bq20z80-V110 + bq29312A Chipset

Technical Reference Manual

Literature Number: SLUU276
June 2007

Texas Instruments

Contents

Preface

1.1 Read this First

This manual discusses modules and peripherals of the bq20z80 device and the use with the bq29312A device to build a complete battery pack gas gauge and protection solution.

1.2 Notational Conventions

Following notation is used, if SBS commands and DataFlash® 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]*
- DataFlash values are set in bold italic e.g.: ***COV Threshold***
- All DataFlash bits and flags are capitalized, set in bold italic and enclosed with square brackets, e.g.: ***[NR]***

All SBS commands, DataFlash 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 DataFlash 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 First-Level Protection Features

The bq20z80 supports a wide range of battery and system protection features that are easily configured or enabled via the integrated DataFlash.

2.1.1 Cell Overvoltage and Cell Undervoltage

The bq20z80 can detect cell overvoltage/undervoltage and protect battery cells from damage from battery cell overvoltage/undervoltage. If the over/undervoltage remains over an adjustable time period, the bq20z80 goes into pack overvoltage/undervoltage condition and switches off the CHG/DSG FET. The bq20z80 recovers from a cell overvoltage condition if all the cell voltages drop below the cell overvoltage recovery threshold. The bq20z80 recovers from cell undervoltage condition if all the cell voltages rise above the cell undervoltage recovery threshold.

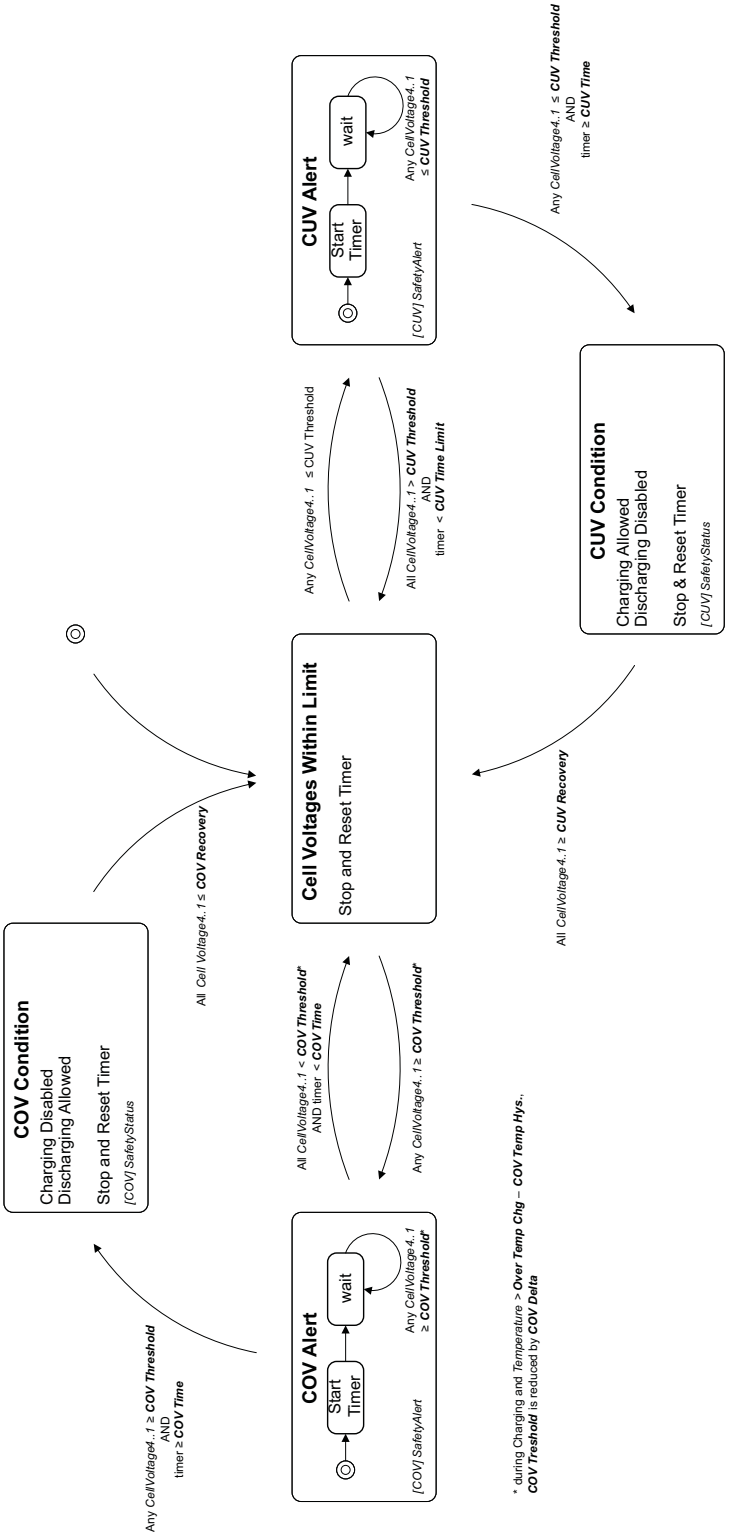

Figure 2-1. COV and CUV

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]*
	ChargingStatus					*[PCHG]*
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 bq20z80 indicates cell overvoltage by setting the *[COV]* flag in *SafetyAlert* if any *CellVoltage4..1* reaches or surpasses the ***COV Threshold*** limit. The bq20z80 goes into cell overvoltage 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 a cell overvoltage 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 bq20z80 recovers from a cell overvoltage condition if all *CellVoltages4..1* are equal to or lower than ***COV Recovery*** limit. On recovery, the *[COV]* flag in *SafetyStatus* is reset, *the [TCA]* flag is reset, and *ChargingCurrent* and *ChargingVoltage* are set back to an appropriate value per the charging algorithm.

In a cell overvoltage condition, the CHG FET is turned on during discharging to prevent overheating of the CHG FET body diode.

The bq20z80 indicates cell undervoltage by setting the *[CUV]* flag in *SafetyAlert* if any *CellVoltage4..1* reaches or drops below the ***CUV Threshold*** limit. The bq20z80 goes into a cell undervoltage 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 a cell undervoltage condition, discharging is disabled and the 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 bq20z80 recovers from a cell undervoltage 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 an appropriate value per the charging algorithm.

In a cell undervoltage 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 bq20z80 can detect battery pack overvoltage/undervoltage and protect the battery pack from damage due to battery pack overvoltage/undervoltage. If the overvoltage/undervoltage remains over an adjustable time period, the bq20z80 goes into a pack overvoltage/undervoltage condition and switches off the CHG/DSG FET. The bq20z80 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.

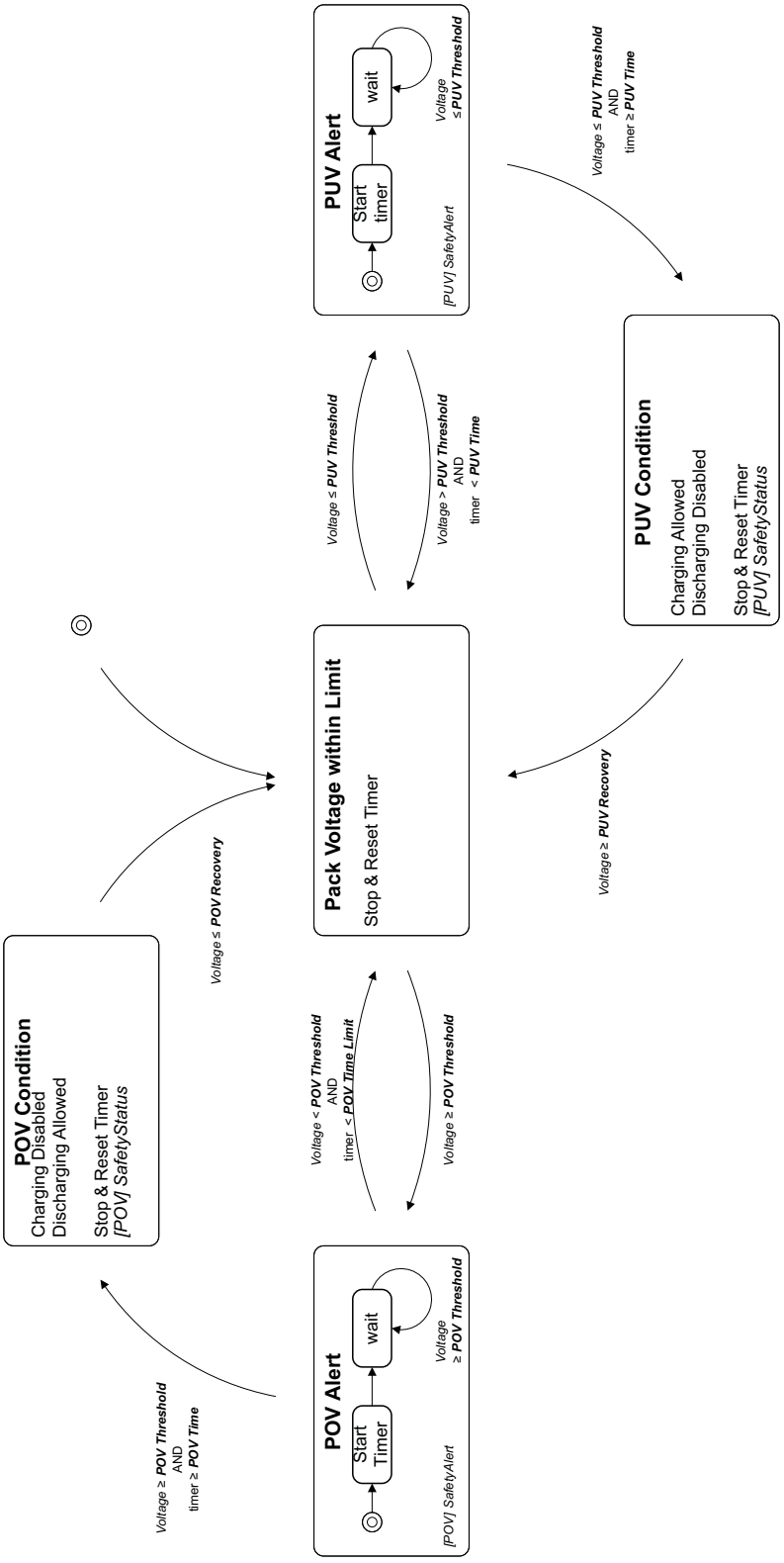

Figure 2-2. POV and PUV

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]*
	ChargingStatus					*[PCHG]*
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 bq20z80 sets the pack overvoltage *[POV]* flag in *SafetyAlert* if pack *Voltage* reaches or surpasses ***POV Threshold*** limit during charging. The bq20z80 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 a pack overvoltage condition, charging is disabled and CHG FET is turned off, *ChargingCurrent* and *ChargingVoltage* are set to zero, the *[POV]* flag in *SafetyAlert* is reset, *the [TCA]* flag in *BatteryStatus* and *[POV]* flag in *SafetyStatus* are set.

The bq20z80 recovers from a pack overvoltage condition if pack *Voltage* is equal to or below ***POV Recovery*** limit. On recovery, the *[POV]* flag in *SafetyStatus* is reset, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set back to an appropriate value per the charging algorithm.

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

The bq20z80 sets the pack undervoltage *[PUV]* flag in *SafetyAlert* if pack *Voltage* reaches or drops below the ***PUV Threshold*** limit during discharging. The bq20z80 changes the pack undervoltage alert to a pack undervoltage condition if the pack voltage stays below the ***PUV Threshold*** limit for a time period of ***PUV Time***. This function is disabled if ***PUV Time*** is set to zero.

In a pack undervoltage condition, 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***, *the [PUV]* flag in *SafetyAlert* is reset, *the [TDA]* and *[FD]* flags are set, *the [XDSG]* flag is set, and *the [PUV]* flag in *SafetyStatus* is set.

The bq20z80 recovers from a pack undervoltage condition if the pack *Voltage* is equal to or above the ***PUV Recovery*** limit. On recovery, the *[PUV]* flag in *SafetyStatus* is reset, *the [XDSG]* flag is reset, the *[TDA]* and [FD] flags are reset, and *ChargingCurrent* and *ChargingVoltage* are set back to an appropriate value per the charging algorithm.

In a pack undervoltage 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 bq20z80 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 the 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]*

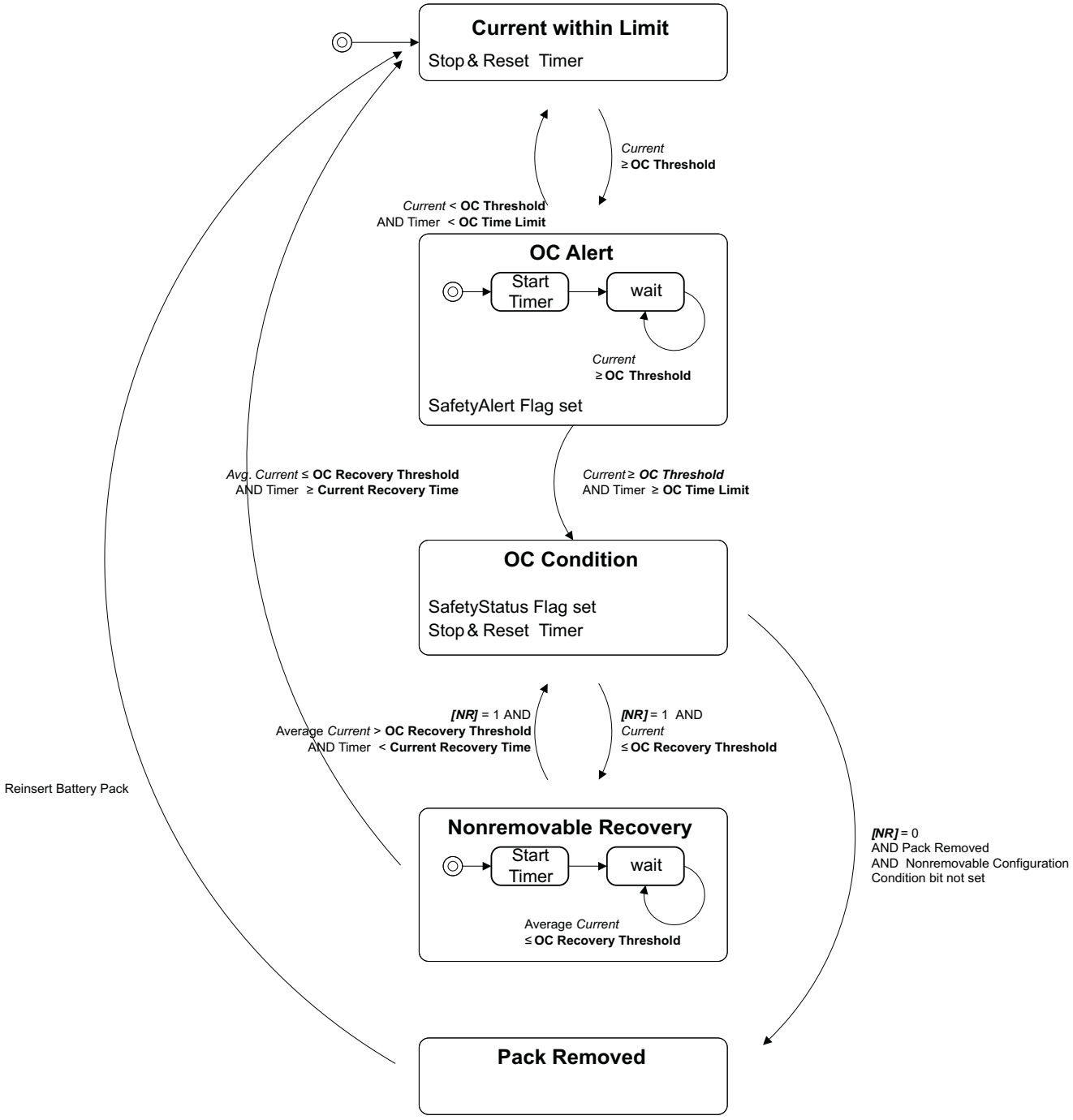

Figure 2-3. OC Protection

For the first two tiers of overcurrent protection, the specific flag in *SafetyAlert* is set if *Current* exceeds the OC threshold. The bq20z80 changes the specific flag in *SafetyAlert* to the specific flag in *SafetyStatus* if *Current* stays above the OC threshold limit for at least OC the 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, *the [TCA]* flag is set, and the appropriate *SafetyStatus* tier flag is set.

However, when the bq20z80 has either of the *[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 the ***[NR]*** flag.

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***, *the [XDSG]* and *[XDSGI]* flags are set, the *[TDA]* flag is set, and the correct tier flag is set in *SafetyStatus*.

When the bq29312A detects a discharge-overcurrent fault, the charge and discharge FETs are turned off, the XALERT pin of the bq20z80 is driven low by the XALERT pin of the bq29312A, and the bq29312A is interrogated. When the bq20z80 identifies the overcurrent condition, the *AFE_Current_Fault* timer is started from 0, the *[TDA]* flag is set, *ChargingCurrent* is set to 0, and *[AOCD]* is set.

However, when the bq20z80 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 the ***[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 condition		*[OCC]*	*[TCA]*		CHG FET disabled, enabled during discharge	0	0
Tier-2 charge	OC alert	*[OCC2]*				Normal	Charging algorithm	Charging algorithm
	OC condition		*[OCC2]*	*[TCA]*		CHG FET disabled, enabled during discharge	0	0
Tier-1 discharge	OC alert	*[OCD]*				Normal	Charging algorithm	Charging algorithm
	OC condition		*[OCD]*	*[TDA]*	*[XDSGI]*, *[XDSG]*	DSG FET disabled, enabled during charge	***Pre-chg Current***	Charging algorithm
Tier-2 discharge	OC alert	*[OCD2]*				Normal	Charging algorithm	Charging algorithm
	OC condition		*[OCD2]*	*[TDA]*	*[XDSGI]*, *[XDSG]*	DSG FET disabled, enabled during charge	***Pre-chg Current***	Charging algorithm
Tier-3 discharge	OC condition		*[AOCD]*	*[TDA]*	*[XDSGI]*, *[XDSG]*	CHG FET and DSG FET disabled	0	Charging algorithm

The bq20z80 can individually configure each overcurrent-protection feature to recover via two different methods based on the ***[NR]*** flag.

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 nonremovable-battery-mode recovery.

Nonremovable-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 the *AFE_Current_Fault* timer to be ≥***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, the *[TDA]* flag is reset, *ChargingCurrent* and *ChargingVoltage* are set to the appropriate value per the charging algorithm, and *[XDSG]*, *[XDSGI]*, and the appropriate *SafetyStatus* flags are reset.

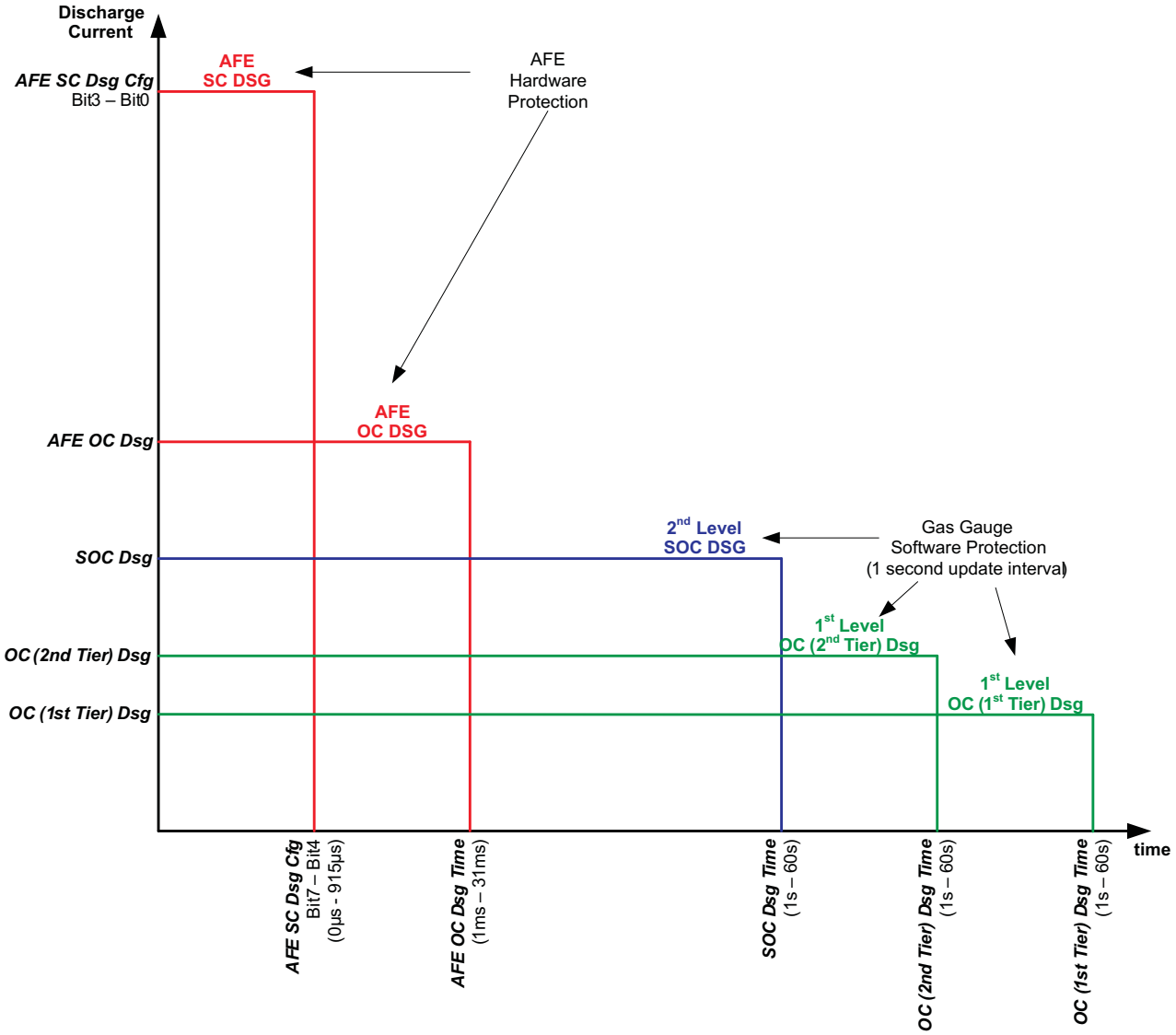

Figure 2-4. Overcurrent Protection Levels

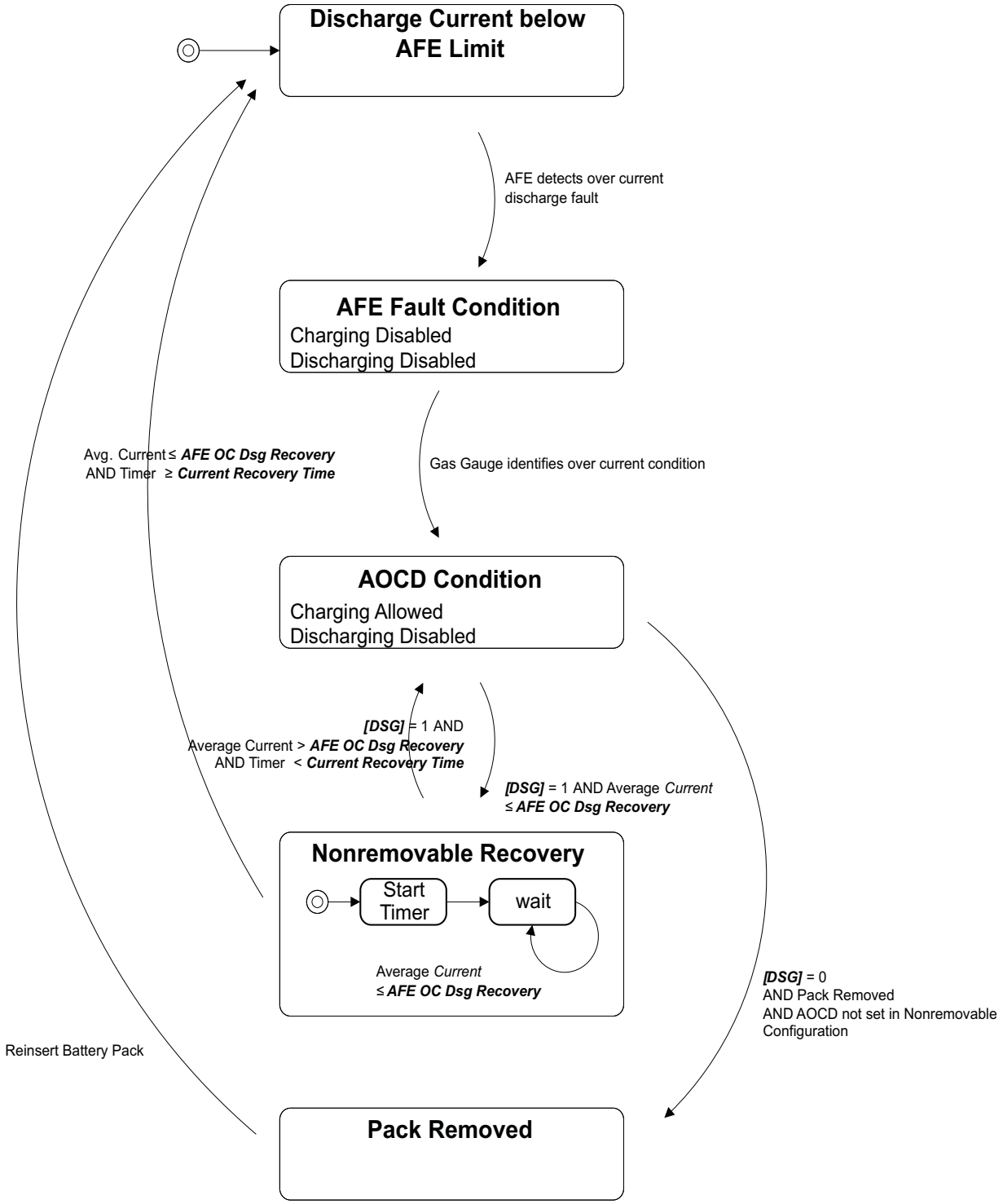

Figure 2-5. AFE Discharge Overcurrent Protection

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 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]
- SBS:SafetyAlert(0x50)
- SBS:SafetyStatus(0x51)
- SBS:OperationStatus(0x54)[XDSGI]

2.1.5 Short-Circuit Protection

The bq20z80 short-circuit protection is controlled by the bq29312A, but is recovered by the bq20z80. This allows different recovery methods to accommodate various applications.

The bq29312A charge short-circuit and discharge short-circuit protection are configured by the bq20z80 dataflash ***AFE SC Chg Cfg*** and ***AFE SC Dsg Cfg*** registers, respectively.

When the bq29312A 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 bq20z80 is driven low by the XALERT pin of the bq29312A and the bq29312A is interrogated. When the bq20z80 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* are 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 bq20z80 short-circuit protection feature can be individually configured to recover via two different methods, based on the ***[NR]*** flag.

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 Nonremovable Battery Mode recovery.

Nonremovable Battery Mode Recovery is where ***[NR]*** = 1. The state of ***Non-Removable Cfg*** has no consequence when the ***[NR]*** flag is set to 1. This recovery requires *AverageCurrent* to be ≤ ***AFE SC Recovery*** threshold and for the internal *AFE_Current_Fault* timer to be ≥ ***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 bq20z80 has overtemperature protection for both charge and discharge conditions.

The bq20z80 sets the overtemperature charging *[OTC] SafetyAlert* flag if pack temperature reaches or surpasses the ***Over Temp Chg*** limit during charging. The bq20z80 changes *[OTC] SafetyAlert* to overtemperature condition if the pack temperature stays above the ***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 the bq20z80 is in the *[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]* SafetyAlert flag is reset, the *[TCA]* flag and *[OTC] SafetyStatus* are set.

The bq20z80 recovers from an *[OTC]* condition if *Temperature* is equal to or below the ***OTC Chg Recovery*** limit. On recovery, *[OTC] SafetyStatus* is reset, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set back to their appropriate values per the charging algorithm, and CHG FET returns to its previous state.

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

The bq20z80 sets the overtemperature discharging *[OTD] SafetyAlert* flag if the pack temperature reaches or surpasses the ***Over Temp Dsg*** limit during discharging. The bq20z80 changes *[OTD] SafetyAlert* to overtemperature 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 the bq20z80 is in the *[OTD]* condition, discharging is disabled and DSG FET is turned off, *ChargingCurrent* and *ChargingVoltage* are set to zero, the *[OTC] SafetyAlert* flag is reset, the *[TDA]* flag is set, the *[XDSG]* flag is set, and the *[OTD]* flag in *SafetyStatus* is set.

The bq20z80 recovers from an *[OTD]* condition if pack temperature is equal to or below the ***OTD Chg Recovery*** limit. On recovery, *[OTD] afetyStatus* is reset, *[TDA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set back to their appropriate values 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	Overtemperature 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, ChargingVoltage = 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 bq20z80 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 bq20z80 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 bq29312A automatically turns off the CHG FET, DSG FET and ZVCHG FET (if used), if the bq29312A does not receive the appropriate frequency on the WDI pin from bq20z80. The bq20z80 has no warning that this is about to happen, but it can report the occurrence once the bq20z80 is able to interrogate the bq29312A.

When the XALERT input of the bq20z80 is triggered by the XALERT pin of the bq29312A, the bq20z80 reads the STATUS register of the bq29312A. If *[WDF]* is set, the bq20z80 also sets *[WDF]* in *SafetyStatus* and periodic verification of the bq29312A RAM is undertaken. If verification of the bq29312A RAM fails, then the FETs turn off. Verification of the bq29312A RAM continues 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 Second-Level Protection Features

The bq20z80 provides features that can be used to indicate a more serious fault via the $\overline{\text{SAFE}}$ and SAFE outputs. 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 bq20z80 goes into permanent failure condition and the appropiate 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 to ***PF Flags 2***.

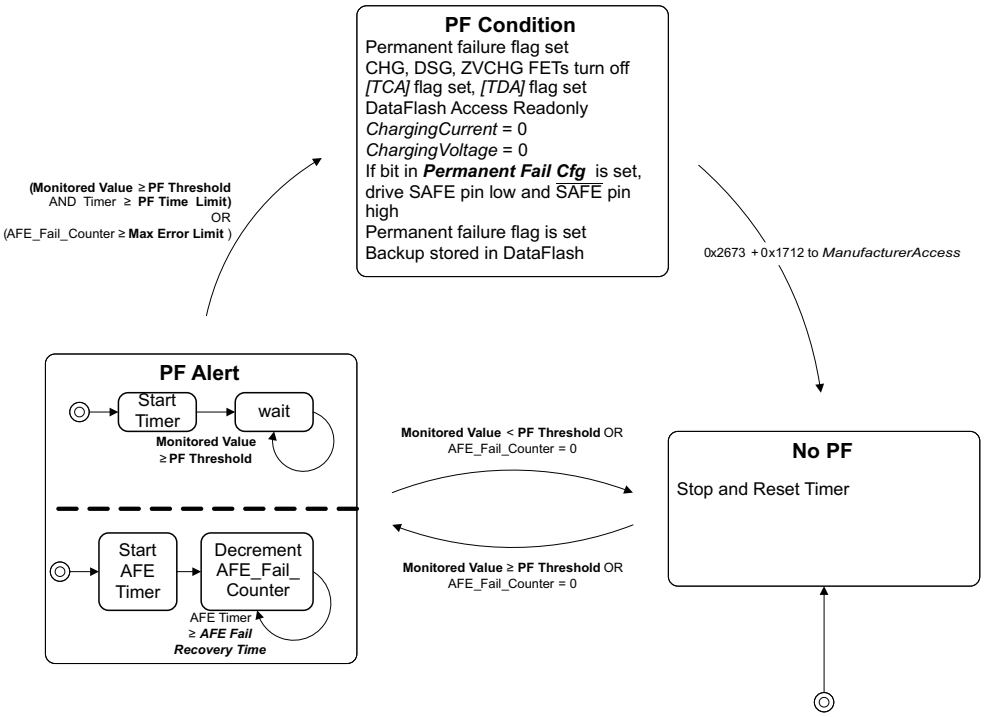

Figure 2-6. Second-Level Protection

2.2.1 Second-Level (Permanent) Failure Actions

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

1. CHG, DSG, and ZVCHG FETs are turned OFF.
2. *[TCA], [TDA]* flags in *BatteryStatus* are set.
3. A backup of SBS data and the complete memory map of the bq29312A is stored to DataFlash.
4. DataFlash write access is then disabled, but the DataFlash can be read.
5. *ChargingCurrent* and *ChargingVoltage* are set to 0.
6. The appropriate bit in *PF Flags 1* is set.
7. If the appropriate bit in ***Permanent Fail Cfg*** is set, then 0x3672 is programmed to ***Fuse Flag***, the $\overline{\text{SAFE}}$ pin is driven and latched low 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	Dataflash 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)
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)
bq29312A 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

The bq20z80 reports a second-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 bq20z80 reports a second-level permanent failure, clears the appropriate *PFAlert* flag, and sets the appropriate *PFStatus* flag. See Table 2-9 for all protection thresholds and Max Alert durations.

Safety Overvoltage Protection— The bq20z80 monitors the pack voltage for extreme values.

Cell Imbalance Fault— The bq20z80 starts cell imbalance fault detection when *Current* is lesser or equal to ***Cell Imbalance Current*** for ***Battery Rest Time*** period. 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.

Second-Level Protection IC Input— The $\overline{\text{PFIN}}$ input of the bq20z80 can be used to determine the state of an external protection device such as the bq294xx. The bq20z80 monitors for the $\overline{\text{PFIN}}$ pin being driven low by an external device.

Safety Overcurrent Protection— The bq20z80 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 bq20z80 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 bq20z80 can detect an open thermistor condition if the temperature function reports extreme temperature values.

Charge and Zero-Volt Charge FET Fault Protection— The bq20z80 monitors if there is, at any time, an attempt to turn off the CHG FET or ZVCHG FET or the CHG bit in the bq29312A OUTPUT register is set and the current still continues to flow.

Discharge FET Fault Protection— The bq20z80 monitors if there is, at any time, an attempt to turn off the DSG FET or the DSG bit in the bq29312A OUTPUT register is set and the current still continues to flow.

Fuse State Detection— The bq20z80 can detect if an attempt has been made to blow the fuse, but this has failed. The bq20z80 monitors if the ***Fuse Flag*** is set to 0x3672 and current is still flowing.

Table 2-9. Time-Limit-Based Second-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***	***Cell Imbalance Fail Voltage***	***Cell Imbalance Time***	*[CIM]*	*[XCIM]*
Second-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***	*[SOPT]*	*[XSOPT]*

Table 2-9. Time-Limit-Based Second-Level Protection (continued)

Protection	Monitored Value	Requirement	PF Threshold	PF Time Limit (Set to 0 to Disable Protection)	*PFAlert* Flag, *PFStatus* Flag,	*Permanent Fail Cfg* Flag
Charge and zero-volt charge FET fault	*Current*	(CHG FET or ZVCHG FET turn off attempt or CHG Flag in bq29312A 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 bq29312A 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):PFIN Detect Time(9)
- 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 bq20z80 reports a second-level permanent failure and sets the appropriate *PFStatus* flag if the internal error counter reaches the max error limit. If the internal error counter is greater than 0, the appropriate permanent failure alert flag is set. The internal error counter is incremented by one if the error happens and decremented by one each fail recovery period.

bq29312A AFE Communication Fault Protection— The bq20z80 continuously validates its read and write communications with the bq29312A. 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 bq20z80 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 bq29312A VCELL output. The bq29312A offset values are verified by reading the values twice and confirming that the readings are within acceptable limits. The maximum difference between two readings is set with ***AFE Init Limit***. The maximum number of read retries, if offset and gain value verification fails and an *[AFE_C]* fault is declared, is set in ***AFE Fail Limit***.

Periodic bq29312A AFE Verification— The bq20z80 periodically (***AFE Check Time***) compares certain RAM content of the bq29312A AFE with that of the bq20z80 DataFlash 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 bq20z80 reports a permanent failure.

bq29312A AFE Init Verification— After a full reset, the bq20z80 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 bq20z80 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 bq20z80 reports a permanent failure error.

Dataflash Failure— The bq20z80 can detect if the DataFlash 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 DataFlash write does not verify; or (iii) if any DataFlash erase does not verify.

Table 2-10. Error-Based Second-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 bq29312A	Decrement of AFE_Fail_Counter by one per ***AFE Fail Recovery Time*** period	***AFE Fail Limit***	*[AFE_C]*	***[XAFE_C]***
Periodic AFE verification	Check RAM of bq29312A with ***AFE Check Time*** period	Decrement of 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 bq29312A after full reset	–	***AFE Init Retry Limit***	*[AFE_C]*	***[XAFE_C]***
DataFlash failure	DataFlash	–	False flash checksum after reset, DataFlash write not verified, DataFlash 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 Time(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 bq20z80 permanent failure can be cleared by sending two *ManufacturerAccess* commands in sequence. The first command sent to *ManufacturerAccess* is 0x2673, the second command sent to *ManufacturerAccess* is 0x1712. After sending these two commands in sequence, *PFStatus* flags are cleared.

Related Variables:

- SBS:ManufacturerAccess(0x00)(0x2673 + 0x1712)
- SBS:PFStatus(0x53)

2.3 Gas Gauging

The bq20z80 measures individual cell voltages, pack voltage, temperature, and current using features of the bq29312A AFE device. The bq20z80 determines battery state of charge by analyzing individual cell voltages when a time exceeding 35 minutes has passed since the last battery charge or discharge activity. The bq20z80 measures charge and discharge activity by monitoring the voltage across a small-value series sense resistor (5 mΩ to 20 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™ Algorithm 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 × R drop near the end of discharge, the bq20z80 must be configured for whatever current (or power) will flow in the future. While it cannot be exactly known, the bq20z80 can use load history such as the average current of the present discharge to make a sufficiently accurate prediction. The bq20z80 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* ×*Voltage*
3 =	*AverageCurrent* (default)	*AverageCurrent* × 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 bq20z80 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 bq20z80 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 Config(80):Load Select(0)
- DF:Gas Gauging:IT Config(80):Load Mode(1)
- DF:Gas Gauging:IT Config(80):Term Voltage(45)
- DF:Gas Gauging:IT Config(80):User Rate-mA(60)
- DF:Gas Gauging:IT Config(80):User Rate-mW(62)
- DF:Gas Gauging:IT Config(80):Reserve Cap-mAh(64)
- DF:Gas Gauging:IT Config(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: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 DataFlash parameters in the subclass *Gas Gauging: Current Thresholds* section. In relaxation mode or discharge mode, the DSG flag in *BatteryStatus* is set.

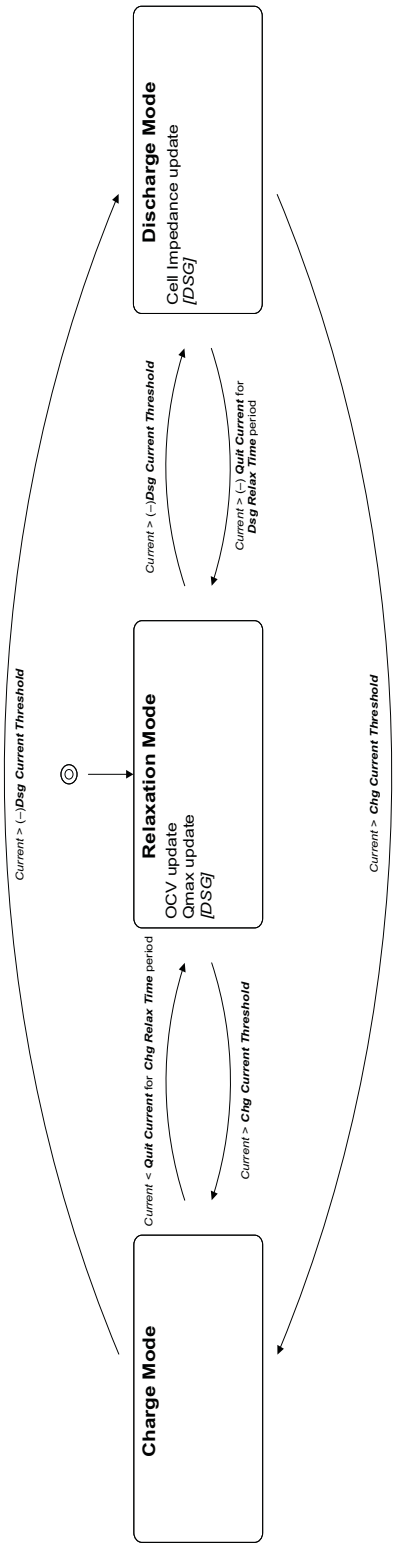

Figure 2-7. Gas Gauge Operating Modes

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***.

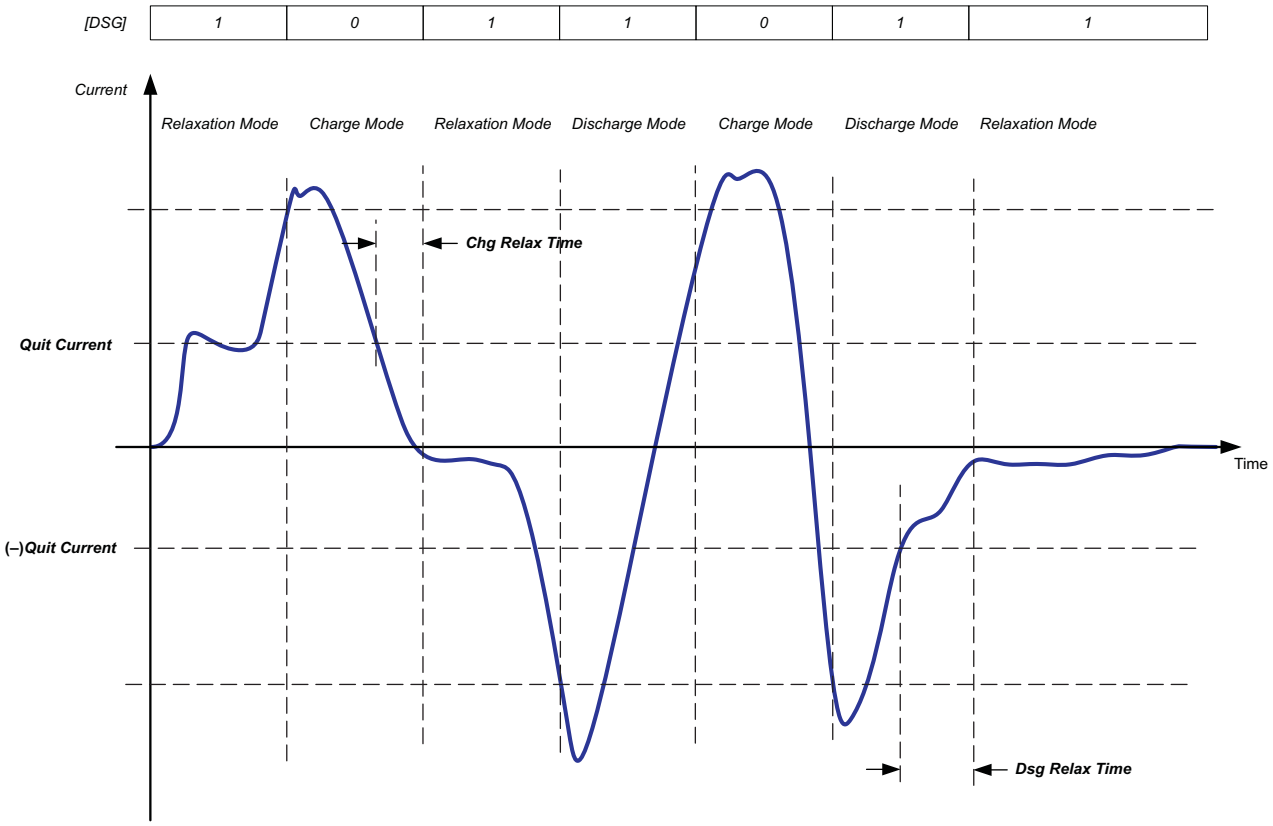

Figure 2-8. Gas Gauge Operating Mode Example

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 bq20z80 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*** DataFlash value.

See the *Theory and Implementation of Impedance Track™ Battery Fuel-Gauging Algorithm in bq20zxx Product Family* application report (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 bq20z80 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 hours in a charged state and 5 hours in a discharged state to ensure that the dV/dt condition is satisfied. If 5 hours is exceeded, a reading is 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 3737 mV and 3800 mV

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 bq20z80 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 SBS-compliant charger using the *ChargingCurrent* and the *ChargingVoltage* functions. The actual charging status of the bq20z80 is indicated with flags and can be read out with the *ChargingStatus* function.

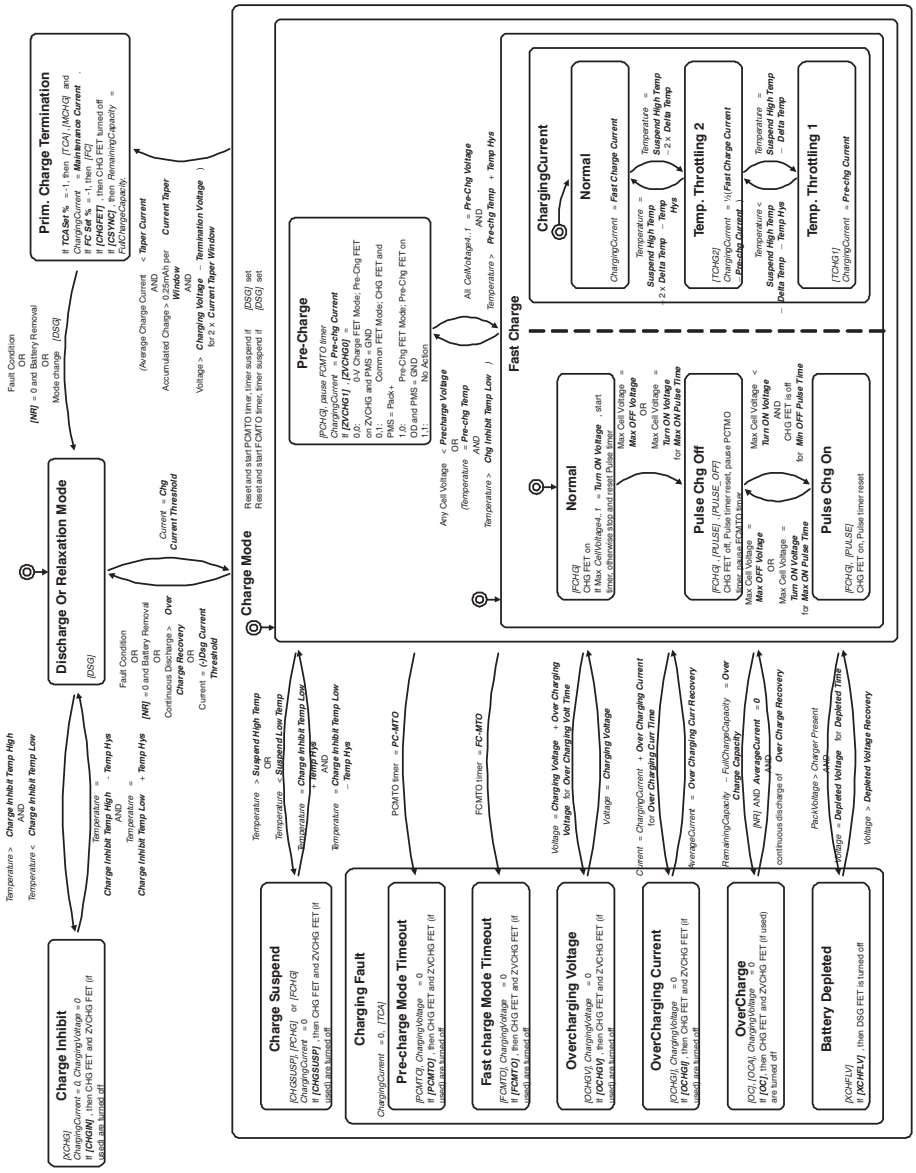

Figure 2-9. Charging

Related Variables:

- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:ChargingStatus(0x55)

2.4.1 Charge Control SMBus Broadcasts

All broadcasts to a host or a SBS-compliant charger are enabled by the *[BCAST]* flag. If the *[HPE]* flag is enabled, master-mode broadcasts to the host address are PEC enabled. If the *[CPE]* flag is enabled, master-mode broadcasts to the SBS-compliant charger address are PEC enabled. When broadcast is enabled, the following broadcasts are sent:

- *ChargingVoltage* and *ChargingCurrent* broadcasts are sent to the SBS-compliant 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 of the previously listed flags have been cleared.
- If any of the *[OCA], [TCA], [OTA] or [TDA]* flags are set, the *AlarmWarning* broadcast is sent to SBS-compliant charger device address every 10 seconds. Broadcasts stop when all of the previously listed flags 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 bq20z80 can determine the chemical state of charge of each cell using the Impedance Track™ algorithm. The cell balancing algorithm used in the bq20z80 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 bq20zxx* 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 bq29312A. 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 500 Ω (typ.) of bq29312A + 2 series input filter resistors, Rχ. For example: if input filter Rχ value is 100 Ω, R = 500 + 2 × Rχ = 700 Ω.

V_avg = 3.6 V

duty_cycle = 0.4 typ.

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

Min Cell Deviation = {[500Ω + (2 × Rχ)] / (0.4 × 3.6V) × 3.6} s/mAh = 1750 s/mAh

Related Variables:

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

2.4.3 Charge-Inhibit Mode

If the bq20z80 is in discharge mode or relaxation mode (*[DSG]* = 1), the bq20z80 goes into the 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 bq20z80 is in charge-inhibit mode.

The bq20z80 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 foregoing conditions are met, when a fault condition is detected, or when the battery is removed if in removable mode (***[NR]*** = 0).

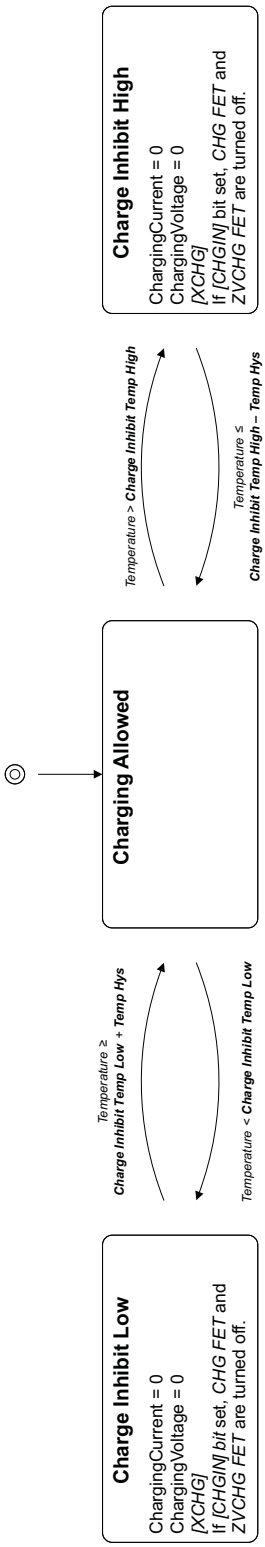

Figure 2-10. Charge Inhibit

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

If the bq20z80 is in charge mode (*[DSG]* = 0), the bq20z80 suspends charging when:

- *[DSG]* flag in *BatteryStatus* is set to 0 AND
- one of the following conditions
  - *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 the ***[CHGSUSP]*** bit in the ***Operation Cfg B*** register is set.

The bq20z80 resumes charging if:

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

On resuming, the bq20z80 clears the *[CHGSUSP]* status flag and sets *ChargingCurrent* according to the appropriate charging mode entered and the CHG and ZVCHG FETs (if used) return to their previous state.

The bq20z80 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).

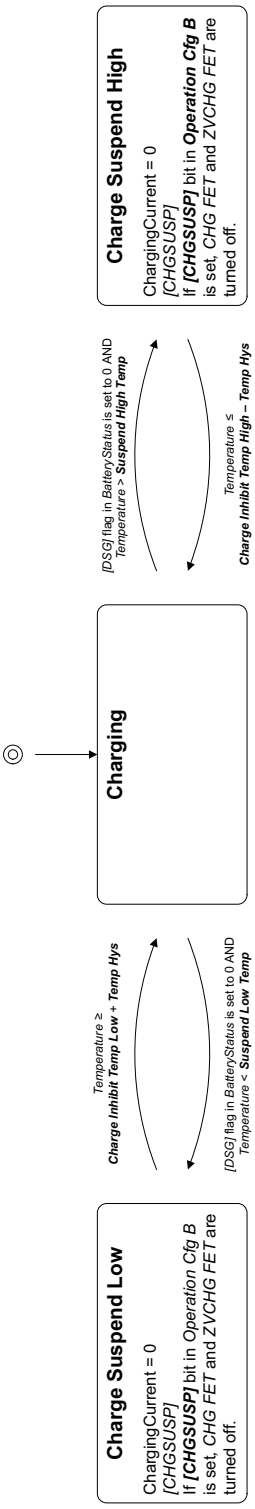

Figure 2-11. Charge Suspend

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(8)
- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(10)
- 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 bq20z80 enters precharge mode during charging if the *Temperature* function reports a temperature between the ***Charge Inhibit Temp Low*** limit and ***Pre-chg Temp*** limit or any cell voltages are below the ***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 the precharge mode.

Table 2-11. Precharge FET

ZVCHG1	ZVCHG0	FET used
0	0	ZVCHG FET
0	1	CHG FET
1	0	OD Pin on bq29312A
1	1	No Action

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

The bq20z80 leaves the precharge mode and clears the *[PCHG]* flag if all cell voltages reach or rise ***Recovery Voltage*** and the reported *Temperature* is equal to or greater than ***Pre-chg Temp*** + ***Temp Hys***. The precharge 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 bq20z80 enters the 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 ×***Delta Temp***)
- *CellVoltage4..1* ≥ ***Pre-chg Voltage***
- *Voltage* ≤ ***Charging Voltage*** + ***Over Charging Voltage***

During fast charge, the *[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(6)
- DF:Charge Control:Fast Charge Cfg(34):Suspend Temp High(10)
- 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 bq20z80 alters *ChargingCurrent* and sets the *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 the ***[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 ×***Delta Temp***)],	(***Charging Current*** –***Pre-chg Current***) / 2	*[TCHG2]*
< (***Charge Suspend Temp High*** – (2 ×***Delta Temp***)) AND ≥ ***Pre-Chg Temp***	***Charging Current***	*[FCHG]*

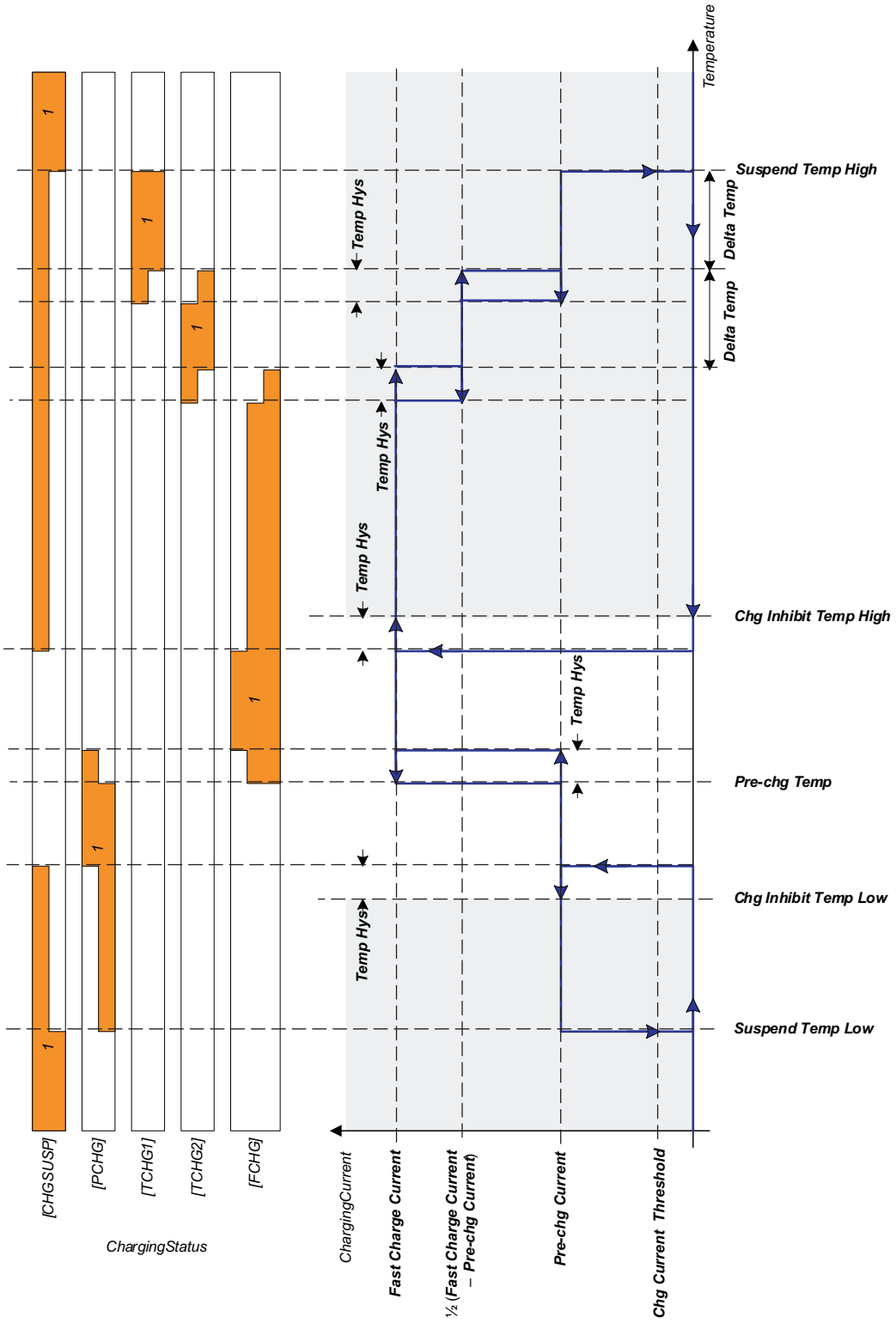

Figure 2-12. Fast-Charge Temperature Throttling

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(6)
- DF:Charge Control:Fast Charge Cfg(34):Suspend Low Temp(8)
- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(10)
- 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 cell voltages are measured 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 ON Voltage*** for ***Max ON Pulse Time***

When these conditions are met, the CHG FET is turned off, and the *[PULSE], [PULSE_OFF]* charging status flags 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 *[PULSE_OFF]* flag is cleared.

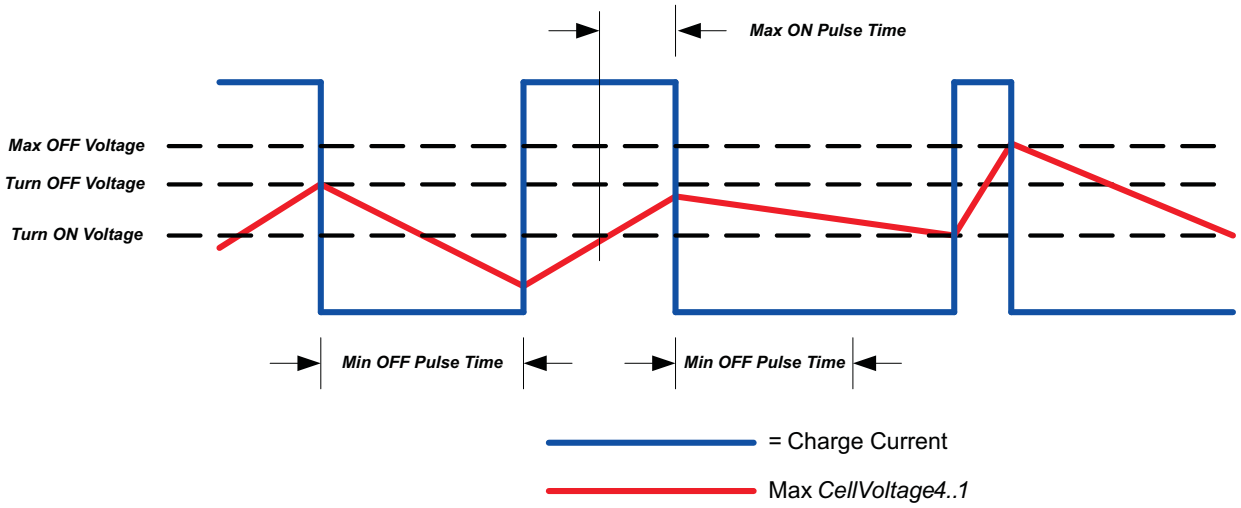

Figure 2-13. Pulse Charging Example

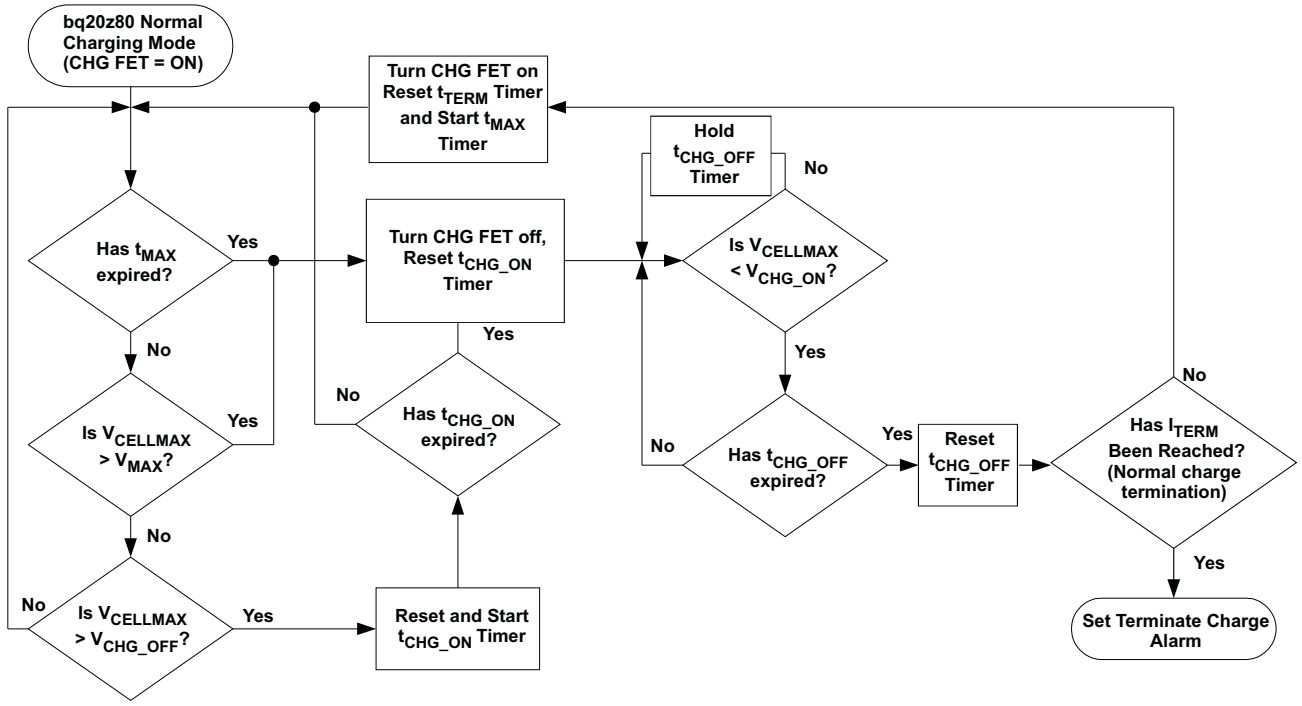

Figure 2-14. Pulse Charging

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], [PULSE_OFF]

2.4.9 Primary Charge Termination

The bq20z80 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* + ***Termination Voltage*** ≥ ***Charging Voltage***

The following parameters change the behavior of bq20z80 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

Table 2-13. Primary Charge Termination (continued)

Parameter	Behavior on Primary Charge Termination
[CSYNC] set	*RemainingCapacity* = *FullChargeCapacity* regardless of ***TCA Set %*** value

Related Variables:

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Termination (36):Maintenance Current(0)
- DF:Charge Control:Termination (36):Taper Current(2)
- DF:Charge Control:Termination (36):Termination Voltage(6)
- DF:Charge Control:Termination (36):Current Taper Window(8)
- DF:Charge Control:Termination (36):TCA Set %(9)
- DF:Charge Control:Termination (36):FC Set %(11)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGFET], [CSYNC]
- 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 bq20z80 can report charging faults in the *ChargingStatus* register. The bq20z80 can be configured to switch off the CHG FET and ZVCHG FET when the charging fault flag matches the set bit in ***Charge Fault Cfg***.

On occurrence of a charging fault:

- The bq20z80 sets the appropriate *ChargingStatus* flag.
- If the flag in *Charge Fault Cfg* and *ChargingStatus* matches, CHG FET and ZVCHG FET (if used) are turned off. The DSG FET is turned off instead if the charging fault is a battery-depleted fault.
- The bq20z80 sets *ChargingCurrent* = 0, *ChargingVoltage* = 0; *ChargingVoltage* is not set to zero if it is a battery-depleted fault.
- The bq20z80 sets the *[TCA]* flag in *BatteryStatus*, *[TDA]* if it is a battery-depleted fault
- The bq20z80 sets the *[OC]* flag in *BatteryStatus* if it iss an overcharge fault.

On recovery:

- The bq20z80 resets the appropriate *ChargingStatus* flags.
- CHG FET and ZVCHG FET, if used, return to previous states. (DSG FET is allowed to turn on instead on recovery from a battery-depleted fault).
- The bq20z80 sets *ChargingCurrent* and *ChargingVoltage* back to previous state according to charging algorithm.
- The bq20z80 resets *[TCA]BatteryStatus* flag, *[TDA]* if it is a battery-depleted fault.

Precharge-Mode Timeout

When *Current* is ≥ ***Chg Current Threshold*** the bq20z80 starts the precharge timer. The precharge timer is suspended during the off phase in pulse charging (*[PULSEOFF]* = 1) and when precharge mode is not active (*[PCHG]* = 0). Set ***PC-MTO*** to zero to disable this feature.

The bq20z80 goes into precharge mode charging timeout if:

- Precharge timer ≥ ***PC-MTO***

The bq20z80 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 bq20z80 starts the fast-charge timer. The fast-charge timer is suspended during the off phase in pulse charge mode (*[PULSEOFF]*= 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 bq20z80 goes into fast-charge-mode charging timeout if:

- Fast charge timer ≥ ***FC-MTO***

The bq20z80 recovers if:

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

Overcharging Voltage

The bq20z80 goes into overcharging voltage mode if:

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

The bq20z80 recovers, if:

- *Voltage* ≤ ***Charging Voltage***

Overcharging Current

The bq20z80 goes into overcharging current mode if:

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

The bq20z80 recovers, if:

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

Overcharge

The bq20z80 goes into overcharge mode if:

- *RemainingCapacity* – *FullChargeCapacity* ≥ ***Over Charge Capacity***

The bq20z80 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 bq20z80 goes into battery depleted mode if:

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

The bq20z80 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 ≥***Over Charging Volt Time***	*Voltage* ≤ ***Charging Voltage***	*[OCHGV]*
Overcharging Current	*Current* ≥ *ChargingCurrent* + ***Over Charging Current*** for ≥ ***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 ≥***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], [PULSEOFF], [PULSE]

2.4.11 Discharge and Charge Alarms

The bq20z80 enables the *[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

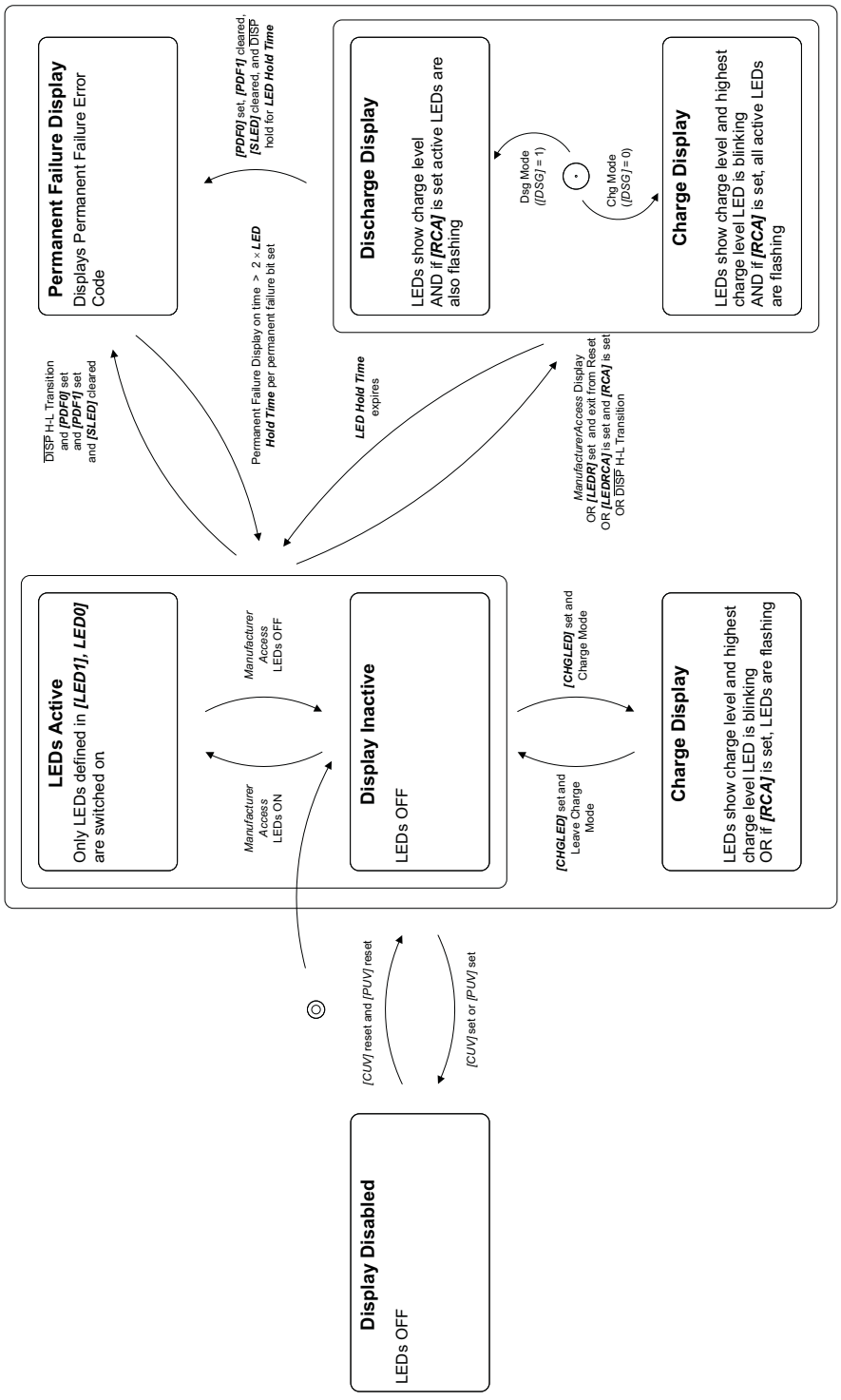

Figure 2-15. Display Activation

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 the *[CUV]* or *[PUV]* flag is set, the display is disabled.

LEDR — Set this flag to activate the display on exit from reset of bq20z80.

LEDRCA— Set this flag to let all active LEDs flash with ***LED Flash Rate*** if the *[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*, Section 2.5.4, for available error codes.

LEDs ON, LEDs OFF, Display ON— *LEDs ON* switches all configured LEDs on, and *LEDs OFF* switches all configured LEDs off. The *Display ON* command simulates an 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 configure 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 bq20z80 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 bq29312A 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 blinks. ***[LEDRCA]***, ***CHG Flash Alarm*** and ***DSG Flash Alarm*** 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 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 stays on for the ***LED Hold Time*** period. The permanent failure display stays on double the ***LED Hold Time*** period for each permanent failure bit set. The maximum value that ***LED Hold Time*** should be set to is 16 s.

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 bq20z80 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*** (e.g.. if *RelativeStateOfCharge* = 36% and 5 LEDs are being used, then LED2 blinks). The blinking is overriden with ***CHG Flash Alarm*** or ***[LEDRCA]***.

If state of charge falls below the flash alarm level, all remaining active LEDs flash at the ***LED Flash Rate***. The flash alarm can be disabled by setting the ***LED Flash Rate*** 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%–0%	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 following table 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 at approximately 1-Hz rate	Off	Off
[FBF]	On	Flashing at approximately 1-Hz rate	Flashing at approximately 2-Hz rate
[PFPFVSHUT]	Off	Flashing at approximately 1-Hz rate	Flashing at approximately 2-Hz rate
Reserved	Flashing at approximately 2-Hz rate	Flashing at approximately 1-Hz rate	On
[SOPT]	On	Flashing at approximately 1-Hz rate	On
[SOCD]	Off	Flashing at approximately 1-Hz rate	On
[SOCC]	Flashing at approximately 2-Hz rate	Flashing at approximately 1-Hz rate	Off
[AFE_P]	On	Flashing at approximately 1-Hz rate	Off

PFStatus	LED3	LED2	LED1
[AFE_C]	Off	Flashing at approximately 1-Hz rate	Off
[DFF]	Flashing at approximately 1-Hz rate	Flashing at approximately 2-Hz rate	Flashing at approximately 2-Hz rate
[DFETF]	Flashing at approximately 1-Hz rate	On	Flashing at approximately 2-Hz rate
[CFETF]	Flashing at approximately 1-Hz rate	Off	Flashing at approximately 2-Hz rate
[CIM]	Flashing at approximately 1-Hz rate	Flashing at approximately 2-Hz rate	On
[SOTD]	Flashing at approximately 1-Hz rate	On	On
[SOTC]	Flashing at approximately 1-Hz rate	Off	On
[SOV]	Flashing at approximately 1-Hz rate	Flashing at approximately 2-Hz rate	Off
[PFIN]	Flashing at approximately 1-Hz 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)

2.6 Device Operating Mode

The bq20z80 has several device power modes. During these modes, the bq20z80 modifies its operation to minimize power consumption from the battery.

2.6.1 Normal Mode

During normal operation, the bq20z80 takes *Current*, *Voltage*, and *Temperature* measurements, performs calculations, updates SBS data, and makes protection and status decisions at 1-second intervals. Between these periods of activity, the bq20z80 is in a reduced power state.

$\overline{\text{PRES}}$ is detected during the measurement period, where the PU pin is pulled high, the $\overline{\text{PRES}}$ input state is read, and PU is released. If $\overline{\text{PRES}}$ is high, the *OperationStatus [PRES]* flag is cleared. If $\overline{\text{PRES}}$ is low, *OperationStatus [PRES]* is set indicating the system is present (the battery is inserted).

If the ***[NR]*** flag 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 Removed Mode/System Present Detection

2.6.2.1 Battery Removed

The bq20z80 detects the battery-removed state if the ***[NR]*** bit is set to 0 AND the $\overline{\text{PRES}}$ input is high (*[PRES]* = 0).

On entry to the battery-removed state, the *[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 bq20z80 exits the battery-removed state if the ***[NR]*** flag is set to 0 AND the $\overline{\text{PRES}}$ input is low (*[PRES]* = 1). When this occurs, the *[TCA]* and *[TDA]* flags are reset.

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

The bq20z80 periodically (every 1 s) pulls the PU output high. Connect this pin to the $\overline{\text{PRES}}$ pin of the bq20z80 via a resistor of approximately 5 kΩ. The bq20z80 measures the $\overline{\text{PRES}}$ input during the PU-active period to determine its state.

The bq20z80 detects that the battery is present in the system via a low state on the $\overline{\text{PRES}}$ input. When this occurs, the bq20z80 enters normal operating mode and sets the *[PRES]* flag in *OperationStatus*. When the pack is removed from the system and the $\overline{\text{PRES}}$ input is high, the bq20z80 enters the battery-removed state and disables the FETs. If the ***[NR]*** bit is set, the $\overline{\text{PRES}}$ 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 bq20z80 measures voltage and temperature in ***Sleep Voltage Time*** intervals and *Current* at ***Sleep Current Time*** intervals. At each interval, the bq20z80 performs calculations, updates SBS data and makes protection and status decisions. Between these periods of activity, the bq20z80 is in a reduced-power state.

The bq20z80 enters sleep mode when the following conditions exist:

- If the ***[NR]*** bit is set to 0, the $\overline{\text{PRES}}$ input must also be high (*[PRES]* = 0) for the bq20z80 to enter sleep,

  AND one of the following conditions must be met:
- (|*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 is set, or if any second-level protection-feature recovery timers are active and have not expired. If ***Sleep Voltage Time*** = 0 or ***Sleep Current Time*** = 0, sleep mode is not entered, and the bq20z80 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 the ***[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 autocalibration of the ADC begins. However, if *Temperature* is ≤ ***Cal Inhibit Temp Low*** or *Temperature* ≥ ***Cal Inhibit Temp High***, autocalibration is not started on entry to sleep mode. The activation of autocalibration is not affected by the state of ***[SLEEP]***, ***Sleep Voltage Time***, ***Sleep Current Time***, or *Current*.

The bq20z80 exits the sleep mode if the absolute value of *Current* is greater than ***Sleep Current***, OR the SMBC or the SMBD inputs transition high, OR any *OperationStatus*, *ChargingStatus*, or *SafetyStatus* flags change state.

In addition, if ***[NR]*** is cleared, the bq20z80 exits the sleep mode when $\overline{\text{PRES}}$ is pulled low (*[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(7)
- DF:Power:Power(68):Bus Low Time(9)
- DF:Power:Power(68):Cal Inhibit Temp Low(10)
- DF:Power:Power(68):Cal Inhibit Temp Low(12)
- DF:Power:Power(68):Sleep Voltage Time(14)
- DF:Power:Power(68):Sleep Current Time(15)
- SBS:ManufacturerAccess(0x00)Sleep(0x0011)
- SBS:Current(0x0a)
- SBS:PFStatus(0x53)
- SBS:OperationStatus(0x54)[PRES]

2.6.4 Shutdown Mode

The bq20z80 enters shutdown mode if the following conditions are met:

- *Voltage* ≤ ***Shutdown Voltage*** AND *Current* ≤ 0
  OR
- (*ManufacturerAccess* shutdown command received AND *Current* = 0) AND voltage at the bq29312A PACK pin < ***Charger Present*** threshold.

When the bq20z80 meets these conditions, the CHG, DSG, and ZVCHG FETs are turned off, and the bq29312A is commanded to shut down. In shutdown mode, the bq20z80 is completely powered down because its supply is removed.

To exit shutdown mode, the voltage at the PACK pin of the bq29312A must be greater than its minimum operating voltage. When this occurs, the bq29312A returns power to the bq20z80, the *[WAKE]* flag is set, and the bq29312A configured. The *[INIT]* flag is set and the *[WAKE]* flag is 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):Charger Present(5)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[INIT]
- SBS:OperationStatus(0x54)[PRES], [WAKE]

2.7 Security (Enables and Disables Features)

There are three levels of secured operation within the bq20z80. 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 bq20z80 to limit access to the SBS functions and DataFlash space and sets the *[SS]* flag. In sealed mode, standard SBS functions have access per the battery data specification, Chapter A. Extended SBS functions and DataFlash 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 bq20z80 to extend access to the SBS and DataFlash space and clears the *[SS]* flag. In unsealed mode, all data, SBS, and DF have read/write access. Unsealing is a two-step command performed by writing the first 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 transition from full-access or unsealed to sealed.

3. Unsealed to Full Access — Instructs the bq20z80 to allow full access to all SBS commands and DataFlash. The bq20z80 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 first 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.

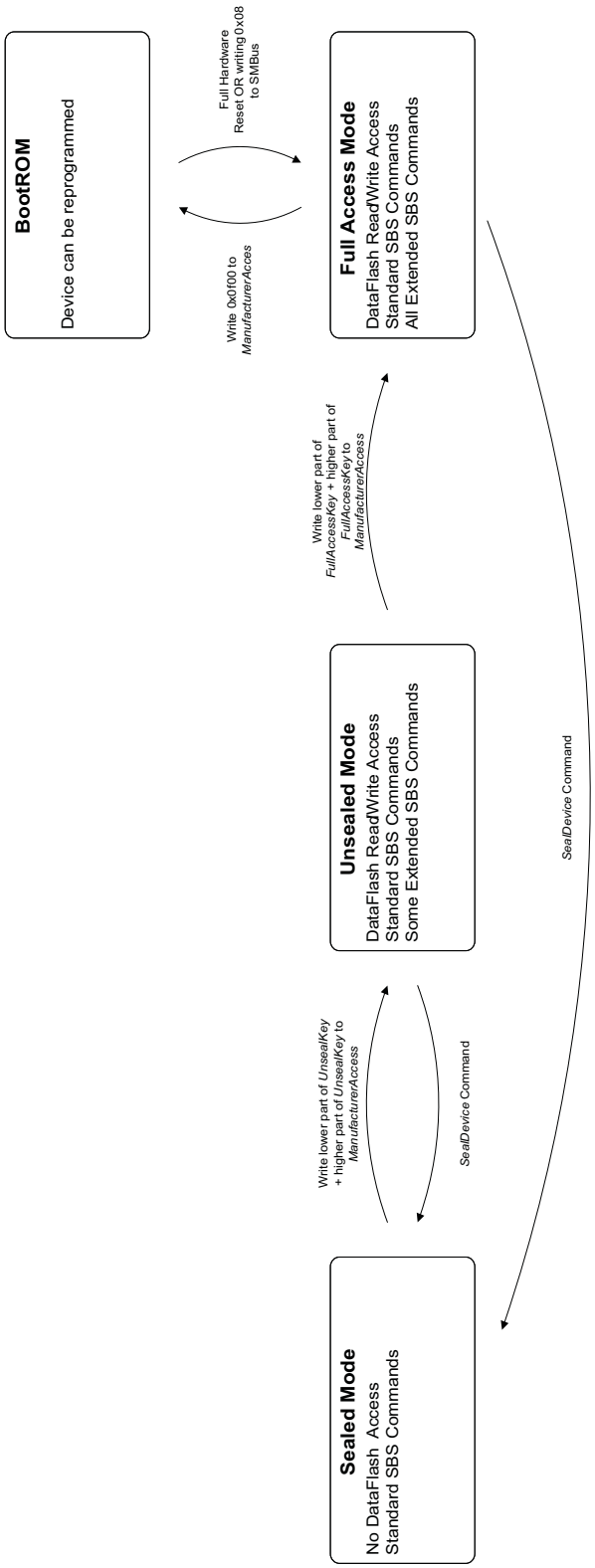

Figure 2-16. Security

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 bq20z80 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 dead band) 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 Autocalibration

The bq20z80 provides an autocalibration feature to cancel the voltage offset error across SR1 and SR2 for maximum charge measurement accuracy. The bq20z80 performs autocalibration 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***. The bq20z80 is capable of automatic offset calibration down to 1 µV.

Related Variables:

- DF:Power:Power(68):Cal Inhibit Temp Low(10)
- DF:Power:Power(68):Cal Inhibit Temp High(12)
- SBS:Temperature(0x08)

2.9 Communications

The bq20z80 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 bq20z80 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 bq20z80 can receive or transmit data with or without PEC.

In the read-word protocol, the bq20z80 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 bq20z80 compares the value to its calculation. If the PEC is correct, the bq20z80 responds with an ACKNOWLEDGE. If it is not correct, the bq20z80 responds with a NOT ACKNOWLEDGE and sets an error code.

In the write-word and block-read in master mode, the host generates an ACKNOWLEDGE after the last byte of data sent by the bq20z80. The bq20z80 then sends the PEC, and the host, acting as a master receiver, generates a NOT ACKNOWLEDGE and a stop condition.

2.9.3 bq20z80 Slave Address

The bq20z80 uses the address 0x16 on SMB for communication.

2.9.4 Broadcasts to SBS-compliant Charger and Battery Host

The bq20z80 can broadcast messages to the SBS-compliant charger and battery host. This can be enabled with the ***[BCAST]*** bit.

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

PEC byte for alarm transmissions in master mode to the battery host can be enabled with the ***[HPE]*** bit.

Related Variables:

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

2.9.5 Extended Bus Low Time

The bq20z80 complies with the SMB timings. But in case extended time-out timing is needed, SMB time-out can be extended with the ***[NCSMB]*** bit.

Related Variables:

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

Standard SBS Commands

The bq20z80 SBS command set meets the SBD v1.1 specification. All SBS values are updated at 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. ManufactuerAccess

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 result of these commands must 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	–	–	0x0800	

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 single byte of reserved DataFlash. E.g., 0xa2 = Version A2.

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	–	–	–	

A.1.1.4 DF Checksum(0x0004)

This function is available when the bq20z80 is in sealed, unsealed, or full-access mode, indicated by the *[SS]* and *[FAS]* flags. A write to this command forces the bq20z80 to generate a checksum of the full DataFlash (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 (> 25 ms).

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 compatible with the equivalent command in the bq2084, and is available while the bq20z80 is in normal operation. This 16-bit word reports the battery status and is formatted the same as the bq2084.

	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 = Precharge
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, see multichemistry support files in the product folder at http://power.ti.com.

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	0x100	

A.1.2 System Control

The commands in this section cause the bq20z80 to take actions when written. No data is returned.

A.1.2.1 Shutdown (0x0010)

Instructs the bq20z80 to verify and enter shutdown mode. This command is only available when the bq20z80 is in unsealed or full-access mode. Shutdown is not entered unless *PackVoltage* < ***Charger Present*** and *Current* ≤ 0.

Related Variables:

- DF:Power:Power(68):Charger Present(5)
- SBS:Current(0x0a)
- SBS:PackVoltage(0x5a)
- SBS:OperationStatus(0x54)[SS], [FAS]

A.1.2.2 Sleep(0x0011)

Instructs the bq20z80 to verify and enter sleep mode if no other command is sent after the *Sleep* command. Any SMB transition wakes up the bq20z80. It takes about 1 minute after the sleep command is issued before the device goes to sleep. This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.3 Seal Device(0x0020)

Instructs the bq20z80 to limit access to the extended SBS functions and DataFlash space, sets the *[SS]* flag, and clears the *[FAS]* flag.

This command is only available when the bq20z80 is in unsealed or full-access mode.

See *Security*, Section 2.7 in this document, for detailed information.

Related Variables:

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

A.1.2.4 IT Enable(0x0021)

This command forces the bq20z80 to begin the Impedance Track™ algorithm and changes ***Update Status***, and the *[QEN]* flag.

This command is only available when the bq20z80 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 $\overline{\text{SAFE}}$ pin low and also SAFE pin high.

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.6 SAFE Clear(0x0031)

This command sets the $\overline{\text{SAFE}}$ pin back to high and also SAFE pin back to low.

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.7 LEDs ON(0x0032)

Activates all configured LEDs to stay on.

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.8 LEDs OFF(0x0033)

Deactivates all configured LEDs.

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.9 Display ON(0x0034)

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

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.10 Calibration Mode(0x0040)

Places the bq20z80 into calibration mode. See the *Data Flash Programming and Calibrating the bq20z80 Family of Gas Gauges* application report (SLUA355) for further details.

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.11 Reset(0x0041)

The bq20z80 undergoes a full reset. The bq20z80 holds the clock line down for a few milliseconds to complete the reset.

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

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

A.1.2.12 BootRom(0x0f00)

The bq20z80 goes into boot ROM mode.

This command is only available when the bq20z80 is in full-access mode.

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

A.1.2.13 Permanent Fail Clear (*PFKey*)

This two-step command must be written to *ManufacturerAccess* in following order: first word of the *PFKey* first followed by the second word of the *PFKey*.

The command instructs the bq20z80 to clear the *PFStatus*, clear the *[PF]* flag, clear the ***Fuse Flag***, reset the $\overline{\text{SAFE}}$ and SAFE pins and unlock the DataFlash for writes.

This command is only available when the bq20z80 is in unsealed or full-access mode.

Related Variables:

- DF:PF Status:Device Status Dataa(96):PF Flags 1(0)
- DF:PF Status:Device Status Dataa(96):Fuse Flag(2)
- SBS:PFStatus(0x46)
- SBS:SafetyStatus(0x51)[PF]
- SBS:PFKey(0x62)

Note: The higher 2 bytes must be immediately followed by the lower 2 bytes. If the clear command fails, the command can only be repeated 4 seconds after previous attempt. If communication other than the lower 2 bytes occurs after the first 2 bytes are sent, the *Permanent Fail Clear* command fails.

A.1.2.14 Unseal Device (*UnsealKey*)

Instructs the bq20z80 to enable access to the SBS functions and DataFlash space and clears the *[SS]* flag. This two-step command must be written to *ManufacturerAccess* in following order: first word of the *UnSealKey* first followed by the second word of the *UnSealKey*.

This command is only available when the bq20z80 is in sealed mode.

See *Security*, Section 2.7 in this document, for detailed information.

Related Variables:

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

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

Instructs the bq20z80 to enable full access to all SBS functions and DataFlash space and set the *[FAS]* flag. This two-step command must be written to *ManufacturerAccess* in following order: first word of the *FullAccessKey* first followed by the second word of the *FullAccessKey*.

This command is only available when the bq20z80 is in unsealed mode.

See *Security*, Section 2.7 in this document, for detailed information.

Related Variables:

- SBS:OperationStatus(0x54)[SS]
- SBS:OperationStatus(0x54)[FAS]
- SBS:FullAcccessKey(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 as follows.

The result of these commands must 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 function sets or gets a low-capacity alarm threshold unsigned integer value with a range of 0 to 65,535 and units of either mAh (*CAPACITY_MODE* = 0) or 10 mWh (*CAPACITY_MODE* = *1*). The default value for *RemainingCapacityAlarm* is stored in ***Rem Cap Alarm***. If *RemainingCapacityAlarm* is set to 0, alarm is disabled.

If *RemainingCapacity* < *RemainingCapacityAlarm*, the *[RCA]* flag is set and the bq20z80 sends an *AlarmWarning* message to the SMBUS host.

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

0 = Remaining capacity alarm is disabled.

1..700 = Remaining capacity limit for the *[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 10 mWh

Related Variables:

- DF:SBS Configuration:Data(48):Rem Cap Alarm(0)
- SBS:BatteryMode[CAPACITY_MODE]
- SBS:RemainingCapacity(0x0f)
- SBS:BatteryStatus(0x16)[RCA]
- SBS:BatteryStatus(0x16)[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 65,535. The default value of *RemaingTimeAlarm* is stored in ***Rem Time Alarm***. If *RemainingTimeAlarm* = 0, this alarm is disabled.

If *AverageTimeToEmpty* < *RemainingTimeAlarm*, the *[RTA]* flag is set and the bq20z80 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, reports the battery 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: CAPACITY_MODE — Sets the units used for capacity information and internal calculation.

0 = Reports in mA or mAh (default)

1 = Reports in 10 mW or 10 mWh

The following functions are instanteously updated after a *[CAPACITY_MODE]* change:

SBS:RemainingCapacityAlarm(0x01)

SBS:AtRate(0x04)

SBS:RemainingCapacity(0x0f)

SBS:FullChargeCapacity(0x10)

SBS:DesignCapacity(0x18)

The following functions are recalculated within 1 second after a *[CAPACITY_MODE]* change:

SBS:RemainingTimeAlarm(0x02)

SBS:AtRateTimeToEmpty(0x06)

SBS:AtRateOK(0x07)

SBS:RunTimeToEmpty(0x11)

SBS:AverageTimeToEmpty(0x12)

SBS:BatteryStatus(0x16)

CHGM: CHARGER_MODE — Enables or disables the bq20z80 transmission of *ChargingCurrent* and *ChargingVoltage* messages to the SBS-compliant charger.

0 = Enable *ChargingVoltage* and *ChargingCurrent* broadcasts to SBS-compliant charger, when charging is desired. (default)

1 = Disable *ChargingVoltage* and *ChargingCurrent* broadcasts to SBS-compliant charger

Related variables:

SBS:ChargingCurrent(0x14)

SBS:ChargingVoltage(0x15)

AM: ALARM_MODE — Enables or disables *AlarmWarning* broadcasts to host and SBS-compliant charger

0 = Enables *AlarmWarning* broadcasts to host and SBS-compliant charger (default). The bq20z80 sends the *AlarmWarning* messages to the SMBus host and the SBS-compliant charger any time an alarm condition is detected.

1 = Disables *AlarmWarning* broadcast to host and SBS-compliant charger. The bq20z80 does not master the SMBus, and *AlarmWarning* messages are not sent to the SMBus Host and the SBS-compliant charger for a period of no more than 65 seconds and no less than 45 seconds. *[ALARM_MODE]* is automatically cleared by the bq20z80 60 seconds after being set to 1.

Note: The system, as a minimum, is required to poll the battery every 10 seconds if the *[ALARM_MODE]* flag is set.

PB: PRIMARY_BATTERY — Sets the role of the battery pack. This flag is not used by the bq20z80 and should be set to 0.

CC: CHARGE_CONTROLLER — Enable or disable internal charge controller. This flag is not used by the bq20z80 and should be set to 0.

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

0 = Battery OK

1 = Condition cycle requested

DF:SBS Configuration:Data(48):CF MaxError Limit(19)

SBS:MaxError(0x0c)

PBS: PRIMARY_BATTERY_SUPPORT — This feature is not supported by bq20z80 and is fixed to 0.

ICC: INTERNAL_CHARGE_CONTROLLER — This flag indicates if the 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 either mA (*[CAPACITY_MODE]* = 0) or 10 mW (*[CAPACITY_MODE]* = 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	–32,768	32,767	0	mA or 10 mW

Related Variables:

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

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 65,534. A value of 65,535 indicates that *AtRate* = 0.

AtRateTimeToFull can report time based on constant current (*[CAPACITY_MODE]* = 0) or constant power (*[CAPACITY_MODE]* = 1), and updates within 1 second after the SMBus host sets the *AtRate* value. The bq20z80 automatically updates *AtRateTimeToFull* based on the *AtRate*function at 1-second intervals.

0..65,534 = Predicted time to full charge, based on *AtRate*

65,535 = 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	65,535	–	min

Related Variables:

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

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 65,534, if the battery is discharged at the *AtRate* value. A value of 65,535 indicates that *AtRate* = 0.

AtRateTimeToEmpty can report time based on constant current (*[LDMD]* = 0), or constant power (*[LDMD]* = 1), and is updated within 1 second after the SMBus host sets the *AtRate* value. The bq20z80 updates *AtRateTimeToEmpty* at 1-second intervals.

0..65,534 = Predicted remaining operating time, based on *AtRate*

65,535 = 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	65,535	–	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 bq20z80 updates this value within 1 second after the SMBus host sets the *AtRate* function value. The bq20z80 updates *AtRateOK* at 1-second intervals.

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

0 = FALSE bq20z80 can**not** deliver energy for 10 seconds actual discharge rate indicated in *AtRate*

1..65,535 = TRUE bq20z80 deliver energy for 10 seconds actual 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	65,535	–	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 bq20z80. It has a range of 0 to 6,553.5°K.

The source of the measured temperature is configured by the ***[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	65,535	–	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 mv to 20,000 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	20,000	–	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 negative indicates discharge.

Any current value within the ***Deadband*** is 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	–32,768	32,767	–	mA

Related Variables:

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

Note: The *Current* function is the average of four internal current measurements over a 1-second period.

A.12 AverageCurrent(0x0b)

This read-word function returns a signed integer value that approximates a 1-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 14.5 s. During the time after a reset and before 14.5 s 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	–32,768	32,767	–	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%.

MaxError is incremented 0.05% for every increment of *CylceCount* after the last QMAX update.

Event	*MaxError* Setting
Full reset	Set to 100%
QMAX and Ra table 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*, in %, with a range of 0% to 100%, with any fractions of % rounded up.

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 Variable:

- 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 following table shows the calculation used, depending on the *CAPACITY_MODE* flag.

CAPACITY_MODE 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)[CAPACITY_MODE]
- SBS:RemainingCapacity(0x0f)

A.16 RemainingCapacity(0x0f)

This read-word function returns an unsigned integer value, with a range of 0 to 65,535, 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 *[CAPACITY_MODE]* flag.

Table A-20. RemainingCapacity

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0f	R	RemainingCapacity	Unsigned integer	2	0	65,535	–	mAh or 10 mWh

Related Variable:

- SBS:BatteryMode(0x03)[CAPACITY_MODE]

A.17 FullChargeCapacity(0x10)

This read-word function returns an unsigned integer value, with a range of 0 to 65,535, of the predicted pack capacity when it is fully charged. This value is expressed in either charge (mAh) or power (10 mWh) depending on the setting of the *[CAPACITY_MODE]* 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	65,535	–	mAh or 10mWh

Related Variable:

- SBS:BatteryMode(0x03)[CAPACITY_MODE]

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 65,534 min. A value of 65,535 indicates battery is not being discharged.

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

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	65,535	–	min

Related Variable:

- SBS:BatteryMode(0x03)[CAPACITY_MODE]

A.19 AverageTimeToEmpty(0x12)

This read-word function returns an unsigned integer value of predicted remaining battery life, in minutes, based upon *AverageCurrent* with a range of 0 to 65,534. A value of 65,535 indicates that the battery is not being discharged.

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

0..65,534 = Predicted remaining battery life, based on *AverageCurrent*

65,535 = 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	65,535	–	min

Related Variables:

- SBS:BatteryMode(0x03)[CAPACITY_MODE]
- 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 65,535. A value of 65,535 indicates that the battery is not being charged.

0..65,534 = Predicted remaining time until full charge

65,535 = 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	65,535	–	min

Related Variables:

- SBS:AverageCurrent(0x0b)

A.21 ChargingCurrent(0x14)

This read-word function returns an unsigned integer value of the desired charging rate, in mA, with a range of 0 to 65,535. A value of 65,535 indicates that a charger should operate as a voltage source outside its maximum regulated current range.

0..65,534 = Desired charging voltage in mA

65,535 = Charger should operate as voltage source outside its maximum regulated voltage 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	65,535	–	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 65,535. A value of 65,535 indicates that the charger should operate as a current source outside its maximum regulated voltage range.

0..65,534 = Desired charging voltage in mV

65,535 = Charger should operate as current source outside its 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	65,535	–	mV

A.23 BatteryStatus(0x16)

This read-word function returns the status of the bq20z80-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 — 1Over Charged Alarm

TCA — Terminate Charge Alarm

OTA — Overtemperature Alarm

TDA — Terminate Discharge Alarm

RCA — Remaining Capacity Alarm; see *SBS:RemainingCapacityAlarm(0x01)* Section A.2.

RTA — Remaining Time Alarm; see *SBS:RemainingTimeAlarm(0x02)*, Section A.3

INIT— Initialized. This flag is set approximately 1 second after device reset, after all SBS parameters have been measured and updated.

DSG — Discharging

0 = bq20z80 is in charging mode

1 = bq20z80 is in discharging mode, relaxation mode or valid charge termination has occurred see:

Gas Gauging,Section C.10

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	bq20z80 processed the function code with no errors detected.
0,0,0,1 =	BUSY	bq20z80 is unable to process the function code at this time.
0,0,1,0 =	Reserved	bq20z80 detected an attempt to read or write to a function code reserved by this version of the specification or bq20z80 detected an attempt to access an unsupported optional manufacturer function code.
0,0,1,1 =	Unsupported	bq20z80 does not support this function code as defined in this version of the specification.
0,1,0,0 =	AccessDenied	bq20z80 detected an attempt to write to a read-only function code.
0,1,0,1 =	Over/Underflow	bq20z80 detected a data overflow or underflow.
0,1,1,0 =	BadSize	bq20z80 detected an attempt to write to a function code with an incorrect data block.
0,1,1,1 =	UnknownError	bq20z80 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 65,535. The default value is stored in DataFlash value ***Cycle Count*** which is updated each time this variable is incremented. There are two different cycle calculations, depending on the ***[CCT]*** bit.

When the bq20z80 is in unsealed or higher-security mode, this block is R/W.

CCT	Cycle Count Calculation
0 =	One cycle count is accumulated discharge of ***CC Threshold***
1 =	One cycle count is accumulated discharge of ***CC %*** × *FullChargeCapacity*. If ***CC Threshold*** is greater than ***CC %*** × *FullChargeCapacity*, ***CC Threshold*** is used for 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	65,535	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]
- SBS:OperationStatus(0x54)[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 *[CAPACITY_MODE]* bit.

When the bq20z80 is in unsealed or higher-security mode, this block is R/W.

Table A-28. DesignCapacity

SBS Cmd.	Mode	Name	CAPACITY_MODE	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x18	R/W	DesignCapacity	0	Unsigned integer	2	0	65,535	4,400	mAh
			1	Unsigned integer	2	0	65,535	6,336	10 mWh

Related Variables:

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- SBS:BatteryMode(0x03)[CAPACITY_MODE]
- SBS:OperationStatus(0x54)[SS]
- SBS:OperationStatus(0x54)[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 65,535. The default value is stored in ***Design Voltage***.

When the bq20z80 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	7,000	18,000	14,400	mV

Related Variables:

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

A.27 SpecificationInfo(0x1a)

This read-word function returns, as an unsigned integer value, the version number of the 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 × 0x1000 + VScale × 0x0100 + SpecID_H × 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 bq20z80 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

Figure A-4. SpecificationInfo

Related Variables:

- DF:SBS Configuration:Data(48):Spec Info(10)
- SBS:OperationStatus(0x54)[SS]
- SBS:OperationStatus(0x54)[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) × 512 + month × 32 + day

The default value for this function is stored in ***Manuf Date***. When the bq20z80 is in unsealed or higher-security mode, this block is R/W.

Table A-31. ManufacturerDate*

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x1b	R/W	ManufacturerDate	Unsigned integer	2	0	65,535	0	

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Year biased by 1980 (0..127)							Month (1..12)				Date (0..31)				
MSB						LSB	MSB			LSB	MSB				LSB

Figure A-5. ManufacturerDate

Related Variables:

- DF:SBS Configuration:Data(48):Manuf Date(12)
- SBS:OperationStatus(0x54)[SS]
- SBS:OperationStatus(0x54)[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 bq20z80 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]
- SBS:OperationStatus(0x54)[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 DataFlash ***Manuf Name***. When the bq20z80 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 Instruments	

Related Variables:

- DF:SBS Configuration:Data(48):Manuf Name(26)
- SBS:OperationStatus(0x54)[SS]
- SBS:OperationStatus(0x54)[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 DataFlash ***Device Name***. When the bq20z80 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	–	–	bq20z80	

Related Variables:

- DF:SBS Configuration:Data(48):Device Name(38)
- SBS:OperationStatus(0x54)[SS]
- SBS:OperationStatus(0x54)[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 in stored in DataFlash ***Device Chemistry***, although it has no use for internal charge control or fuel gauging. When the bq20z80 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	

Related Variables:

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

A.33 ManufacturerData(0x23)

This read-block function returns several configuration DataFlash elements with an absolute maximum length of 14 Data + 1 length byte (stored in *ManufacturerData* length byte). The manufacturing data elements shown in Table A-36 are stored in the *ManufacturerData* subclass. When the bq20z80 is in unsealed or higher-security mode, this block is R/W.

Table A-36. Manufacturer Data

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		
bq20z80 counter	10	Partial reset counter	
	11	Full reset counter	
	12	Watchdog reset counter	
	13	Checksum	

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

A.34 Authenticate(0x2f)

This read/write-block function allows the host to authenticate the bq20z80-based battery using an 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	–	–	–	

Related Variables:

- None

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 65,535. *CellVoltage1* corresponds to the bottommost series cell element, while *CellVoltage4* corresponds to the topmost 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	65,535	–	mV
0x3d		CellVoltage3					–	
0x3e		CellVoltage2					–	
0x3f		CellVoltage1					–	

Related Variables:

- none

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	65,535	—	mAh or 10 mWh
0x02	R/W	RemainingTimeAlarm	Unsigned int	2	0	65,535	—	min
0x03	R/W	BatteryMode	Hex	2	0x0000	0xffff	—	
0x04	R/W	AtRate	Signed int	2	–32,768	32,767	—	mA or 10mW
0x05	R	AtRateTimeToFull	Unsigned int	2	0	65,535	—	min
0x06	R	AtRateTimeToEmpty	Unsigned int	2	0	65,535	—	min
0x07	R	AtRateOK	Unsigned int	2	0	65,535	—	
0x08	R	Temperature	Unsigned int	2	0	65,535	—	0.1 K
0x09	R	Voltage	Unsigned int	2	0	20,000	—	mV

Table A-39. SBS COMMANDS (continued)

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0a	R	Current	Signed int	2	–32,768	32,767	—	mA
0x0b	R	AverageCurrent	Signed int	2	–32,768	32,767	—	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	RemainingCapacity	Unsigned int	2	0	65,535	—	mAh or 10mWh
0x10	R	FullChargeCapacity	Unsigned int	2	0	65,535	—	mAh or 10mWh
0x11	R	RunTimeToEmpty	Unsigned int	2	0	65,535	—	min
0x12	R	AverageTimeToEmpty	Unsigned int	2	0	65,535	—	min
0x13	R	AverageTimeToFull	Unsigned int	2	0	65,535	—	min
0x14	R	ChargingCurrent	Unsigned int	2	0	65,535	—	mA
0x15	R	ChargingVoltage	Unsigned int	2	0	65,535	—	mV
0x16	R	BatteryStatus	Unsigned int	2	0x0000	0xffff	—	
0x17	R/W	CycleCount	Unsigned int	2	0	65,535	—	
0x18	R/W	DesignCapacity	Unsigned int	2	0	65,535		mAh or 10mWh
0x19	R/W	DesignVoltage	Unsigned int	2	7000	16,000	14400	mV
0x1a	R/W	SpecificationInfo	Unsigned int	2	0x0000	0xffff	0x0031	
0x1b	R/W	ManufactureDate	Unsigned int	2	0	65,535	0	
0x1c	R/W	SerialNumber	Hex	2	0x0000	0xffff	0x0001	
0x20	R/W	ManufacturerName	String	11+1	—	—	Texas Instruments	
0x21	R/W	DeviceName	String	7+1	—	—	bq20z80	
0x22	R/W	DeviceChemistry	String	4+1	—	—	LION	
0x23	R	ManufacturerData	String	14+1	—	—	—	
0x2f	R/W	Authenticate	String	20+1	—	—	—	
0x3c	R	CellVoltage4	Unsigned int	2	0	65,535		mV
0x3d	R	CellVoltage3	Unsigned int	2	0	65,535		mV
0x3e	R	CellVoltage2	Unsigned int	2	0	65,535		mV
0x3f	R	CellVoltage1	Unsigned int	2	0	65,535		mV

Extended SBS Commands

The extended SBS commands are only available when bq20z80 device is in unsealed mode and full-access mode, indicated by the *[SS]* flag.

Related Variables:

- SBS:ManufacturerAccess(0x00):Seal Access(0x0020)
- SBS:OperationStatus(0x54)[SS]
- 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 bq29312A memory map followed by 2 bytes of the internal bq20z80 AFE_Fail_Counter.

Table B-1. AFEData

Data	Byte	Name	Format
bq29312A	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	
bq20z80	9	Internal AFE_Fail_Counter high byte	
	10	Internal AFE_Fail_Counter low 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 write/read-word function allows direct control of the FETs for test purposes. The bq20z80 overrides this command unless in normal mode.

	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 — bq29312A OD pin control.

0 = Disable OD pin (high-Z)

1 = Enable OD pin (open drain)

ZVCHG — Zero-Volt (Precharge) charge FET Control

0 = Turn OFF precharge FET

1 = turn ON precharge FET

CHG — Charge FET Control

0 = Turn OFF CHG FET. CHG FET does not 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 does not turn off 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 *CAPACITY_MODE* flag.

CAPACITY_MODE	*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)[CAPACITY_MODE]

B.4 SafetyAlert(0x50)

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

See the "1st Level Safety" 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	Reserved	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

COV— 1 = Cell overvoltage alert

HWDG— 1 = Host watchdog alert

WDF— 1 = AFE watchdog alert

AOCD— 1 = 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 Safety" 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 aleconditionrt

PF— 1 = Permanent failure and SAFE pin has been driven high and $\overline{\text{SAFE}}$ pin has been driven low.

HWDG— 1 = Host watchdog condition

WDF— 1 = AFE watchdog condition

AOCD— 1 = 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, but have not reached the required time to trigger a *PFAlert* failure. *[PFVSHUT]* indicates only conditions for shutdown are met.

See the "2nd Level Safety" 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	PFVSHUT	Reserved	SOPT	SOCD	SOCC	AFE_P	ACE_C
Low Byte	Reserved	DFETF	CFETF	CIM	SOTD	SOTC	SOV	PFIN

LEGEND: All values read-only

Figure B-4. PFAlert

FBF— = 1: Fuse Blow Failure alert

PFVSHUT— = 1: *Voltage* and *Current* conditions for shutdown are met

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

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 bq20z80 permanent-failure condition.

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

See the *2nd Level Safety* 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	PFVSHUT	Reserved	SOPT	SOCD	SOCC	AFE_P	AFE_C
Low Byte	DFF	DFETF	CFETF	CIM	SOTD	SOTC	SOV	PFIN

LEGEND: All values read-only

Figure B-5. PFStatus

FBF— 1 = Fuse Blow Failure

PFVSHUT— 1 = *Voltage* and *Current* conditions for shutdown are met AND another permanent failure occurred.

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 = DataFlash 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 status of the operation status of the bq20z80.

	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

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 mode

CSV— 1 = DataFlash checksum value has been generated

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

WAKE— 1 = bq20z80 WAKE mode

DSG— Replica of the SBS:BatteryStatus(0x16)[DISCHARGING] 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	PULSEOFF	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 progresses

PULSEOFF— 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	Full resets	Low byte	Unsigned integer	1	0	255	–	
			Partial 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	65,535	–	

B.12 PackVoltage(0x5a)

This read–word function returns an unsigned integer representing the measured voltage from the AFE pack pin, in mV, with a range of 0 to 65,535.

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	65,535	–	mV

B.13 AverageVoltage(0x5d)

This read-word function returns a signed integer value that approximates a 1-minute rolling average of the sum of cell voltages in mV, with a range of 0 to 65,535.

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	65,535	–	mV

Related Variables:

- SBS:Voltage(0x09)

B.14 UnSealKey(0x60)

This read/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 bq20z80 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	FullAccessKey	Hex	4	0x0000 0000	0xffff ffff	–	

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

B.15 FullAccessKey(0x61)

This read/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 bq20z80 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 first and second words 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	0x0000 0000	0xffff ffff	–	

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

B.16 PFKey(0x62)

This read/write block command allows the user to change the Permanent-Failure-Clear key. This function is only available when the bq20z80 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	0x0000 0000	0xffff ffff	–	

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

B.17 AuthenKey3(0x63)

This read/write block command stores byte 12-byte 15 of the 16-byte-long authentication key. This function is only available when the bq20z80 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
0x62	R/W	AuthenKey3	Hex	4	0x0000 0000	0xffff ffff	0x0123 4567	

Related Variables:

- None

B.18 AuthenKey2(0x64)

This read/write block command stores byte 8–byte 11 of the 16-byte-long authentication key. This function is only available when the bq20z80 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	0x0000 0000	0xffff ffff	0x89ab cdef	

Related Variables:

- None

B.19 AuthenKey1(0x65)

This read/write block command stores byte 4–byte 7 of the 16-byte-long authentication key. This function is only available when the bq20z80 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	0x0000 0000	0xffff ffff	0xfedc ba98	

Related Variables:

- None

B.20 AuthenKey0(0x66)

This read/write block command stores byte 0-byte 3 of the 16-byte-long authentication key. This function is only available when the bq20z80 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	0x0000 0000	0xffff ffff	0x7654 3210	

Related Variables:

- none

B.21 ManufacturerInfo(0x70)

This read-block function returns the data stored in ***Manuf. Info***, where byte 0 is the MSB with a maximum length of 8 data + 1 length byte. When the bq20z80 is in unsealed or full-access mode, this block is R/W.

Table B-13. ManfacturerInfo

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x70	R/W	ManufacturerInfo	string	8+1				

Related Variables:

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

B.22 SenseResistor(0x71)

This read/write command allows the user to change the sense resistor value used in µΩ. The bq20z80 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	65,535	–	µΩ

B.23 DataFlashClass(0x77)

This write word function set the bq20z80 DataFlash subclass, where data can be accessed by following *DataFlassSubClass1..8* commands.

See "DataFlash Access" 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 DataFlash.

Table B-15. DataFlashClass

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x77	W	DataFlashClass	Hex	2	0x0000	0xffff	–	

Related Variables:

- SBS:DataFlashSubClass1..8(0x78..0x7f)

B.24 DataFlashClassSubClass1..8(0x78..0x7f)

These commands are used to access the consecutive 32-byte pages of each subclass. *DataFlashClassSubClass1* gets byte 0 to 31 of the subclass, *DataFlashClassSubClass2* get bytes 32 to 63, and so on.

Note: Any DF location deemed Reserved responds with a *NACK* unless the bq20z80 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	DataFlashClassSubClass1	Hex	32	0	31	–	
0x79	R/W	DataFlashClassSubClass2	Hex	32	32	63	–	
0x7a	R/W	DataFlashClassSubClass3	Hex	32	64	95	–	
0x7b	R/W	DataFlashClassSubClass4	Hex	32	96	127	–	
0x7c	R/W	DataFlashClassSubClass5	Hex	32	128	159	–	
0x7d	R/W	DataFlashClassSubClass6	Hex	32	160	191	–	
0x7e	R/W	DataFlashClassSubClass7	Hex	32	192	223	–	
0x7f	R/W	DataFlasClasshSubClass8	Hex	32	224	255	–	

Related Variables:

- SBS:DataFlashClass(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	0xff	—	
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	0xffff	—	
0x53	R	PFStatus	Hex	2	0x0000	0xffff	—	
0x54	R	OperationStatus	Hex	2	0x0000	0xffff	—	
0x55	R	ChargingStatus	Hex	2	0x0000	0xffff	—	
0x57	R	ResetData	Hex	2	0x0000	0xffff	—	
0x58	R	WDResetData	Unsigned int	2	0	65,535	—	
0x5a	R	PackVoltage	Unsigned int	2	0	65,535	—	mV
0x5d	R	AverageVoltage	Unsigned int	2	0	65,535		mV
0x60	R/W	UnSealKey	Hex	4	0x0000 0000	0xffff ffff	—	
0x62	R/W	PFKey	Hex	4	0x0000 0000	0xffff ffff	—	
0x63	R/W	AuthenKey3	Hex	4	0x0000 0000	0xffff ffff	—	
0x64	R/W	AuthenKey2	Hex	4	0x0000 0000	0xffff ffff	—	
0x65	R/W	AuthenKey1	Hex	4	0x0000 0000	0xffff ffff	—	
0x66	R/W	AuthenKey0	Hex	4	0x0000 0000	0xffff ffff	—	
0x70	R/W	ManufacturerInfo	String	8+1	—	—	—	
0x71	R/W	SenseResistor	Unsigned int	2	0	65,535	—	µΩ
0x77	R/W	DataFlashClass	Hex	2	0x0000	0xffff	—	
0x78	R/W	DataFlashSubClass1	Hex	32	—	—	—	
0x79	R/W	DataFlashSubClass2	Hex	32	—	—	—	
0x7a	R/W	DataFlashSubClass3	Hex	32	—	—	—	
0x7b	R/W	DataFlashSubClass4	Hex	32	—	—	—	
0x7c	R/W	DataFlashSubClass5	Hex	32	—	—	—	
0x7d	R/W	DataFlashSubClass6	Hex	32	—	—	—	
0x7e	R/W	DataFlashSubClass7	Hex	32	—	—	—	
0x7f	R/W	DataFlashSubClass8	Hex	32	—	—	—	

DataFlash

CAUTION

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

DataFlash can only be updated if *Voltage* or *PackVoltage* ≥ ***Flash Update OK Voltage***. DataFlash reads and writes are verified according to the method detailed in the *Second-Level Safety* section of this data sheet.

Note: DataFlash updates are disabled when *[PF] SafetyStatus* flag is set.

C.1 Accessing DataFlash

In different security modes, the DataFlash access conditions change. See *Manufacturer Access*, Section A.1 and *Security*, Section 2.7, for further details.

SECURITY MODE	NORMAL DataFlash ACCESS
BootROM	N/A
Full access	R/W
Unsealed	R/W
Sealed	N/A

C.1.1 DataFlash Interface

The bq20z80 DataFlash is organized into subclasses where each DataFlash 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: DataFlash commands are NACKed if bq20z80 is in sealed mode (*[SS]* flag is set).

Each subclass can be addressed individually by using the *DataFlashClass* command and the data within each subclass is accessed by using the *DataFlashClassSubClass1..8* commands.

Reading and Writing subclass data are block operations which are 32 bytes long each. but data can be written in shorter block sizes. 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 bq20z80 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:DataFlashClass(0x77)
- SBS:DataFlashClassSubClass1..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 bq20z80 using *DataFlashClass* command.
2. Read a block of data using *DataFlashClassSubClass1..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 *DataFlashClassSubClass1* command reads only the first 32 bytes in a subclass, the *DataFlashClassSubClass2* command reads the second 32 bytes in a subclass and so on. For example, if the subclass has 40 bytes, *DataflashClassSubClass1* + *DataflashClassSubClass1* 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 bq20z80 using *DataFlashClass* command.
2. Write a block of data using *DataFlashClassSubClass1..8* command. A subclass can hold up to 256 bytes of data, but subclass data can only be written in 32-byte-long data blocks. The *DataFlashClassSubClass1* command writes only the first 32 bytes in a subclass, the *DataFlashClassSubClass2* 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 must be changed, use *DataflashClassSubClass2* 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 (0x17)
  - SMB CMD 0x77 with 0x0050 as data (= 80 decimal)
- Read Subclass (2 blocks are needed as its over 32 bytes long)
  - SMB Slave 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 bq20z80:

- Write Subclass ID
  - SMB Slave Address (0x17)
  - 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 (second 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 bq20z80:

- 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 bq20z80 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	3,700	5,000	4,300	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***, bq20z80 goes into cell overvoltage condition. This function is disabled if ***COV Time*** is set to 0.

In cell overvoltage condition, the CHG FET is turned off, the charging current and charging voltage is set to 0, the terminate charge alarm 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	60	2	s

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 bq20z80 recovers from cell overvoltage condition, if all cell voltages are equal to or lower than the ***COV Recovery*** threshold level. On recovery the *ChargingCurrent* and *ChargingVoltage* is set to appropriate value by 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	4,400	3,900	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 above the overtemperature limit. ***COV Threshold*** compensation is disabled when ***COV Delta*** is set to 0. The temperature limit is defined by following formula:

Temperature > ***Over Temp Chg*** –***COV Temp Hyst***

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

C.2.1.5 COV Temp. Hyst. (Offset 6)

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

Table C-5. COV Temp. Hyst.

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	6	COV Temp. Hyst.	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)
- DF:1st Level Safety:Temperature(2):Overtemp Chg(0)
- SBS:Temperature(0x08)
- SBS:BatteryStatus(0x16)[DSG]

C.2.1.6 POV Threshold (Offset 7)

The bq20z80 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	18,000	17,500	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***, bq20z80 goes into pack overvoltage condition. This function is disabled if ***POV Time*** is set to 0.

In pack overvoltage 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	60	2	s

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 bq20z80 recovers from pack overvoltage condition, if the *Voltage* is equal to or lower than the ***POV Recovery*** threshold level. On recovery the charging current and voltage is set to appropriate value per 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	17,000	16,000	mV

Related Variables:

- DF:1st Level Safety:Voltage(0):POV Threshold(7)
- DF:1st Level Safety:Voltage(0):POV Recovery(10)
- 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 bq20z80 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	3,500	2,200	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:SafetyStatus(0x50)[CUV]

C.2.1.10 CUV Time (Offset 14)

If *[CUV]* in *SafetyAlert* time period exceeds ***CUV Time***, the bq20z80 goes into cell undervoltage 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	60	2	s

Related Variables:

- DF:1st Level Safety:Voltage(0):CUV Threshold(12)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-Charge Current(0)
- SBS:Charging Current(0x14)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:BatteryStatus(0x16)[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 bq20z80 recovers from cell undervoltage condition, if all *CellVoltage4..1* are equal to or higher than the ***CUV Recovery*** threshold. On recovery the *ChargingCurrent* and *ChargingVoltage* are set to appropriate value by charging algorithm, the *[TDA]* flag is 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	3,600	3,000	mV

Related Variables:

- DF:1st Level Safety:Voltage(0):CUV Threshold(12)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:BatteryStatus(0x16)[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.2.1.12 PUV Threshold (Offset 17)

The bq20z80 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	18,000	11,000	mV

Related Variables:

- DF:1st Level Safety:Voltage(0):PUV Time(19)
- DF:Power:Power(68):Shutdown Voltage(2)
- DF:Power:Power(68):Shutdown Time(4)
- 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 bq20z80 goes into pack undervoltage condition. This function is disabled if ***PUV Time*** is set to 0.

In pack undervoltage condition, the DSG FET is turned off, the charging current is set to pre charge current value, the *[TDA]* is set, the *[FD]* flag is 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	60	2	s

Related Variables:

- DF:1st Level Safety:Voltage(0):PUV Threshold(17)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-Charge Current(0)
- DF:Power:Power(68):Shutdown Voltage(2)
- DF:Power:Power(68):Shutdown Time(4)
- SBS:Voltage(0x09)
- SBS:Charging Current(0x14)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:BatteryStatus(0x16)[FD]
- SBS:SafetyAlert(0x50)[PUV]
- SBS:SafetyStatus(0x51)[PUV]
- SBS:OperationStatus(0x54)[XDSG]

C.2.1.14 PUV Recovery (Offset 20)

The bq20z80 recovers from pack undervoltage condition if the pack voltage is equal to or higher than the ***PUV Recovery*** threshold level. On recovery *[TDA]* is 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	16,000	12,000	mV

Related Variables:

- DF:1st Level Safety:Voltage(0):CUV 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 bq20z80 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) Charge	Unsigned integer	2	0	20,000	6,000	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 overcurrent charge time, bq20z80 goes into overcurrent charge condition. This function is disabled if ***OC (1st Tier) Chg Time*** is set to 0.

In overcurrent while charging condition, the CHG FET is turned off, the *ChargeCurrent* and *ChargeVoltage* is set to 0, the *[TCA]* is set, the *[OCC]* in *SafetyAlert* is cleared and the *[OCC]* 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	60	2	s

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 bq20z80 recovers from overcurrent charge condition in non removable battery mode, if the *AverageCurrent* is equal to or lower than the ***OC Chg Recovery*** threshold for the length of ***Current Recovery Time***. The bq20z80 recovers in removable battery mode by removing and reinserting the battery pack. On recovery the *ChargingCurrent* and *ChargingVoltage* are set to appropriate value per charging algorithm, *[TCA]* is reset and the *[OCC]* 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	–1,000	1,000	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 bq20z80 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	20,000	6,000	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***, bq20z80 goes into overcurrent discharge condition. This function is disabled if ***OC (1st Tier) Dsg Time*** is set to 0.

In pack overcurrent discharge condition, the DSG FET is turned off and locked, the *ChargeCurrent* is set to ***Pre-charge Current***, the *[TCA]* is set, the *[FD]* flag is set, the *[OCD]* in *SafetyAlert* is reset, the *[OCD]* in *SafetyStatus* is set and the *[XDSG]* 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	60	2	s

Related Variables:

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg(0)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-Charge 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 bq20z80 recovers from overcurrent discharge condition in non removable battery mode, if the *AverageCurrent* is equal to or lower than the ***OC Dsg Recovery*** current level for the length of ***Current Recovery Time***. On recovery the *ChargingCurrent* and *ChargingVoltage* is set to appropriate value per charging algorithm, *[TCA]* is reset, the *[OCD] SafetyStatus* is reset and the *[XDSG]* 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	1,000	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: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 bq20z80 sets the *[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 (2st Tier) Chg	Unsigned integer	2	0	20,000	8,000	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 bq20z80 goes into overcurrent charge condition. This function is disabled if ***OC (2nd Tier) Chg Time*** is set to 0.

In pack overcharge condition, the CHG FET is turned off and locked, the *ChargingCurrent* and *ChargingVoltage* are set to 0, the *[TCA]* is set, the *[OCC2] SafetyAlert* is reset and the *[OCC2] SafetyStatus* 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	60	2	s

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 bq20z80 sets the *[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	22,000	6,000	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 bq20z80 goes into overcurrent discharge condition. This function is disabled if ***OC (2nd Tier) Dsg Time*** is set to 0.

In pack overcurrent discharge condition, the DSG FET is turned off and locked, the *ChargingCurrent* is set to *Pre-Charge Current*, the terminate discharge alarm (*[TDA]*) is set, the fully discharged *[FD]* flag is set, the *[OCD2]* in *SafetyAlert* is reset, the *[OCD2]* in *SafetyStatus* is set and the *[XDSG]* 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	60	2	s

Related Variables:

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg(0)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-Charge Current(0)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TDA], [FD]
- 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* must be below the overcurrent charge/discharge recovery threshold to recover from an overcurrent 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	60	8	s

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 bq29312A AFE device. See overload threshold register of bq29312A 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	0	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 bq29312A

0x00–0x1f = sets the voltage threshold between 50 mV and 205 mV in 5-mV 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 bq29312A AFE device. If an overcurrent discharge condition is reported by bq29312A, *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	0	0x0f	0x0f	

OLT3, OLT2, OLT1, OLT0 — Sets the overload voltage delay of bq29312A

0x00–0x0f = sets the overvoltage trip delay between 1 ms and 31 ms in 1-ms 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 bq20z80 recovers from overcurrent 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 charging current and voltage is set to appropriate value per charging algorithm, terminate discharge alarm is reset, the *[AOCD]* in *SafetyStatus* is reset and the operation status discharge fault 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	1,000	100	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:SafetyStatus(0x51)[AOCD]

C.2.2.15 AFE SC Chg Cfg (Offset 21)

The ***AFE SC Charge Cfg*** is programmed into the SCC register of bq29312A AFE device.
AFE SC Charge Cfg sets the short circuit charging voltage threshold and the short circuit in charging delay of the bq29312A.

If bq20z80 identifies short circuit situation from bq29312A, *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* in *BatteryStatus* is set and the *[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	0	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

LEGEND: –

Figure C-2. SCC Register

SCCT3, SCCT2, SCCT1, SCCT0 — Sets the short circuit delay in charging of bq29312A

0x00–0x0f = sets the short circuit in charging delay between 0 µs and 915 µs in 61-µs steps

SCCV3, SCCV2, SCCV1, SCCV0 — Sets the short circuit voltage threshold in charging of bq29312A

0x00–0x0f = sets the short-circuit voltage threshold between 0.1 V and 0.475 V in 25-mV 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 bq29312A AFE device. The ***AFE SC Dsg Cfg*** sets the the short circuit discharging voltage threshold and the short circuit in discharging delay of the bq29312A.

If bq20z80 identifies discharge short circuit situation from bq29312A, *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	0	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

LEGEND: –

Figure C-3. SCD Register

SCDT3, SCDT2, SCDT1, SCDT0 — Sets the short-circuit delay in discharging of bq29312A

0x00–0x0f = sets the short-circuit delay in discharging between 0 µs and 915 µs in 61-µs steps

SCDV3, SCDV2, SCDV1, SCDV0 — Sets the short circuit voltage threshold in discharging of bq29312A

0x00–0x0f = sets the short-circuit voltage threshold between 0.1 V and 0.475 V in 25-mV 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 bq20z80 recovers from overcurrent discharge 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* is set to an appropriate value per the charging algorithm, *[TDA]*, *[TCA]* in *BatteryStatus* is reset, *[SCC]*, *[SCD]* in *SafetyStatus* is 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(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:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[SCC]
- SBS:SafetyStatus(0x51)[SCD]
- SBS:OperationStatus(0x54)[XDSG]

C.2.3 Temperature (Subclass 2)

C.2.3.1 Over Temp Chg (Offset 0)

The bq20z80 sets the *[OTC]* in *SafetyAlert* if 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	1,200	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, bq20z80 goes into overtemperature charge condition. This function is disabled if ***OT Chg Time*** is set to 0.

In charging overtemperature condition, the *ChargingVoltage* and *ChargingCurrent* is set to 0, the *[OTA]* in *BatteryStatus* is set, *[TCA]* is set, the *[OTC]* in *SafetyAlert* is reset and the *[OTC]* in *SafetyStatus* is set. If *[OTFET]* bit is enabled, 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	60	2	s

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 bq20z80 recovers from overtemperature charge condition, if the *Temperature* is equal to or lower than the ***OT Chg Recovery*** level. On recovery the CHG FET returns to normal operating state, the *ChargingCurrent* and *ChargingVoltage* are set to appropriate value per charging algorithm, the *[OTA]* is reset and the *[OTC]* 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	1,200	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 bq20z80 sets the *[OTD]* in *SafetyAlert* if *Temperature* function value is equal to or higher than discharging overtemperature threshold (***Over Temp Dsg***).

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	1,200	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***, bq20z80 goes into overtemperature discharge condition. This function is disabled if ***OT Dsg Time*** is set to 0.

In discharging overtemperature condition, the *ChargingVoltage* and *ChargingCurrent* are set to 0, the *[OTA]* battery status is set, the *[OTD]* in *SafetyAlert* is reset and the *[OTD] SafetyStatus* is set. If *[OTFET]* bit is enabled, 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	60	2	s

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]
- SBS:SafetyAlert(0x50)[OTD]
- SBS:SafetyStatus(0x51)[OTD]
- SBS:OperationStatus(0x54)[XDSG]

C.2.3.6 OT Dsg Recovery (Offset 8)

The bq20z80 recovers from overtemperature discharge condition, if the *Temperature* function reports a temperature equal to or lower than the ***OT Dsg Recovery*** level. On recovery the DSG FET returns to normal operating state, the *ChargingCurrent* and *ChargingVoltage* are set to appropriate value per charging algorithm, the *[OTA]* is reset, the *[OTD] SafetyStatus* is reset and the *[XDSG]* 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	1,200	550	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]
- SBS:OperationStatus(0x54)[XDSG]

C.2.4 Host Comm (Subclass 3)

C.2.4.1 Host Watchdog Timeout (Offset 0)

The bq20z80 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]* & *[TDA]* in *BatteryStatus* are set, *[HWDG]* in *SafetyStatus* is set and *[XDSG]* in *OperationStatus* is set.

bq20z80 recovers if valid SMBus communication resumes. On recovery FETs returns to normal operating state, *ChargingVoltage* and *ChargingCurrent* are set to appropriate value per charging algorithm, *[TCA]* & *[TDA]* Battery status is cleared, *[HWDG]* in *SafetyStatus* is reset and *[XDSG]* in *SafetyStatus* 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	s

Related Variables:

- DF:1st Level Safety:Temperature(2):Over Temp Chg (0)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:BatteryStatus(0x16)[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 bq20z80 sets the *[SOV]* flag in *SafetyAlert* if the *Voltage* function 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	20,000	18,000	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] SafetyAlert* time period exceeds the *SOV Time* limit,the bq20z80 goes into safety overvoltage condition, *[SOV]* alarm is cleared and if *[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	30	0	s

Related Variables:

- DF:2nd Level Safety:Voltage(16):SOV Threshold(0)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(6)[XSOV]
- SBS:Voltage(0x09)
- SBS:PFAlert(0x52)[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 bq20z80 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 bq20z80 starts cell imbalance measurements. The bq20z80 sets the *[CIM]* in *PFAlert* if the bq20z80 measures a difference between any *CellVoltage4..1* are 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	5,000	1,000	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] SafetyAlert* time period exceeds the ***Cell mbalance Time*** limit, bq20z80 goes into cell imbalance condition, *[CIM]* alert is cleared and if ***[XCIM]*** in permanent fail configuration 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	30	0	s

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:1st Level Safety:Temperature(2):Over Temp Chg (0)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(6)[XSOV]
- SBS:PFAlert(0x52)[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 bq20z80 starts detecting cell imbalance. Set to 0 to disable cell imbalance detection.

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	65,535	1,800	s

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 PFIN Detect Time (Offset 9)

If $\overline{\text{PFIN}}$ pin logic low, *[PFIN]* in *PFAlert* is set. If the *[PFIN]* PF alert time period exceeds PFIN detect time, *[PFIN]* alert is reset and if ***[XPFIN]*** in permanent fail configuration is set, the SAFE pin is also driven high. This function is disabled if ***PFIN Detect Time*** is set to 0.

Table C-45. PFIN Detect Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	9	PFIN Detect Time	Unsigned integer	1	0	30	0	s

Related Variables:

- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(6)[XPFIN]
- SBS:PFAlert(0x52)[PFIN]

C.3.2 Current (Subclass 17)

C.3.2.1 SOC Chg (Offset 0)

The bq20z80 sets the *[SOCC]* in *SafetyAlert* if *Current* is equal to or higher than the ***SOC Chg*** threshold.

Table C-46. 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	30,000	10,000	mA	

Related Variables:

- DF:2nd Level Safety:Current(17):SOC Chg Time(2)
- DF:Configuration:Registers(Subclass 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 *SafetyAlert* time period exceeds the ***SOC Chg Time***, bq20z80 goes into SOCC condition, *[SOCC]* alert is cleared and if ***[XSOCC]*** in permanent fail configuration is set, the SAFE pin is driven high. This function is disabled if ***SOC Chg Time*** is set to 0.

Table C-47. 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	30	0	s	

Related Variables:

- DF:2nd Level Safety:Voltage(16):SOV Threshold(0)
- DF:Configuration:Registers(Subclass 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 bq20z80 sets the *[SOCD] SafetyAlert* if discharge *Current* is equal to or higher than the ***(–)SOC Dsg*** threshold.

Table C-48. 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	30,000	10,000	mA

Related Variables:

- DF:2nd Level Safety:Current(17):SOC Chg Time(2)
- DF:Configuration:Registers(Subclass 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] SafetyAlert* time period exceeds safety overcurrent charge time, bq20z80 goes into SOCD condition, *[SOCD]* alert is cleared and if *[XSOCD]* bit in permanent fail configuration is set, the SAFE pin is driven high. This function is disabled if ***SOCD Dsg Time*** is set to 0.

Table C-49. 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	30	0	s

Related Variables:

- DF:2nd Level Safety:Voltage(16):SOC Dsg(3)
- DF:Configuration:Registers(Subclass 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 bq20z80 sets the *[SOTC] SafetyAlert* if *Temperature* is equal to or higher than the ***SOT Chg*** threshold during charging (***[DSG]*** = 0).

Table C-50. 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	1,200	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]* in *SafetyAlert* time period exceeds safety overtemperature charging time, bq20z80 goes into SOTC condition, *[SOTC]* alert is cleared and if ***[XSOTC]*** in permanent fail configuration is set, the SAFE pin is driven high. This function is disabled if *SOT Chg Time* is set to 0.

Table C-51. 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	30	0	s

Related Variables:

- DF:2nd Level Safety:Temperature(18):SOT Chg(0)
- DF:Configuration:Registers(Subclass 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 bq20z80 sets the *SOTD SafetyAlert* if the temperature is equal to or higher than the *SOT Dsg* threshold during discharging (*[DSG]* = 1).

Table C-52. 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	1,200	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 *SafetyAlert* time period exceeds ***SOT DSG Time***, bq20z80 goes into *[SOTD]* condition, *[SOTD]* alert is reset and if ***[XSOTD]*** in permanent fail configuration is set, the SAFE pin is driven high. This function is disabled if ***SOT Dsg Time*** is set to 0.

Table C-53. 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	30	0	s

Related Variables:

- DF:2nd Level Safety:Temperature(18):SOT Dsg(3)
- DF:Configuration:Registers(Subclass 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 bq20z80 sets the *[SOPT]* flag in *SafetyAlert* if thermistor *Temperature* is equal to or lower than the ***Open Thermistor*** threshold.

Table C-54. 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	–1,000	1,200	–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 *SafetyAlert* time period exceeds ***Open Time*** period, bq20z80 goes into *[SOPT]* condition, *[SOPT]* alert is reset, and if ***[XSOPT]*** in permanent fail configuration is set, the SAFE pin is driven high. This function is disabled if ***Open Time*** is set to 0.

Table C-55. Open Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	7	Open Time	Unsigned integer	1	0	30	0	s

Related Variables:

- DF:2nd Level Safety:Temperature(18):Open Thermistor(66)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(6)[XSOPT]
- SBS:Temperature(0x08)
- SBS:PFAlert(0x52)[SOPT]

C.3.4 FET Verification (Subclass 19)

C.3.4.1 FET Fail Limit (Offset 0)

The bq20z80 sets the *[CFETF] SafetyAlert* if bq20z80 tries to turn off CHG FET and charge *Current* is equal to or higher than the ***FET Fail Limit*** threshold.

The bq20z80 sets the *[DFETF] SafetyAlert* if bq20z80 tries to turn off DSG FET and the discharge *Current* is equal to or lower than the (–)***FET Fail Limit*** threshold.

Table C-56. 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]
- SBS:PFAlert(0x52)[DFETF]

C.3.4.2 FET Fail Time (Offset 2)

If the *[CFETF]* alert time period exceeds (–)***FET Fail Time*** the bq20z80 goes into *[CFETF]* condition, *[CFETF]* alert is reset and if ***[XCFETF]*** in permanent fail configuration 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 the FET fail time, bq20z80 goes into *[DFETF]* condition, *[DFETF]* alert is reset and if ***[XDFETF]*** in permanent fail configuration is set, the SAFE pin is driven high. This function is disabled if ***FET Fail Time*** is set to 0.

Table C-57. FET Fail Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
19	FET Verification	2	FET Fail Time	Unsigned integer	1	0	30	0	s

Related Variables:

- DF:2nd Level Safety:FET Verification(19):FET Fail Limit(0)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(6)[XCFETF]
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(6)[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 bq20z80 compares periodically with a period of AFE check time the certain RAM content and expected control bit states of bq29132A AFE with the values stored in DataFlash. If an error is detected, the internal AFE fail counter is incremented. Set to 0 to disable *[AFE_P]* faults

Table C-58. 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	s

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, bq20z80 reports *[AFE_C]* permanent failure and if *[XAFE_C]* in permanent fail configuration is set, the SAFE pin is driven high. This function is disabled if ***AFE Fail Limit*** is set to zero.

Table C-59. AFE Fail Limit

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
20	FET Verification	1	AFE Fail Limit	Unsigned integer	1	0	500	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(Subclass 64):Permanent Fail Cfg(6)[XAFE_P]
- SBS:AFEData(0x45)
- SBS:PFStatus(0x53)[AFE_P]

C.3.5.3 AFE Fail Recovery Time (Offset 2)

The bq20z80 decrements the internal AFE fail counter by one each AFE fail recovery time period to a minimum of zero.

Table C-60. AFE Fail Recovery Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
20	FET Verification	2	AFE Fail Recovery Time	Unsigned integer	1	0	255	20	s

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. If the compared values are different by more than ***AFE Init Limit***, the values are read again and the process repeats. If a good coomparison is not obtained within ***AFE Init Retry Limit*** attempts, an *[AFE_C]* permanent failure occurs.

Table C-61. AFE Init Retry Limit

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
20	FET 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 same value, after a full reset.

Table C-62. AFE Init Limit

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
20	FET 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 bq20z80 sets the *[FBF]* flag in *SafetyAlert* 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-63. Fuse Fail Limit

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
21	FET 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)
- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- SBS:Current(0x0a)
- SBS:PFAlert(0x52)[FBF]

C.3.6.2 Fuse Fail Time (Offset 2)

If the [FBF] in *SafetyAlert* time period exceeds fuse fail time, bq20z80 reports a FBF permanent error and *[FBF]* alert is reset. This function is disabled if set to 0.

Table C-64. Fuse Fail Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
21	FET Verification	2	Fuse Fail Time	Unsigned integer	1	0	30	0	s

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 *[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, CHG FET and ZVCHG FET (if used) are switched off and *[XCHG]* in *ChargingStatus* is set during charge inhibit mode.

Table C-65. 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	1,200	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 *[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, CHG FET and ZVCHG FET (if used) are switched off and *[XCHG]* charging status is set in charge inhibit mode.

Table C-66. 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	1,200	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]* charging status is cleared. If ***[NR]*** flag is cleared, fault condition can be cleared by removing and reinserting the battery pack.

Table C-67. 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 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 bq20z80 sets the *ChargingCurrent* to the ***Pre-charge Current*** value, when in the precharge mode.

Table C-68. Pre-chg Current

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
33	Pre-Chg Cfg	0	Pre-chg Current	Unsigned integer	2	0	2,000	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 bq20z80 enters the precharge mode and the *[PCHG]* flag in *ChargingStatus* is set. The bq20z80 leaves the precharge mode if *Temperature* rises above ***Pre-chg Temp*** + ***Temp Hys*** and all *CellVoltage4..1* are above ***Recovery Voltage*** level. On recovery *[PCHG]* status is cleared.

Table C-69. Pre-chg Temp

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
33	Pre-Chg Cfg	2	Pre-chg Temp	Signed integer	2	–400	1,200	120	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: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 bq20z80 enters the precharge mode and sets the *[PCHG]* in *ChargingStatus* if any *CellVoltage4..1* drops below the ***Pre-chg Voltage*** threshold.

Table C-70. Pre-chg Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
33	Pre-Chg Cfg	4	Pre-chg voltage	Unsigned integer	2	0	20,000	3,000	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 bq20z80 enters the fast charge mode from the precharge mode and sets *[FCHG]* 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-71. Recovery Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
33	Pre-Chg Cfg	6	Recovery Voltage	Unsigned integer	2	0	20,000	3,100	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 bq20z80 sets the *ChargingCurrent* to the ***Fast Charge Current*** value, when fast charge mode.

Table C-72. 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	10,000	4,000	mA

Related Variables:

- SBS:ChargingCurrent(0x14)
- SBS:ChargingStatus(0x55)[FCHG]

C.4.3.2 Charging Voltage (Offset 2)

The bq20z80 sets the *ChargingVoltage* to this limit in fast charge mode.

Table C-73. 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	20,000	16,800	mV

Related Variables:

- SBS:ChargingVoltage(0x15)
- SBS:ChargingStatus(0x55)[FCHG]

C.4.3.3 Over Charging Voltage (Offset 4)

This value has no function, see ***Over Charging Voltage*** in charging faults section.

Table C-74. Over Charging Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Fast Charge Cfg	4	Over Charging Voltage	Unsigned integer	2	0	2,000	500	mV

Related Variables:

- DF:Charge Control:Charging Faults(38):Over Charging Voltage(2)

C.4.3.4 Delta Temp (Offset 6)

Delta Temp defines the temperature range where the *ChargingCurrent* adjusted based on *Temperature*. The limits are ***Suspend High Temp*** –***Delta Temp*** and ***Suspend High Temp*** – (2 ×***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	6	Delta Temp	Signed integer	2	0	500	50	0.1°C

Related Variables:

- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(10)
- DF:Pre-Charge Cfg(33):Recovery Voltage(6)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingStatus(0x55)[PCHG]

C.4.3.5 Suspend Low Temp (Offset 8)

If the battery pack *Temperature* drops below ***Suspend Low Temp***, the *AverageCurrent* is above ***Chg Current Threshold*** threshold and bq20z80 is in charge mode (*[DSG]* = 0), the bq20z80 suspends charging. On suspend, *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 ***[CHGSUSP]*** bit is set. The bq20z80 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	8	Suspend Low Temp	Signed integer	2	–400	1,200	–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(10)
- 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)
- SBS:ChargingStatus(0x55)[CHGSUSP]

C.4.3.6 Suspend High Temp (Offset 10)

If battery pack *Temperature* rises above ***Suspend Temperature High***, the *AverageCurrent* is above the ***Chg Current Threshold*** and the bq20z80 is in charge mode (*[DSG]* = 0), the bq20z80 suspends charging. On suspend, *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 ***[CHGSUSP]*** bit is set. The bq20z80 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 Low Temp	Signed integer	2	–400	1,200	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 High Temp(10)
- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- SBS:Temperature(0x08)
- SBS:AverageCurrrent(0x0b)
- SBS:BatteryStatus(0x16)
- 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 ***Turn ON Voltage*** in pulse charge mode *[PULSE_OFF]* = 1 and the CHG FET is off for a least ***Min OFF Pulse Time***the bq20z80 turns on the CHG FET again, sets *[PULSE]* and resets *[PULSE_OFF]*.

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	5,000	4,150	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]
- SBS:ChargingStatus(0x55)[PULSEOFF]

C.4.4.2 Turn OFF Voltage (Offset 2)

If any cell voltage during charging is equal or is above ***Max OFF Voltage*** OR ***Turn OFF Voltage*** for ***Max On Pulse Time***, the bq20z80 enters pulse charge mode and sets *[PULSE]* or *[PULSE_OFF]* charging status.

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	5,000	4,250	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], [PULSEOFF]

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 s

Related Variables:

- DF:Charge Control:Pulse Charge Cfg(35):Turn OFF Voltage(2)
- SBS:ChargingStatus(0x55)[PULSE]
- SBS:ChargingStatus(0x55)[PULSEOFF]

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 s

Related Variables:

- DF:Charge Control:Pulse Charge Cfg(35):Turn ON Voltage(2)
- SBS:Charging Status(0x55)[PULSE], [PULSEOFF]

C.4.4.5 Max OFF Voltage (Offset 6)

The bq20z80 enters pulse charge mode and sets *[PULSE]* and *[PULSE_OFF]* charging status, if the maximum cell voltage is equal to or above ***Turn OFF Voltage***.

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	5,000	4,270	mV

Related Variables:

- DF:Charge Control:Pulse Charge Cfg(35):Turn OFF Voltage(2)
- SBS:Charging Status(0x55)[PULSE], [PULSEOFF]

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	1,000	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 or higher than ***Charging Voltage*** – ***Termination Voltage***, bq20z80 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	1,000	250	mA

Related Variables:

- DF:Charge Control:Termination Cfg(36):Current Taper Window(8)
- SBS:Current(0x0a)

C.4.5.3 Termination Voltage (Offset 6)

For valid primary charge termination pack *Voltage* must equal to or higher than ***Charging Voltage*** reduced by ***Termination Voltage***.

Table C-85. Termination Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
36	Termination Cfg	6	Termination Voltage	Unsigned integer	2	0	1,000	300	mV

Related Variables:

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(8)
- 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	60	40	s

Related Variables:

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(8)
- DF:Charge Control:Termination Cfg(36):Taper Current(2)
- DF:Charge Control:Termination Cfg(36):Termination Voltage(6)
- SBS:Current(0x0a)

C.4.5.5 TCA Set % (Offset 9)

If set between 0% and 100%, *[TCA]* battery status is set if *RelativeStateOfCharge* is equal to or above ***TCA Set %***. Set to –1 to disable this function. If set to –1, *[MCHG]* flag and *[TCA]* flag is 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)

If set between 0% and 100%, *[TCA]* battery status 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)

If set between 0% and 100%, *[FC]* battery status 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)

If set between 0% and 100%, *[FC]* battery status is cleared if *RelativeStateOfCharge* reaches or sinks below ***FC Clear %***. Set to –1% to disable this function. It is recommended 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(10)
- 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 balance time per mAh, before bq20z80 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	65,535	1,750	s/mAh

Related Variables:

- none

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 the sum of *ChargingVoltage* and ***Over Charging Voltage*** for a time period over ***Over Charging Volt Time***, *[OCHGV]* 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	3,000	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 *Voltage* is equal to or greater than the sum of *ChargingVoltage* and ***Over Charging Voltage*** for a time period over charging volt time, *[OCHGV]* is set and the CHG FETs and ZVCHG FET (if used) are turned off if *[OCHGV]* is also set in ***Charge Fault Cfg***. The bq20z80 recovers if *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	60	2	s

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 over ***Over Charging Curr Time***, bq20z80 goes into overcharging current error, *[OCHGI]* is set and the CHG FET and ZVCHG FET (if used) are turned off if *[OCHGI]* is also set in ***Charge Fault Cfg***.

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	2,000	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 over ***Over Charging Curr Time***, bq20z80 goes into overcharging error and *[OCHGI]* is set and the CHG FET and ZVCHG FET (if used) are turned off if *[OCHGI]* is also set in ***Charge Fault Cfg***. The bq20z80 recovers if *AverageCurrent* is equal to or smaller than the ***Over Charging Current 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	2	0	60	2	s

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 bq20z80 recovers from over charging current fault if *AverageCurrent* is equal to or smaller than ***Over Charging Curr Recov***. On recovery *[OCHGI]* is reset and CHG FET returns to previous state.

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 Current	Unsigned integer	2	0	2,000	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 bq20z80 goes into depleted voltage fault and sets *[XCHGLV]*, if charger is present (*PackVoltage* > ***Charger Present***) and pack *Voltage* is equal to or lower than ***Depleted Voltage*** for a period equal to or greater ***Depleted Voltage Time***. The DSG FET is also turned off and CHG FET and ZVCHG FET are set according to *[ZVCHG1], [ZVCHG0]* bits if *[XCHLFV]* 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	16,000	8,000	mV

Related Variables:

- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[XCHFLV]
- DF:Power:Power(68):Charger Present(5)
- SBS:Voltage(0x09)

- SBS:PackVoltage(0x5a)
- SBS:ChargingStatus(0x55)[XCHGLV]

C.4.7.7 Depleted Voltage Time(Offset 10)

The bq20z80 goes into depleted voltage error and sets *[XCHGLV]*, if charger is present and pack *Voltage* is equal to or lower than ***Depleted Voltage*** for a period equal to or greater ***Depleted Voltage Time***. If ***[XCHLFV]*** is set in ***Charge Fault Cfg*** the DSG FET is also turned off if and CHG FET and ZVCHG FET are set according to precharge 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	60	2	s

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)[XCHGLV]
- SBS:Voltage(0x09)
- SBS:ChargingStatus(0x55)[XCHGLV]

C.4.7.8 Depleted Recovery (Offset 11)

The bq20z80 recovers from depleted voltage error 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 ZCHHG FET return to previous state.

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	16,000	8,500	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 bq20z80 goes into overcharge error and sets *[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 ***[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	4,000	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 bq20z80 recovers from over charge in non removable battery mode (***[NR]*** = 1), if it is continously 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):OperationB Cfg(2)[NR]
- SBS:FullChargeCapacity(0x10)
- SBS:RemainingCapacity(0x0f)
- SBS:ChargingStatus(0x55)[OC]

C.4.7.11 FC-MTO (Offset 17)

If charge current is equal to or greater than charge current threshold for ***FC-MTO*** time period, the bq20z80 generates a fast charge mode time out fault and sets *[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	65,535	10,800	s

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, bq20z80 generates a precharge mode time out error and sets *[PCMTO]* flag. The CHG FET and ZVCHG FET (if used) are also turned of if *[PCTMO]* 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	65,535	3,600	s

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 registers sets the behavior of the charge, discharge FETs in fault condition.

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	0xff	0x00	

7	6	5	4	3	2	1	0
RSVD	RSVD	PCMTO	FCMTO	OCHGV	OCHGI	OC	XCHGLV
R	R	R/W	R/W	R/W	R/W	R/W	R/W

LEGEND: R/W = read/write; R = read-only; RSVD = reserved and **must** be programmed to 0.

Figure C-4. Charge Fault Cfg Register

PCMTO — If set, CHG FET and ZVCHG FET (if used) are turned off when a precharge time-out fault occurs.

FCMTO — If set, CHG FET and ZVCHG FET (if used) are is 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 and ZVCHG FET (if used) are turned off when charge current fault occurs.

OC — If set, CHG FET and ZVCHG FET (if used) are turned off when overcharge fault occurs.

XCHFLV — 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)

The default value of *RemainingCapacityAlarm* is stored in this variable and copied to the SBS value on bq20z80 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-V110 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	1,000	432	10 mWh

Related Variables:

- SBS:RemainingCapacityAlarm(0x01)

C.5.1.3 Rem Time Alarm (Offset 4)

The default value of *RemainingTimeAlarm* is stored in this variable and copied to the SBS value on bq20z80 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 this variable and copied to the SBS value on bq20z80 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 this variable and copied to the SBS value on bq20z80 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	7,000	18,000	14,400	mV

Related Variables:

- SBS:DesignVoltage(0x19)

C.5.1.6 Spec Info (Offset 10)

The default value of *SpecificationInfo* is stored in this variable and copied to the SBS value on bq20z80 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 this variable and copied to the SBS value on bq20z80 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(1)	Unsigned integer	2	0	65,535	0	

(1) 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 this variable and copied to the SBS value on bq20z80 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 this variable and copied to the SBS value on bq20z80 initialization. When SBS value changes this value 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	65,535	0	

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 *[CCT]* bit is cleared, the cycle count function counts the accumulated discharge of ***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	32,767	4,400	mAh

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg B(2)[CCT]
- SBS:CycleCount(0x17)

C.5.1.11 CC % (Offset 20)

If *[CCT]* bit is set, the cycle count function counts the accumulated discharge of (*FullChargeCapacity* ×***CC %***) as one cycle. If (*FullChargeCapacity* ×***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 this limit, *CONDITION_FLAG* 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)[CONDITION_FLAG]
- SBS:MaxError(0x0c)

C.5.1.13 Design Capacity (Offset 22)

If *CAPACITY_MODE* is set to 0, the *DesignCapacity* function reports this value.

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	65,535	4,400	mAh

Related Variables:

- DF:Gas Gauging:IT Config(80):Load Select(0)
- SBS:BatteryMode(0x03)[CAPACITY_MODE]
- SBS:DesignCapacity(0x18)
- SBS:StateOfHealth(0x4f)

C.5.1.14 Design Energy (Offset 24)

If *CAPACITY_MODE* is set to 1, this value the design capacity function reports this value.

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	65,535	6,336	10mWh

- DF:Gas Gauging:IT Config(80):Load Select(0)
- SBS:BatteryMode(0x03)[CAPACITY_MODE]
- SBS:DesignCapacity(0x18)
- SBS:StateOfHealth(0x4f)

C.5.1.15 Manuf Name (Offset 26)

The *ManufacturerName* function returns a string stored in this value. 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 this value. 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			bq20z80	ASCII

Related Variables:

- SBS:DeviceName(0x21)

C.5.1.17 Device Chemistry (Offset 46)

The *DeviceChemistry* function returns a string stored in this value. 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%, bq20z80 sets *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below below this value. 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%, bq20z80 clears *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above this value. 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%, bq20z80 sets *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below this value. 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%, bq20z80 clears *[FD]*

flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above this value. 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)[TDA]

C.5.2.5 TDA Set Volt Threshold (Offset 4)

bq20z80 sets *[TDA]* flag in *BatteryStatus* if *Voltage* is equal to or lower than this value 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	16,800	5,000	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 bq20z80 sets *[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 Voltage 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	60	5	s

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)

bq20z80 clears *[TDA]* if *Voltage* is equal to or above than this value. ***TDA Clear Volt*** clears *[TDA]* only if *[TDA]* is set by ***TDA Set Volt Threshold***. It does not clear *[TDA]* if *[TDA]* is set by ***TDA Set %*** or any other functions.

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	16,800	5,500	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)

bq20z80 sets *[FD]* flag if *Voltage* is equal to or lower than this value for a period equal to or greater than ***FD Set 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	16,800	5,000	mV

Related Variables:

- DF:SBS Configuration:Configuration(49):FD Set Volt Time(11)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[FD]

C.5.2.9 FD Set Volt Time (Offset 11)

bq20z80 sets *[FD]* if *Voltage* is equal to or lower than this value for a period equal to or greater than ***FD Set Volt Time***. Set to 0 to disable this feature.

Table C-130. FD Set Volt Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	11	FD Set Volt Time	Unsigned integer	1	0	60	5	s

Related Variables:

- DF:SBS Configuration:Configuration(49):TDA Set Volt Threshold(4)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[FD]

C.5.2.10 FD Clear Volt (Offset 12)

bq20z80 clears *[FD]* if pack voltage is equal to or above than this value.

Table C-131. TDA 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	16,800	5,500	mV

Related Variables:

- DF:SBS Configuration:Configuration(49):TDA Set Volt Time(6)
- 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 this value as part of its return.

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	0	

Related Variables:

- SBS:ManufacturerData(0x23)

C.6.1.2 PCB Lot Code (Offset 2)

The *ManufacturerData* function reports this value as part of its return.

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	0	

Related Variables:

- SBS:ManufacturerData(0x23)

C.6.1.3 Firmware Version (Offset 4)

The *ManufacturerData* function reports this value as part of its return.

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	0	

Related Variables:

- SBS:ManufacturerData(0x23)

C.6.1.4 Hardware Revision (Offset 6)

The *ManufacturerData* function reports this value as part of its return.

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	0	

Related Variables:

- SBS:ManufacturerData(0x23)

C.6.1.5 Cell Revision (Offset 8)

The *ManufacturerData* function reports this value as part of its return.

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	0	

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 this variable. The maximum text length is 8 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	8 + 1	12345678	ASCII		

Related Variables:

- SBS:ManufacturerInfo(0x70)

C.6.3 Lifetime Data (Subclass 59)

C.6.3.1 Lifetime Max Temp (Offset 0)

If *[QEN]* flag is set, this DataFlash 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 *[QEN]* flag is set, this DataFlash value 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	1,400	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 *[QEN]* flag is set, this DataFlash value 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*** for a period 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	–32,768	32,767	3,500	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 *[QEN]* flag is set, this DataFlash value 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	–32,768	32,767	3,200	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 *[QEN]* flag is set, this DataFlash value 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	–32,768	32,767	14,000	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 *[QEN]* flag is set, this DataFlash value 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	–32,768	32,767	14,000	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 *[QEN]* flag is set, this DataFlash value is updated if one of the following conditions are met:

- internal averaged charge current – ***Lifetime Max Chg Current*** > 100 mA
- internal averaged charge current > ***Lifetime Max Chg Current*** for a period > 60 seconds
- internal averaged 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	–32,768	32,767	1,500	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 *[QEN]* flag is set, this DataFlash value is updated if one of the following conditions are met:

- ***Lifetime Max Dsg Current*** – internal averaged discharge current < –100 mA
- ***Lifetime Max Dsg Current*** > internal averaged discharge current for a period > 60 seconds
- ***Lifetime Max Dsg Current*** > internal averaged 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	–32,768	32,767	–3,000	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 *[QEN]* flag is set, this DataFlash value is updated if one of the following conditions are met:

- (Internal measured voltage × internal measured current) – ***Lifetime Max Chg Power*** > 1,000 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	–32,768	32,767	1,500	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 *[QEN]* flag is set, this DataFlash value is updated if one of the following conditions is 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	–32,768	32,767	–1,500	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 Lifetime Max AvgDsg Cur (Offset 22)

If *[QEN]* flag is set, this DataFlash value 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*** > nternally measured average discharge current AND any other lifetime value is updated.

Table C-148. Lifetime Max AvgDsg Current

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	–32,768	32,767	–1,000	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 Lifetime Max AvgDsg Power (Offset 26)

If *[QEN]* flag is set, this DataFlash value is updated if one of the following conditions are met:

- ***Lifetime Max AvgDsg Power*** – averaged (internal measured voltage × internal measured current) > 1,000 mW
- ***Lifetime Max AvgDsg Power*** > averaged (internal measured voltage × internal measured current) for a period > 60 seconds
- ***Lifetime Max AvgDsg Power*** > averaged (internal measured voltage × internal measured current) AND any other lifetime value is updated.

Table C-149. Lifetime Max Dsg Power

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	26	Lifetime Max AvgDsg Power	Signed integer	2	–32,768	32,767	–1,500	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 *[QEN]* flag is set, this DataFlash value is updated if one of the following conditions are met:

- 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	1,400	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 ***Lifetime Avg Temp*** calculation. Multiply this value by 225 s to get the total time 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	140,000,000	0	

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 enable, disable or configures various features of bq20z80

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	0xffff	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-5. 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 *[RCA]* battery status bit is set.

0 = LED display is not activated when *[RCA]*flag in *BatteryStatus* is set. (default)

1 = if 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 LED display while charging.

0 = Display not activated by charging, requires pushbutton event or SMBus command. (default)

1 = Display active during charging.

DMODE — This bit sets the display to show relative state of charge or absolute state of charge.

0 = Display reflects relative state of charge (default)

1 = Display reflects absolute state of charge

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 bq20z80 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 bq20z80 to enter Sleep mode if SMBus lines are low.

0 = bq20z80 never enters Sleep mode

1 = bq20z80 enters Sleep mode under normal Sleep entry criteria (default)

Related Variables:

SBS:ManufacterAccess(0x00):Sleep(0x0011)

TEMP1, TEMP0 — These bits configures 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 bq20z80 display to be used in serial or parallel mode. 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 ZVCHG or CHG FET in Zero-Volt/Precharge modes.

0,0 = ZVCHG

0,1 = CHG (default)

1,0 = OD of bq29312A

1,1 = No Action

C.7.1.2 Operation Cfg B (Offset 2)

This register enable, disable or configures various features of bq20z80

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	PFD1	PFD0	RESCAP	NCSMB	NRCHG	CSYNC	CHGTERM	CCT
Low Byte	CHGSUSP	OTFET	CHGFET	CHGIN	NR	CPE	HPE	BCAST

Figure C-6. Operation Cfg B

PFD1, PFD0 — Configure the Permanent Failure LED display. Function is disabled if *[SLED]* 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(0)

DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(0)

NCSMB — Enables extended SMBUS $t_{TIMEOUT}$

0 = Normal SMBUS $t_{TIMEOUT}$ (default)

1 = Extended SMBUS $t_{TIMEOUT}$

NRCHG — Enables the CHG FET to remain on during sleep when bq20z80 is in non removable battery mode.

0 = CHG FET turns off in Sleep Mode if ***[NR]*** bit is set (default)

1 = CHG FET remains on in Sleep Mode if ***[NR]*** bit is set

Related Variables:

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

CSYNC — Enables the bq20z80 to write *RemainingCapacity* to equal *FullChargeCapacity* when a valid charge termination is detected.

0 = *RemainingCapacity* is not modified on valid primary charge termination

1 = *RemainingCapacity* is written up to equal *FullChargeCapacity* on valid primary charge termination. (default)

Related Variables:

SBS:RemainingCapacity(0x0f)

SBS:FullChargeCapacity(0x10)

CHGTERM — This bit enables or disables *[TCA], [FC]* flag in *BatteryStatus* to be cleared after charger termination confirmed.

0 = *[TCA], [FC]* are not cleared by primary charge termination confirmation, but are cleared by other means. (default)

1 = *[TCA], [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 of increasing *Cycle Count*.

0 = bq20z80 uses ***CC Threshold*** value. (default)

1 = bq20z80 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 %(20)

SBS:FullChargeCapacity(0x10)

CHGSUSP — This bit enables bq20z80 to turn off CHG FET (and ZVCHG FET) when in charge suspend mode.

0 = No FET change in Charge Suspend mode. (default)

1 = CHG FET and ZVCHG FET (if used) turns 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 *[OTC]* flag is set then the CHG FET is turned off and when *[OTD]* flag is set then the DSG FET is turned off. (default)

Related Variables:

SBS:SafetyStatus(0x16)[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]* set). (default)

1 = CHG FET turns off at charge termination.

Related Variables:

SBS:SafetyStatus(0x16)[TCA]

CHGIN — This bit enable the CHG FET and ZVCHG FET (if used) to turn off when the bq20z80 is in charge-inhibit mode.

0 = No FET change in charge-inhibit mode. (default)

1 = Charge and ZVCHG, if used, turn off in charge-inhibit mode.

Related Variables:

SBS:ChargingStatus(0x55)[XCHG]

NR — This bit configures the bq20z80 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 SBS-compliant 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 battery host for master-mode alarm messages.

0 = No PEC byte on alarm warning to host (default)

1 = PEC byte on alarm warning to host

BCAST — This bit enables or disables SBS broadcasts to SBS-compliant 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 determines the method in which *RelativeStateOfCharge* is updated to 100% when charging is complete.

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	0x0001	0x0000	

Related Variables:

- SBS:RelativeStateOfCharge(0x0d)

	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	RSVD	PRE_ZT_PF_En	RSVD

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

Figure C-7. Operation Cfg C

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.

1 = All PFs are allowed regardless of whether Impedance Tracking has been enabled or not.

Related Variables:

- SBS:Voltage(0x09)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- 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)

C.7.1.4 Permanent Fail Cfg (Offset 6)

The Permanent Failure Configuration register enables or disables the use of the SAFE pin or $\overline{\text{SAFE}}$ pin when the corresponding permanent fail error occurs and the corresponding bit is set in ***Permanent Fail Cfg***. If the SAFE pin is driven low and the $\overline{\text{SAFE}}$ pin is driven high, the ***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	4	Permanent Fail Cfg	Hex	2	0x0000	0xffff	0x0000	

Related Variables:

- DF:PF Status:Device Status Data(96):PF Flags1(0)
- DF:PF Status:DeviceStatusData(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-8. Permanent Fail Cfg

XPFVSHUT — If bit is set AND any permanent failure happens AND the bq20z80 goes into shutdown, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[PFVSHUT]

XSOPT — If bit is set AND open thermistor failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOPT]

XSOCD — If bit is set AND discharge safety overcurrent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOCD]

XSOCC — If bit is set AND charge safety overcurrent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOCC]

XSOCD — If bit is set AND discharge safety overcurrent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOCD]

XAFE_P — If bit is set AND periodic AFE-communications permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[AFE_P]

XAFE_C — If bit is set AND AFE-communications permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[AFE_C]

XDFF — If bit is set AND DataFlash fault permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[DFF]

XDFETF — If bit is set AND discharge FET permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[DFETF]

XCFETF — If bit is set AND CHG FET permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[CFETF]

XCIM — If bit is set AND cell imbalance permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[CIM]

XSOTD — If bit is set AND discharge overtemperature permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOTD]

XSOTC — If bit is set AND charge overtemperature permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOTC]

XSOV — If bit is set AND safety overvoltage permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[SOV]

XPFIN — If bit is set AND external input indication permanent failure occurs, the SAFE pin is set to high.

DF:PF Status:Device Status Data(96):PF Flags1(0)[PFIN]

C.7.1.5 Non-Removable Cfg (Offset 8)

If bq20z80 is in removable battery mode (***[NR]*** = 0), these bits sets the recovery method from first-level security errors. If corresponding bit is set,If bit is set, it gives an additional ***[NR]*** = 1 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	0xffff	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-9. Non-Removable Cfg

OCD— Overcurrent in Discharge

OCC— Overcurrent in Charge

OCD2— Overcurrent in Discharge – Tier 2

OCC2— Overcurrent in Charge – Tier 2

OC— Overcharge

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 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	65,535	512	500 µs

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 at 50% duty cycle for 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	65,535	1,024	500 µs

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	65,535	100	500 µs

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. The maximum value that ***LED Hold Time*** should be se to is 16s.

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	16	4	s

Related Variables:

- DF:LED Support:LED Cfg(67):LED Delay(4)

C.8.1.5 CHG Flash Alarm (Offset 7)

If bq20z80 is in charge mode (*[DSG]* = 0) and battery charge is below this threshold, 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 bq20z80 is in charge mode (*[DSG]* = 0) and 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 bq20z80 is in charge mode (*[DSG]* = 0) and 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 bq20z80 is in charge mode (*[DSG]* = 0) and 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 bq20z80 is in charge mode (*[DSG]* = 0) and 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 bq20z80 is in charge mode (*[DSG]* = 0) and 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 bq20z80 is in discharge mode (*[DSG]* = 1) and battery charge is below this threshold, remaining enabled LEDs starts flashing with ***LED Flash Rate***, if activated.

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	CHG Flash Alarm	Signed integer	1	–1	101	10	%

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE]
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:BatteryStatus(0x16)[DSG]

C.8.1.12 DSG Thresh 1 (Offset 14)

If bq20z80 is in discharge mode (*[DSG]* = 1) and 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 bq20z80 is in discharge mode (*[DSG]* = 1) and 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	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.8.1.14 DSG Thresh 3 (Offset 16)

If bq20z80 is in discharge mode (*[DSG]* = 1) and 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	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.8.1.15 DSG Thresh 4 (Offset 17)

If bq20z80 is in discharge mode (*[DSG]* = 1) and 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	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.8.1.16 DSG Thresh 5 (Offset 18)

If bq20z80 is in discharge mode (*[DSG]* = 1) and 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	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.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 flash update. If battery pack *Voltage* is below this threshold, no flash update is made.

Table C-173. 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	6,000	20,000	7,500	mV

Related Variables:

- DF:Power:Power(68):Charger Present(5)
- SBS:Voltage(0x09)

C.9.1.2 Shutdown Voltage (Offset 2)

The bq20z80 goes into shutdown mode if battery *Voltage* is equal to or less than ***Shutdown Voltage*** for ***Shutdown Time*** period and has been out of shutdown mode at least for ***Shutdown Time*** period.

Table C-174. 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	5,000	20,000	7,000	mV

Related Variables:

- DF:1st Level Safety:Voltage(0):PUV Threshold(17)
- DF:1st Level Safety:Voltage(0):PUV Time(19)
- DF:Power:Power(68):Shutdown Time(4)
- SBS:Voltage(0x09)
- SBS:PFAlert(0x52)[PFVSHUT]

C.9.1.3 Shutdown Time (Offset 4)

The bq20z80 goes into shutdown mode if battery *Voltage* is equal to or less than ***Shutdown Voltage*** for ***Shutdown Time*** period and has been out of shutdown mode at least for ***Shutdown Time*** period. The *[PFVSHUT]* flag indicates if condition for shutdown is met.

PUV Time should be set at least 1s more than ***Shutdown Time*** to ensure correct function of the shutdown mode of bq20z80.

Table C-175. 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	60	10	s

Related Variables:

- DF:1st Level Safety:Voltage(0):PUV Threshold(17)
- DF:1st Level Safety:Voltage(0):PUV Time(19)
- DF:Power:Power(68):Shutdown Voltage(2)
- SBS:Voltage(0x09)
- SBS:PFAlert(0x52)[PFVSHUT]

C.9.1.4 Charger Present (Offset 5)

The bq20z80 detects a charger when the voltage at PACK pin of bq29312A is above this threshold.

Table C-176. Charger Present

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	5	Charger Present	Unsigned integer	2	0	23,000	3,000	mV

Related Variables:

- DF:Power:Power(68):Flash Update OK Voltage(0)
- SBS:PackVoltage(0x5a)

C.9.1.5 Sleep Current (Offset 7)

The bq20z80 is allowed to go into sleep mode if charge or discharge current is below this threshold. Sleep Mode can be enabled with the ***[SLEEP]*** bit. If the absolute value of *Current* is above this value, the bq20z80 returns to normal mode.

Table C-177. Sleep Current

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	7	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(9)
- SBS:ManufacturerAccess(0x00):Sleep(0x0011)
- SBS:Current(0x0a)

C.9.1.6 Bus Low Time (Offset 9)

The bq20z80 is allowed to go into sleep mode if sleep mode is enabled with the ***[SLEEP]*** bit if SMBus is low for a period greater than this value.

Table C-178. Bus low Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	9	Bus Low Time	Unsigned integer	1	0	255	5	s

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Power:Power(68):Sleep Current(7)

C.9.1.7 Cal Inhibit Temp Low (Offset 10)

The bq20z80 does not perform autocalibration on entry to sleep mode, if *Temperature* is below ***Cal Inhibit Temp Low*** or above ***Cal Inhibit Temp High***.

Table C-179. Cal Inhibit Temp Low

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	10	Cal Inhibit Temp Low	Signed integer	2	–400	1,200	50	0.1°C

Related Variables:

- DF:Power:Power(68):Cal Inhibit Temp High(12)
- SBS:Temperature(0x08)

C.9.1.8 Cal Inhibit Temp High (Offset 12)

The bq20z80 does not perform autocalibration on entry to sleep mode, if *Temperature* is below ***Cal Inhibit Temp Low*** or above ***Cal Inhibit Temp High***

Table C-180. Cal Inhibit Temp High

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	12	Cal Inhibit Temp High	Signed integer	2	–400	1,200	450	0.1°C

Related Variables:

- DF:Power:Power(68):Cal Inhibit Temp Low(10)
- SBS:Temperature(0x08)

C.9.1.9 Sleep Voltage Time (Offset 14)

During sleep mode, temperature and voltages are measured in ***Sleep Voltage Time*** intervals.

Table C-181. Sleep Voltage Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	14	Sleep Voltage Time	Unsigned integer	1	0	100	5	s

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.9.1.10 Sleep Current Time (Offset 15)

During sleep mode, current is measured in ***Sleep Current Time*** intervals.

Table C-182. Sleep Current Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	15	Sleep Current Time	Unsigned integer	1	0	255	20	s

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 remaining capacity 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* ×*Voltage*
3 =	*AverageCurrent* (default)	*AverageCurrent* × average *Voltage*
4 =	***Design Capacity*** / 5	***Design Energy*** / 5
5 =	*AtRate* (mA)	*AtRate* (10 mW)
6 =	***User Rate-mA***	***User Rate-10mWh***

Table C-183. 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 Config(80):Load Mode(1)
- DF:Gas Gauging:IT Config(80):User Rate-mA(60)
- DF:Gas Gauging:IT Config(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)[CAPACITY_MODE]
- SBS:AtRate(0x04)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)

C.10.1.2 Load Mode (Offset 1)

This value defines the load mode used used by the Impedance Track™ algorithm for remaining capacity calculation.

0 = Constant Current (default)

1 = Constant Power

Table C-184. 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 Config(80):Load Select(0)

C.10.1.3 Term Voltage (Offset 45)

This value is the absolute minimum pack voltage used by the Impedance Track™ algorithm for capacity calculation and should also set to the absolute minimum pack voltage used by application. The reserve capacity function also reserves charge where zero RemainingCapacity is reported and the ***Term Voltage*** is reached.

Table C-185. 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	–32,768	32,767	12,000	mV

Related Variables:

- DF:Gas Gauging:IT Config(80):Reserve Cap-mAh(64)
- DF:Gas Gauging:IT Config(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 remaining capacity calculation if selected by ***Load Select***.

Table C-186. 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	–9,000	–2,000	0	mA

Related Variables:

- DF:Gas Gauging:IT Config(80):Load Select(0)
- DF:Gas Gauging:IT Config(80):Load Mode(1)

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 remaining capacity calculation if selected by ***Load Select***.

Table C-187. 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	–14,000	–3,000	0	10 mW

Related Variables:

- DF:Gas Gauging:IT Config(80):Load Select(0)
- DF:Gas Gauging:IT Config(80):Load Mode(1)

C.10.1.6 Reserve Cap-mAh (Offset 64)

This value reserves a amount of charge in mAh (***CAPACITY_MODE*** = 0) for the system to react if the *RemainingCapacity* reports zero energy remains in the battery. The ***Reserve Cap-mAh*** reserves a amount of charge between the final ***Term Voltage*** is reached and the *RemainingCapacity* reports 0 energy. The *FullChargeCapacity* function reports the internally full-charge capacity reduced by ***Reserve Cap-mAh***.

Table C-188. 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	9,000	0	mAh

Related Variables:

- DF:Gas Gauging:IT Config(80):Load Mode(1)
- DF:Gas Gauging:IT Config(80):Term Voltage(45)
- DF:Configuration:Registers(64):Operation Cfg B(2)[RESCAP]
- SBS:BatteryMode(0x03):[CAPACITY_MODE]
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)

C.10.1.7 Reserve Cap-mWh (Offset 66)

This value reserves a amount of charge in 10 mWh (***CAPACITY_MODE*** = 1) for the system to react if the *RemainingCapacity* reports zero energy remains in the battery. The ***Reserve Cap-mWh*** reserves a amount of charge between the final ***Term Voltage*** is reached and the *RemainingCapacity* reports 0 energy. The *FullChargeCapacity* function reports the internally full-charge capacity reduced by ***Reserve Cap-mAh***.

Table C-189. 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	14,000	0	10 mWh

Related Variables:

- DF:Gas Gauging:IT Config(80):Load Mode(1)
- DF:Gas Gauging:IT Config(80):Term Voltage(45)
- DF:Configuration:Registers(64):Operation Cfg B(2)[RESCAP]
- SBS:BatteryMode(0x03):[CAPACITY_MODE]
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)

C.10.2 Current Thresholds (Offset 81)

C.10.2.1 Dsg Current Threshold (Offset 0)

bq20z80 enters discharge mode from relaxation mode or charge mode if *Current* < (–)***Dsg Current Threshold***

Table C-190. Dsg Current Threshold

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	IT Cfg	0	Dsg Current Threshold	Unsigned integer	2	0	2,000	100	mA

Related Variables:

- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

C.10.2.2 Chg Current Threshold (Offset 2)

bq20z80 enters charge mode from relaxation mode or discharge mode if *Current* > ***Chg Current Threshold***.

Table C-191. Chg Current Threshold

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	IT Cfg	2	Chg Current Threshold	Unsigned integer	2	0	2,000	50	mA

Related Variables:

- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

C.10.2.3 Quit Current (Offset 4)

The bq20z80 enters relaxation mode from charge mode if *Current* goes below ***Quit Current*** for ***Chg Relax Time***. The bq20z80 also enters relaxation mode from discharge mode if *Current* goes above (–)***Quit Current*** for ***Dsg Relax Time***.

Table C-192. Quit Current

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	IT Cfg	4	Quit Current	Unsigned integer	2	0	1,000	10	mA

Related Variables:

- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]

C.10.2.4 Dsg Relax Time (Offset 6)

bq20z80 enters relaxation mode from discharge mode if *Current* goes above (–)***Quit Current*** for at least ***Dsg Relax Time***.

Table C-193. Dsg Relax Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	IT Cfg	6	Dsg Relax Time	Unsigned integer	1	0	255	1	s

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)

bq20z80 enters relaxation mode from charge mode if *Current* goes below ***Quit Current*** for at least ***Chg Relax Time***

Table C-194. Chg Relax Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	IT Cfg	6	Chg Relax Time	Unsigned integer	1	0	255	60	s

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)

This value defines the maximum chemical capacity for all cells used for capacity calculation. The value should be taken directly from battery cell datasheet.

Table C-195. 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	65,535	4,400	mAh
		2	Qmax Cell 1		2	0	65,535	4,400	mAh
		4	Qmax Cell 2		2	0	65,535	4,400	mAh
		6	Qmax Cell 3		2	0	65,535	4,400	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. Usually get set to the smallest value of ***QMax Cell 0*** .. ***QMax Cell 0***.

Table C-196. 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	65,535	4,400	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 *ManufactureAccess* to enable or disable 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-197. 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	2	0x00	0x06	0	

Related Variables:

- SBS:ManufactureAccess(0x00):IT Enable(0x0021)

C.10.3.4 Avg I Last Run (Offset 21)

The bq20z80 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 remaining capacity calculation. It is not recommended to change this value.

Table C-198. 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	–32,768	32,767	–2,000	mA

Related Variables:

- DF:Gas Gauging:IT Config(80):Load Select(0)
- DF:Gas Gauging:IT Config(80):Load Mode(1)

C.10.3.5 Avg P Last Run (Offset 23)

The bq20z80 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 remaining capacity calculation. It is not recommended to change this value.

Table C-199. 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	–32,768	32,767	–3,022	10 mW

Related Variables:

- DF:Gas Gauging:IT Config(80):Load Select(0)
- DF:Gas Gauging:IT Config(80):Load Mode(1)

C.10.3.6 Delta Voltage (Offset 25)

The bq20z80 stores the maximum difference of *Voltage* during during short load spikes and normal load, so the Impedance Track™ algorithm can calculate remaining capacity for pulsed loads. It is not recommended to change this value.

Table C-200. 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	–32,768	32,767	0	mV

Related Variables:

- SBS:Voltage(0x09)

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 and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cell impedance update

0xff	Cell impedance newer updated

Table C-201. 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 bq20z80 stores and updates the impedance profile for cell 0 in this table.

Table C-202. 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	32,767	160	2^{-10} Ω
		4	Cell0 R_a 1			0	32,767	166	
		6	Cell0 R_a 2			0	32,767	153	
		8	Cell0 R_a 3			0	32,767	151	
		10	Cell0 R_a 4			0	32,767	145	
		12	Cell0 R_a 5			0	32,767	152	
		14	Cell0 R_a 6			0	32,767	176	
		16	Cell0 R_a 7			0	32,767	204	
		18	Cell0 R_a 8			0	32,767	222	
		20	Cell0 R_a 9			0	32,767	254	
		22	Cell0 R_a 10			0	32,767	315	
		24	Cell0 R_a 11			0	32,767	437	
		26	Cell0 R_a 12			0	32,767	651	
		28	Cell0 R_a 13			0	32,767	1,001	
		30	Cell0 R_a 14			0	32,767	1,458	

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 and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cell impedance update
0xff	Cell impedance newer updated		

Table C-203. 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 bq20z80 stores and updates the impedance profile for cell 1 in this table.

Table C-204. Cell1 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a1	2	Cell1 R_a 0	Signed integer	2	0	32,767	160	2^{-10} Ω
		4	Cell1 R_a 1			0	32,767	166	
		6	Cell1 R_a 2			0	32,767	153	
		8	Cell1 R_a 3			0	32,767	151	
		10	Cell1 R_a 4			0	32,767	145	
		12	Cell1 R_a 5			0	32,767	152	
		14	Cell1 R_a 6			0	32,767	176	
		16	Cell1 R_a 7			0	32,767	204	
		18	Cell1 R_a 8			0	32,767	222	
		20	Cell1 R_a 9			0	32,767	254	
		22	Cell1 R_a 10			0	32,767	315	
		24	Cell1 R_a 11			0	32,767	437	
		26	Cell1 R_a 12			0	32,767	651	
		28	Cell1 R_a 13			0	32,767	1,001	
		30	Cell1 R_a 14			0	32,767	1,458	

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 and QMAX updated	0x00	Table not used & QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cel impedance update
0xff	Cell impedance newer updated		

Table C-205. 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 bq20z80 stores and updates the impedance profile for cell 2 in this table.

Table C-206. Cell2 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a2	2	Cell2 R_a 0	Signed integer	2	0	32,767	160	2^{-10} Ω
		4	Cell2 R_a 1			0	32,767	166	
		6	Cell2 R_a 2			0	32,767	153	
		8	Cell2 R_a 3			0	32,767	151	
		10	Cell2 R_a 4			0	32,767	145	
		12	Cell2 R_a 5			0	32,767	152	
		14	Cell2 R_a 6			0	32,767	176	
		16	Cell2 R_a 7			0	32,767	204	
		18	Cell2 R_a 8			0	32,767	222	
		20	Cell2 R_a 9			0	32,767	254	
		22	Cell2 R_a 10			0	32,767	315	
		24	Cell2 R_a 11			0	32,767	437	
		26	Cell2 R_a 12			0	32,767	651	
		28	Cell2 R_a 13			0	32,767	1,001	
		30	Cell2 R_a 14			0	32,767	1,458	

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 and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode & cell impedance updated	0xff	Table never used, no QMAX or cel impedance update
0xff	Cell impedance newer updated		

Table C-207. 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 bq20z80 stores and updates the impedance profile for cell 3 in this table.

Table C-208. Cell3 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a3	2	Cell3 R_a 0	Signed integer	2	0	32,767	160	2^{-10} Ω
		4	Cell3 R_a 1			0	32,767	166	
		6	Cell3 R_a 2			0	32,767	153	
		8	Cell3 R_a 3			0	32,767	151	
		10	Cell3 R_a 4			0	32,767	145	
		12	Cell3 R_a 5			0	32,767	152	
		14	Cell3 R_a 6			0	32,767	176	
		16	Cell3 R_a 7			0	32,767	204	
		18	Cell3 R_a 8			0	32,767	222	
		20	Cell3 R_a 9			0	32,767	254	
		22	Cell3 R_a 10			0	32,767	315	
		24	Cell3 R_a 11			0	32,767	437	
		26	Cell3 R_a 12			0	32,767	651	
		28	Cell3 R_a 13			0	32,767	1,001	
		30	Cell3 R_a 14			0	32,767	1,458	

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 and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cel impedance update
0xff	Cell impedance newer updated		

Table C-209. 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	0x0000	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 bq20z80 stores and updates the impedance profile for cell 0 in this table.

Table C-210. xCell0 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a0x	2	xCell0 R_a 0	Signed integer	2	0	32,767	160	2^{-10} Ω
		4	xCell0 R_a 1			0	32,767	166	
		6	xCell0 R_a 2			0	32,767	153	
		8	xCell0 R_a 3			0	32,767	151	
		10	xCell0 R_a 4			0	32,767	145	
		12	xCell0 R_a 5			0	32,767	152	
		14	xCell0 R_a 6			0	32,767	176	
		16	xCell0 R_a 7			0	32,767	204	
		18	xCell0 R_a 8			0	32,767	222	
		20	xCell0 R_a 9			0	32,767	254	
		22	xCell0 R_a 10			0	32,767	315	
		24	xCell0 R_a 11			0	32,767	437	
		26	xCell0 R_a 12			0	32,767	651	
		28	xCell0 R_a 13			0	32,767	1,001	
		30	xCell0 R_a 14			0	32,767	1,458	

Related Variables:

- DF:Ra Table:R_a0x(89):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 and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cell impedance update
0xff	Cell impedance newer updated		

Table C-211. 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	0x0000	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 bq20z80 stores and updates the impedance profile for cell 1 in this table.

Table C-212. xCell1 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a1x	2	xCell1 R_a 0	Signed integer	2	0	32,767	160	2^{-10} Ω
		4	xCell1 R_a 1			0	32,767	166	
		6	xCell1 R_a 2			0	32,767	153	
		8	xCell1 R_a 3			0	32,767	151	
		10	xCell1 R_a 4			0	32,767	145	
		12	xCell1 R_a 5			0	32,767	152	
		14	xCell1 R_a 6			0	32,767	176	
		16	xCell1 R_a 7			0	32,767	204	
		18	xCell1 R_a 8			0	32,767	222	
		20	xCell1 R_a 9			0	32,767	254	
		22	xCell1 R_a 10			0	32,767	315	
		24	xCell1 R_a 11			0	32,767	437	
		26	xCell1 R_a 12			0	32,767	651	
		28	xCell1 R_a 13			0	32,767	1,001	
		30	xCell1 R_a 14			0	32,767	1,458	

Related Variables:

- DF:Ra Table:R_a0x(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 and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cell impedance update
0xff	Cell impedance newer updated		

Table C-213. 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	0x0000	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 bq20z80 stores and updates the impedance profile for cell 2 in this table.

Table C-214. xCell2 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a2x	2	xCell2 R_a 0	Signed integer	2	0	32,767	160	2^{-10} Ω
		4	xCell2 R_a 1			0	32,767	166	
		6	xCell2 R_a 2			0	32,767	153	
		8	xCell2 R_a 3			0	32,767	151	
		10	xCell2 R_a 4			0	32,767	145	
		12	xCell2 R_a 5			0	32,767	152	
		14	xCell2 R_a 6			0	32,767	176	
		16	xCell2 R_a 7			0	32,767	204	
		18	xCell2 R_a 8			0	32,767	222	
		20	xCell2 R_a 9			0	32,767	254	
		22	xCell2 R_a 10			0	32,767	315	
		24	xCell2 R_a 11			0	32,767	437	
		26	xCell2 R_a 12			0	32,767	651	
		28	xCell2 R_a 13			0	32,767	1,001	
		30	xCell2 R_a 14			0	32,767	1,458	

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 and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in process	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cell impedance update
0xff	Cell impedance newer updated		

Table C-215. 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	0x0000	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 bq20z80 stores and updates the impedance profile for cell 3 in this table.

Table C-216. xCell3 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a3x	2	xCell3 R_a 0	Signed integer	2	0	32,767	160	2^{-10} Ω
		4	xCell3 R_a 1			0	32,767	166	
		6	xCell3 R_a 2			0	32,767	153	
		8	xCell3 R_a 3			0	32,767	151	
		10	xCell3 R_a 4			0	32,767	145	
		12	xCell3 R_a 5			0	32,767	152	
		14	xCell3 R_a 6			0	32,767	176	
		16	xCell3 R_a 7			0	32,767	204	
		18	xCell3 R_a 8			0	32,767	222	
		20	xCell3 R_a 9			0	32,767	254	
		22	xCell3 R_a 10			0	32,767	315	
		24	xCell3 R_a 11			0	32,767	437	
		26	xCell3 R_a 12			0	32,767	651	
		28	xCell3 R_a 13			0	32,767	1,001	
		30	xCell3 R_a 14			0	32,767	1,458	

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 ***PF Flags 1*** register indicates the reason that bq20z80 has entered permanent failure. If the failure flag in ***PF Flags 1*** matches the bit in ***Permanent Fail Cfg***, the SAFE pin is driven low, the $\overline{\text{SAFE}}$ pin is driven high and ***Fuse Flag*** is set to 0x3672. The SAFE pin or $\overline{\text{SAFE}}$ pin can be used to blow a 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-217. 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	0xffff	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	Reserved	SOPT	SOCD	SOCC	AFE_P	ACE_C
Low Byte	DFF	DFETF	CFETF	CIM	SOTD	SOTC	SOV	PFIN

LEGEND: All values read-only

Figure C-10. PF Flags 1

FBF— = 1: Fuse Blow Failure. the fuse has not cut off current, even though the SAFE pin output has been driven low and the $\overline{\text{SAFE}}$ pin has been driven high.

PFVSHUT— = 1: Another Permanent Failure has occurred AND device went to 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-Communication permanent failure

AFE_C— =1 AFE-Communications permanent failure

DFF— = 1: DataFlash 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 bq29312A 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 and the SAFE pin is driven low

0x0000 = No failure (default)

0x3672 = ***Permanent Fail Cfg*** flag matches ***PF Flags 1*** flag and SAFE pin is driven low and the $\overline{\text{SAFE}}$ pin is driven high

Table C-218. 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	0x3672	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* value is captured and stored into in this DataFlash register.

Table C-219. 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	65,535	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 into in this DataFlash register.

Table C-220. 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	9,999	0	mV

Related Variables:

- SBS:CellVoltage4(0x3c)

C.12.1.5 PF C3 Voltage (Offset 8)

When a permanent failure is detected, the *CellVoltage3* is captured and stored into in this DataFlash register.

Table C-221. 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	9,999	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 into in this DataFlash register.

Table C-222. 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	9,999	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 into in this DataFlash register.

Table C-223. 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	9,999	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 into in this DataFlash register.

Table C-224. 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	–32,768	32,767	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 into in this DataFlash register.

Table C-225. 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	–9,999	9,999	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 into in this DataFlash register.

Table C-226. 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	0	

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 this vaDataFlash register.

Table C-227. 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	65,535	0	mAh

Related Variables:

- SBS:BatteryMode(0x03)[CAPACITY_MODE]
- SBS:RemainingCapacity(0x0f)

C.12.1.12 PF RC-10mWh (Offset 22)

When a permanent failure is detected, *RemainingCapacity* in mAh is captured and stored into in this DataFlash register.

Table C-228. 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-mWh	Unsigned integer	2	0	65,535	0	10 mWh

Related Variables:

- SBS:BatteryMode(0x03)[CAPACITY_MODE]
- SBS:RemainingCapacity(0x0f)

C.12.1.13 PF Chg Status (Offset 24)

When a permanent failure is detected, *ChargingStatus* flags are captured and stored into in this DataFlash register.

Table C-229. 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, *SafetyStatus* flags are captured and stored into in this DataFlash register.

Table C-230. 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 first occurance of permanent failure, when PFStatus changes from 0x0000, then the *PFStatus* flags are 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-231. 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	0xffff	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 bq20z80 detects a permanent failure, a complete copy of bq29312A register values is stored to these register values.

Table C-232. 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-233. 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	–1E128	1E128	0.471	

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-234. 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	–1E128	1E128	140,500	

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 0.5 mV.

Table C-235. 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	32,767	2,450	0.5mV

Related Variables:

- None

C.13.1.4 AFE Corr (Offset 10)

This Value stores the AFE common mode gain compensation. It is not recommended to change the default value.

Table C-236. AFE Corr

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	10	AFE Corr	Signed integer	2	0	32,767	1,288	2^{-32}/mV

Related Variables:

- none

C.13.1.5 AFE Pack Gain (Offset 12)

This register value stores the scale factor for the voltage at PACK pin of the bq29312A AFE.

Table C-237. 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	65,535	30,625	mV/cnt

Related Variables:

- none

C.13.1.6 CC Offset (Offset 14)

This register value stores the coulomb counter offset compensation. It is set by automatic calibration of the bq20z80. It is not recommended to change this value.

Table C-238. 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	–32,768	32,767	–12,250	

Related Variables:

- none

C.13.1.7 Board Offset (Offset 16)

This register value stores the compensation for PCB dependant coulomb counter offset. It is recommended to use characterization data of actual PCB to set this value.

Table C-239. 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	1	–128	127	0	

Related Variables:

- Calibration:Data(104):CC Offset(14)

C.13.1.8 Int Temp Offset (Offset 17)

This register value stores the internal temperature sensor offset compensation. Use calibration routines to set this value.

Table C-240. Int Temp Offset

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	17	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.13.1.9 Ext1 Temp Offset (Offset 18)

This register value stores the temperature sensor offset compensation for the external temperature sensor 1 connected at TS1 pin of the bq20z80. Use calibration routines to set this value.

Table C-241. Ext1 Temp Offset

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	18	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.13.1.10 Ext2 Temp Offset (Offset 19)

This register value stores the temperature sensor offset compensation for the external temperature sensor 2 connected at TS2 pin of the bq20z80. Use calibration routines to set this value.

Table C-242. Ext2 Temp Offset

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	19	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 CC calibration when in calibration mode.

Table C-243. 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	65,535	3,000	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-244. 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	65,535	16,800	mV

Related Variables:

- SBS:Voltage(0x09)

C.13.2.3 Temp Signal (Offset 4)

This value sets the temperature used for temperature calibration in calibration mode

Table C-245. 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	65,535	2,980	0.1°C

Related Variables:

- SBS:Temperature(0x08)

C.13.2.4 CC Offset Time (Offset 6)

This value sets the time used for CC Offset calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiplies of 250. Numbers less than 250 cause a CC offset calibration error. Numbers greater than 250 aee rounded down to the nearest multiple of 250.

Table C-246. 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	65,535	250	ms

Related Variables:

- Calibration:Data(104):CC Offset(14)

C.13.2.5 ADC Offset Time (Offset 8)

This constant defines the time for ADC offset calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiplies of 32. Numbers less than 32 cause an ADC offset calibration error. Numbers greater than 32 are rounded down to the nearest multiple of 32.

Table C-247. 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	65,535	32	ms

Related Variables:

- none

C.13.2.6 CC Gain Time (Offset 10)

This constant defines the time for the coulomb counter gain calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiplies of 250. Numbers less than 250 cause a CC gain calibration error. Numbers greater than 250 are rounded down to the nearest multiple of 250.

Table C-248. 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	65,535	250	ms

Related Variables:

- Calibration:Data(104):CC Gain(0)

C.13.2.7 Voltage Time (Offset 12)

This constant defines the time for voltage calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiplies of 1984. Numbers less than 1984 cause a voltage calibration error. Numbers greater than 1984 are rounded down to the nearest multiple of 1984.

Table C-249. 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	65,535	1,984	ms

Related Variables:

- SBS:Voltage(0x09)

C.13.2.8 Temperature Time (Offset 14)

This constant defines the time for temperature calibration in calibration mode. More time means more accuracy. The legitimate values for this constant are integer multiplies of 32. Numbers less than 32 cause a temperature calibration error. Numbers greater than 32 are rounded down to the nearest multiple of 32.

Table C-250. 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	65,535	32	ms

Related Variables:

- Calibration:Data(104):Int Temp Offset(17)
- Calibration:Data(104):Ext1 Temp Offset(18)
- Calibration:Data(104):Ext2 Temp Offset(19)
- SBS:Temperature(0x08)

C.13.2.9 Cal Mode Timeout (Offset 17)

The bq20z80 exits calibration mode automatically after ***Calibration Mode Timeout*** period.

Table C-251. 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	65,535	38,400	s / 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

These values characterize the external temperature sense resistor connected to TS1 pin or TS2 pin of bq20z80. The default values characterize the Semitec 103AT NTC resistor. Do not modify these values without consulting TI.

Table C-252. 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	–32,768	32,767	–28,285	s
		2	Ext Coef 2					20,848	
		4	Ext Coef 3					–7,537	
		6	Ext Coef 4					4,012	
		8	Ext Min AD					0	
		10	Ext Max Temp					4,012	

Related Variables:

- None

C.13.3.2 Int Coef 1..4, Int Min AD, Int Max Temp

These values characterize the internal temperature sense resistor of the bq20z80. Do not modify this values without consulting TI.

Table C-253. 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	–32,768	32,767	0	s
		14	Int Coef 2					0	
		16	Int Coef 3					–11,136	
		18	Int Coef 4					5,754	
		20	Int Min AD					0	
		22	Int Max Temp					5,754	

Related Variables:

- None

C.13.4 Current (Subclass 107)

C.13.4.1 Filter (Offset 0)

This constant 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 s/ln(1/a) (default 14.5 s)

Table C-254. 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*** is reported as 0 mA by the SBS *Current* function.

Table C-255. 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 SR1 and SR2 pin used for capacity accumulation in units of 290 nV. Any voltages within±***CC Deadband*** does not contribute to capacity accumulation.

Table C-256. 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	290 nV

Related Variables:

- SBS:RemainingCapacity(0x0f)

C.13.4.4 CC Max Deadband (Offset 3)

This constant defines the limit in CC counts (about 10 µV/cnt) at which the CC input is measured using a sample size defined by ***CC Deadband Sample***. If the absolute voltage between SR1 pin and SR2 pin is below ***CC Max DeadBand***, bq20z80 increases sample time to ensure accuracy

Table C-257. CC Max Deadband

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
107	Current	3	CC Max Deadband	Unsigned integer	1	0	255	5	290 nV

Related Variables:

- DF:Calibration:Current(107):CC Deadband Sample(4)

C.13.4.5 CC Deadband Sample (Offset 4)

This constant defines the sample size of CC conversions used to measure the voltage between SR1 pin and SR2 pin for deadband evaluation.

Table C-258. CC Deadband Sample

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
107	Current	4	CC Deadband Sample	Unsigned integer	2	0	65,535	256	

Related Variables:

- None

C.13.4.6 CC Max Offset Sample (Offset 5)

This constant defines the sample size of CC readings used in the CC auto-offset calibration.

Table C-259. CC Max Offset Sample

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
107	Current	5	CC Max Offset Sample	Unsigned integer	2	0	65,535	64	

Related Variables:

- none

C.14 DataFlash Values

Table C-260. DataFlash VALUES

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
1st Level Safety	0	Voltage	0	COV Threshold	U2	3,700	5,000	4,300	mV
			2	COV Time	U1	0	60	2	s
			3	COV Recovery	U2	0	4,400	3,900	mV
			5	COV Delta	U1	0	200	20	mV
			6	COV Temp. Hys	U1	0	250	100	0.1°C
			7	POV Threshold	U2	0	18,000	17,500	mV
			9	POV Time	U1	0	60	2	s
			10	POV Recovery	U2	0	17,000	16,000	mV
			12	CUV Threshold	U2	0	3,500	2,200	mV
			14	CUV Time	U1	0	60	2	s
			15	CUV Recovery	U2	0	3,600	3,000	mV
			17	PUV Threshold	U2	0	16,000	11,000	mV
			19	PUV Time	U1	0	60	2	s
			20	PUV Recovery	U2	0	16,000	12,000	mV
1st Level Safety	1	Current	0	OC (1st Tier) Chg	U2	0	20,000	6,000	mA
			2	OC (1st Tier) Chg Time	U1	0	60	2	s
			3	OC Chg Recovery	I2	–1,000	1,000	200	mA
			5	OC (1st Tier) Dsg	U2	0	20,000	6,000	mA
			7	OC (1st Tier) Dsg Time	U1	0	60	2	s
			8	OC Dsg Recovery	U2	0	1,000	200	mA
			10	OC (2nd Tier) Chg	U2	0	20,000	8,000	mA
			12	OC (2nd Tier) Chg Time	U1	0	60	2	s
			13	OC (2nd Tier) Dsg	U2	0	22,000	8,000	mA
			15	OC (2nd Tier) Dsg Time	U1	0	60	2	s
			16	Current Recovery Time	U1	0	60	8	s
			17	AFE OC Dsg	H1	0x00	0x1f	0x12	
			18	AFE OC Dsg Time	H1	0x00	0x0f	0xff	
			19	AFE OC Dsg Recovery	U2	10	1,000	100	mA
			21	AFE SC Chg Cfg	H1	0x00	0xff	0x77	
			22	AFE SC Dsg Cfg	H1	0x00	0xff	0x77	
			23	AFE SC Recovery	U2	0	200	1	mA

Table C-260. DataFlash VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
1st Level Safety	2	Temperature	0	Over Temp Chg	U2	0	1,200	550	0.1°C
			2	OT Chg Time	U1	0	60	2	s
			3	OT Chg Recovery	U2	0	1,200	500	0.1°C
			5	Over Temp Dsg	U2	0	1,200	600	0.1°C
			7	OT Dsg Time	U1	0	60	2	s
			8	OT Dsg Recovery	U2	0	1,200	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	U2	0	20,000	18,000	mV
			2	SOV Time	U1	0	30	0	s
			3	Cell Imbalance Current	U1	0	200	5	mA
			4	Cell Imbalance Fail Voltage	U2	0	5,000	1,000	mV
			6	Cell Imbalance Time	U1	0	30	0	s
			7	Battery Rest Time	U2	0	65,535	1,800	s
			9	PFIN Detect Time	U1	0	30	0	s
2nd Level Safety	17	Current	0	SOC Chg	U2	0	30,000	10,000	mA
			2	SOC Chg Time	U1	0	30	0	s
			3	SOC Dsg	U2	0	30,000	10,000	mA
			5	SOC Dsg Time	U1	0	30	0	s
2nd Level Safety	18	Temperature	0	SOT Chg	U2	0	1,200	650	0.1°C
			2	SOT Chg Time	U1	0	30	0	s
			3	SOT Dsg	U2	0	1,200	750	0.1°C
			5	SOT Dsg Time	U1	0	30	0	s
			6	Open Thermistor	I2	–1,000	1,200	–333	0.1°C
			8	Open Time	I1	0	30	0	s
2nd Level Safety	19	FET Verification	0	FET Fail Limit	U2	0	500	20	mA
			2	FET Fail Time	U1	0	30	0	s
2nd Level Safety	20	AFE Verification	0	AFE Check Time	U1	0	255	0	s
			1	AFE Fail Limit	U1	0	255	10	
			2	AFE Fail Recovery Time	U1	0	255	20	s
			3	AFE Init Retry Limit	U1	0	255	6	
			4	AFE Init Limit	U1	0	255	20	
2nd Level Safety	21	Fuse Verification	0	Fuse Fail Limit	U2	0	20	2	mA
			2	Fuse Fail Time	U1	0	30	0	s
Charge Control	32	Charge Inhibit Cfg	0	Chg Inhibit Temp Low	I2	–400	1,200	0	0.1°C
			2	Chg Inhibit Temp High	I2	–400	1,200	450	0.1°C
			4	Temp Hys	I2	0	100	10	0.1°C
Charge Control	33	Pre-Charge Cfg	0	Pre-chg Current	U2	0	2,000	250	mA
			2	Pre-chg Temp	I2	–400	1,200	120	0.1°C
			4	Pre-chg Voltage	U2	0	20,000	3,000	mV
			6	Recovery Voltage	U2	0	20,000	3,100	mV
Charge Control	34	Fast Charge Cfg	0	Fast Charge Current	U2	0	10,000	4,000	mA
			2	Charging Voltage	U2	0	20,000	16,800	mV
			4	Over Charging Voltage	U2	0	2,000	500	mV
			6	Delta Temp	I2	0	500	50	0.1°C
			8	Suspend Low Temp	I2	–400	1,200	–50	0.1°C
			10	Suspend High Temp	I2	–400	1,200	550	0.1°C

Table C-260. DataFlash VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
Charge Control	35	Pulse Charge Cfg	0	Turn ON Voltage	U2	0	5,000	4,150	mV
			2	Turn OFF Voltage	U2	0	5,000	4,250	mV
			4	Max ON Pulse Time	U1	0	240	240	s/4
			5	Min OFF Pulse Time	U1	0	240	0	s/4
			6	Max OFF Voltage	U2	0	5,000	4,270	mV
Charge Control	36	Termination Cfg.	0	Maintenance Current	U2	0	1,000	0	mA
			2	Taper Current	U2	0	1,000	250	mA
			6	Termination Voltage	U2	0	1,000	300	mV
			8	Current Taper Window	U1	0	60	40	s
			9	TCA Set %	I1	–1	100	–1	%
			10	TCA Clear %	I1	–1	100	95	%
			11	FC Set %	I1	–1	100	–1	%
			12	FC Clear %	I1	–1	100	98	%
Charge Control	37	Cell Balancing Cfg	0	Min Cell Deviation	U2	0	65,535	1,750	s/mAH
Charge Control	38	Charging Faults	0	Over Charging Voltage	U2	0	3,000	500	mV
			2	Over Charging Volt Time	U1	0	60	2	s
			3	Over Charging Current	U2	0	2,000	500	mA
			5	Over Charging Curr Time	U1	0	60	2	s
			6	Over Charging Curr Recov	U2	0	2,000	100	mA
			8	Depleted Voltage	U2	0	16,000	8,000	mV
			10	Depleted Voltage Time	U1	0	60	2	s
			11	Depleted Recovery	U2	0	16,000	8,500	mV
			13	Over Charge Capacity	U2	0	4,000	300	mAh
			15	Over Charge Recovery	U2	0	100	2	mAh
			17	FC-MTO	U2	0	65,535	10,800	s
			19	PC-MTO	U2	0	65,535	3,600	s
			21	Charge Fault Cfg	H1	0x00	0xff	0	
SBS Configuration	48	Data	0	Rem Cap Alarm	U2	0	700	300	mAh
			2	Rem Energy Alarm	U2	0	1,000	432	10 mWh
			4	Rem Time Alarm	U2	0	30	10	min
			6	Init Battery Mode	H2	0x0000	0xffff	0x0081	
			8	Design Voltage	U2	7000	18,000	14,400	mV
			10	Spec Info	H2	0x0000	0xffff	0x0031	
			12	Manuf Date	U2	0	65,355	0	
			14	Ser. Num.	H2	0x0000	0xffff	0x0001	
			16	Cycle Count	U2	0	65,535	0	
			18	CC Threshold	I2	100	32,767	4,400	mAh
			20	CC %	U1	0	100	90	%
			21	CF MaxError Limit	U1	0	100	100	%
			22	Design Capacity	U2	0	65,535	4,400	mAh
			24	Design Energy	U2	0	65,535	6,336	10 mWh
			26	Manuf Name	S12	–	–	Texas Inst.	
			38	Device Name	S8	–	–	bq20z80	
			46	Device Chemistry	S5	–	–	LION	

Table C-260. DataFlash 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	%
			1	TDA Clear %	I1	–1	100	8	%
			2	FD Set %	I1	–1	100	2	%
			3	FD Clear %	I1	–1	100	5	%
			4	TDA Set Volt Threshold	U2	0	16,800	5,000	mV
			6	TDA Set Volt Time	U1	0	60	5	s
			7	TDA Clear Volt	U2	0	16,800	5,500	mV
			9	FD Set Volt Threshold	U2	0	16,800	5,000	mV
			11	FD Volt Time	U1	0	60	5	s
			12	FD Clear Volt	U2	0	16,800	5,500	mV
System Data	56	Manufacturer Data	0	Pack Lot Code	H2	0x0000	0xffff	0x0000	
			2	PCB Lot Code	H2	0x0000	0xffff	0x0000	
			4	Firmware Version	H2	0x0000	0xffff	0x0000	
			6	Hardware Revision	H2	0x0000	0xffff	0x0000	
			8	Cell Revision	H2	0x0000	0xffff	0x0000	
System Data	58	Manufacturer Info	0	Manuf. Info	S9	–	–	12345678	
System Data	59	LifeTime Data	0	Lifetime Max Temp	I2	0	1,400	300	0.1°C
			2	Lifetime Min Temp	I2	–600	1,400	200	0.1°C
			4	Lifetime Max Cell Voltage	U2	0	65,535	3,500	mV
			6	Lifetime Min Cell Voltage	U2	0	65,535	3,200	mV
			8	Lifetime Max Pack Voltage	U2	0	65,535	14,000	mV
			10	Lifetime Min Pack Voltage	U2	0	65,535	12,800	mV
			12	Lifetime Max Chg Current	I2	–32,768	32,767	1,500	mA
			14	Lifetime Max Dsg Current	I2	–32,768	32,767	–3,000	mA
			16	Lifetime Max Chg Power	I2	–32,768	32,767	1,500	0.1 W
			18	Lifetime Max Dsg Power	I2	–32,768	32,767	–1,500	0.1 W
			22	Life Max AvgDsg Cur	I2	–32,768	32,767	–1,000	mA
			26	Life Max AvgDsg Pow	I2	–32,768	32,767	–1,500	0.1 W
			28	Lifetime Avg Temp	I2	0	1,400	250	0.1°C
System Data	60	LifeTime Temp Samples	0	LT Temp Samples	U4	0	140,000,000	0	
Configuration	64	Registers	0	Operation Cfg A	H2	0x0000	0xffff	0x0F29	
			2	Operation Cfg B	H2	0x0000	0xffff	0x6440	
			4	Operation Cfg C	H2	0x0000	0xffff	0x0000	
			6	Permanent Fail Cfg	H2	0x0000	0xffff	0x0000	
			8	Non-Removable Cfg	H2	0x0000	0xffff	0x0000	

Table C-260. DataFlash VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
LED Support	67	LED Cfg	0	LED Flash Rate	U2	0	65,535	512	500 µs
			2	LED Blink Rate	U2	0	65,535	1024	500 µs
			4	LED Delay	U2	1	65,535	100	500 µs
			6	LED Hold Time	U1	0	16	4	s
			7	CHG Flash Alarm	I1	–1	101	10	%
			8	CHG Thresh 1	I1	–1	101	0	%
			9	CHG Thresh 2	I1	–1	101	20	%
			10	CHG Thresh 3	I1	–1	101	40	%
			11	CHG Thresh 4	I1	–1	101	60	%
			12	CHG Thresh 5	I1	–1	101	80	%
			13	DSG Flash Alarm	I1	–1	101	10	%
			14	DSG Thresh 1	I1	–1	101	0	%
			15	DSG Thresh 2	I1	–1	101	20	%
			16	DSG Thresh 3	I1	–1	101	40	%
			17	DSG Thresh 4	I1	–1	101	60	%
			18	DSG Thresh 5	I1	–1	101	60	%
Power	68	Power	0	Flash Update OK Voltage	U2	6,000	20,000	7,500	mV
			2	Shutdown Voltage	U2	5,000	20,000	7,000	mV
			4	Shutdown Time	U1	0	60	10	s
			5	Charger Present	U2	0	23,000	3,000	mV
			7	Sleep Current	U2	0	100	10	mA
			9	Bus Low Time	U1	0	255	5	s
			10	Cal Inhibit Temp Low	I2	–400	1,200	50	0.1°C
			12	Cal Inhibit Temp High	I2	–400	1,200	450	0.1°C
			14	Sleep Voltage Time	U1	0	100	5	s
			15	Sleep Current Time	U1	0	255	20	s
Gas Gauging	80	IT Cfg	0	Load Select	U1	0	255	3	
			1	Load Mode	U1	0	255	0	
			45	Term Voltage	I2	–32,768	32,767	12,000	mV
			60	User Rate-mA	I2	–9,000	–2,000	0	mA
			62	User Rate-mW	I2	–14,000	–3,000	0	mW
			64	Reserve Cap-mAh	I2	0	9,000	0	mAh
			66	Reserve Cap-mWh	I2	0	14,000	0	mWh
Gas Gauging	81	Current Thresholds	0	Dsg Current Threshold	U2	0	2,000	100	mA
			2	Chg Current Threshold	U2	0	2,000	50	mA
			4	Quit Current	U2	0	1,000	10	mA
			6	Dsg Relax Time	U1	0	255	1	s
			7	Chg Relax Time	U1	0	255	60	s
Gas Gauging	82	State	0	Qmax Cell 0	U2	0	65,535	4,400	mAh
			2	Qmax Cell 1	U2	0	65,535	4,400	mAh
			4	Qmax Cell 2	U2	0	65,535	4,400	mAh
			6	Qmax Cell 3	U2	0	65,535	4,400	mAh
			8	Qmax Pack	U2	0	65,535	4,400	mAh
			12	Update Status	H1	0x00	0x06	0x00	
			21	Avg I Last Run	I2	–32,768	32,767	–2,000	mA
			23	Avg P Last Run	I2	–32,768	32,767	–3,022	10 mW
			25	Delta Voltage	I2	–32,768	32,767	0	mV

Table C-260. DataFlash VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
Ra Table	88	R_a0	0	Cell0 R_a flag	H2	0x0000	0xffff	0xff55	
			2	Cell0 R_a 0	I2	–32,768	32,767	160	
			4	Cell0 R_a 1	I2	–32,768	32,767	166	
			6	Cell0 R_a 2	I2	–32,768	32,767	153	
			8	Cell0 R_a 3	I2	–32,768	32,767	151	
			10	Cell0 R_a 4	I2	–32,768	32,767	145	
			12	Cell0 R_a 5	I2	–32,768	32,767	152	
			14	Cell0 R_a 6	I2	–32,768	32,767	176	
			16	Cell0 R_a 7	I2	–32,768	32,767	204	
			18	Cell0 R_a 8	I2	–32,768	32,767	222	
			20	Cell0 R_a 9	I2	–32,768	32,767	254	
			22	Cell0 R_a 10	I2	–32,768	32,767	315	
			24	Cell0 R_a 11	I2	–32,768	32,767	437	
			26	Cell0 R_a 12	I2	–32,768	32,767	651	
			28	Cell0 R_a 13	I2	–32,768	32,767	1,001	
			30	Cell0 R_a 14	I2	–32,768	32,767	1,458	
Ra Table	89	R_a1	0	Cell1 R_a flag	H2	0x0000	0xffff	0xff55	
			2	Cell1 R_a 0	I2	–32,768	32,767	160	
			4	Cell1 R_a 1	I2	–32,768	32,767	166	
			6	Cell1 R_a 2	I2	–32,768	32,767	153	
			8	Cell1 R_a 3	I2	–32,768	32,767	151	
			10	Cell1 R_a 4	I2	–32,768	32,767	145	
			12	Cell1 R_a 5	I2	–32,768	32,767	152	
			14	Cell1 R_a 6	I2	–32,768	32,767	176	
			16	Cell1 R_a 7	I2	–32,768	32,767	204	
			18	Cell1 R_a 8	I2	–32,768	32,767	222	
			20	Cell1 R_a 9	I2	–32,768	32,767	254	
			22	Cell1 R_a 10	I2	–32,768	32,767	315	
			24	Cell1 R_a 11	I2	–32,768	32,767	437	
			26	Cell1 R_a 12	I2	–32,768	32,767	651	
			28	Cell1 R_a 13	I2	–32,768	32,767	1,001	
			30	Cell1 R_a 14	I2	–32,768	32,767	1,458	
Ra Table	90	R_a2	0	Cell2 R_a flag	H2	0x0000	0xffff	0xff55	
			2	Cell2 R_a 0	I2	–32,768	32,767	160	
			4	Cell2 R_a 1	I2	–32,768	32,767	166	
			6	Cell2 R_a 2	I2	–32,768	32,767	153	
			8	Cell2 R_a 3	I2	–32,768	32,767	151	
			10	Cell2 R_a 4	I2	–32,768	32,767	145	
			12	Cell2 R_a 5	I2	–32,768	32,767	152	
			14	Cell2 R_a 6	I2	–32,768	32,767	176	
			16	Cell2 R_a 7	I2	–32,768	32,767	204	
			18	Cell2 R_a 8	I2	–32,768	32,767	222	
			20	Cell2 R_a 9	I2	–32,768	32,767	254	
			22	Cell2 R_a 10	I2	–32,768	32,767	315	
			24	Cell2 R_a 11	I2	–32,768	32,767	437	
			26	Cell2 R_a 12	I2	–32,768	32,767	651	
			28	Cell2 R_a 13	I2	–32,768	32,767	1,001	
			30	Cell2 R_a 14	I2	–32,768	32,767	1,458	
Ra Table	91	R_a3	0	Cell3 R_a flag	H2	0x0000	0xffff	0xff55	

Table C-260. DataFlash VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
			2	Cell3 R_a 0	I2	–32,768	32,767	160	
			4	Cell3 R_a 1	I2	–32,768	32,767	166	
			6	Cell3 R_a 2	I2	–32,768	32,767	153	
			8	Cell3 R_a 3	I2	–32,768	32,767	151	
			10	Cell3 R_a 4	I2	–32,768	32,767	145	
			12	Cell3 R_a 5	I2	–32,768	32,767	152	
			14	Cell3 R_a 6	I2	–32,768	32,767	176	
			16	Cell3 R_a 7	I2	–32,768	32,767	204	
			18	Cell3 R_a 8	I2	–32,768	32,767	222	
			20	Cell3 R_a 9	I2	–32,768	32,767	254	
			22	Cell3 R_a 10	I2	–32,768	32,767	315	
			24	Cell3 R_a 11	I2	–32,768	32,767	437	
			26	Cell3 R_a 12	I2	–32,768	32,767	651	
			28	Cell3 R_a 13	I2	–32,768	32,767	1,001	
			30	Cell3 R_a 14	I2	–32,768	32,767	1,458	
Ra Table	92	R_a0x	0	xCell0 R_a flag	H2	0x0000	0xffff	0xffff	
			2	xCell0 R_a 0	I2	–32,768	32,767	160	
			4	xCell0 R_a 1	I2	–32,768	32,767	166	
			6	xCell0 R_a 2	I2	–32,768	32,767	153	
			8	xCell0 R_a 3	I2	–32,768	32,767	151	
			10	xCell0 R_a 4	I2	–32,768	32,767	145	
			12	xCell0 R_a 5	I2	–32,768	32,767	152	
			14	xCell0 R_a 6	I2	–32,768	32,767	176	
			16	xCell0 R_a 7	I2	–32,768	32,767	204	
			18	xCell0 R_a 8	I2	–32,768	32,767	222	
			20	xCell0 R_a 9	I2	–32,768	32,767	254	
			22	xCell0 R_a 10	I2	–32,768	32,767	315	
			24	xCell0 R_a 11	I2	–32,768	32,767	437	
			26	xCell0 R_a 12	I2	–32,768	32,767	651	
			28	xCell0 R_a 13	I2	–32,768	32,767	1,001	
			30	xCell0 R_a 14	I2	–32,768	32,767	1,458	
Ra Table	93	R_a1x	0	xCell1 R_a flag	H2	0x0000	0xffff	0xffff	
			2	xCell1 R_a 0	I2	–32,768	32,767	160	
			4	xCell1 R_a 1	I2	–32,768	32,767	166	
			6	xCell1 R_a 2	I2	–32,768	32,767	153	
			8	xCell1 R_a 3	I2	–32,768	32,767	151	
			10	xCell1 R_a 4	I2	–32,768	32,767	145	
			12	xCell1 R_a 5	I2	–32,768	32,767	152	
			14	xCell1 R_a 6	I2	–32,768	32,767	176	
			16	xCell1 R_a 7	I2	–32,768	32,767	204	
			18	xCell1 R_a 8	I2	–32,768	32,767	222	
			20	xCell1 R_a 9	I2	–32,768	32,767	254	
			22	xCell1 R_a 10	I2	–32,768	32,767	315	
			24	xCell1 R_a 11	I2	–32,768	32,767	437	
			26	xCell1 R_a 12	I2	–32,768	32,767	651	
			28	xCell1 R_a 13	I2	–32,768	32,767	1,001	
			30	xCell1 R_a 14	I2	–32,768	32,767	1,458	
Ra Table	94	R_a2x	0	xCell2 R_a flag	H2	0x0000	0xffff	0xffff	
			2	xCell2 R_a 0	I2	–32,768	32,767	160	

Table C-260. DataFlash VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
			4	xCell2 R_a 1	I2	–32,768	32,767	166	
			6	xCell2 R_a 2	I2	–32,768	32,767	153	
			8	xCell2 R_a 3	I2	–32,768	32,767	151	
			10	xCell2 R_a 4	I2	–32,768	32,767	145	
			12	xCell2 R_a 5	I2	–32,768	32,767	152	
			14	xCell2 R_a 6	I2	–32,768	32,767	176	
			16	xCell2 R_a 7	I2	–32,768	32,767	204	
			18	xCell2 R_a 8	I2	–32,768	32,767	222	
			20	xCell2 R_a 9	I2	–32,768	32,767	254	
			22	xCell2 R_a 10	I2	–32,768	32,767	315	
			24	xCell2 R_a 11	I2	–32,768	32,767	437	
			26	xCell2 R_a 12	I2	–32,768	32,767	651	
			28	xCell2 R_a 13	I2	–32,768	32,767	1,001	
			30	xCell2 R_a 14	I2	–32,768	32,767	1,458	
Ra Table	95	R_a3x	0	xCell3 R_a flag	H2	0x0000	0xffff	0xffff	
			2	xCell3 R_a 0	I2	–32,768	32,767	160	
			4	xCell3 R_a 1	I2	–32,768	32,767	166	
			6	xCell3 R_a 2	I2	–32,768	32,767	153	
			8	xCell3 R_a 3	I2	–32,768	32,767	151	
			10	xCell3 R_a 4	I2	–32,768	32,767	145	
			12	xCell3 R_a 5	I2	–32,768	32,767	152	
			14	xCell3 R_a 6	I2	–32,768	32,767	176	
			16	xCell3 R_a 7	I2	–32,768	32,767	204	
			18	xCell3 R_a 8	I2	–32,768	32,767	222	
			20	xCell3 R_a 9	I2	–32,768	32,767	254	
			22	xCell3 R_a 10	I2	–32,768	32,767	315	
			24	xCell3 R_a 11	I2	–32,768	32,767	437	
			26	xCell3 R_a 12	I2	–32,768	32,767	651	
			28	xCell3 R_a 13	I2	–32,768	32,767	1,001	
			30	xCell3 R_a 14	I2	–32,768	32,767	1,458	
PF Status	96	Device Status Data	0	PF Flags 1	H2	0x0000	0xffff	0x0000	
			2	Fuse Flag	H2	0x0000	0xffff	0x0000	
			4	PF Voltage	U2	0	65,535	0	mV
			6	PF C4 Voltage	U2	0	9,999	0	mV
			8	PF C3 Voltage	U2	0	9,999	0	mV
			10	PF C2 Voltage	U2	0	9,999	0	mV
			12	PF C1 Voltage	U2	0	9,999	0	mV
			14	PF Current	I2	–32,768	32,767	0	mA
			16	PF Temperature	U2	0	9,999	0	0.1 K
			18	PF Batt Stat	H2	0x0000	0xffff	0x0000	
			20	PF RC-mAh	U2	0	65,535	0	mAh
			22	PF RC-10mWh	U2	0	65,535	0	10 mWh
			24	PF Chg Status	H2	0x0000	0xffff	0x0000	
			26	PF Safety Status	H2	0x0000	0xffff	0x0000	
			28	PF Flags 2	H2	0x0000	0xffff	0x0000	
PF Status	97	AFE Regs	0	AFE Status	H1	0x00	0xffff	0x00	
			1	AFE Output	H1	0x00	0xffff	0x00	
			2	AFE State	H1	0x00	0xffff	0x00	
			3	AFE Function	H1	0x00	0xffff	0x00	

Table C-260. DataFlash VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
			4	AFE Cell Select	H1	0x00	0xffff	0x00	
			5	AFE OLV	H1	0x00	0xffff	0x00	
			6	AFE OLT	H1	0x00	0xffff	0x00	
			7	AFE SCC	H1	0x00	0xffff	0x00	
			8	AFE SCD	H1	0x00	0xffff	0x00	
Calibration	104	Data	0	CC Gain	F4	–1.00E+128	1.00E+128	0.471	
			4	CC Delta	F4	–1.00E+128	1.00E+128	140,500	
			8	Ref Voltage	I2	0	32,767	24,500	50 µV
			10	AFE Corr	U2	0	65,535	1,288	
			12	AFE Pack Gain	U2	0	65,535	30,625	
			14	CC Offset	I2	–32,768	32,767	–12,250	
			16	Board Offset	I1	–128	127	0	
			17	Int Temp Offset	I1	–128	127	0	
			18	Ext1 Temp Offset	I1	–128	127	0	
			19	Ext2 Temp Offset	I1	–128	127	0	
Calibration	105	Config	0	CC Current	U2	0	65,535	3,000	mA
			2	Voltage Signal	U2	0	65,535	16,800	mV
			4	Temp Signal	U2	0	65,535	2,980	K
			6	CC Offset Time	U2	0	65,535	250	ms
			8	ADC Offset Time	U2	0	65,535	32	ms
			10	CC Gain Time	U2	0	65,535	250	ms
			12	Voltage Time	U2	0	65,535	1,984	ms
			14	Temperature Time	U2	0	65,535	32	ms
			17	Cal Mode Timeout	U2	0	65,535	38,400	s/128
Calibration	106	Temp Model	0	Ext Coef 1	I2	–32,768	32,767	–28,285	s
			2	Ext Coef 2	I2	–32,768	32,767	20,848	s
			4	Ext Coef 3	I2	–32,768	32,767	–7,537	s
			6	Ext Coef 4	I2	–32,768	32,767	4,012	s
			8	Ext Min AD	I2	–32,768	32,767	0	s
			10	Ext Max Temp	I2	–32,768	32,767	4,012	s
			12	Int Coef 1	I2	–32,768	32,767	0	s
			14	Int Coef 2	I2	–32,768	32,767	0	s
			16	Int Coef 3	I2	–32,768	32,767	–11,136	s
			18	Int Coef 4	I2	–32,768	32,767	5,754	s
			20	Int Min AD	I2	–32,768	32,767	0	s
			22	Int Max Temp	I2	–32,768	32,767	5,754	s
Calibration	107	Current	0	Filter	U1	0	255	239	mA
			1	Deadband	U1	0	255	3	mA
			2	CC Deadband	U1	0	255	34	290 nV
			3	CC Max Deadband	U1	0	255	5	290 nV
			4	CC Deadband Sample	U2	0	65,535	256	
			6	CC Max Offset Sample	U2	0	65,535	64	

Glossary

ADC	Analog-to-digital converter
AFE	Analog front end
alert	A warning set by bq20z80
bit	A single bit in an SBS command or DataFlash value which can be changed by user
CC	Coulomb counter
CHG FET	Charge FET, connected to CHG pin of bq29312A; used by bq29312A to enable or disable charging
COV	Cell overvoltage
CPU	Central processing unit
CUV	Cell undervoltage
DF	DataFlash
DSG	Flag set by bq20z80 to indicate charge (DSG = 0) or discharge (DSG = 1)
DSG FET	Discharge FET, connected to DSG pin of bq29312A; used by bq29312A to enable or disable discharging
FAS	Full-access security
FBF	Fuse blow failure
FC	Fully charged
FCHG	Fast charge
FCTMO	Fast-charge timeout
FD	Fully discharged
flag	A single bit in an SBS command or DataFlash value which is set by bq20z80 or bq29312A and indicates a status change
IC	Integrated circuit
LED	Light-emitting diode
Li-Ion	Lithium-Ion
NR	Nonremovable
OC	Overcurrent
OCA	Overcharge alarm
OTC	Overtemperature charging
OTD	Overtemperature discharging
PCHG	Precharge
PCTMO	Precharge timeout
PEC	Packet error checking

PF	Permanent fail
POV	Pack overvoltage
PRES	System-present flag
PUV	Pack undervoltage
RBI	Reserve battery input
RCA	Remaining capacity alarm
SBS	Smart battery system
SCC	Short-circuit charge
SCD	Short-circuit discharge
SMBus	System management bus
SOC	Safety overcurrent
SOT	Safety overtemperature
SS	Sealed mode flag
TCA	Terminate-charge alarm
TDA	Terminate Discharge Alarm
ZVCHG FET	Precharge FET, connected to ZVCHG pin of bq29312A; depending on configuration it is used for precharging and/or zero-volt charging
XDSG	Discharge-fault flag

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