | 65535 | 1984 | ms |
| Calibration | 105 | Config | 14 | Temperature Time | U2 | 0 | 65535 | 32 | s |
| Calibration | 105 | Config | 17 | Cal Mode Timeout | U2 | 0 | 65535 | 38400 | 1/128 s |
| Calibration | 106 | Temp Model | 0 | Ext Coef 1 | I2 | -32768 | 32767 | -28285 | s |
| Calibration | 106 | Temp Model | 2 | Ext Coef 2 | I2 | -32768 | 32767 | 20848 | s |
| Calibration | 106 | Temp Model | 4 | Ext Coef 3 | I2 | -32768 | 32767 | -7537 | s |
| Calibration | 106 | Temp Model | 6 | Ext Coef 4 | I2 | -32768 | 32767 | 4012 | s |
| Calibration | 106 | Temp Model | 8 | Ext Min AD | I2 | -32768 | 32767 | 0 | s |
| Calibration | 106 | Temp Model | 10 | Ext Max Temp | I2 | -32768 | 32767 | 4012 | s |
| Calibration | 106 | Temp Model | 12 | Int Coef 1 | I2 | -32768 | 32767 | 0 | s |
| Calibration | 106 | Temp Model | 14 | Int Coef 2 | I2 | -32768 | 32767 | 0 | s |
| Calibration | 106 | Temp Model | 16 | Int Coef 3 | I2 | -32768 | 32767 | -11136 | s |
| Calibration | 106 | Temp Model | 18 | Int Coef 4 | I2 | -32768 | 32767 | 5754 | s |
| Calibration | 106 | Temp Model | 20 | Int Min AD | I2 | -32768 | 32767 | 0 | s |
| Calibration | 106 | Temp Model | 22 | Int Max Temp | I2 | -32768 | 32767 | 5754 | s |
| Calibration | 107 | Current | 0 | Filter | U1 | 0 | 255 | 239 | |
| Calibration | 107 | Current | 1 | Deadband | U1 | 0 | 255 | 3 | mA |

**Table C-262. DATA FLASH VALUES (continued)**

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units |
|---|---|---|---|---|---|---|---|---|---|
| Calibration | 107 | Current | 2 | CC Deadband | U1 | 0 | 255 | 34 | 294 nV |

# Glossary

| | |
|---|---|
| ADC | Analog to Digital Converter |
| AFE | Analog Front End |
| alert | a warning set by the bq20z90/bq20z95 |
| bit | a single bit in a SBS command or Data Flash value which can be changed by the user |
| CC | Coulomb Counter |
| CHG FET | charge FET, connected to the CHG pin of the bq29330; used by the bq29330 to enable or disable charging |
| COV | Cell Over Voltage |
| CPU | Central Processing Unit |
| CUV | Cell Under Voltage |
| DF | Data Flash |
| DSG | flag set by the bq20z90/bq20z95 to indicate charge (DSG= 0) or discharge (DSG=1) |
| DSG FET | discharge FET, connected to the DSG pin of the bq29330; used by the bq29330 to enable or disable discharging |
| FAS | Full Access Security |
| FBF | Fuse Blow Failure |
| FC | Fully Charged |
| FCHG | Fast Charge |
| FCMTO | Fast Charge Timeout |
| FD | Fully Discharged |
| flag | a single bit in a SBS command or Data Flash value which is set by the bq20z90/bq20z95 or the bq29330 and indicates a status change |
| IC | Integrated Circuit |
| LED | Light Emitting Diode |
| Li-Ion | Lithium-Ion |
| NR | Non-Removable |
| OC | Over Current |
| OCA | Over Charge Alarm |
| OCV | Open Circuit Voltage |
| OTC | Over Temperature Charging |
| OTD | Over Temperature Discharging |
| PCHG | Pre-Charge |

| | |
|---|---|
| PCMTO | Pre-Charge Timeout |
| PEC | Packet Error Checking |
| PF | Permanent Fail |
| POV | Pack Over Voltage |
| PRES | System Present Flag |
| PUV | Pack Under Voltage |
| Qmax | Maximum Chemical Capacity |
| RCA | Remaining Capacity Alarm |
| RSOC | Relative State of Charge |
| SBS | Smart Battery System |
| SCC | Short Circuit Charge |
| SCD | Short Circuit Discharge |
| SMBus | System Management Bus |
| SOC | Safety Over Current |
| SOT | Safety Over Temperature |
| SS | Sealed mode flag |
| TCA | Terminate Charge Alarm |
| TDA | Terminate Discharge Alarm |
| ZVCHG FET | pre- charge FET, connected to the ZVCHG pin of the bq29330; depending on the configuration it is used for pre-charging and/or zero-volt charging |
| XDSG | Discharge Fault flag |

# Revision History

| Changes from Original (June 2006) to A Revision | Page |
|---|---|
| • Added Min CIM-check voltage threshold. | 25 |
| • Added Cell Voltage based Shutdown feature. | 59 |
| • Changed Manufacturer Info size, default value, and access ability. | 96 |
| • Added Min CIM-check voltage threshold | 119 |
| • Changed Manufacturer Info size, default value, and access ability. | 150 |
| • Added [SHUTV] bit in Operation Cfg C. | 161 |
| • Added Cell Shutdown Voltage threshold | 171 |
| • Added Cell Shutdown Time. | 171 |

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

# Index

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