bq20z70 + bq29330 Chipset

Technical Reference Manual

Literature Number: SLUU250A
June 2006 – Revised June 2006

TEXAS INSTRUMENTS

Contents

Preface

1.1 Read this First

This manual discusses modules and peripherals of the bq20z70 device and the use with the bq29330 device to build a complete battery pack gas gauge and protection solution.

1.2 Notational Conventions

Following notation is used, if SBS commands and 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.: *[PRES]*
- 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:ManufacturerAccess(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)[SLEEP].

Detailed Description

2.1 1st Level Protection Features

The bq20z70 supports a wide range of battery and system protection features that are easily configured via the integrated data flash.

2.1.1 Cell Overvoltage and Cell Undervoltage

The bq20z70 can detect cell overvoltage/undervoltage and protect battery cells from damage from battery cell overvoltage/undervoltage. If *Voltage* remains over/under the corresponding thresholds for a period of 2s, the bq20z70 goes into pack overvoltage/undervoltage condition and switches off the CHG/DSG FET. The bq20z70 recovers from a cell overvoltage condition if all the cell voltages drop below the cell overvoltage recovery threshold. The bq20z70 recovers from cell undervoltage condition if all the cell voltages rise above the cell undervoltage recovery threshold.

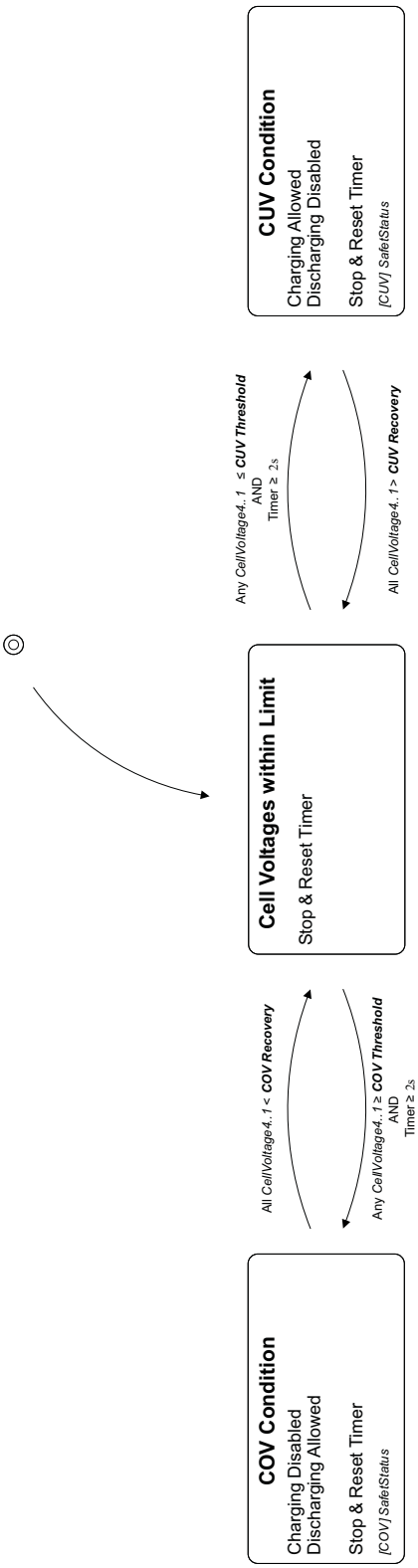

Figure 2-1. COV and CUV

Table 2-1. COV and CUV

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

The bq20z70 indicates cell over voltage condition by setting the *[COV]* flag in *SafetyStatus* if any *CellVoltage4..1* reaches or surpasses the ***COV Threshold*** limit during charging and stays above ***COV Threshold*** limit for 2s.

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

The bq20z70 recovers from cell over voltage condition if all *CellVoltages4..1* are equal to or lower than ***COV Recovery*** limit. On recovery the *[COV]* flag in *SafetyStatus* is reset, *[TCA]* flag is reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate value per the charging algorithm.

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

The bq20z70 indicates cell under voltage by setting the *[CUV]* flag in *SafetyStatus* if any *CellVoltage4..1* reaches or drops below the ***CUV Threshold*** limit during discharging and stays below ***CUV Threshold*** limit for 2s.

In cell under voltage condition, discharging is disabled and DSG FET is turned off and ZVCHG FET (if used) is turned on, *ChargingCurrent* is set to ***Pre-chg Current***, *[TDA]* and *[FD]* flags in *BatteryStatus* and the *[CUV]* flag in *SafetyStatus* are set.

The bq20z70 recovers from cell under voltage condition if all *CellVoltages4..1* are equal to or higher than ***CUV Recovery*** limit. On recovery the *[CUV]* flag in *SafetyStatus* is reset, *[XDSG]* flag is reset, the *[TDA]* and *[FD]* flags are reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate value per the charging algorithm.

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

Related Variables:

- DF:1st Level Safety:Voltage(0):COV Threshold(0)
- DF:1st Level Safety:Voltage(0):COV Recovery(3)
- DF:1st Level Safety:Voltage(0):CUV Threshold(12)
- 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:SafetyStatus(0x51)[CUV],[COV]
- SBS:OperationStatus(0x54)[XDSG]

2.1.2 Charge and Discharge Overcurrent

The bq20z70 has overcurrent protection for charge and discharge. This requires that 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 2s.

Table 2-2. Charge and Discharge Overcurrent

Protection	OC Threshold	OC Time Limit	OC Recovery Threshold	*SafetyStatus* Flag
Tier-1 Charge	***OC (1st Tier)Chg***	2s	100mA	*[OCC]*
Tier-1 Discharge	***OC (1st Tier) Dsg***	2s	-100mA	*[OCD]*
Tier-3 Discharge	***AFE OC Dsg***	***AFE OC Dsg Time***	-100mA for ***Current Recovery Time***	*[AOCD]*

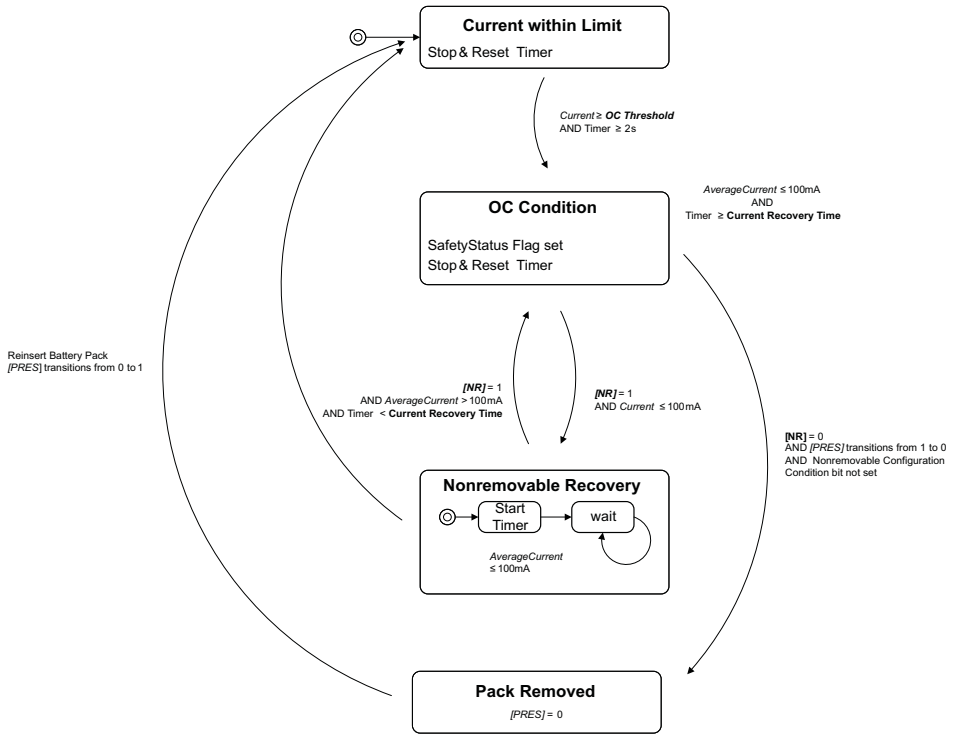

Figure 2-2. OC Protection

For overcurrent protection, the specific flag in *SafetyStatus* is set if the *Current* stays above the OC Threshold limit for at least 2s.

After 2s of excessive current detection during charging, the CHG FET is turned off and ZVCHG FET (if used) is turned off. When this occurs, the internal *AFE_Current_Fault* timer is started from 0, *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* flag is set and *[OCC]* flag is set.

However, when the bq20z70 has *[OCC]* flag in *SafetyStatus* set, the CHG FET is turned on again during discharge (*Current* ≤ (-) ***Dsg Current Threshold***). This prevents overheating of the CHG FET body diode during discharge. No other flags change state until full recovery is reached. This action is not affected by the setting of ***[NR]*** flag.

After 2s of excessive current detection during discharging, the DSG FET is turned off and the ZVCHG FET (if used) is turned on. When this occurs the *AFE_Current_Fault* timer is started from 0, *ChargingCurrent* is set to ***Pre-chg Current***, *[XDSG]* flag is set, *[TDA]* flag is set, and *[OCD]* flag is set.

When the bq29330 detects a discharge-overcurrent fault, the charge and discharge FETs are turned off, the XALERT pin of the bq20z70 is driven low by the XALERT pin of the bq29330, and the bq29330 is interrogated. When the bq20z70 identifies the overcurrent condition, the *AFE_Current_Fault* timer is started from 0, *[TDA]* flag is set, *ChargingCurrent* is set to 0, and *[AOCD]* is set.

However, when the bq20z70 has either *[OCD]*, *[AOCD]* set, the DSG FET is turned on again during charging (*Current* ≥ ***Chg Current Threshold***). This prevents overheating of the discharge-FET body diode during charge. No other flags change state until full recovery is reached. This action is not affected by the state of ***[NR]*** bit.

Table 2-3. Overcurrent Conditions

Protection	**Condition**	**Flags**			**FET**	**Charging Current**	**Charging Voltage**
		SafetyStatus	*BatteryStatus*	*OperationStatus*			
Tier-1 Charge	OC Condition	*[OCC]*	*[TCA]*		CHG FET disabled, enabled during discharge	0	0
Tier-1 Discharge	OC Condition	*[OCD]*	*[TDA]*	*[XDSG]*	DSG FET disabled, enabled during charge	***Pre-chg Current***	charging algorithm
Tier-3 Discharge	OC Condition	*[AOCD]*	*[TDA]*	*[XDSG]*	CHG FET and DSG FET disabled	0	charging algorithm

The bq20z70 can individually configure each overcurrent-protection feature to recover via two different methods based on ***[NR]*** bit.

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

Non-removable Battery Mode Recovery when ***[NR]*** = 1. The state of ***Non-Removable Cfg*** has no consequence. This recovery requires *AverageCurrent* to be ≤ 100mA during charging and *AverageCurrent* to be ≥ (-) 100mA during discharging, and for the *AFE_Current_Fault* timer ≥ ***Current Recovery Time***.

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

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

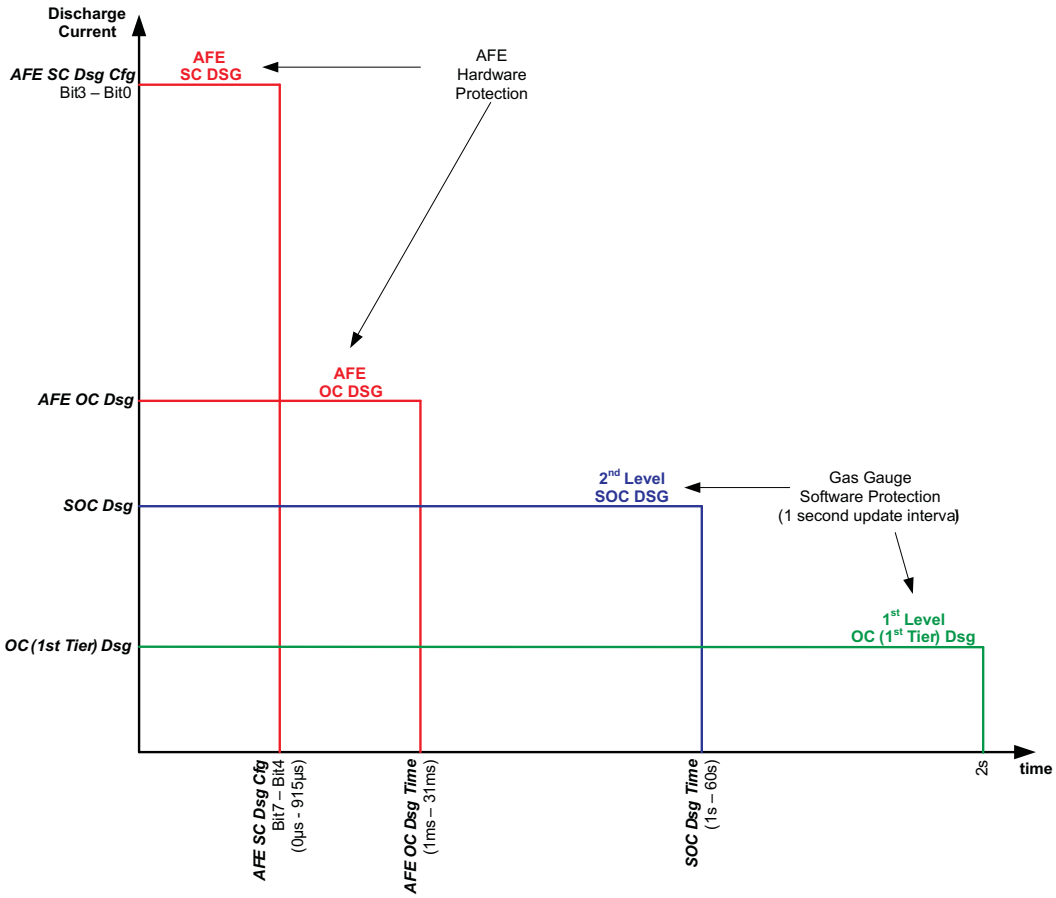

Figure 2-3. Overcurrent Protection Levels

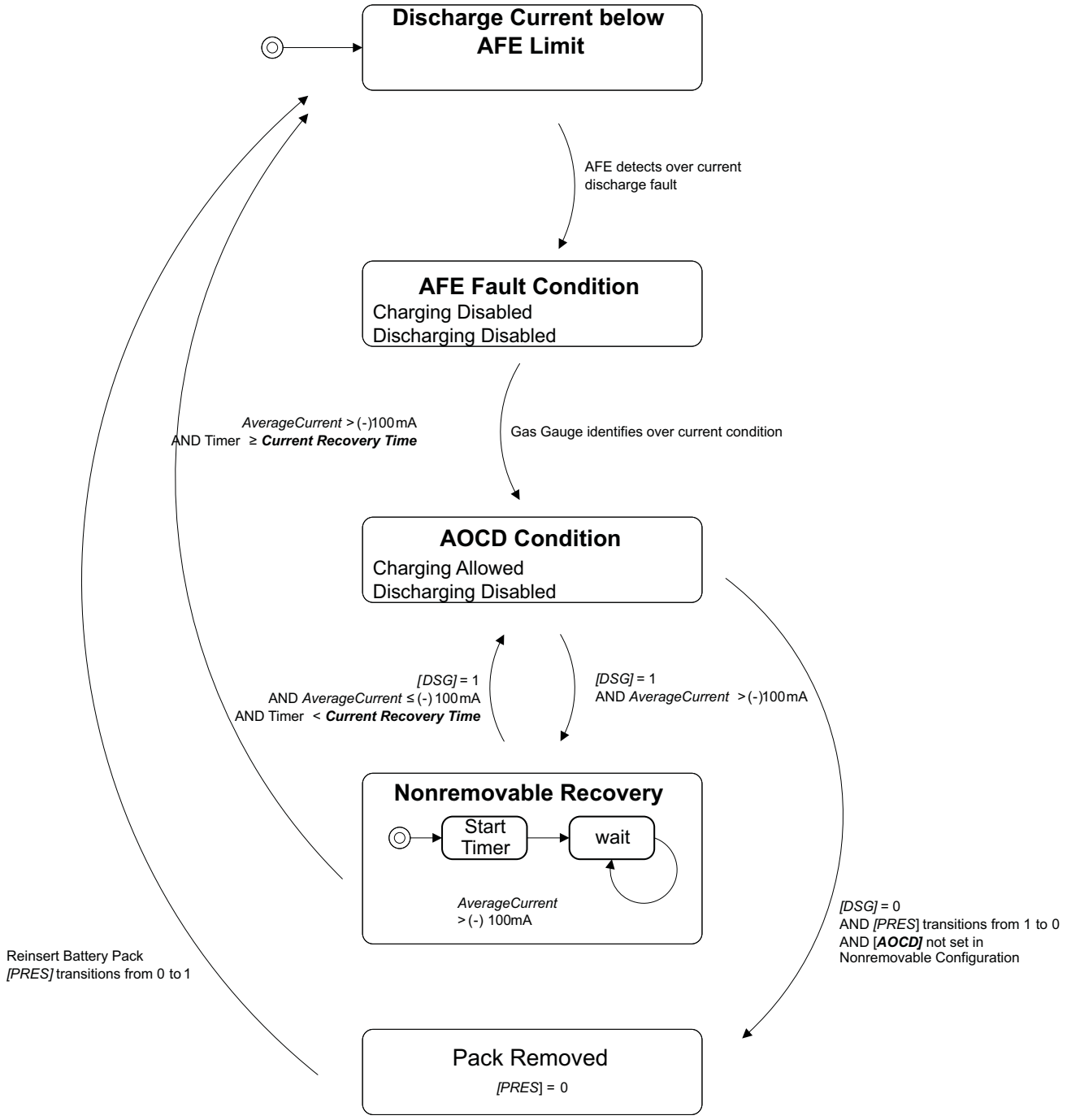

Figure 2-4. AFE Discharge Over Current Protection

Related Variables:

- DF:1st Level Safety:Current(1):OC(1st Tier) Chg(0)
- DF:1st Level Safety:Current(1):OC(1st Tier) Dsg(5)
- DF:1st Level Safety:Current(1):Current Recovery Time(16)
- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- DF:1st Level Safety:Current(1):AFE OC Dsg Time(18)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(0)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]

- DF:Configuration:Registers(64):Non-Removable Cfg(8)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyStatus(0x51)[OCC],[OCD],[AOCD]
- SBS:OperationStatus(0x54)[XDSG]

2.1.3 Short-Circuit Protection

The bq20z70 short-circuit protection is controlled by the bq29330, but is recovered by the bq20z70. This allows different recovery methods to accommodate various applications.

The bq29330 charge short-circuit and discharge short-circuit protection are configured by the bq20z70 dataflash ***AFE SC Chg Cfg*** and ***AFE SC Dsg Cfg*** registers, respectively.

When the bq29330 detects a short circuit in charge or short circuit in discharge fault, the charge and discharge FETs are turned off, the XALERT pin of the bq20z70 is driven low by the XALERT pin of the bq29330 and the bq29330 is interrogated. When the bq20z70 identifies the short-circuit condition (charge or discharge current direction), the internal *AFE_Current_Fault* timer is started from 0, either *[TCA]* or *[TDA]* battery status is set, *ChargingCurrent* and *ChargingVoltage* is set to 0 and either *[SCC]* or *[SCD]* is set. If the short-circuit condition is in discharge, then *[XDSG]* flag is also set.

However, when the bq20z70 has *[SCC]* flag 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. Also, when the bq20z70 has *[SOD]* set, the DSG FET is 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 setting of ***[NR]*** flag.

Each bq20z70 short-circuit protection feature can be individually configured to recover via two different methods, based on ***[NR]*** flag.

Standard Recovery is when ***[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 when ***[NR]*** = 1. The state of ***Non-Removable Cfg*** has no consequence when ***[NR]*** flag is set to 1. This recovery requires, during charging *AverageCurrent* to be ≤ 5mA, during discharging *AverageCurrent* to be ≥ (-) 5mA 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 2-4. 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	5mA

Table 2-4. Short Circuit Protection (continued)

Short Circuit	Condition	Flags set	FET	Charging Current	Charging Voltage	Clear Threshold
Discharge	***AFE SC Dsg Cfg***	*[SCD]SafetyStatus*, *[TDA]*, *[XDSG]*	DSG FET disabled, enabled during charge	0	0	-5mA

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: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]

2.1.4 Overtemperature Protection

The bq20z70 has overtemperature protection for both charge and discharge conditions.

The bq20z70 sets the over temperature charging *[OTC] SafetyStatus* flag, if pack temperature reaches or surpasses ***Over Temp Chg*** limit during charging for a 2s time period.

If *[OTFET]* is set and bq20z70 is in *[OTC]* condition, charging is disabled and CHG FET is turned off, ZVCHG FET (if used) is turned off, *ChargingCurrent* and *ChargingVoltage* is set to zero, *[TCA]* flag and *[OTC] SafetyStatus* are set.

In an *[OTC]* condition, the CHG FET is turned on again during discharge (*Current* ≤ (-) ***Dsg Current Threshold***) to prevent overheating of the CHG FET body diode.

The bq20z70 recovers from an *[OTC]* condition, if *Temperature* is ≤***OTC Chg Recovery*** limit. On recovery *[OTC] SafetyStatus* is reset, *[TCA]* is reset, *ChargingCurrent* and *ChargingVoltage* are set back to their appropriate value per charging algorithm, and CHG FET returns to previous state.

The bq20z70 sets the over temperature discharging *[OTD] SafetyStatus* flag, if pack temperature reaches or surpasses ***Over Temp Dsg*** limit during discharging for a 2s time period.

If *[OTFET]* is set and bq20z70 is in *[OTD]* condition, discharging is disabled and DSG FET is turned off, *ChargingCurrent* is set to zero, *[TDA]* flag is set, *[XDSG]* flag is set and *[OTD]* flag in *SafetyStatus* is set.

In an *[OTD]* condition, the DSG FET is turned on during charging (*Current* ≥ ***Chg Current Threshold***) to prevent overheating of the DSG FET body diode.

The bq20z70 recovers from an *[OTD]* condition, if pack temperature is ≤***OTD Chg Recovery*** limit. On recovery *[OTD] SafetyStatus* is reset, *[TDA]* is reset, *ChargingCurrent* is set back to their appropriate value per charging algorithm, and DSG FET is allowed to switch on again.

Table 2-5. Overtemperature Protection

	Overtemp Threshold	Time Limit	Overtemp Condition	Recovery Threshold
Charge	***Over Temp Chg***	2s	*[OTC] SafetyStatus* Flag, *[TCA]* set, ChargingCurrent =0, ChargingVoltage = 0, (CHG FET off if *[OTFET]* set)	***OT Chg Recovery***
Discharge	***Over Temp Dsg***	2s	*[OTD] SafetyStatus* Flag, *[TDA]* Set, ChargingCurrent =0, (*[XDSG]* set and DSG FET off if *[OTFET]* flag set)	***OT Dsg Recovery***

Related Variables:

- DF:1st Level Safety:Temperature(2):Over Temp Chg(0)
- DF:1st Level Safety:Temperature(2):OT Chg Recovery(3)
- DF:1st Level Safety:Temperature(2):Over Temp Dsg(5)
- 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:SafetyStatus(0x51)[OTC],[OTD]
- SBS:OperationStatus(0x54)[XDSG]

2.1.5 AFE Watchdog

The bq29330 automatically turns off the CHG FET, DSG FET and ZVCHG FET (if used), if the bq29330 does not receive the appropriate frequency on the WDI pin from bq20z70. The bq20z70 has no warning that this is about to happen, but it can report the occurrence once the bq20z70 is able to interrogate the bq29330.

When the XALERT input of the bq20z70 is triggered by the XALERT pin of the bq29330, the bq20z70 reads the STATUS register of the bq29330. If *[WDF]* is set, the bq20z70 also sets *[WDF]* in *SafetyStatus* and periodic verification of the bq29330 RAM is undertaken. If verification of the bq29330 RAM fails then the FETs will turn off. Verification of the bq29330 RAM will continue once every second. If the periodic verification passes, then *[WDF]* in *SafetyStatus* is cleared and the FETs return to normal operation.

Related Variables:

- SBS:SafetyStatus(0x51)[WDF]

2.2 2nd Level Protection Features

The bq20z70 provides features that can be used to indicate a more serious fault via the SAFE output. This output 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, then bq20z70 goes into permanent failure condition and the appropriate flag is set in *PFStatus*.

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

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

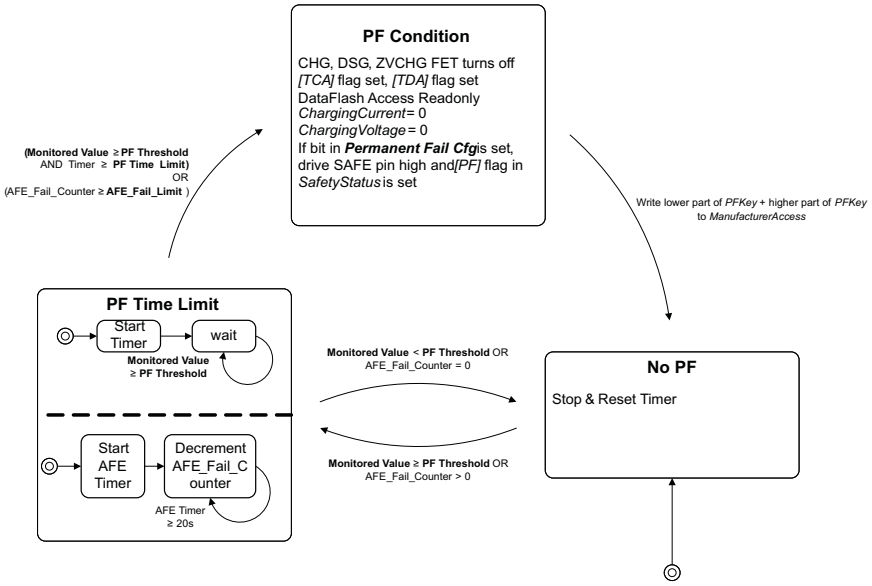

Figure 2-5. 2nd Level Protection

2.2.1 2nd Level (Permanent) Failure Actions

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

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

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):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

bq20z70 reports a 2nd level protection by setting the appropriate flag in the *PFStatus* function if the monitored value reaches or rises above the Protection Threshold for a period of Max Alert duration. See the table for all Protection Thresholds and Max Alert durations.

Safety Overvoltage Protection — The bq20z70 monitors the pack voltage for extreme values.

Cell Imbalance Fault — The bq20z70 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.

2nd Level Protection IC Input — The $\overline{\text{PFIN}}$ input of the bq20z70 can be used to determine the state of an external protection device such as the bq294xx. The bq20z70 watches for $\overline{\text{PFIN}}$ pin being driven low by an external device.

Safety Overcurrent Protection — The bq20z70 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 bq20z70 monitors the pack temperature during charging and discharging. The overtemperature thresholds and time limits can be set independently for charging and discharging.

Charge and Zero-Volt Charge FET Fault Protection — The bq20z70 monitors if there is, at any time, an attempt to turn off the CHG FET or ZVCHG FET or the CHG bit in the bq29330 OUTPUT register is set and the current still continues to flow.

Discharge FET Fault Protection — The bq20z70 monitors if there is, at any time, an attempt to turn off the DSG FET or the DSG bit in the bq29330 OUTPUT register is set and the current still continues to flow.

Table 2-6. Time Limit Based 2nd Level Protection

Protection	Monitored Value	Requirement	PF Threshold	PF Time Limit (set to 0 to disable Protection)	*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]*
2nd Level Protection IC Input	$\overline{\text{PFIN}}$ pin	-	$\overline{\text{PFIN}}$ pin low	***PFIN Detect Time***	*[PFIN]*	*[XPFIN]*
Safety Overcurrent Charge	*Current*	*Current* > 0	***SOC Chg***	***SOC Chg Time***	*[SOCC]*	*[XSOCC]*
Safety Overcurrent Discharge	*(-)Current*	*Current* < 0	***SOC Dsg***	***SOC Dsg Time***	*[SOCD]*	*[XSOCD]*
Safety Overtemperature Chg	*Temperature*	*Current* > 0	***SOT Chg***	***SOT Chg Time***	*[SOTC]*	*[XSOTC]*
Safety Overtemperature Dsg	*Temperature*	*Current* < 0	***SOT Dsg***	***SOT Dsg Time***	*[SOTD]*	*[XSOTD]*
Charge and Zero-Volt Charge FET Fault	*Current*	(CHG FET or ZVCHG FET turn off attempt or CHG Flag in bq29330 OUTPUT register set) and *Current* >0	50mA	***FET Fail Time***	*[CFETF]*	*[XCFETF]*
Discharge FET Fault	*(-)Current*	(DSG FET turn off attempt or DSG Flag in bq29330 OUTPUT register set) and *Current* < 0	(-)50mA	***FET Fail Time***	*[DFETF]*	*[XDFETF]*

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:FET Verification(19):FET Fail Time(2)
- 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):PF Flags 2(28)
- SBS:Temperature(0x08)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:SafetyStatus(0x51)[PF]
- SBS:PFStatus(0x53)

2.2.3 Limit based Protection

The bq20z70 reports a 2nd level permanent failure and sets the appropriate *PFStatus* flag if the internal error counter reaches the max error limit. The internal error counter is incremented by one if the error happens and decremented by one each fail recovery period.

bq29330 AFE Communication Fault Protection — The bq20z70 periodically validates its read and write communications with the bq29330. If either a read or write verify fails, an internal AFE_Fail_Counter is incremented. If the AFE_Fail_Counter reaches ***AFE Fail Limit***, the bq20z70 reports a *[AFE_C]* permanent failure. If the ***AFE Fail Limit*** is set to 0, this feature is disabled. An *[AFE_C]* fault can also be declared if, after a full reset, the initial gain and offset values read from the AFE cannot be verified. These values are A/D readings of the bq29330 VCELL output. The bq29330 offset values are verified by reading the values twice and confirming that the readings are within acceptable limits. The max difference between 2 readings is fixed at 20 . The maximum number of read retries, if offset and gain value verification fails and *[AFE_C]* fault is declared, is set in ***AFE Fail Limit***.

Dataflash Failure — The bq20z70 can detect if the data flash is not operating correctly. A permanent failure is reported when either: (i) After a full reset the instruction flash checksum does not verify; (ii) if any data flash write does not verify; or (iii) if any data flash erase does not verify.

Table 2-7. Error Based 2nd Level Protection

Protection	Monitored Value	Fail Recovery	Max Error Limit (set to 0 to disable Protection)	*PFStatus* Flag	*Permanent Fail Cfg* Flag
AFE Communication Fault	Periodic Communication with bq29330	Decrement of AFE_Fail_Counter by one per 20s time period	***AFE Fail Limit***	*[AFE_C]*	***[XAFE_C]***
Data Flash Failure	Dataflash	-	false flash checksum after reset, dataflash write not verified, dataflash erase not verified	*[DFF]*	***[XDFF]***

Related Variables:

- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)
- 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):PF Flags 1(28)
- SBS:PFStatus(0x53)

2.2.4 Clearing Permanent Failure

The bq20z70 permanent failure can be cleared by sending two *ManufacturerAccess* commands in sequence: the first word of the *PFKey* followed by the second word of the *PFKey*. After sending these two commands in sequence, *PFStatus* flags are cleared. Refer to Permanent Fail Clear (*PFKey*) Manufacturer access for further details.

Related Variables:

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

2.3 Gas Gauging

The bq20z70 measures individual cell voltages, pack voltage, temperature, and current using features of the bq29330 AFE device. The bq20z70 determines battery state of charge by analyzing individual cell voltages when a time exceeding 35 minutes has passed since the batteries last charge or discharge activity. The bq20z70 measures charge and discharge activity by monitoring the voltage across a small-value series sense resistor (10mΩ typ.) between the cell stack negative terminal and the negative terminal of the battery pack. The battery state of charge is subsequently adjusted during load or charger application using the integrated charge passed through the battery.

2.3.1 Impedance Track Configuration

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

Load Select — In order to compensate for the I x R drop near the end of discharge, the bq20z70 needs to be configured for whatever current (or power) will flow in the future. While it can not be exactly known, the bq20z70 can use load history such as the average current of the present discharge to make a sufficiently accurate prediction. The bq20z70 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 =	previous average discharge current from last run	previous average discharge power from last run
1 =	present average discharge current	present average discharge power
2 =	*Current*	*Current* x *Voltage*
3 =	*AverageCurrent* (default)	*AverageCurrent* x average *Voltage*
4 =	***Design Capacity*** / 5	***Design Energy*** / 5
5 =	*AtRate* (mA)	*AtRate* (10 mW)
6 =	***User Rate-mA***	***User Rate-mW***

Pulsed Load Compensation and Termination Voltage — In order to take into account pulsed loads, while calculating remaining capacity until ***Term Voltage*** threshold is reached, the bq20z70 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 bq20z70 allows an amount of capacity to be reserved in either mAh (***Reserve Cap-mAh***, ***Load Mode*** = 0) or 10 mWh (***Reserve Cap-mWh***, ***Load Mode*** = 1) units between the point where *RemainingCapacity* function reports zero capacity, and the absolute minimum pack voltage, ***Term Voltage***. This enables a system to report zero energy, but still have enough reserve energy to perform a controlled shutdown, or to provide an extended sleep period for the host system.

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

Related Variables:

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- DF:Configuration:Operation Cfg B(2)[RESCAP]
- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- DF:Gas Gauging:IT Cfg(80):Term Voltage(45)
- DF:Gas Gauging:IT Cfg(80):User Rate-mA(60)
- DF:Gas Gauging:IT Cfg(80):User Rate-mW(62)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(64)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(66)
- DF:Gas Gauging:State(82):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 data flash parameters in the subclass 'Gas Gauging: Current Thresholds' section. In Relaxation Mode or Discharge Mode, the DSG flag in *BatteryStatus* is set.

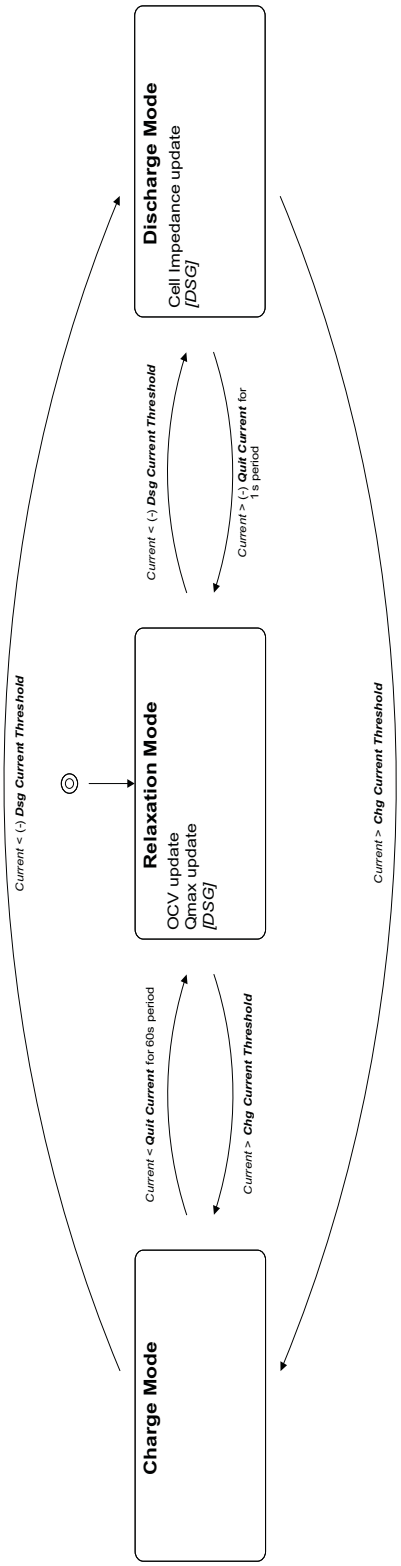

Figure 2-6. Gas Gauge Operating Modes

Charge mode is exited and Relaxation mode is entered when *Current* goes below ***Quit Current*** for a period of 60s. 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 1s. Charge mode is entered when *Current* goes above ***Chg Current Threshold***.

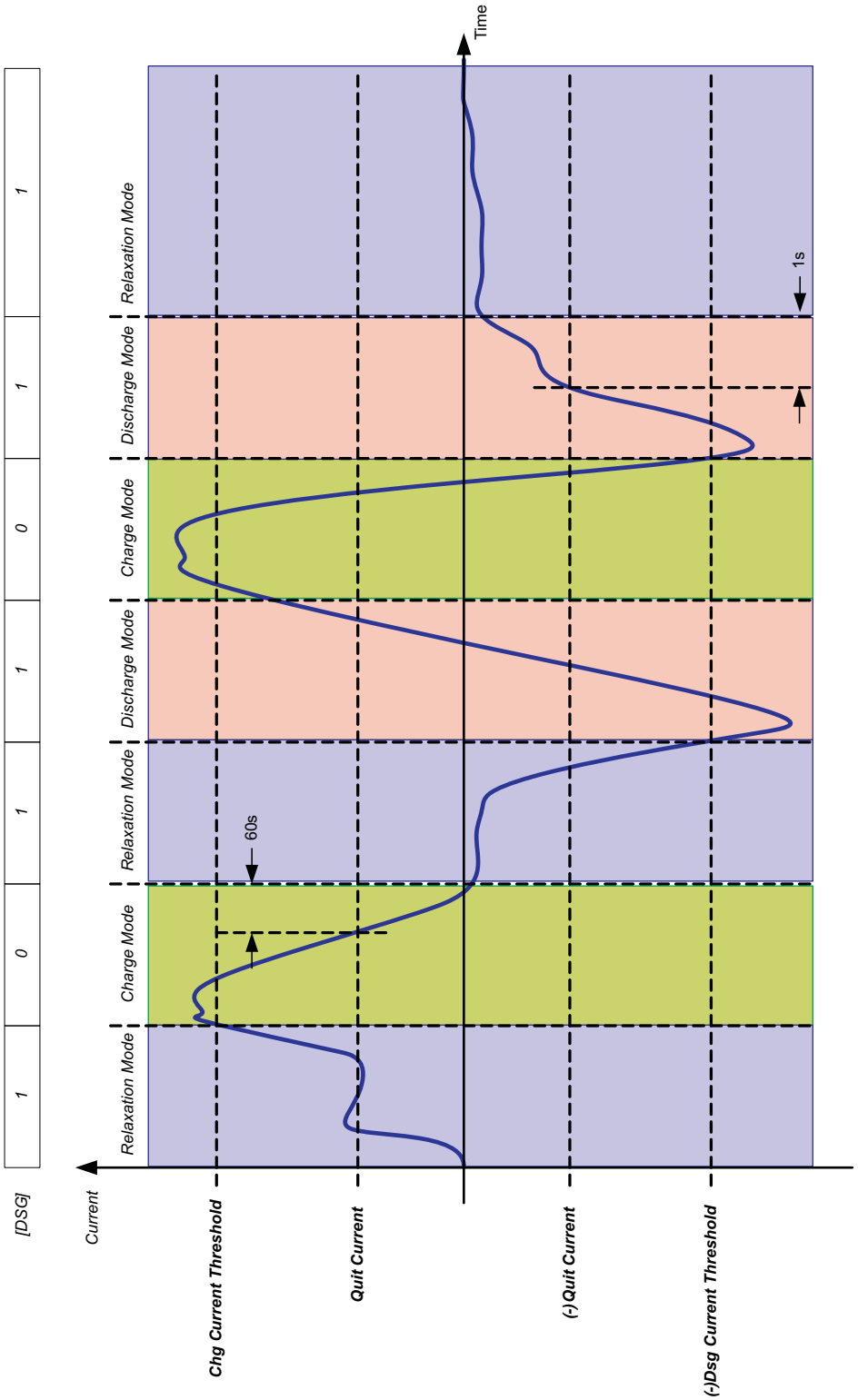

Figure 2-7. Gas Gauge Operating Mode Example

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)
- 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 bq20z70 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 Cfg(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 "Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm" application note (SLUA364) for further details.

Related Variables:

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

2.3.3.2 Qmax Update Conditions

The bq20z70 updates the no-load full capacity (Qmax) when two open circuit voltage (OCV) readings are taken. These OCV readings are taken when the battery is in a relaxed state before and after charge or discharge activity. A relaxed state is achieved if the battery voltage has a dV/dt of < 4 µV/s. Typically it takes 2 hrs in a charged state and 5 hrs in a discharged state to ensure that the dV/dt condition is satisfied. If 5 hrs is exceeded, a reading will be taken even if the dV/dt condition was not satisfied. A Qmax update is disqualified under the following conditions:

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

- **Delta Capacity: If the capacity change between suitable battery rest periods is less than 37%.**
- **Voltage: If *CellVoltage4..1*is within the range of 3737mV and 3800mV for the default LIONchemistry.** Refer to "Support of Multiple Li-Ion Chemistries w/Impedance Track(TM) Gas Gauges", application note, (SLUA372) for the voltage ranges of other chemistries.

Related Variables:

- DF:SBS Configuration:Data(48):Device Chemistry(46)
- 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 bq20z70 can report the appropriate charging current needed for the constant charging current and the charging voltage needed for constant voltage charging per charging algorithm to a smart charger using the *ChargingCurrent* and the *ChargingVoltage* functions. The actual charging status of bq20z70 is indicated with flags and can be read out with the *ChargingStatus* function.

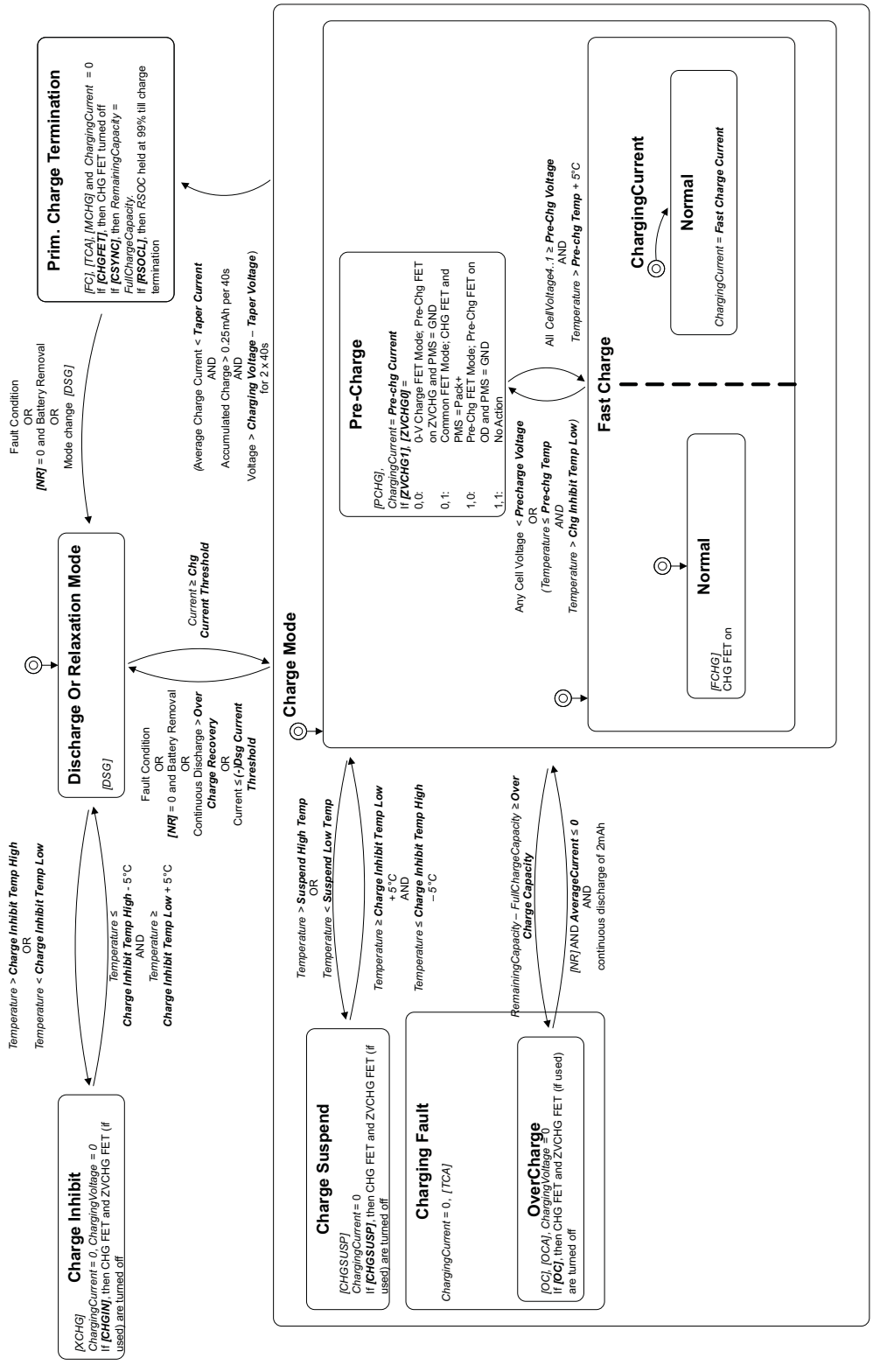

Figure 2-8. Charging

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

2.4.1 Charge Control SMBus Broadcasts

All broadcasts to a host or a smart charger are enabled by the ***[BCAST]*** bit. The *[ChgM]* and *[AM]* modes in *BatteryMode* are enabled by setting the ***[BCAST]*** bit. If the ***[HPE]*** bit is enabled, transmissions to the host and receiving communications from all sources are PEC enabled. If the ***[CPE]*** flag is enabled, Master-Mode broadcasts to the Smart-Charger address are PEC enabled. When broadcast is enabled, the following broadcasts are sent:

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

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg B(2)[CPE],[HPE],[BCAST]
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OCA],[TCA],[OTA],[TDA],[RCA],[RTA]
- SBS:BatteryMode(0x03)[ChgM],[AM]

2.4.2 Cell Balancing

The bq20z70 can determine the chemical state of charge of each cell using the Impedance Track™ algorithm. The cell balancing algorithm used in the bq20z70 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 bq20z80" Application Report (SLUA340).

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

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

The bypass time needed for each cell is calculated as:

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

Where:

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

V_avg = 3.6V

duty_cycle = 0.4 typ.

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

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

Related Variables:

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

2.4.3 Charge Inhibit Mode

If the bq20z70 is in discharge mode or relaxation mode (*[DSG]* = 1), the bq20z70 goes into charge inhibit mode and sets the *ChargingCurrent* and *ChargingVoltage* values to 0 to inhibit charging if:

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

In charge inhibit mode the *[XCHG]* flag in *ChargingStatus* is set. If ***[CHGIN]*** bit in ***Operation Cfg B*** is set, the CHG FET and ZVCHG FET (if used) are also turned off when the bq20z70 is in charge-inhibit mode.

The bq20z70 allows charging to resume when:

- *Temperature* ≥ ***Charge Inhibit Temp Low*** + 5°C AND
- *Temperature* ≤ ***Charge Inhibit Temp High*** - 5°C

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

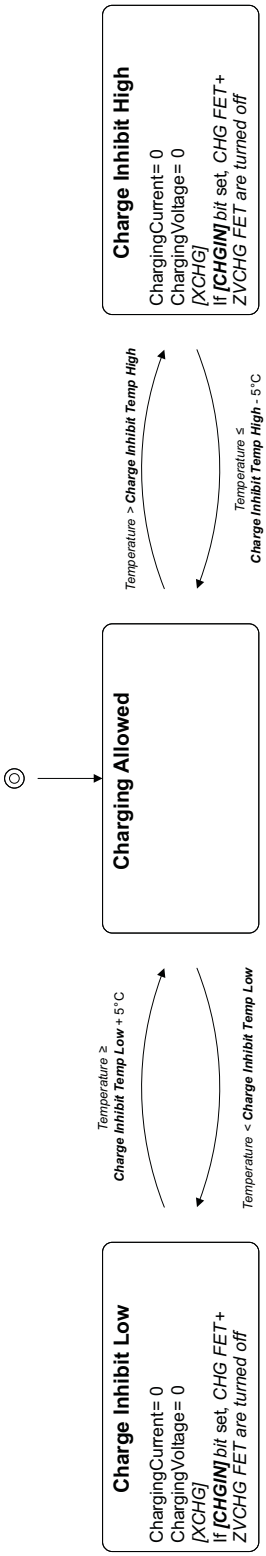

Figure 2-9. Charge Inhibit

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:Configuration:Registers(64):Operation Cfg B(2)[CHGIN],[NR]
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[XCHG]

2.4.4 Charge Suspend Mode

The bq20z70 suspends charging when:

- one of the following conditions
  - *Temperature* < ***Suspend Low Temp***, OR
  - *Temperature* > ***Suspend High Temp***

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

The bq20z70 resumes charging if:

- *Temperature* ≥ ***Charge Inhibit Temp Low*** + 5°C, AND
- *Temperature* ≤ ***Charge Inhibit Temp High*** – 5°C.

Upon resuming, the bq20z70 clears the *[CHGSUSP]* status flag, sets *ChargingCurrent* according to the appropriate charging mode entered and the CHG and ZVCHG FETs (if used) return to their previous state.

The bq20z70 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)

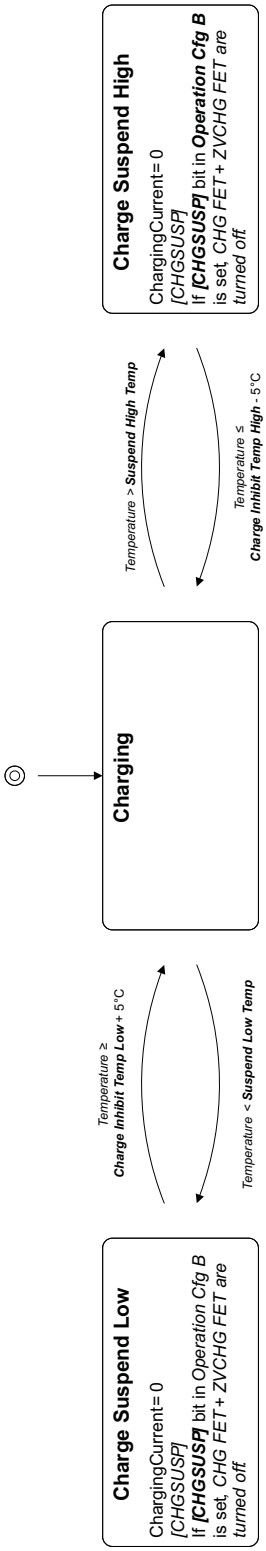

Figure 2-10. Charge Suspend

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

2.4.5 Precharge

The bq20z70 enters precharge mode during charging if the *Temperature* function reports a temperature between ***Charge Inhibit Temp Low*** limit and ***Pre-chg Temp*** limit or any cell voltages are below ***Pre-chg Voltage*** limit. Precharge mode is also entered if any of the *SafetyStatus* flags *[CUV]* or *[OCD]* are set.

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

Table 2-8. Precharge FET

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

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

The bq20z70 leaves Pre-charge mode and clears the *[PCHG]* flag if all cell voltages reach or rise above ***Recovery Voltage*** and the reported *Temperature* is equal to or greater than ***Pre-chg Temp*** + 5°C. Pre-charge mode is also exited if charge inhibit 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],[OCD],[OCD2]
- SBS:ChargingStatus(0x55)[PCHG]

2.4.6 Fast Charge

The bq20z70 enters fast charge mode and sets *ChargingCurrent* to ***Fast Charge Current*** and *ChargingVoltage* to ***Charging Voltage*** when all of the following conditions are met.

- *Temperature* ≥ ***Pre-chg Temp***
- *Temperature* ≤ ***Charge Suspend Temp High***
- *CellVoltage4..1* ≥ ***Pre-chg Voltage***

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

Related Variables:

- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Temp(2)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Voltage(4)
- DF:Charge Control:Fast Charge Cfg(34):Fast Charge Current(0)
- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Fast Charge Cfg(34):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 Primary Charge Termination

The bq20z70 determines charge termination if:

- Average Charge Current < ***Taper Current*** during 2 consecutive 40s time periods, AND
- the accumulated change in capacity must be > 0.25mAh per period during 2 consecutive 40s time periods, AND
- *Voltage* + ***Taper Voltage*** ≥ ***Charging Voltage***

Upon entering charge termination status, *[TCA]* and *[FC]* flags are set, *[MCHG]* is flag set, *ChargingCurrent* = 0.

The following parameters change the behavior of bq20z70 on charge termination:

Table 2-9. Primary Charge Termination

Parameter	Behavior on Primary Charge Termination
[CHGFET] set	CHG FET turned off
[CSYNC] set	*RemainingCapacity* = *FullChargeCapacity*
[RSOCL] set	*RelativeStateOfCharge* is held at 99% until primary charge termination occurs and displays 100% only upon entering primary charge termination state.
[RSOCL] cleared	*RelativeStateOfCharge* is **not** held at 99% until primary charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.

Related Variables:

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(2)
- DF:Charge Control:Termination (36):Taper Current(2)
- DF:Charge Control:Termination (36):Taper Voltage(6)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGFET],[CSYNC]
- DF:Configuration:Registers(64):Operation Cfg C(4)[RSOCL]
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA],[FC]
- SBS:ChargingStatus(0x55)[MCHG]

2.4.8 Charging Faults

The bq20z70 can report charging faults in the *ChargingStatus* register.

Overcharge

The bq20z70 goes into overcharge mode if battery pack is charged in excess of *FullChargeCapacity* by an amount greater than ***Over Charge Capacity***. Also, *ChargingCurrent* = 0, *ChargingVoltage* = 0, *[TCA]* and *[OCA]* flags in *BatteryStatus* and *[OC]* flag in *ChargingStatus* are set. If ***Over Charge Capacity*** is set to 0, this feature is completely disabled.

The bq20z70 recovers if any of the following conditions are met:

- Pack removed and reinserted (***[NR]*** = 0)
- Continuous amount of discharge over 2mAh and *AverageCurrent* < 0, when ***[NR]*** = 1
- *RemainingCapacity* ≤ ***FC Clear %***

On recovery, *[TCA]* and *[OCA]* flags in *BatteryStatus* and *[OC]* flag in *ChargingStatus* are cleared.

Table 2-10. Charging Faults

Charge Fault	Fault Condition	Recovery Condition	*ChargingStatus* Flag
Overcharge	Charge in excess of *FullChargeCapacity* ≥ ***Over Charge Capacity***	Pack removed and reinserted if ***[NR]*** = 0, OR continuous amount of discharge of 2mAh if ***[NR]*** = 1, OR *RemainingCapacity* ≤ ***FC Clear %***	*[OC]*

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 Charge Capacity(13)
- 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)[TCA],[OCA]
- SBS:ChargingStatus(0x55)[FCHG]

2.4.9 Discharge and Charge Alarms

The bq20z70 enables *[TDA], [FD], [TCA] and [FC]* flags in *BatteryStatus* to be set or cleared on the following thresholds based on *RelativeStateOfCharge*. All thresholds can be disabled by setting them to -1. ***FC Clear %*** should not be disabled by setting to -1.

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

The *[TDA]* flag 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

Related Variables:

- DF:Charge Control:Termination Cfg.(36):TCA Clear %(10)
- 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)
- SBS:Voltage(0x09)

- SBS:RelativeStateOfCharge(0x0d)

2.5 Device Operating Mode

The bq20z70 has several device power modes. During these modes, the bq20z70 modifies its operation to minimize power consumption from the battery.

2.5.1 Normal Mode

During normal operation, the bq20z70 takes *Current*, *Voltage*, and *Temperature* measurements, performs calculations, updates SBS data, and makes protection and status decisions at one-second intervals. Between these periods of activity, the bq20z70 is in a reduced power state.

$\overline{\text{PRES}}$ is sampled once per second and if $\overline{\text{PRES}}$ is high, *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 ***[NR]*** bit is set, the $\overline{\text{PRES}}$ input can be left floating as it is not monitored.

Related Variables:

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

2.5.2 Battery Pack Removed Mode/System Present Detection

2.5.2.1 Battery Pack Removed

The bq20z70 detects the Battery Pack Removed state if ***[NR]*** bit is set to 0 AND the $\overline{\text{PRES}}$ input is high (*[PRES]* = 0).

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

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

The bq20z70 exits the Battery Pack Removed state if ***[NR]*** flag is set to 0, AND the $\overline{\text{PRES}}$ input is low (*[PRES]* = 1). When this occurs, *[TCA]* and *[TDA]* flags are reset.

Related Variables:

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

2.5.2.2 System Present

$\overline{\text{PRES}}$ is sampled once per second and if $\overline{\text{PRES}}$ is high, *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 ***[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]

2.5.3 Sleep Mode

In Sleep mode, the bq20z70 measures Voltage and Temperature every 5s intervals and *Current* every 20s. At each interval, the bq20z70 performs calculations, updates SBS data and makes protection and status decisions. Between these periods of activity, the bq20z70 is in a reduced-power state.

The bq20z70 enters Sleep mode when the following conditions exist:

- If ***[NR]*** bit is set to 0, the $\overline{\text{PRES}}$ input must also be high, *[PRES]* = 0, for the bq20z70 to enter sleep. AND one of the following conditions:
- (|*Current*| $\leq$ 10mA) AND (SMBus is low for 5s***)*** AND (***[SLEEP]*** bit is set)

OR

- (|*Current*| ≤ 10mA) AND (*ManufacturerAccess* Sleep command is received) AND (***[SLEEP]*** is set).

Entry to Sleep mode is blocked if any of the *PF Status* flags are set.

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

Also, on entry to Sleep mode, the auto calibration of the A/DC begins. However, if *Temperature* is ≤ 5°C or *Temperature* ≥ 45°C, Auto Calibration is not started on entry to sleep mode. The activation of auto calibration is not affected by the state of ***[SLEEP]***, nor *Current*.

The bq20z70 exits Sleep mode when one or more of the following conditions exist:

- If ***[NR]*** bit is set to 0, the $\overline{\text{PRES}}$ is pulled low, *[PRES]* = 1
- (|*Current*| > 10mA)
- SMBC or SMBD inputs transition high
- *OperationStatus*, *ChargingStatus* or *SafetyStatus* flags are set
- Wake function enabled by setting ***Wake Current Reg*** and a voltage across SRP and SRN

Related Variables:

- DF:Power:Power(68):Wake Current Reg(16)
- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR], [NRCHG]
- SBS:ManufacturerAccess(0x00)Sleep(0x0011)
- SBS:Current(0x0a)
- SBS:SafetyStatus(0x51)
- SBS:OperationStatus(0x54)[PRES]

2.5.4 Wake Function

The bq20z70 can exit sleep mode, if enabled, by the presence of a voltage across SRP and SRN. The level of current signal needed is defined in ***Wake Current Reg***.

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

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

Figure 2-11. Wake Current Reg

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

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

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

Table 2-11. Wake Current Reg

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

Related Variables:

- DF:Power:Power(68):Wake Current Reg(16)
- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:Current(0x0a)

2.5.5 Shutdown Mode

The bq20z70 enters Shutdown mode if the following conditions are met:

- *Voltage* ≤ ***Shutdown Voltage*** AND *Current* ≤ 0 for a period greater than 10s
  OR
- (*ManufacturerAccess* shutdown command received AND *Current* = 0) AND voltage at the bq29330 PACK pin < ***Charger Present*** threshold.

When the bq20z70 meets these conditions, the CHG, DSG, and ZVCHG FETs are turned off, and the bq29330 is commanded to shut down. In Shutdown mode, the bq20z70 is completely powered down because its supply is removed.

To exit Shutdown mode, the voltage at the PACK pin of the bq29330 must be greater than its minimum operating voltage. When this occurs, the bq29330 returns power to the bq20z70, the *[WAKE]* flag is set, and the bq29330 configured. The *[INIT]* and *[WAKE]* flags are cleared after approximately 1 s when all SBS parameters have been measured and updated.

Related Variables:

- DF:Power:Power(68):Shutdown Voltage(2)
- DF:Power:Power(68):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]

2.6 Security (Enables and Disables Features)

There are three levels of secured operation within the bq20z70. 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 bq20z70 to limit access to the SBS functions and data flash space and sets the *[SS]* flag. In sealed mode, standard SBS functions have access per the Smart Battery Data Specification - Appendix A. Extended SBS Functions and data flash are not accessible. Once in sealed mode, the part can never permanently return to Unsealed or Full Access modes.

2. Sealed to Unsealed — Instructs the bq20z70 to extend access to the SBS and data flash space and clears the *[SS]* flag. In unsealed mode, all data, SBS, and DF have read/write access. Unsealing is a 2 step command performed by writing the 1st word of the *UnSealKey* to *ManufacturerAccess* followed by the second word of the *UnSealKey* to *ManufacturerAccess*. The unseal key can be read and changed via the extended SBS block command *UnSealKey* when in Full Access Mode. To return to the Sealed mode, either a hardware reset is needed, or the *ManufacturerAccess* seal device command is needed to transit from Full Access or Unsealed to Sealed.

3. Unsealed to Full Access — Instructs the bq20z70 to allow Full Access to all SBS commands and data flash. The bq20z70 is shipped from TI in this mode. The keys for Unsealed to Full Access can be read and changed via the extended SBS block command *FullAccessKey* when in Full Access mode. Changing from Unsealed to Full Access is performed by using the *ManufacturerAccess* command, by writing the 1st word of the *FullAccessKey* to *ManufacturerAccess* followed by the second word of the *FullAccessKey* to *ManufacturerAccess*. The full access key can be read and changed via the extended SBS block command *FullAccessKey* when in Full Access Mode. In Full Access mode, the command to go to Boot ROM can be sent.

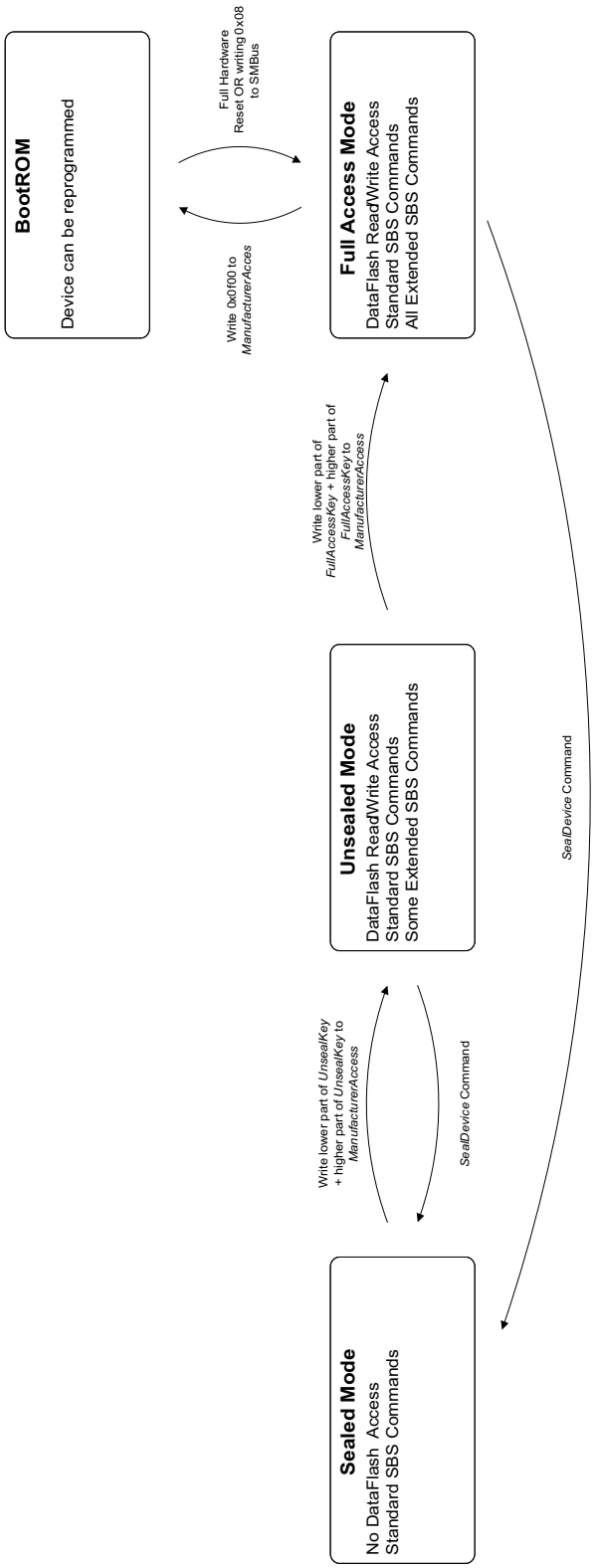

Figure 2-12. Security

Related Variables:

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

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

2.7 Calibration

2.7.1 Coulomb Counter Dead Band

The bq20z70 does not accumulate charge or discharge for gas gauging when the current input is below the dead-band current threshold. The threshold is programmed in ***CC Deadband*** (Coulomb Counter Deadband) and should be set sufficiently high to prevent false signal detection with no charge or discharge flowing through the sense resistor.

Related Variables:

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

2.7.2 Auto Calibration

The bq20z70 provides an auto-calibration feature to cancel the voltage offset error across SRP and SRN for maximum charge measurement accuracy. The bq20z70 performs auto-calibration when the SMBus lines stay low continuously for a minimum of 5 s and *Temperature* is within bounds of 5°C and 45°C.

Related Variables:

- SBS:Temperature(0x08)

2.8 Communications

The bq20z70 uses SMBus v1.1 with Master Mode and packet error checking (PEC) options per the SBS specification.

2.8.1 SMBus On and Off State

The bq20z70 detects an SMBus off state when SMBC and SMBD are logic-low for ≥ 2 seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

2.8.2 Packet Error Checking

The bq20z70 can receive or transmit data with or without PEC.

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

In the write-word protocol, the bq20z70 receives the PEC after the last byte of data from the host. After receipt of the PEC, the bq20z70 compares the value to its calculation. If the PEC is correct, the bq20z70 responds with an ACKNOWLEDGE. If it is not correct, the bq20z70 responds with a NOT ACKNOWLEDGE and sets an error code. If host supports PEC, the ***[HPE]*** bit should be set to 1.

In the read-word and block-read in master mode, the host generates an ACKNOWLEDGE after the last byte of data sent by the bq20z70. The bq20z70 then sends the PEC, and the host, acting as a master-receiver, generates a NOT ACKNOWLEDGE and a stop condition.

Related Variables:

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

2.8.3 bq20z70 Slave Address

The bq20z70 uses the address 0x16 on SMB for communication.

2.8.4 Broadcasts to Smart Charger and Smart Battery Host

The bq20z70 can broadcast messages to the smart battery charger and smart battery host. This can be enabled with the ***[BCAST]*** bit.

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

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

Related Variables:

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

Standard SBS Commands

The bq20z70 SBS command set meets the SBD v1.1 specification. All SBS Values are updated in 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 need to be read from *ManufacturerAccess* after a write with the command word to *ManufacturerAccess*.

A.1.1.1 Device Type(0x0001)

Returns the IC part number.

Table A-2. Device Type

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0001	R	Device Type	hex	2	-	-	0x0700	

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	-	-	0x0101	

A.1.1.3 Hardware Version(0x0003)

Returns the hardware version stored in single byte of reserved data flash. 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 only available when the bq20z70 is in unsealed mode or full access mode, indicated by the *[SS]* and *[FAS]* flag. A write to this command forces the bq20z70 to generate a checksum of the full Data Flash (DF) array and. The generated checksum is then returned within 45 ms.

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

Table A-5. DF Checksum

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

A.1.1.5 Manufacturer Status(0x0006)

This function is available while the bq20z70 is in normal operation. This 16-bit word reports the battery status.

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

LEGEND: All bits are read-only

Figure A-1. Manufacturer Status

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

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

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

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

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

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

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

0,1 = Cell imbalance failure

1,0 = Safety voltage failure

1,1 = FET failure

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

0,0,0,0 = Wake Up
0,0,0,1 = Normal Discharge
0,0,1,1 = Pre-Charge
0,1,0,1 = Charge
0,1,1,1 = Charge Termination
1,0,0,1 = 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 Pack Removed

A.1.1.6 Chemistry ID(0x0008)

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

Table A-6. Chemistry ID

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0008	R	Chemistry ID	hex	2	0x0000	0xffff	0x100	

A.1.2 System Control

The commands in this section cause the bq20z70 to take actions when written. No data is returned.

A.1.2.1 Shutdown(0x0010)

Instructs the bq20z70 to verify and enter shutdown mode. This command is only available when the bq20z70 is in Unsealed or Full Access mode. Shutdown will not be 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 bq20z70 to verify and enter sleep mode , if no other command is sent after *Sleep* command. Any SMB transition will wake up bq20z70. It takes about 1 min before the device will go to sleep. This command is only available when the bq20z70 is in Unsealed or Full Access mode.

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]

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

A.1.2.3 Seal Device(0x0020)

Instructs the bq20z70 to limit access to the extended SBS functions and data flash space, set *[SS]* flag and clears *[FAS]* flag.

This command is only available when the bq20z70 is in Unsealed or Full Access mode.

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

Related Variables:

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

A.1.2.4 IT Enable(0x0021)

This command forces the bq20z70 to begin the Impedance Track™ algorithm and changes ***Update Status***, and the *[QEN]* flag.

This command is only available when the bq20z70 is in Unsealed or Full Access mode.

Related Variables:

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

A.1.2.5 SAFE activation(0x0030)

This command drives the SAFE pin high.

This command is only available when the bq20z70 is in Unsealed or Full Access mode.

Related Variables:

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

A.1.2.6 SAFE Clear(0x0031)

This command sets the SAFE pin back to low.

This command is only available when the bq20z70 is in Unsealed or Full Access mode.

Related Variables:

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

A.1.2.7 Calibration Mode(0x0040)

Places the bq20z70 into calibration mode. See "Data Flash Programming and Calibrating the bq20z70 and bq20z90 family of Gas Gauges" application note (SLUA379) for further details.

This command is only available when the bq20z70 is in Unsealed or Full Access mode.

Related Variables:

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

A.1.2.8 Reset(0x0041)

The bq20z70 undergoes a full reset. The bq20z70 holds the clock line down for a few milli-seconds to complete the reset.

This command is only available when the bq20z70 is in Unsealed or Full Access mode.

Related Variables:

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

A.1.2.9 BootRom(0x0f00)

The bq20z70 goes into BootRom Mode.

This command is only available when the bq20z70 is in Full Access mode.

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

A.1.2.10 Permanent Fail Clear(*PFkey*)

This 2 step command needs to be written to *ManufacturerAccess* in following order: 1st word of the *PFKey* followed by the 2nd word of the *PFKey*. The default 1st word is 0x2673 and the default 2nd word is 0x1712.

It instructs the bq20z70 to clear the *PFStatus*, clear the *[PF]* flag, reset the SAFE pin and unlock the data flash for writes.

This command is only available when the bq20z70 is in Unsealed or Full Access mode.

Related Variables:

- DF:PF Status:Device Status Data(96):PF Flags 1(0)
- DF:PF Status:Device Status Data(96):PF Flags 2(28)
- SBS:PFStatus(0x46)
- SBS:SafetyStatus(0x51)[PF]
- SBS:PFKey(0x62)

Note: Higher 2 bytes must be immediately followed by lower 2 bytes. If clear command fails, 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.1.2.11 Unseal Device (*UnsealKey*)

Instructs the bq20z70 to enable access to the SBS functions and data flash space and clears *[SS]* flag. This 2 step command needs to be written to *ManufacturerAccess* in following order: 1st word of the *UnSealKey* followed by the 2nd word of the *UnSealKey*.

This command is only available when the bq20z70 is in Sealed mode

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

Related Variables:

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

A.1.2.12 Full Access Device (*FullAccessKey*)

Instructs the bq20z70 to enable full access all SBS functions and data flash space and set the *[FAS]* flag. This 2 step command needs to be written to *ManufacturerAccess* in following order: 1st word of the *FullAccessKey* followed by the 2nd word of the *FullAccessKey*.

This command is only available when the bq20z70 is in Unsealed mode

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

Related Variables:

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

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

0x0051 = SBS:SafetyStatus(0x51)

0x0053 = SBS:PFStatus(0x53)

0x0054 = SBS:OperationStatus(0x54)

0x0055 = SBS:ChargingStatus(0x55)

0x0057 = SBS:ResetData(0x57)

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 65535 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*, *[RCA]* flag is set and bq20z70 sends *AlarmWarning* message to SMBUS host.

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

0 = Remaining capacity alarm is disabled

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

Table A-7. RemainingCapacityAlarm

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

Related Variables:

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

A.3 RemainingTimeAlarm(0x02)

This read or write-word function sets or gets the *RemainingTimeAlarm* unsigned integer value in minutes with a range of 0 to 65,535. The default value of *RemaingTimeAlarm* is stored in ***Rem Time Alarm***. If *RemainingTimeAlarm* = 0, this alarm is disabled.

If *AverageTimeToEmpty* < *RemainingTimeAlarm*, *[RTA]* flag is set and bq20z70 sends *AlarmWarning* message to SMBus host.

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

0 = Remaining time alarm is disabled

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

Table A-8. RemainingTimeAlarm

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

Related Variables:

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

A.4 BatteryMode(0x03)

This read- or write-word function selects the various battery operational modes and reports the battery's capabilities, 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

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 10mW or 10mWh

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

SBS:RemainingCapacityAlarm(0x01)

SBS:AtRate(0x04)

SBS:RemainingCapacity(0x0f)

SBS:FullChargeCapacity(0x10)

Following functions are recalculated within 1 second after *[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 bq20z70's transmission of *ChargingCurrent* and *ChargingVoltage* messages to the Smart Battery Charger.

0 = Enable *ChargingVoltage* and *ChargingCurrent* broadcasts to smart battery charger by setting the ***[BCAST]*** bit in ***Operation Cfg B*** , when charging is desired.

1 = Disable *ChargingVoltage* and *ChargingCurrent* broadcasts to smart battery charger by clearing the ***[BCAST]*** bit in ***Operation Cfg B*** (default).

related variables:

SBS:ChargingCurrent(0x14)

SBS:ChargingVoltage(0x15)

AM: ALARM_MODE — enable or disable *AlarmWarning* broadcasts to host and smart batter charger

0 = Enable *AlarmWarning* broadcast to host and smart battery charger by setting the ***[BCAST]*** bit in ***Operation Cfg B***. The bq20z70 sends the *AlarmWarning* messages to the SMBus Host and the Smart Battery Charger any time an alarm condition is detected

1 = Disable *AlarmWarning* broadcast to host and smart battery charger clearing the ***[BCAST]*** bit in ***Operation Cfg B*** (default). The bq20z70 does not master the SMBus, and *AlarmWarning* messages are not sent to the SMBus Host and the Smart Battery Charger.

Note: The system, as a minimum, is required to poll the Smart 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 bq20z70 and should be set to 0.

CC: CHARGE_CONTROLLER — Enable or disable internal charge controller. This flag is not used by bq20z70 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 (20)

SBS:MaxError(0x0c)

PBS: PRIMARY_BATTERY_SUPPORT — Primary battery support is not supported by bq20z70 and is fixed to 0.

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

A.5 AtRate(0x04)

This read- or write-word function is the first half of a two-function call set used to set the *AtRate* value used in calculations made by the *AtRateTimeToFull*, *AtRateTimeToEmpty* and *AtRateOK* functions. The *AtRate* units are in either mA (*[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	-32768	32767	0	mA or 10mW

Related Variables:

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

A.6 AtRateTimeToFull(0x05)

This read-word function returns an unsigned integer value of the predicted remaining time to fully charge the battery using a CC-CV method at the *AtRate* value in minutes, with a range of 0 to 65534. A value of 65,535 indicates that the *AtRate* = 0.

AtRateTimeToFull can report time based on constant current (*[CAPACITY_MODE]* = 0) or constant power (*[CAPACITY_MODE]* = 1), and updates within one second after the SMBus host sets the *AtRate* value. The bq20z70 automatically updates *AtRateTimeToFull* based on the *AtRate*function at one-second intervals.

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

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

Table A-10. AtRateTimeToFull

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

Related Variables:

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

A.7 AtRateTimeToEmpty(0x06)

This read-word function returns an unsigned integer value of the predicted remaining operating time in minutes with a range of 0 to 65534, if the battery is discharged at the *AtRate* value. A value of 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 one second after the SMBus host sets the *AtRate* value. The bq20z70 updates *AtRateTimeToEmpty* at one-second intervals.

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

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

Table A-11. AtRateTimeToEmpty

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

Related Variables:

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

A.8 AtRateOK(0x07)

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

The bq20z70 updates this value within one second after the SMBus host sets the *AtRate* function value. The bq20z70 updates *AtRateOK* at one-second intervals.

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

0 = FALSE bq20z70 can **not** deliver energy for 10 seconds actual discharge rate indicated in *AtRate*

1..65535 = TRUE bq20z70 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	65535	-	min

Related Variables:

- SBS:AtRate(0x04)

A.9 Temperature(0x08)

This read-word function returns an unsigned integer value of the temperature in units of 0.1°K, as measured by the bq20z70. It has a range of 0 to 6553.5°K.

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

Table A-13. Temperature

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

Related Variables:

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

A.10 Voltage(0x09)

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

Table A-14. Voltage

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

A.11 Current(0x0a)

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

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

Table A-15. Current

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

Related Variables:

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

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

A.12 AverageCurrent(0x0b)

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

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

Table A-16. AverageCurrent

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

Related Variables:

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

A.13 MaxError(0x0c)

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

Internally MaxError is incremented 0.05% for every increment of *CylceCount* after the last Qmax update. The displayed*MaxError* is incremented by 1% points.

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

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 fractions of % rounded up.

If ***RSOCL*** bit, in ***Operation Cfg C***, is set, then *RelativeStateOfCharge* is held at 99% until primary charge termination occurs and displays 100% only upon entering primary charge termination state.

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

Table A-18. RelativeStateOfCharge

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

Related Variables:

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

A.15 AbsoluteStateOfCharge(0x0e)

This read-word function returns an unsigned integer value of the predicted remaining battery capacity expressed in %, with a range of 0 to 100% with any fractions of % rounded up. The table below shows the calculation used depending on *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)[CapM]
- SBS:RemainingCapacity(0x0f)

A.16 RemainingCapacity(0x0f)

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

Related Variables:

- SBS:BatteryMode(0x03)[CapM]

A.17 FullChargeCapacity(0x10)

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

Related Variables:

- SBS:BatteryMode(0x03)[CapM]

A.18 RunTimeToEmpty(0x11)

This read-word function returns an unsigned integer value of the predicted remaining battery life at the present rate of discharge, in minutes, with a range of 0 to 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 *[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	65535	-	min

Related Variables:

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

65535 = battery is not being discharged

Table A-23. AverageTimeToEmpty

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

Related Variables:

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

A.20 AverageTimeToFull(0x13)

This read-word function returns an unsigned integer value of predicted remaining time until the battery reaches full charge, in minutes, based on *AverageCurrent* with a range of 0 to 65,535. A value of 65,535 indicates that the battery is not being charged.

0..65534 = predicted remaining time until full charge

65535 = battery is not being charged

Table A-24. AverageTimeToFull

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

Related Variables:

- SBS:AverageCurrent(0x0b)

A.21 ChargingCurrent(0x14)

This read-word function returns an unsigned integer value of the desired charging 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..65534 = desired charging voltage in mA

65535 = charger should operate as voltage source outside it's 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	65535	-	mA

A.22 ChargingVoltage(0x15)

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

0..65534 = desired charging voltage in mV

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

Table A-26. ChargingVoltage

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

A.23 BatteryStatus(0x16)

This read-word function returns the status of the bq20z70-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

Figure A-3. BatteryStatus

OCA —1 = Over Charged Alarm

TCA —1 = Terminate Charge Alarm

OTA —1 = Over Temperature Alarm

TDA —1 = Terminate Discharge Alarm

RCA —Remaining Capacity Alarm

1 = Remaining Capacity Alarm is set

see:

SBS:RemainingCapacityAlarm(0x01)

RTA —Remaining Time Alarm

1 = Remaining Time Alarm is set

see:

SBS:RemainingTimeAlarm(0x02)

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

DSG —Discharging

0 = bq20z70 is in charging mode

1 = bq20z70 is in discharging mode, relaxation mode or valid charge termination has occurred

see:

"Gas Gauging Mode" chapter in this document

FC — 1 = Fully Charged

FD — 1 = Fully Discharged

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

0,0,0,0 =	OK	bq20z70 processed the function code with no errors detected.
0,0,0,1 =	BUSY	bq20z70 is unable to process the function code at this time.
0,0,1,0 =	Reserved	bq20z70 detected an attempt to read or write to a function code reserved by this version of the specification or bq20z70 detected an attempt to access an unsupported optional manufacturer function code.

0,0,1,1 =	Unsupported	bq20z70 does not support this function code.
0,1,0,0 =	AccessDenied	bq20z70 detected an attempt to write to a read-only function code.
0,1,0,1 =	Over/Underflow	bq20z70 detected a data overflow or underflow.
0,1,1,0 =	BadSize	bq20z70 detected an attempt to write to a function code with an incorrect data block.
0,1,1,1 =	UnknownError	bq20z70 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. One cycle count is accumulated discharge of ***CC Threshold***.

When the bq20z70 is in Unsealed or Full Access mode, this block is R/W.

Table A-27. CycleCount

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

Related Variables:

- DF:SBS Configuration:Data(48)Cycle Count(16)
- DF:SBS Configuration:Data(48)CC Threshold(18)
- SBS:OperationStatus(0x54)[SS],[FAS]

A.25 DesignCapacity(0x18)

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

The *DesignCapacity* value is expressed in either current (mAh at a C/5 discharge rate) or power, (0.1 mWh at a P/5 discharge rate) depending on the setting of *[CAPACITY_MODE]* bit.

When the bq20z70 is in Unsealed or Full Access 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	65535	4400	mAh
			1	unsigned integer	2	0	65535	6336	0.1 mWh

Related Variables:

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

A.26 DesignVoltage(0x19)

This read-word function returns an unsigned integer value of the theoretical voltage of a new pack, in mV, with a range of 0 to 65,535. The default value is stored in ***Design Voltage***.

When the bq20z70 is in Unsealed or Full Access mode, this block is R/W.

Table A-29. DesignVoltage

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

Related Variables:

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

A.27 SpecificationInfo(0x1a)

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

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

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

VScale (voltage scaling) and IPScale (current scaling) should always be set to zero. The default setting is stored in ***Spec Info***. When the bq20z70 is in Unsealed or Full Access mode, this block is R/W.

Table A-30. SpecificationInfo

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

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

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

Figure A-4. SpecificationInfo

Related Variables:

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

A.28 ManufactureDate(0x1b)

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

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

The default value for this function is stored in ***Manuf Date***. When the bq20z70 is in Unsealed or Full Access 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	65535	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],[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 bq20z70 is in Unsealed or Full Access mode, this block is R/W.

Table A-32. SerialNumber

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

Related Variables:

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

A.30 ManufacturerName(0x20)

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

The default setting of this function is stored in dataflash ***Manuf Name***. When the bq20z70 is in Unsealed or Full Access mode, this block is R/W.

Table A-33. ManufacturerName

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

Related Variables:

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

A.31 DeviceName(0x21)

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

The default setting of this function is stored in dataflash ***Device Name***. When the bq20z70 is in Unsealed or Full Access 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	-	-	bq20z70	ASCII

Related Variables:

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

A.32 DeviceChemistry(0x22)

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

The default setting of this function is in stored in dataflash ***Device Chemistry*** although it has no use for internal charge control or fuel gauging. When the bq20z70 is in Unsealed or Full Access mode, this block is R/W.

Table A-35. DeviceChemistry

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

Related Variables:

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

A.33 ManufacturerData(0x23)

This read-block function returns several configuration data flash elements with an absolute maximum length of 7 Data + 1 length byte (stored in Manufacturer Data Length). The Manufacturing data elements shown below are stored in the Manufacturer Data subclass. When the bq20z70 is in Unsealed or Full Access mode, this block is R/W.

Table A-36. ManufacturerData

Data	Byte	Name	Format
Manufacturer Data	0	Firmware Version	hex
	1		
	2	Hardware Revision	
bq20z70 Counter	3	Partial Reset Counter	
	4	Full Reset Counter	
	5	Watchdog Reset Counter	
	6	Check Sum	
	7	String Length Byte	

Related Variables:

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

A.34 Authenticate(0x2f)

This read/write-block function allows the host to authenticate the bq20z70-based battery using a SHA-1 authentication transform with a length of 20 data bytes + 1 length byte. See *SHA-1 Authentication* chapter and *Using SHA-1 in bq20zxx Family of Gas Gauges* application report (SLUA359) for detailed information.

Table A-37. Authenticate

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

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 bottom most series cell element, while *CellVoltage4* corresponds to the top most series cell element.

Table A-38. CellVoltage4..1

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

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	65535	—	mAh or 10mWh
0x02	R/W	RemainingTimeAlarm	unsigned int	2	0	65535	—	min
0x03	R/W	BatteryMode	hex	2	0x0000	0xffff	—	
0x04	R/W	AtRate	signed int	2	-32768	32767	—	mA or 10mW
0x05	R	AtRateTimeToFull	unsigned int	2	0	65535	—	min
0x06	R	AtRateTimeToEmpty	unsigned int	2	0	65535	—	min
0x07	R	AtRateOK	unsigned int	2	0	65535	—	
0x08	R	Temperature	unsigned int	2	0	65535	—	0.1°K
0x09	R	Voltage	unsigned int	2	0	20000	—	mV
0x0a	R	Current	signed int	2	-32768	32767	—	mA

Table A-39. SBS COMMANDS (continued)

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0b	R	AverageCurrent	signed int	2	-32768	32767	—	mA
0x0c	R	MaxError	unsigned int	1	0	100	—	%
0x0d	R	RelativeStateOfCharge	unsigned int	1	0	100	—	%
0x0e	R	AbsoluteStateOfCharge	unsigned int	1	0	100	—	%
0x0f	R/W	RemainingCapacity	unsigned int	2	0	65535	—	mAh or 10mWh
0x10	R	FullChargeCapacity	unsigned int	2	0	65535	—	mAh or 10mWh
0x11	R	RunTimeToEmpty	unsigned int	2	0	65535	—	min
0x12	R	AverageTimeToEmpty	unsigned int	2	0	65535	—	min
0x13	R	AverageTimeToFull	unsigned int	2	0	65535	—	min
0x14	R	ChargingCurrent	unsigned int	2	0	65535	—	mA
0x15	R	ChargingVoltage	unsigned int	2	0	65535	—	mV
0x16	R	BatteryStatus	unsigned int	2	0x0000	0xffff	—	
0x17	R/W	CycleCount	unsigned int	2	0	65535	—	
0x18	R/W	DesignCapacity	unsigned int	2	0	65535	—	mAh or 10mWh
0x19	R/W	DesignVoltage	unsigned int	2	7000	16000	14400	mV
0x1a	R/W	SpecificationInfo	unsigned int	2	0x0000	0xffff	0x0031	
0x1b	R/W	ManufactureDate	unsigned int	2	0	65535	0	
0x1c	R/W	SerialNumber	hex	2	0x0000	0xffff	0x0001	
0x20	R/W	ManufacturerName	String	11+1	—	—	Texas Instruments	ASCII
0x21	R/W	DeviceName	String	7+1	—	—	bq20z70	ASCII
0x22	R/W	DeviceChemistry	String	4+1	—	—	LION	ASCII
0x23	R	ManufacturerData	String	14+1	—	—	—	ASCII
0x2f	R/W	Authenticate	String	20+1	—	—	—	ASCII
0x3c	R	CellVoltage4	unsigned int	2	0	65535	—	mV
0x3d	R	CellVoltage3	unsigned int	2	0	65535	—	mV
0x3e	R	CellVoltage2	unsigned int	2	0	65535	—	mV
0x3f	R	CellVoltage1	unsigned int	2	0	65535	—	mV

Extended SBS Commands

The extended SBS commands are only available when bq20z70 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 bq29330 memory map followed by 2 bytes of the internal bq20z70 AFE_Fail_Counter.

Table B-1. AFEData

Data	Byte	Name	Format
bq29330	0	AFE Status	hex
	1	AFE Output	
	2	AFE State	
	3	AFE Function	
	4	AFE Cell Select	
	5	AFE OLV	
	6	AFE OLT	
	7	AFE SCC	
	8	AFE SCD	
bq20z70	9	internal AFE_Fail_Counter high byte	
	10	internal AFE_Fail_Counter low byte	
	11	String Length Byte	

Related Variables:

- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)

B.2 FETControl(0x46)

This write/read-word function allows direct control of the FETs for test purposes. bq20z70 overrides this commands 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 — bq29330 GPOD pin control.

0 = disable GPOD pin (high-Z)

1 = enable GPOD pin (open drain)

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

0 = turn OFF pre-charge FET

1 = turn ON pre-charge FET

CHG — Charge FET Control

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

1 = turn ON CHG FET

DSG — Discharge FET Control

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

1 = turn ON DSG FET

B.3 StateOfHealth(0x4f)

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

B.4 SafetyStatus(0x51)

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

See the "1st Level Safety" chapter for further details.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	OTD	OTC	OCD	OCC	RSVD	RSVD	RSVD	RSVD
Low Byte	CUV	COV	PF	RSVD	WDF	AOCD	SCC	SCD

LEGEND: All Values Read Only

Figure B-2. SafetyStatus

OTD — 1 = Discharge overtemperature condition

OTC — 1 = Charge overtemperature condition

OCD — 1 = Discharge overcurrent condition

OCC — 1 = Charge overcurrent condition

CUV — 1 = Cell undervoltage condition

COV — 1 = Cell overvoltage condition

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

WDF — 1 = AFE watchdog condition

AOCD — 1 = Discharge overcurrent condition

SCC — 1 = Charge short-circuit condition

SCD — 1 = Discharge short-circuit condition

B.5 PFStatus(0x53)

The permanent failure status register indicates the source of the bq20z70 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):PF Flags 1(0)
- DF:PF Status:Device Status Data(96):PF Flags 2(28)

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

LEGEND: All Values Read Only

Figure B-3. PFStatus

SOCD — 1 = Discharge Safety Overcurrent permanent failure

SOCC — 1 = Charge Safety-Overcurrent 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.6 OperationStatus(0x54)

This read-word function returns the current status of the operation status of the bq20z70.

	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	RSVD	RSVD	RSVD	VOK	QEN

LEGEND: All Values Read Only

Figure B-4. 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 = Data Flash checksum value has been generated

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

WAKE — 1 = bq20z70 WAKE mode

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

XDSG — 1 = Discharge fault

VOK — 1 = Voltages are OK for a Qmax update

QEN — 1 = Qmax updates are enabled

B.7 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	RSVD	RSVD	FCHG	RSVD
Low Byte	RSVD	CB	RSVD	RSVD	RSVD	RSVD	OC	RSVD

LEGEND: All Values Read Only

Figure B-5. ChargingStatus

XCHG — 1 = Charging disabled

CHGSUSP — 1 = Charging suspend conditions exist

PCHG — 1 = Precharging conditions exist

MCHG — 1 = Maintenance charging conditions exist

FCHG — 1 = Fast charging conditions exist

CB — 1 = Cell balancing in progress

OC — 1 = Overcharge fault

B.8 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	high byte	unsigned integer	1	0	255	-	
			partial resets	low byte	unsigned integer	1	0	255	-	

B.9 WDResetData(0x58)

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

Table B-3. WDResetData

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

B.10 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	65535	-	mV

B.11 AverageVoltage(0x5d)

This read-word function returns a signed integer value that approximates a one-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	65535	-	mV

Related Variables:

- SBS:Voltage(0x09)

B.12 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 bq20z70 is in the Full-Access mode, indicated by a cleared *[FAS]* flag.

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

Table B-6. UnSealKey

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

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

B.13 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 bq20z70 is in the Full-Access mode, indicated by a cleared *[FAS]* flag.

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

Table B-7. FullAccessKey

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

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

B.14 PFKey(0x62)

This read/write block command allows the user to change the Permanent-Failure-Clear key. This function is only available when the bq20z70 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

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

The default key values for permanent fail clear are 0x2673 and 0x1712.

Table B-8. PFKey

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

Related Variables:

- SBS:OperationStatus(0x54)[FAS]

B.15 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 bq20z70 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	0x00000000	0xffffffff	0x10325476	

Related Variables:

- none

B.16 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 bq20z70 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

Table B-10. AuthenKey2

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x64	R/W	AuthenKey2	hex	4	0x00000000	0xffffffff	0x98BADCFE	

Related Variables:

- none

B.17 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 bq20z70 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

Table B-11. AuthenKey1

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x65	R/W	AuthenKey1	hex	4	0x00000000	0xffffffff	0xEFCDAB89	

Related Variables:

- none

B.18 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 bq20z70 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

Table B-12. AuthenKey0

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

Related Variables:

- none

B.19 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 bq20z70 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],[FAS]

B.20 SenseResistor(0x71)

This read/write command allows the user to change the sense resistor value used in μΩ. The bq20z70 automatically updates the respective calibration data on receipt of a new sense resistor value.

Table B-14. SenseResistor

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

B.21 DataFlashSubClassID(0x77)

This write word function set the bq20z70 dataflash subclass, where data can be accessed by following *DataFlassSubClass1..8* commands.

See "Data Flash 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 Data Flash.

Table B-15. DataFlashSubClassID

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

Related Variables:

- SBS:DataflashSubClass1..8(0x78..0x7f)

B.22 DataFlashSubClassPage1..8(0x78..0x7f)

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

Note: Any DF location deemed Reserved responds with a *NACK* unless the bq20z70 is in the correct security state to allow access.

Table B-16. DataFlashSubClass1..8

SBS Cmd.	Mode	Name	Format	Size in Bytes	Subclass Offset	Subclass Offset	Default Value	Unit
0x78	R/W	DataFlashSubClassPage1	hex	32	0	31	-	
0x79	R/W	DataFlashSubClassPage2	hex	32	32	63	-	
0x7a	R/W	DataFlashSubClassPage3	hex	32	64	95	-	
0x7b	R/W	DataFlashSubClassPage4	hex	32	96	127	-	
0x7c	R/W	DataFlashSubClassPage5	hex	32	128	159	-	
0x7d	R/W	DataFlashSubClassPage6	hex	32	160	191	-	
0x7e	R/W	DataFlashSubClassPage7	hex	32	192	223	-	
0x7f	R/W	DataFlasClasshSubClass8	hex	32	224	255	-	

Related Variables:

- SBS:DataFlashSubClassID(0x77)

B.23 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	—	%
0x51	R	SafetyStatus	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	—	
0x5a	R	PackVoltage	unsigned int	2	0	65535	—	mV
0x5d	R	AverageVoltage	unsigned int	2	0	65535	—	mV
0x60	R/W	UnSealKey	hex	4	0x00000000	0xffffffff	—	
0x61	R/W	FullAccessKey	hex	4	0x00000000	0xffffffff	—	
0x62	R/W	PFKey	hex	4	0x00000000	0xffffffff	—	
0x63	R/W	AuthenKey3	hex	4	0x00000000	0xffffffff	—	
0x64	R/W	AuthenKey2	hex	4	0x00000000	0xffffffff	—	
0x65	R/W	AuthenKey1	hex	4	0x00000000	0xffffffff	—	
0x66	R/W	AuthenKey0	hex	4	0x00000000	0xffffffff	—	
0x70	R/W	ManufacturerInfo	String	8+1	—	—	—	
0x71	R/W	SenseResistor	unsigned int	2	0	65535	—	μΩ
0x77	R/W	DataFlashSubClassID	hex	2	0x0000	0xffff	—	
0x78	R/W	DataFlashSubClassPage1	hex	32	—	—	—	
0x79	R/W	DataFlashSubClassPage2	hex	32	—	—	—	
0x7a	R/W	DataFlashSubClassPage3	hex	32	—	—	—	
0x7b	R/W	DataFlashSubClassPage4	hex	32	—	—	—	
0x7c	R/W	DataFlashSubClassPage5	hex	32	—	—	—	
0x7d	R/W	DataFlashSubClassPage6	hex	32	—	—	—	
0x7e	R/W	DataFlashSubClassPage7	hex	32	—	—	—	
0x7f	R/W	DataFlashSubClassPage8	hex	32	—	—	—	

Data Flash

CAUTION

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

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

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

C.1 Accessing Data Flash

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

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

C.1.1 Data Flash Interface

The bq20z70 data flash is organized into subclasses where each data flash variable is assigned an offset within its numbered subclass. For example: the ***Pre-chg Temp*** threshold location is defined as:

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

Note: Data Flash commands are NACK'ed if bq20z70 is in sealed mode (*[SS]* flag is set).

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

Reading and Writing subclass data are block operations which are 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 bq20z70 and the values are not rejected by the gas gauge. Writing an incorrect value may result in hardware failure due to firmware program interpretation of the invalid data. The data written is persistent, so a Power On Reset does resolve the fault.

Related Variables:

- SBS:DataFlashSubClassID(0x77)

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

C.1.2 Reading a SubClass

Information required:

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

Procedure:

1. Write the SubClassID to bq20z70 using *DataFlashSubClassID* command.
2. Read a block of data using *DataFlashSubClassPage1..8* command. A subclass can hold up to 256 bytes of data, but subclass data can only be read in 32 byte long data blocks. The *DataFlashSubClassPage1* command reads only the first 32 bytes in a subclass, the *DataFlashSubClassPage2* command reads the second 32 bytes in a subclass and so on. For example if the subclass has 40 bytes, *DataFlashSubClassPage1* + *DataFlashSubClassPage1* 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 bq20z70 using *DataFlashSubClassID* command.
2. Write a block of data using *DataFlashSubClassPage1..8* command. A subclass can hold up to 256 bytes of data, but subclass data can only be write in 32 byte long data blocks. The *DataFlashSubClassPage1* command writes only the first 32 bytes in a subclass, the *DataFlashSubClassPage2* command writes the second 32 bytes in a subclass and so on. For example if the subclass has 40 bytes and data in offset 34 of the subclass needs to be changed, use *DataFlashSubClassPage2* to write data from byte 32 - 40 of the subclass.

C.1.4 Example

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

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

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

Overwrite offset 45 of received data with 8.7 V:

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

Write the complete subclass back to the bq20z70:

- Write Subclass ID
  - SMB Slave Address (0x16)
  - SMB CMD 0x77 with 0x0050 as data
- Write Subclass

- SMB Slave Address (0x17)
- SMB CMD 0x78 with 32 bytes of data
- SMB CMD 0x79 with 32 bytes of data

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

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

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

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

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

Write the updated block back to the bq20z70:

- 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 bq20z70 sets the *[COV]* flag in *SafetyStatus* if any *CellVoltage4..1* is equal to or higher than the ***COV Threshold*** for a period of 2s.

Table C-1. COV Threshold

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

Related Variables:

- DF:1st Level Safety:Voltage(0):COV Recovery(3)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:Battery Status(0x16)[TCA]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyStatus(0x51)[COV]

C.2.1.2 COV Recovery (Offset 3)

The bq20z70 recovers from cell over voltage 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-2. COV Recovery

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

Related Variables:

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

C.2.1.3 CUV Threshold (Offset 12)

The bq20z70 sets the *[CUV] SafetyStatus* if any *CellVoltage4..1* is equal to or lower than the ***CUV Threshold*** for a period of 2s.

Table C-3. CUV Threshold

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

Related Variables:

- DF:1st Level Safety:Voltage(0):CUV Recovery(15)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-Charge Current(0)
- SBS:Charging Current(0x14)
- SBS:BatteryStatus(0x16)[TDA],[FD]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyStatus(0x51)[CUV]
- SBS:OperationStatus(0x54)[XDSG]

C.2.1.4 CUV Recovery (Offset 15)

The bq20z70 recovers from cell under voltage 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-4. CUV Recovery

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

Related Variables:

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

C.2.2 Current (Subclass 1)

C.2.2.1 OC (1st Tier) Chg (Offset 0)

The bq20z70 sets the *[OCC] SafetyStatus* if charge *Current* is equal to or higher than the ***OC (1st Tier) Chg*** threshold for a period of 2s.

In overcurrent while charging condition, the CHG FET is turned off, the *ChargeCurrent* and *ChargeVoltage* is set to 0, the *[TCA]* is set and the *[OCC]* in *SafetyStatus* is set.

The bq20z70 recovers from over current charge condition in non removable battery mode, if the *AverageCurrent* is equal to or lower than 100mA for the length of ***Current Recovery Time***. The bq20z70 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-5. 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	20000	6000	mA

Related Variables:

- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyStatus(0x51)[OCC]

C.2.2.2 OC (1st Tier) Dsg (Offset 5)

The bq20z70 sets the *[OCD] SafetyStatus* if the discharge *Current* is equal to or higher than the ***OC (1st Tier) Dsg*** threshold for a period of 2s.

In overcurrent discharge condition, the DSG FET is turned off, the *ChargeCurrent* is set to ***Pre-charge Current***, the *[TCA]* is set, the *[FD]* flag is set, the *[OCD]* in *SafetyStatus* is set and the *[XDSG]* is set.

The bq20z70 recovers from over current discharge condition in non removable battery mode, if the *AverageCurrent* is equal to or lower than 100mA 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-6. OC (1st Tier) Dsg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	5	OC (1st Tier) Dsg	unsigned integer	2	0	20000	6000	mA

Related Variables:

- DF:Charge Control:Pre-Charge Cfg(33):Pre-Charge Current(0)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:OperationStatus(0x54)[XDSG]

C.2.2.3 Current Recovery Time (Offset 16)

The ***Current Recovery Time*** sets the minimum time period where the *AverageCurrent* need to be below over current charge/discharge recovery threshold to recover from over current charge/discharge condition.

Table C-7. 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	Sec

Related Variables:

- SBS:AverageCurrent(0x0b)

C.2.2.4 AFE OC Dsg (Offset 17)

The ***AFE OC Dsg*** threshold sets the OLV register of bq29330 AFE device. See overload threshold register of bq29330 datasheet for more details and appropriate values to use.

Table C-8. 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 bq29330

0x00 - 0x1f = sets the voltage threshold between 50mV and 205mV in 5mV steps.

Related Variables:

- DF:1st Level Safety:Current(1):AFE OC Dsg Time(18)

C.2.2.5 AFE OC Dsg Time (Offset 18)

The ***AFE OC Discharge Time*** is programmed into the OLT register of bq29330 AFE device. If an overcurrent discharge condition is reported by bq29330, *ChargingCurrent* is set to 0, *[TDA]* in ***BatteryStatus*** is set and *[AOCD]* in *SafetyStatus* is set.

The bq20z70 recovers from over current discharge condition in non removable battery mode, if the *AverageCurrent* is equal to or lower than the (-)100mA 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-9. 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 bq29330

0x00 - 0x0f = sets the overvoltage trip delay between 1ms - 31ms in 1ms steps

Related Variables:

- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[AOCD]

C.2.2.6 AFE SC Chg Cfg (Offset 21)

The ***AFE SC Charge Cfg*** is programmed into the SCC register of bq29330 AFE device. ***AFE SC Charge Cfg*** sets the short circuit charging voltage threshold and the short circuit in charging delay of the bq29330.

If bq20z70 identifies short circuit situation from bq29330, *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TCA]* in *BatteryStatus* is set and the *[SCC]* in *SafetyStatus* is set.

The bq20z70 recovers from short circuit charge condition in non removable battery mode, if *AverageCurrent* is equal to or lower than the 5mA for the length of ***Current Recovery Time***. On recovery the *ChargingCurrent* and *ChargingVoltage* is set to appropriate value per charging algorithm, , *[TCA]* in *BatteryStatus* is reset, the *[SCC]* in *SafetyStatus* is reset.

Table C-10. 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

Figure C-2. SCC Register

SCCT3, SCCT2, SCCT1, SCCT0 — Sets the short circuit delay in charging of bq29330

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

SCCV3, SCCV2, SCCV1, SCCV0 — Sets the short circuit voltage threshold in charging of bq29330

0x00 - 0x0f = sets the short circuit voltage threshold between 0.1V and 0.475V in 25mV steps

Related Variables:

- 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)[TCA]
- SBS:SafetyStatus(0x51)[SCC]

C.2.2.7 AFE SC Dsg Cfg (Offset 22)

The ***AFE SC Dsg Cfg*** is programmed into the SCD register of bq29330 AFE device. The ***AFE SC Dsg Cfg*** sets the short circuit discharging voltage threshold and the short circuit in discharging delay of the bq29330.

If bq20z70 identifies discharge short circuit situation from bq29330, *ChargingCurrent* and *ChargingVoltage* are set to 0, *[TDA]* in *BatteryStatus* is set, *[SCD]* in *SafetyStatus* is set and *[XDSG]* in *OperationStatus* is set.

The bq20z70 recovers from short circuit discharge condition in non removable battery mode, if *AverageCurrent* is equal to or greater than the (-)5mA for the length of ***Current Recovery Time***. On recovery the *ChargingCurrent* and *ChargingVoltage* is set to appropriate value per charging algorithm, *[TDA]*, in *BatteryStatus* is reset, *[SCD]* in *SafetyStatus* is reset and the *[XDSG]* is reset

Table C-11. 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

Figure C-3. SCD Register

SCDT3, SCDT2, SCDT1, SCDT0 — Sets the short circuit delay in discharging of bq29330

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

SCDV3, SCDV2, SCDV1, SCDV0 — Sets the short circuit voltage threshold in discharging of bq29330

0x00 - 0x0f = sets the short circuit voltage threshold between 0.1V and 0.475V in 25mV steps

Related Variables:

- 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)[SCD]
- SBS:OperationStatus(0x54)[XDSG]

C.2.3 Temperature (Subclass 2)

C.2.3.1 Over Temp Chg (Offset 0)

The bq20z70 sets the *[OTC]* in *SafetyStatus* if pack *Temperature* is equal to or higher than the ***Over Temp Chg*** threshold for a period of 2s.

In charging overtemperature condition, the *ChargingVoltage* and *ChargingCurrent* is set to 0, the *[OTA]* in *BatteryStatus* is set, *[TCA]* is set, the *[OTC]* in *SafetyStatus* is set. If *[OTFET]* bit is enabled, CHG FET also turns off.

Table C-12. Over Temp Chg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	0	Over Temp Chg	unsigned integer	2	0	1200	550	0.1°C

Related Variables:

- DF:1st Level Safety:Temperature(2):OT Chg Recovery (3)
- DF:Configuration:Registers(64):Operation Cfg B(2)[OTFET]
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA],[TCA]
- SBS:SafetyStatus(0x51)[OTC]
- SBS:Temperature(0x08)

C.2.3.2 OT Chg Recovery (Offset 3)

The bq20z70 recovers from over temperature charge condition, if the *Temperature* is equal to or lower than the ***OT Chg Recovery*** level. On recovery the CHG FET returns to 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-13. OT Chg Recovery

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	3	OT Chg Recovery	unsigned integer	2	0	1200	500	0.1°C

Related Variables:

- DF:1st Level Safety:Temperature(2):Over Temp Chg (0)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA]
- SBS:SafetyStatus(0x51)[OTC]

C.2.3.3 Over Temp Dsg (Offset 5)

The bq20z70 sets the *[OTD]* in *SafetyStatus* if *Temperature* function value is equal to or higher than ***Over Temp Dsg*** threshold for a period of 2s.

In discharging overtemperature condition, the *ChargingCurrent* is set to 0, the *[OTA]* battery status is set, the *[OTD] SafetyStatus* is set. If *[OTFET]* bit is enabled, DSG FET also turns off and *[XDSG]* in *OperationStatus* is set.

Table C-14. Over Temp Dsg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	5	Over Temp Dsg	unsigned integer	2	0	1200	600	0.1°C

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg B(2)[OTFET]
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA]
- SBS:SafetyStatus(0x51)[OTD]
- SBS:OperationStatus(0x54)[XDSG]

C.2.3.4 OT Dsg Recovery (Offset 8)

The bq20z70 recovers from over temperature 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-15. OT Dsg Recovery

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	8	OT Dsg Recovery	unsigned integer	2	0	1200	550	0.1°C

Related Variables:

- DF:1st Level Safety:Temperature(2):Over Temp Chg (0)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[OTA]
- SBS:SafetyStatus(0x51)[OTC]
- SBS:OperationStatus(0x54)[XDSG]

C.3 2nd Level Safety

C.3.1 Voltage (Subclass 16)

C.3.1.1 SOV Threshold (Offset 0)

The bq20z70 sets the *[SOV]* flag in *PF Status* if the *Voltage* function reports a value equal to or higher than the ***SOV Threshold***.

Table C-16. SOV Threshold

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	0	SOV Threshold	unsigned integer	2	0	20000	18000	mV

Related Variables:

- DF:2nd Level Safety:Voltage(16):SOV Time(2)
- SBS:Voltage(0x09)
- SBS:PFStatus(0x53)[SOV]

C.3.1.2 SOV Time (Offset 2)

If the *Voltage* exceeds*[SOV]* threshold for a time period of *SOV Time* limit, the bq20z70 goes into safety over voltage condition, *[SOV]* in *PF Status* is set 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-17. SOV Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	2	SOV Time	unsigned integer	1	0	30	0	Sec

Related Variables:

- DF:2nd Level Safety:Voltage(16):SOV Threshold(0)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOV]
- SBS:Voltage(0x09)
- SBS:PFStatus(0x53)[SOV]

C.3.1.3 Cell Imbalance Current (Offset 3)

The battery pack *Current* must be below the ***Cell Imbalance Current*** limit for ***Cell Imbalance Time*** before bq20z70 starts detecting cell imbalance.

Table C-18. 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 bq20z70 starts cell imbalance measurements. The bq20z70 sets the *[CIM]* in *PFStatus* if the bq20z70 measures a difference between any *CellVoltage4..1* are equal to or higher than the ***Cell Imbalance Fail Voltage*** threshold for a period of ***Cell Imbalance Time***.

Table C-19. Cell Imbalance Fail Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	4	Cell Imbalance Fail Voltage	unsigned integer	2	0	5000	1000	mV

Related Variables:

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(6)
- DF:2nd Level Safety:Voltage(16):Battery Rest Time(7)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFStatus(0x53)[CIM]

C.3.1.5 Cell Imbalance Time (Offset 6)

If the measured voltage difference between cells is higher than the ***Cell Imbalance Fail Voltage*** threshold for a period of ***Cell Imbalance Time*** limit, bq20z70 goes into cell imbalance condition, *[CIM]* in *PF Status* is set 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-20. 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	Sec

Related Variables:

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(4)
- DF:2nd Level Safety:Voltage(16):Battery Rest Time(7)
- DF:1st Level Safety:Temperature(2):Over Temp Chg (0)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOV]
- SBS:PFStatus(0x53)[CIM]

C.3.1.6 Battery Rest Time (Offset 7)

The battery *Current* must be below ***Cell Imbalance Current*** limit for at least ***Battery Rest Time*** period before bq20z70 starts detecting cell imbalance. Set to 0 to disable cell imbalance detection.

Table C-21. Battery Rest Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	7	Battery Rest Time	unsigned integer	2	0	65535	1800	Sec

Related Variables:

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(3)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(4)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(6)
- SBS:Current(0x0a)

C.3.1.7 PFIN Detect Time (Offset 9)

If $\overline{\text{PFIN}}$ pin logic low for a period of PFIN detect time, *[PFIN]* in *PFStatus* is set. 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-22. 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	Sec

Related Variables:

- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XPFIN]
- SBS:PFStatus(0x53)[PFIN]

C.3.2 Current (Subclass 17)

C.3.2.1 SOC Chg (Offset 0)

The bq20z70 sets the *[SOCC]* in *PF Status* if *Current* is equal to or higher than the ***SOC Chg*** threshold for a period of ***SOC Chg Time***.

Table C-23. SOC Chg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
17	Current	0	SOC Chg	unsigned integer	2	0	30000	10000	mA

Related Variables:

- DF:2nd Level Safety:Current(17):SOC Chg Time(2)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOCC]
- SBS:Current(0x0a)
- SBS:PFStatus(0x53)[SOCC]

C.3.2.2 SOC Chg Time (Offset 2)

If the *Current* is equal to or higher than the ***SOC Chg*** threshold, *[SOCC]* in *PFStatus* is set 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-24. 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	Sec

Related Variables:

- DF:2nd Level Safety:Voltage(16):SOV Threshold(0)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOCC]
- SBS:Current(0x0a)
- SBS:PFStatus(0x53)[SOCC]

C.3.2.3 SOC Dsg (Offset 3)

The bq20z70 sets the *[SOCD] PF Status* if discharge *Current* is equal to or higher than the ***(-)SOC Dsg*** threshold for a period of ***SOC Dsg Time***.

Table C-25. SOC Dsg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
17	Current	3	SOC Dsg	unsigned integer	2	0	30000	10000	mA

Related Variables:

- DF:2nd Level Safety:Current(17):SOC Chg Time(2)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOCC]
- SBS:Current(0x0a)
- SBS:PFStatus(0x53)[SOCD]

C.3.2.4 SOC Dsg Time (Offset 5)

If the discharge *Current* is equal to or higher than the ***(-)SOC Dsg*** threshold for a period of ***SOC Dsg Time***, *[SOCD]* in *PF Status* is set 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-26. 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	Sec

Related Variables:

- DF:2nd Level Safety:Voltage(16):SOC Dsg(3)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOCD]
- SBS:Current(0x0a)
- SBS:PFStatus(0x53)[SOCD]

C.3.3 Temperature (Subclass 18)

C.3.3.1 SOT Chg (Offset 0)

The bq20z70 sets the *[SOTC] PF Status* if *Temperature* is equal to or higher than the ***SOT Chg*** threshold during charging (***[DSG]*** = 0) for a period of ***SOT Chg Time***.

Table C-27. SOT Chg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	0	SOT Chg	unsigned integer	2	0	1200	650	0.1°C

Related Variables:

- DF:2nd Level Safety:Temperature(18):SOT Chg Time(2)
- SBS:Temperature(0x08)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFStatus(0x53)[SOTC]

C.3.3.2 SOT Chg Time (Offset 2)

If the *Temperature* is equal to or higher than the ***SOT Chg*** threshold during charging for a time period of safety over temperature charging time, bq20z70 goes into SOTC condition, *[SOTC]* in *PF Status* 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-28. 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	Sec

Related Variables:

- DF:2nd Level Safety:Temperature(18):SOT Chg(0)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOTC]
- SBS:Temperature(0x08)
- SBS:PFStatus(0x53)[SOTC]

C.3.3.3 SOT Dsg (Offset 3)

The bq20z70 sets the *[SOTD] PF Status* if *Temperature* is equal to or higher than the ***SOT Dsg*** threshold during discharging (*[DSG]* = 1) for a period of ***SOT Dsg Time***.

Table C-29. SOT Dsg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	3	SOT Dsg	unsigned integer	2	0	1200	750	0.1°C

Related Variables:

- DF:2nd Level Safety:Temperature(18):SOT Dsg Time(5)
- SBS:Temperature(0x08)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFStatus(0x53)[SOTD]

C.3.3.4 SOT Dsg Time (Offset 5)

If *Temperature* is equal to or higher than the ***SOT Dsg*** threshold during discharging (*[DSG]* = 1) for a period of ***SOT Dsg Time***, bq20z70 goes into *[SOTD]* condition, *[SOTD]* in *PF Status* is set 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-30. 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	Sec

Related Variables:

- DF:2nd Level Safety:Temperature(18):SOT Dsg(3)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XSOTD]
- SBS:Temperature(0x08)
- SBS:PFStatus(0x53)[SOTD]

C.3.4 FET Verification (Subclass 19)

C.3.4.1 FET Fail Time (Offset 2)

If bq20z70 tries to turn off CHG FET and charge *Current* is equal to or higher than 50mA for a time period of ***FET Fail Time*** the bq20z70 goes into *[CFETF]* condition, *[CFETF]* in *PF Status* is 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 bq20z70 tries to turn off DSG FET and the discharge *Current* is equal to or lower than the -50mA for a time period of ***FET fail time***, bq20z70 goes into *[DFETF]* condition, *[DFETF]* in *PF Status* is set 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-31. 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	Sec

Related Variables:

- DF:2nd Level Safety:FET Verification(19):FET Fail Time(2)
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XCFETF]
- DF:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XDFETF]
- SBS:Current(0x0a)
- SBS:PFStatus(0x53)[CFETF],[DFETF]

C.3.5 AFE Verification (Subclass 20)

C.3.5.1 AFE Fail Limit (Offset 1)

The bq20z70 continuously validates its read and write communications with the bq29330. If either a read or write verify fails, an internal AFE_Fail_Counter is incremented. If the AFE_Fail_Counter reaches ***AFE Fail Limit***, the bq20z70 reports a *[AFE_C]* permanent failure and if *[XAFE_C]* in permanent fail configuration is set, the SAFE pin is driven high. If the ***AFE Fail Limit*** is set to 0, this feature is disabled.

Table C-32. 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:Configuration:Registers(Subclass 64):Permanent Fail Cfg(4)[XAFE_C]
- SBS:AFEData(0x45)
- SBS:PFStatus(0x53)[AFE_C]

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.

If in charge inhibit mode the *Temperature* rises above ***Chg Inhibit Temp Low*** + 5°C, 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-33. Chg Inhibit Temp Low

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Inhibit Cfg	0	Chg Inhibit Temp Low	signed integer	2	–400	1200	0	0.1°C

Related Variables:

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

If in charge inhibit mode the *Temperature* falls below ***Chg Inhibit Temp High*** - 5°C, 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-34. Chg Inhibit Temp High

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Inhibit Cfg	2	Chg Inhibit Temp High	signed integer	2	–400	1200	450	0.1°C

Related Variables:

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF: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.4.2 Pre-Charge Cfg (Subclass 33)

C.4.2.1 Pre-chg Current (Offset 0)

The bq20z70 sets the *ChargingCurrent* to the ***Pre-charge Current*** value, when in pre-charge mode.

Table C-35. 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	2000	250	mA

Related Variables:

- SBS:ChargingCurrent(0x14)

C.4.2.2 Pre-chg Temp (Offset 2)

If the battery *Temperature* drops below the ***Pre-chg Temp***, bq20z70 enters pre-charge mode and *[PCHG]* flag in *ChargingStatus* is set. bq20z70 leaves pre-charge mode if *Temperature* rises above ***Pre-chg Temp*** + 5°C and all *CellVoltage4..1* are above ***Recovery Voltage*** level. On recovery *[PCHG]* status is cleared.

Table C-36. 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	1200	120	0.1°C

Related Variables:

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- 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 bq20z70 enters pre-charge mode and sets the *[PCHG]* in *ChargingStatus* if any *CellVoltage4..1* drops below the ***Pre-chg Voltage*** threshold.

Table C-37. 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	20000	3000	mV

Related Variables:

- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:ChargingStatus(0x55)[PCHG]

C.4.2.4 Recovery Voltage (Offset 6)

The bq20z70 enters fast charge mode from pre charge mode and sets the *[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*** + 5°C.

Table C-38. 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	20000	3100	mV

Related Variables:

- 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 bq20z70 sets the *ChargingCurrent* to the ***Fast Charge Current*** value, when in fast charge mode.

Table C-39. Fast Charge Current

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Fast Charge Cfg	0	Fast Charge Current	unsigned integer	2	0	10000	4000	mA

Related Variables:

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

C.4.3.2 Charging Voltage (Offset 2)

The bq20z70 sets the *ChargingVoltage* to this value in fast charge mode.

Table C-40. Charging Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Fast Charge Cfg	2	Charging Voltage	unsigned integer	2	0	20000	16800	mV

Related Variables:

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

C.4.3.3 Suspend Low Temp (Offset 6)

If the battery pack *Temperature* drops below ***Suspend Low Temp***, the *AverageCurrent* is above ***Chg Current Threshold*** and bq20z70 is in charge mode (*[DSG]* = 0), the bq20z70 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 bq20z70 returns to normal charging and clears *[CHGSUSP]*, if *Temperature* rises above ***Chg Inhibit Temp Low*** + 5°C.

Table C-41. Suspend Low Temp

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Fast Charge Cfg	6	Suspend Low Temp	signed integer	2	-400	1200	-50	0.1°C

Related Variables:

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)
- DF:Charge Control:Fast Charge Cfg(34):Suspend Low Temp(6)
- 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.4.3.4 Suspend High Temp (Offset 8)

If battery pack *Temperature* rises above ***Suspend Temperature High***, the *AverageCurrent* is above the ***Chg Current Threshold*** and the bq20z70 is in charge mode (*[DSG]* = 0), the bq20z70 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 bq20z70 returns to normal charging and clears *[CHGSUSP]*, if temperature drops below ***Chg Inhibit Temp High*** - 5°C.

Table C-42. Suspend High 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	1200	550	0.1°C

Related Variables:

- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp Low(0)
- DF:Charge Control:Charge Inhibit Cfg(32):Chg Inhibit Temp High(2)
- DF:Charge Control:Fast Charge Cfg(34):Suspend High Temp(8)
- 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 Termination Cfg (Subclass 36)

C.4.4.1 Taper Current (Offset 2)

If battery *Current* falls below ***Taper Current*** for 2 consecutive windows of 40s each during charging and *Voltage* is equal or higher than ***Charging Voltage*** - ***Taper Voltage***, bq20z70 recognizes valid primary charge termination.

Table C-43. Taper Current

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
36	Termination Cfg	2	Taper Current	unsigned integer	2	0	1000	250	mA

Related Variables:

- SBS:Current(0x0a)

C.4.4.2 Taper Voltage (Offset 6)

For valid primary charge termination pack *Voltage* must equal to or higher than ***Charging Voltage*** - ***Taper Voltage***.

Table C-44. Taper Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
36	Termination Cfg	6	Taper Voltage	unsigned integer	2	0	1000	300	mV

Related Variables:

- DF:Charge Control:Fast Charge Cfg(34):Charging Voltage(8)
- SBS:Voltage(0x09)

C.4.4.3 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-45. 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:

- SBS:RelativeStateOfCharge(0x0d)
- SBS:BatteryStatus(0x16)[TCA]

C.4.4.4 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-46. 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.4.5 Cell Balancing Cfg (Subclass 37)

C.4.5.1 Min Cell Deviation (Offset 0)

This value defines the conversion factor for calculating cell balancing time per cell in balance time per mAh, before bq20z70 starts balancing cell capacity during charging. If ***Min Cell Deviation*** is set to 0, cell balancing is disabled.

Table C-47. Min Cell Deviation

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
37	Cell Balancing Cfg	0	Min Cell Deviation	unsigned integer	2	0	65535	1750	Sec/mAh

Related Variables:

- none

C.4.6 Charging Faults (Subclass 38)

C.4.6.1 Over Charge Capacity (Offset 13)

The bq20z70 goes into overcharge error and sets *[OC]* flag in *ChargingStatus* if the internal counted remaining capacity exceeds *FullChargeCapacity* + ***Over Charge Capacity***.

The bq20z70 recovers from over charge in non removable battery mode(***[NR]*** = 1), if it is continuously discharged by an amount of 2mAh.

Table C-48. Over Charge Capacity

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	13	Over Charge Capacity	unsigned integer	2	0	4000	300	mAh

Related Variables:

- SBS:FullChargeCapacity(0x10)
- SBS:ChargingStatus(0x55)[OC]

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 bq20z70 initialization.

Table C-49. 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)

The default value of *RemainingEnergyAlarm* is stored in this variable.

Table C-50. Rem Time Alarm

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	2	Rem Energy Alarm	unsigned integer	2	0	1000	432	mWh

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 bq20z70 initialization.

Table C-51. 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 bq20z70 initialization.

Table C-52. 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 bq20z70 initialization.

Table C-53. Design Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	8	Design Voltage	unsigned integer	2	7000	18000	14400	mV

Related Variables:

- SBS:DesignVoltage(0x19)

C.5.1.6 Spec Info (Offset 10)

The default value of *SpecificationInfo* is stored in this variable and copied to the SBS value on bq20z70 initialization.

Table C-54. 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 bq20z70 initialization.

Table C-55. Manuf Date

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	12	Manuf Date	unsigned integer	2	0	65535	0	Day + Mo*32 + (Yr -1980)*512

Related Variables:

- SBS:ManufactureDate(0x1b)

C.5.1.8 Ser. Num. (Offset 14)

The default value of *SerialNumber* is stored in this variable and copied to the SBS value on bq20z70 initialization.

Table C-56. 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 bq20z70 initialization. When SBS value changes this value is also updated.

Table C-57. Cycle Count

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	16	Cycle Count	unsigned integer	2	0	65535	0	

Related Variables:

- DF:SBS Configuration:Data(48):CC Threshold(18)
- SBS:CycleCount(0x17)

C.5.1.10 CC Threshold (Offset 18)

The cycle count function counts the accumulated discharge of ***CC Threshold*** value as one cycle.

Table C-58. CC Threshold

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	18	CC Threshold	signed integer	2	100	32767	4400	mAh

Related Variables:

- SBS:CycleCount(0x17)

C.5.1.11 CF Max Error Limit (Offset 21)

If *MaxError* function value is greater than this limit, *CONDITION_FLAG* is set.

Table C-59. 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.5.1.12 Design Capacity (Offset 22)

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

Table C-60. Design Capacity

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	22	Design Capacity	unsigned integer	2	0	65535	4400	mAh

Related Variables:

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

C.5.1.13 Design Energy (Offset 24)

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

Table C-61. Design Energy

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	24	Design Energy	unsigned integer	2	0	65535	6336	0.1Wh

Related Variables:

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

C.5.1.14 Manuf Name (Offset 26)

The *ManufacturerName* function returns a string stored in this value. The maximum text length is 11 characters.

Table C-62. 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.5.1.15 Device Name (Offset 38)

The *DeviceName* function returns a string stored in this value. The maximum text length is 7 characters.

Table C-63. 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			bq20z70	ASCII

Related Variables:

- SBS:DeviceName(0x21)

C.5.1.16 Device Chemistry (Offset 46)

The *DeviceChemistry* function returns a string stored in this value. The maximum text length is 4 characters.

Table C-64. 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%, bq20z70 sets *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below this value. Set to -1% to disable this function.

Table C-65. 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%, bq20z70 clears *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above this value. Set to -1% to disable this function.

Table C-66. 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%, bq20z70 sets *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below this value. Set to -1% to disable this function.

Table C-67. 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%, bq20z70 clears *[FD]*flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above this value. Set to -1% to disable this function.

Table C-68. 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)

bq20z70 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-69. TDA Set Volt Threshold

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	4	TDA Set Volt Threshold	unsigned integer	2	0	16800	5000	mV

Related Variables:

- DF:SBS Configuration:Configuration(49):TDA Set Volt Time(6)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[TDA]

C.5.2.6 TDA Set Volt Time (Offset 6)

The bq20z70 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-70. 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	0	Sec

Related Variables:

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

C.5.2.7 TDA Clear Volt (Offset 7)

bq20z70 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 will not clear *[TDA]* if *[TDA]* is set by ***TDA Set %*** or any other functions.

Table C-71. TDA Clear Volt

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	7	TDA Clear Volt	unsigned integer	2	0	16800	5500	mV

Related Variables:

- DF:SBS Configuration:Configuration(49):TDA Set Volt Threshold(4)
- DF:SBS Configuration:Configuration(49):TDA Set Volt Time(6)
- SBS:Voltage(0x09)
- SBS:BatteryStatus(0x16)[TDA]

C.6 System Data

C.6.1 Manufacturer Info (Subclass 58)

C.6.1.1 Manuf. Info (Offset 0)

The *ManufacturerInfo* function returns the string stored in this variable. The maximum text length is 8 characters.

Table C-72. 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.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 bq20z70

Table C-73. 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	0x033b	0x033b	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	CC1	CC0
Low Byte	RSVD	RSVD	SLEEP	TEMP1	TEMP0	RSVD	ZVCHG1	ZVCHG0

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

Figure C-4. Operation Cfg A

CC1, CC0 — These bits configure the bq20z70 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 bq20z70 to enter Sleep mode if SMBus lines are low.

0 = bq20z70 never disables Sleep mode

1 = bq20z70 enters Sleep mode under normal Sleep entry criteria (default)

Related Variables:

SBS:ManufacturerAccess(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)

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 = GPOD of bq29330

1,1 = No Action

C.7.1.2 Operation Cfg B (Offset 2)

This register enable, disable or configures various features of bq20z70

Table C-74. 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	0x3eff	0x3eff	

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	RSVD	RESCAP	NCSMB	NRCHG	CSYNC	CHGTERM	RSVD
Low Byte	CHGSUSP	OTFET	CHGFET	CHGIN	NR	CPE	HPE	BCAST

Figure C-5. Operation Cfg B

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 — Disables SMBUS $t_{TIMEOUT}$ feature. Use this bit with caution.

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

1 = Extended SMBUS $t_{TIMEOUT}$

NRCHG — Enables the CHG FET to remain on during sleep when bq20z70 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 bq20z70 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):TCA Clear %(10)

DF:Charge Control:Termination Cfg(36):FC Clear %(12)

SBS:Current(0x0a)

SBS:BatteryStatus(0x16)[FC], [TCA]

CHGSUSP — This bit enables bq20z70 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 bq20z70 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 bq20z70 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(6)

CPE —This bit enables or disables PEC transmissions to the smart-battery charger for master-mode alarm messages.

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

1 = PEC byte on alarm warning to charger

HPE —This bit enables or disables PEC transmissions to the smart-battery host for master-mode alarm messages and receiving communications from all sources in slave-mode. If host uses PEC is bit should be set.

0 = No PEC byte on alarm warning to host and receiving communications from all sources in slave-mode (default)

1 = PEC byte on alarm warning to host and receiving communications from all sources in slave-mode. If host uses PEC is bit should be set.

BCAST —This bit enables or disables SBS broadcasts to smart 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)

Table C-75. 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	

	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	RSVD	RSOCL

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

Figure C-6. Operation Cfg C

RSOCL — This bits configures the RelativeStateofCharge display during charge termination.

0 = *RelativeStateOfCharge* is **not** held at 99% until primary charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.

1 = *RelativeStateOfCharge* is held at 99% until primary charge termination occurs and displays 100% only upon entering primary charge termination state.

C.7.1.4 Permanent Fail Cfg (Offset 6)

The Permanent Failure Configuration register enables or disables the use of the 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 high.

Table C-76. Permanent Fail Cfg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
64	Configuration	6	Permanent Fail Cfg	hex	2	0x0000	0x4dff	0x0000	

Related Variables:

- DF:PF Status:Device Status Data(96):PF Flags1(0)

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	XPFVSHUT	RSVD	RSVD	XSOCD	XSOCC	RSVD	XAFE_C
Low Byte	XDFF	XDFETF	XCFETF	XCIM	XSOTD	XSOTC	XSOV	XPFIN

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

Figure C-7. Permanent Fail Cfg

XPFVSHUT — If bit is set AND any permanent failure happens AND the bq20z70 goes into shutdown, 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 error occurs, the SAFE pin is set to high.

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_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 Data Flash 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 bq20z70 is in removable battery mode (***[NR]*** = 0), these bits sets the recovery method from 1st level security errors. If corresponding 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-77. 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	0x3027	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	RSVD	RSVD	RSVD	RSVD
Low Byte	RSVD	RSVD	OC	RSVD	RSVD	AOCD	SCC	SCD

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

Figure C-8. Non-Removable Cfg

OCD — Overcurrent in Discharge

OCC — Overcurrent in Charge

OC — Over Charge Capacity

AOCD — AFE Overcurrent in Discharge

SCC — Short Circuit in Charge

SCD — Short Circuit in Discharge

C.8 Power

C.8.1 Power (Subclass 68)

C.8.1.1 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 will be made. If charger present is detected with ***Charger Present***, the is value is bypassed and flash can be updated.

Table C-78. Flash Update OK Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	0	Flash Update OK Voltage	unsigned integer	2	6000	20000	7500	mV

Related Variables:

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

C.8.1.2 Shutdown Voltage (Offset 2)

The bq20z70 goes into shutdown mode if battery *Voltage* is equal to or less than ***Shutdown Voltage*** for 10s and has been out of shutdown mode at least for 10s.

Table C-79. Shutdown Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	2	Shutdown Voltage	unsigned integer	2	5000	20000	7000	mV

Related Variables:

- SBS:Voltage(0x09)

C.8.1.3 Charger Present (Offset 5)

The bq20z70 detects a charger when the voltage at PACK pin of bq29330 is above this threshold. If a charger is detected, it overrides ***Flash Update Ok Voltage*** and flash can be updated.

Table C-80. 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	23000	3000	mV

Related Variables:

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

C.8.1.4 Wake Current Reg (Offset 16)

Wake Current Reg configures the current threshold required to wake the bq20z70 from sleep mode by detecting voltage across SRN and SRP.

Table C-81. Wake Current Reg

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	16	Wake Current Reg	hex	1	0x00	0xff	0x00	

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

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

Figure C-9. Wake Current Reg

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

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

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

Table C-82. Wake Current Reg

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

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:Current(0x0a)

C.9 Gas Gauging

C.9.1 IT Cfg (Offset 80)

C.9.1.1 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* x *Voltage*
3 =	*AverageCurrent* (default)	*AverageCurrent* x average *Voltage*
4 =	***Design Capacity*** / 5	***Design Energy*** / 5
5 =	*AtRate* (mA)	*AtRate* (10 mW)
6 =	***User Rate-mA***	***User Rate-10mWh***

Table C-83. Load Select

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	0	Load Select	unsigned integer	1	0	255	3	

Related Variables:

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- DF:Gas Gauging:IT Cfg(80):User Rate-mA(60)
- DF:Gas Gauging:IT Cfg(80):User Rate-10mW(62)
- SBS:BatteryMode(0x03)[CapM]
- SBS:AtRate(0x04)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)

C.9.1.2 Load Mode (Offset 1)

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

0 = Constant Current (default)

1 = Constant Power

Table C-84. Load Mode

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	1	Load Mode	unsigned integer	1	0	255	0	

Related Variables:

- DF:Gas Gauging:IT Cfg(80):Load Select(0)

C.9.1.3 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-85. Term Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	45	Term Voltage	signed integer	2	-32768	32767	12000	mV

Related Variables:

- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(64)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(66)
- SBS:Voltage(0x09)
- SBS:RemainingCapacity(0x0f)

C.9.1.4 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-86. 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	-9000	-2000	0	mA

Related Variables:

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

C.9.1.5 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-87. 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	-14000	-3000	0	10 mW

Related Variables:

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

C.9.1.6 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-88. Reserve Cap-mAh

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	64	Reserve Cap-mAh	signed integer	2	0	9000	0	mAh

Related Variables:

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

C.9.1.7 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-89. Reserve Cap-mAh

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	66	Reserve Cap-mWh	signed integer	2	0	14000	0	10 mWh

Related Variables:

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

C.9.2 Current Thresholds (Offset 81)

C.9.2.1 Dsg Current Threshold (Offset 0)

bq20z70 enters discharge mode from relaxation mode or charge mode if *Current* < (-) ***Dsg Current Threshold***

Table C-90. 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	2000	100	mA

Related Variables:

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

C.9.2.2 Chg Current Threshold (Offset 2)

bq20z70 enters charge mode from relaxation mode or discharge mode if *Current* > ***Chg Current Threshold***.

Table C-91. 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	2000	50	mA

Related Variables:

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

C.9.2.3 Quit Current (Offset 4)

The bq20z70 enters relaxation mode from charge mode if *Current* goes below ***Quit Current*** for a period of 60s. The bq20z70 also enters relaxation mode from discharge mode if *Current* goes above ***(-)Quit Current*** for a period of 1s.

Table C-92. 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	1000	10	mA

Related Variables:

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

C.9.3 State (Offset 82)

C.9.3.1 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-93. 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	65535	4400	mAh
		2	Qmax Cell 1		2	0	65535	4400	mAh
		4	Qmax Cell 2		2	0	65535	4400	mAh
		6	Qmax Cell 3		2	0	65535	4400	mAh

Related Variables:

- DF:Gas Gauging:State(82):Qmax Pack(8)
- SBS:OperationStatus(0x54)[QEN]

C.9.3.2 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-94. 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	65535	4400	mAh

Related Variables:

- DF:Gas Gauging:State(82):Qmax Cell 0(0)
- DF:Gas Gauging:State(82):Qmax Cell 1(2)
- DF:Gas Gauging:State(82):Qmax Cell 2(4)
- DF:Gas Gauging:State(82):Qmax Cell 3(6)
- SBS:OperationStatus(0x54)[QEN]

C.9.3.3 Update Status (Offset 12)

It is recommended to use *ManufactureAccess* to enable or disable Impedance Track™ algorithm updating.

0x00 = no Impedance Track™ algorithm updating (default)

0x02 = Qmax updated

0x04 = Impedance Track™ algorithm updating

0x06 = Qmax updated + Impedance Track™ algorithm updating

Table C-95. 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.9.3.4 Delta Voltage (Offset 25)

The bq20z70 stores the maximum difference of *Voltage* 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-96. Delta Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	25	Delta Voltage	signed integer	2	-32768	32767	0	mV

Related Variables:

- SBS:Voltage(0x09)

C.10 Ra Table

C.10.1 R_a0 (Subclass 88)

C.10.1.1 Cell0 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 0. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-97. 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.10.1.2 Cell0 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 0 in this table.

Table C-98. Cell0 R_a

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
88	R_a0	2	Cell0 R_a 0	signed integer	2	0	32767	160	2^-10 Ω
		4	Cell0 R_a 1			0	32767	166	
		6	Cell0 R_a 2			0	32767	153	
		8	Cell0 R_a 3			0	32767	151	
		10	Cell0 R_a 4			0	32767	145	
		12	Cell0 R_a 5			0	32767	152	
		14	Cell0 R_a 6			0	32767	176	
		16	Cell0 R_a 7			0	32767	204	
		18	Cell0 R_a 8			0	32767	222	
		20	Cell0 R_a 9			0	32767	254	
		22	Cell0 R_a 10			0	32767	315	
		24	Cell0 R_a 11			0	32767	437	
		26	Cell0 R_a 12			0	32767	651	
		28	Cell0 R_a 13			0	32767	1001	
		30	Cell0 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a0(88):Cell0 R_a Flag(0)

C.10.2 R_a1 (Subclass 89)

C.10.2.1 Cell1 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 1. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-99. 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.10.2.2 Cell1 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 1 in this table.

Table C-100. 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	32767	160	2^-10 Ω
		4	Cell1 R_a 1			0	32767	166	
		6	Cell1 R_a 2			0	32767	153	
		8	Cell1 R_a 3			0	32767	151	
		10	Cell1 R_a 4			0	32767	145	
		12	Cell1 R_a 5			0	32767	152	
		14	Cell1 R_a 6			0	32767	176	
		16	Cell1 R_a 7			0	32767	204	
		18	Cell1 R_a 8			0	32767	222	
		20	Cell1 R_a 9			0	32767	254	
		22	Cell1 R_a 10			0	32767	315	
		24	Cell1 R_a 11			0	32767	437	
		26	Cell1 R_a 12			0	32767	651	
		28	Cell1 R_a 13			0	32767	1001	
		30	Cell1 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a1(89):Cell1 R_a Flag(0)

C.10.3 R_a2 (Subclass 90)

C.10.3.1 Cell2 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 2. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-101. 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.10.3.2 Cell2 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 2 in this table.

Table C-102. 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	32767	160	2^-10 Ω
		4	Cell2 R_a 1			0	32767	166	
		6	Cell2 R_a 2			0	32767	153	
		8	Cell2 R_a 3			0	32767	151	
		10	Cell2 R_a 4			0	32767	145	
		12	Cell2 R_a 5			0	32767	152	
		14	Cell2 R_a 6			0	32767	176	
		16	Cell2 R_a 7			0	32767	204	
		18	Cell2 R_a 8			0	32767	222	
		20	Cell2 R_a 9			0	32767	254	
		22	Cell2 R_a 10			0	32767	315	
		24	Cell2 R_a 11			0	32767	437	
		26	Cell2 R_a 12			0	32767	651	
		28	Cell2 R_a 13			0	32767	1001	
		30	Cell2 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a2(90):Cell2 R_a Flag(0)

C.10.4 R_a3 (Subclass 91)

C.10.4.1 Cell3 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 3. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-103. 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.10.4.2 Cell3 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 3 in this table.

Table C-104. 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	32767	160	2^-10 Ω
		4	Cell3 R_a 1			0	32767	166	
		6	Cell3 R_a 2			0	32767	153	
		8	Cell3 R_a 3			0	32767	151	
		10	Cell3 R_a 4			0	32767	145	
		12	Cell3 R_a 5			0	32767	152	
		14	Cell3 R_a 6			0	32767	176	
		16	Cell3 R_a 7			0	32767	204	
		18	Cell3 R_a 8			0	32767	222	
		20	Cell3 R_a 9			0	32767	254	
		22	Cell3 R_a 10			0	32767	315	
		24	Cell3 R_a 11			0	32767	437	
		26	Cell3 R_a 12			0	32767	651	
		28	Cell3 R_a 13			0	32767	1001	
		30	Cell3 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a3(91):Cell3 R_a Flag(0)

C.10.5 R_a0x (Subclass 92)

C.10.5.1 xCell0 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 0. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-105. 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.10.5.2 xCell0 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 0 in this table.

Table C-106. 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	32767	160	2^-10 Ω
		4	xCell0 R_a 1			0	32767	166	
		6	xCell0 R_a 2			0	32767	153	
		8	xCell0 R_a 3			0	32767	151	
		10	xCell0 R_a 4			0	32767	145	
		12	xCell0 R_a 5			0	32767	152	
		14	xCell0 R_a 6			0	32767	176	
		16	xCell0 R_a 7			0	32767	204	
		18	xCell0 R_a 8			0	32767	222	
		20	xCell0 R_a 9			0	32767	254	
		22	xCell0 R_a 10			0	32767	315	
		24	xCell0 R_a 11			0	32767	437	
		26	xCell0 R_a 12			0	32767	651	
		28	xCell0 R_a 13			0	32767	1001	
		30	xCell0 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a0x(89):xCell0 R_a Flag(0)

C.10.6 R_a1x (Subclass 93)

C.10.6.1 xCell1 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 1. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-107. 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.10.6.2 xCell1 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 1 in this table.

Table C-108. 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	32767	160	2^-10 Ω
		4	xCell1 R_a 1			0	32767	166	
		6	xCell1 R_a 2			0	32767	153	
		8	xCell1 R_a 3			0	32767	151	
		10	xCell1 R_a 4			0	32767	145	
		12	xCell1 R_a 5			0	32767	152	
		14	xCell1 R_a 6			0	32767	176	
		16	xCell1 R_a 7			0	32767	204	
		18	xCell1 R_a 8			0	32767	222	
		20	xCell1 R_a 9			0	32767	254	
		22	xCell1 R_a 10			0	32767	315	
		24	xCell1 R_a 11			0	32767	437	
		26	xCell1 R_a 12			0	32767	651	
		28	xCell1 R_a 13			0	32767	1001	
		30	xCell1 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a0x(93):xCell1 R_a Flag(0)

C.10.7 R_a2x (Subclass 94)

C.10.7.1 xCell2 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 2. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-109. 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.10.7.2 xCell2 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 2 in this table.

Table C-110. 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	32767	160	2^-10 Ω
		4	xCell2 R_a 1			0	32767	166	
		6	xCell2 R_a 2			0	32767	153	
		8	xCell2 R_a 3			0	32767	151	
		10	xCell2 R_a 4			0	32767	145	
		12	xCell2 R_a 5			0	32767	152	
		14	xCell2 R_a 6			0	32767	176	
		16	xCell2 R_a 7			0	32767	204	
		18	xCell2 R_a 8			0	32767	222	
		20	xCell2 R_a 9			0	32767	254	
		22	xCell2 R_a 10			0	32767	315	
		24	xCell2 R_a 11			0	32767	437	
		26	xCell2 R_a 12			0	32767	651	
		28	xCell2 R_a 13			0	32767	1001	
		30	xCell2 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a2x(94):xCell2 R_a Flag(0)

C.10.8 R_a3x (Subclass 95)

C.10.8.1 xCell3 R_a flag (Offset 0)

This value indicates the validity of the cell impedance table for cell 3. It is recommended not to change this value.

High Byte		Low Byte	
0x00	cell impedance & Qmax updated	0x00	table not used & Qmax updated
0x05	relaxation mode and Qmax update in 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-111. 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.10.8.2 xCell3 R_a 0..14 (Offset 2..30)

The bq20z70 stores and updates the impedance profile for cell 3 in this table.

Table C-112. 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	32767	160	2^-10 Ω
		4	xCell3 R_a 1			0	32767	166	
		6	xCell3 R_a 2			0	32767	153	
		8	xCell3 R_a 3			0	32767	151	
		10	xCell3 R_a 4			0	32767	145	
		12	xCell3 R_a 5			0	32767	152	
		14	xCell3 R_a 6			0	32767	176	
		16	xCell3 R_a 7			0	32767	204	
		18	xCell3 R_a 8			0	32767	222	
		20	xCell3 R_a 9			0	32767	254	
		22	xCell3 R_a 10			0	32767	315	
		24	xCell3 R_a 11			0	32767	437	
		26	xCell3 R_a 12			0	32767	651	
		28	xCell3 R_a 13			0	32767	1001	
		30	xCell3 R_a 14			0	32767	1458	

Related Variables:

- DF:Ra Table:R_a3x(95):xCell3 R_a Flag(0)

C.11 PF Status

C.11.1 Device Status Data (Subclass 96)

C.11.1.1 PF Flags 1 (Offset 0)

The flags in ***PF Flags 1*** register indicates the reason that bq20z70 has entered permanent failure. If the failure flag in ***PF Flags 1*** matches the bit in ***Permanent Fail Cfg***, the SAFE pin is driven high. The 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-113. 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(4)
- DF:PF Status:Device Status Data(96):PF Flags 2(28)
- SBS:PFStatus(0x53)

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
High Byte	RSVD	XPFVSHUT	RSVD	RSVD	SOCD	SOCC	RSVD	ACE_C
Low Byte	DFF	DFETF	CFETF	CIM	SOTD	SOTC	SOV	PFIN

LEGEND: All Values Read Only

Figure C-10. PF Flags 1

XPFVSHUT — = 1: Another Permanent Failure has occurred AND device went to shutdown after that event

SOCD — = 1: Safety Overcurrent in Discharge permanent failure

SOCC — = 1: Safety Overcurrent in Charge permanent failure

AFE_C — =1 AFE-Communications permanent failure

DFF — = 1: Data Flash Fault permanent failure

DFETF — = 1: Discharge FET permanent failure

CFETF — = 1: Charge FET permanent failure

CIM — = 1: Cell-Imbalance permanent failure

SOTD — = 1: Discharge Safety Overtemperature permanent failure

SOTC — = 1: Charge Safety Overtemperature permanent failure

SOV — = 1: Safety-Overvoltage permanent failure

PFIN — = 1: External PFIN Input of bq29330 Indication of a Permanent Failure.

C.11.1.2 PF Flags 2 (Offset 28)

On first occurrence of permanent failure, when PFStatus changes from 0x0000, then the *PFStatus* flags will 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-114. 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 Calibration

C.12.1 Data (Subclass 104)

C.12.1.1 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-115. 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.12.1.2 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-116. 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	140500	

Related Variables:

- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)

C.12.1.3 Ref Voltage (Offset 8)

This register value stores the AFE reference voltage in units of 0.5 mV.

Table C-117. Ref Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	8	Ref Voltage	signed integer	2	0	32767	2450	0.5mV

Related Variables:

- none

C.12.1.4 AFE Pack Gain (Offset 12)

This register value stores the scale factor for the voltage at PACK pin of the bq29330 AFE.

Table C-118. 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	65535	30625	mV/cnt

Related Variables:

- none

C.12.1.5 CC Offset (Offset 14)

This register value stores the coulomb counter offset compensation. It is set by automatic calibration of the bq20z70. It is not recommended to change this value.

Table C-119. CC Offset

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	14	CC Offset	signed integer	2	-32768	32767	-12250	

Related Variables:

- none

C.12.1.6 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-120. 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.12.1.7 Int Temp Offset (Offset 18)

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

Table C-121. Int Temp Offset

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	18	Int Temp Offset	signed integer	1	-128	127	0	

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x08)

C.12.1.8 Ext1 Temp Offset (Offset 19)

This register value stores the temperature sensor offset compensation for the external temperature sensor 1 connected at TS1 pin of the bq20z70. Use calibration routines to set this value.

Table C-122. Ext1 Temp Offset

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	19	Ext1 Temp Offset	signed integer	1	-128	127	0	

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x08)

C.12.1.9 Ext2 Temp Offset (Offset 20)

This register value stores the temperature sensor offset compensation for the external temperature sensor 2 connected at TS2 pin of the bq20z70. Use calibration routines to set this value.

Table C-123. Ext2 Temp Offset

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	20	Ext2 Temp Offset	signed integer	1	-128	127	0	

Related Variables:

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x08)

C.12.2 Config (Subclass 105)

C.12.2.1 CC Current (Offset 0)

This value sets the current used for CC calibration when in calibration mode.

Table C-124. 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	65535	3000	mA

Related Variables:

- SBS:Current(0x0a)

C.12.2.2 Voltage Signal (Offset 2)

This value sets the voltage used for calibration when in calibration mode.

Table C-125. 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	65535	16800	mV

Related Variables:

- SBS:Voltage(0x09)

C.12.2.3 Temp Signal (Offset 4)

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

Table C-126. 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	65535	2980	0.1°C

Related Variables:

- SBS:Temperature(0x08)

C.12.2.4 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 will cause a CC offset calibration error. Numbers greater than 250 will be rounded down to the nearest multiple of 250.

Table C-127. CC Offset Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	6	CC Offset Time	unsigned integer	2	0	65535	250	mSec

Related Variables:

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

C.12.2.5 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 will cause a ADC offset calibration error. Numbers greater than 32 will be rounded down to the nearest multiple of 32.

Table C-128. ADC Offset Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	8	ADC Offset Time	unsigned integer	2	0	65535	32	mSec

Related Variables:

- none

C.12.2.6 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 will cause a CC gain calibration error. Numbers greater than 250 will be rounded down to the nearest multiple of 250.

Table C-129. CC Gain Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	10	CC Gain Time	unsigned integer	2	0	65535	250	mSec

Related Variables:

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

C.12.2.7 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 will cause a voltage calibration error. Numbers greater than 1984 will be rounded down to the nearest multiple of 1984.

Table C-130. Voltage Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	12	Voltage Time	unsigned integer	2	0	65535	1984	mSec

Related Variables:

- SBS:Voltage(0x09)

C.12.2.8 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 will cause a temperature calibration error. Numbers greater than 32 will be rounded down to the nearest multiple of 32.

Table C-131. Temperature Time

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	14	Temperature Time	unsigned integer	2	0	65535	32	mSec

Related Variables:

- Calibration:Data(104):Int Temp Offset(18)
- Calibration:Data(104):Ext1 Temp Offset(19)
- Calibration:Data(104):Ext2 Temp Offset(20)
- SBS:Temperature(0x08)

C.12.2.9 Cal Mode Timeout (Offset 17)

The bq20z70 will exit calibration mode automatically after ***Calibration Mode Timeout*** period.

Table C-132. Cal Mode Timeout

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	17	Cal Mode Timeout	unsigned integer	2	0	65535	38400	Sec / 128

Related Variables:

- SBS:ManufacturerAccess(0x00):Calibration Mode(0x0040)

C.12.3 Temp Model (Subclass 106)

C.12.3.1 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 bq20z70. The default values characterize the Semitec 103AT NTC resistor. Do not modify these values without consulting TI.

Table C-133. Ext Coef 1..4, Ext Min AD, Ext Max Temp

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
106	Temp Model	0	Ext Coef 1	signed integer	2	-32768	32767	-28285	Sec
		2	Ext Coef 2					20848	
		4	Ext Coef 3					-7537	
		6	Ext Coef 4					4012	
		8	Ext Min AD					0	
		10	Ext Max Temp					4012	

Related Variables:

- none

C.12.3.2 Int Coef 1..4, Int Min AD, Int Max Temp

These values characterize the internal temperature sense resistor of the bq20z70. Do not modify this values without consulting TI.

Table C-134. Int Coef 1..4, Int Min AD, Int Max Temp

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
106	Temp Model	12	Int Coef 1	signed integer	2	-32768	32767	0	Sec
		14	Int Coef 2					0	
		16	Int Coef 3					-11136	
		18	Int Coef 4					5754	
		20	Int Min AD					0	
		22	Int Max Temp					5754	

Related Variables:

- none

C.12.4 Current (Subclass 107)

C.12.4.1 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 sec/ln(1/a) (default 14.5 sec)

Table C-135. 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.12.4.2 Deadband (Offset 1)

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

Table C-136. 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.12.4.3 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-137. 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 DataFlash Values

Table C-138. 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	I2	3700	5000	4300	mV
1st Level Safety	0	Voltage	3	COV Recovery	I2	0	4400	3900	mV
1st Level Safety	0	Voltage	12	CUV Threshold	I2	0	3500	2200	mV
1st Level Safety	0	Voltage	15	CUV Recovery	I2	0	3600	3000	mV
1st Level Safety	1	Current	0	OC (1st Tier) Chg	I2	0	20000	6000	mA
1st Level Safety	1	Current	5	OC (1st Tier) Dsg	I2	0	20000	6000	mA
1st Level Safety	1	Current	16	Current Recovery Time	U1	0	60	8	s
1st Level Safety	1	Current	17	AFE OC Dsg	H1	0x00	0x1f	0x12	
1st Level Safety	1	Current	18	AFE OC Dsg Time	H1	0x00	0xff	0x0f	
1st Level Safety	1	Current	21	AFE SC Chg Cfg	H1	0x00	0xff	0x77	
1st Level Safety	1	Current	22	AFE SC Dsg Cfg	H1	0x00	0xff	0x77	
1st Level Safety	2	Temperature	0	Over Temp Chg	I2	0	1200	550	0.1°C
1st Level Safety	2	Temperature	3	OT Chg Recovery	I2	0	1200	500	0.1°C
1st Level Safety	2	Temperature	5	Over Temp Dsg	I2	0	1200	600	0.1°C
1st Level Safety	2	Temperature	8	OT Dsg Recovery	I2	0	1200	550	0.1°C
2nd Level Safety	16	Voltage	0	SOV Threshold	I2	0	20000	18000	mV
2nd Level Safety	16	Voltage	2	SOV Time	U1	0	30	0	s
2nd Level Safety	16	Voltage	3	Cell Imbalance Current	I1	0	200	5	mA
2nd Level Safety	16	Voltage	4	Cell Imbalance Fail Voltage	I2	0	5000	1000	mV
2nd Level Safety	16	Voltage	6	Cell Imbalance Time	U1	0	30	0	s
2nd Level Safety	16	Voltage	7	Battery Rest Time	U2	0	65535	1800	s
2nd Level Safety	16	Voltage	9	PFIN Detect Time	U1	0	30	0	s
2nd Level Safety	17	Current	0	SOC Chg	I2	0	30000	10000	mA
2nd Level Safety	17	Current	2	SOC Chg Time	U1	0	30	0	s
2nd Level Safety	17	Current	3	SOC Dsg	I2	0	30000	10000	mA
2nd Level Safety	17	Current	5	SOC Dsg Time	U1	0	30	0	s
2nd Level Safety	18	Temperature	0	SOT Chg	I2	0	1200	650	0.1°C
2nd Level Safety	18	Temperature	2	SOT Chg Time	U1	0	30	0	s
2nd Level Safety	18	Temperature	3	SOT Dsg	I2	0	1200	750	0.1°C
2nd Level Safety	18	Temperature	5	SOT Dsg Time	U1	0	30	0	s
2nd Level Safety	19	FET Verification	2	FET Fail Time	U1	0	30	0	s
2nd Level Safety	20	AFE Verification	1	AFE Fail Limit	U1	0	255	10	

Table C-138. DATAFLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
Charge Control	32	Charge Inhibit Cfg	0	Chg Inhibit Temp Low	I2	-400	1200	0	0.1°C
Charge Control	32	Charge Inhibit Cfg	2	Chg Inhibit Temp High	I2	-400	1200	450	0.1°C
Charge Control	33	Pre-Charge Cfg	0	Pre-chg Current	I2	0	2000	250	mA
Charge Control	33	Pre-Charge Cfg	2	Pre-chg Temp	I2	-400	1200	120	0.1°C
Charge Control	33	Pre-Charge Cfg	4	Pre-chg Voltage	I2	0	20000	3000	mV
Charge Control	33	Pre-Charge Cfg	6	Recovery Voltage	I2	0	20000	3100	mV
Charge Control	34	Fast Charge Cfg	0	Fast Charge Current	I2	0	10000	4000	mA
Charge Control	34	Fast Charge Cfg	2	Charging Voltage	I2	0	20000	16800	mV
Charge Control	34	Fast Charge Cfg	6	Suspend Low Temp	I2	-400	1200	-50	0.1°C
Charge Control	34	Fast Charge Cfg	8	Suspend High Temp	I2	-400	1200	550	0.1°C
Charge Control	36	Termination Cfg.	2	Taper Current	I2	0	1000	250	mA
Charge Control	36	Termination Cfg.	6	Taper Voltage	I2	0	1000	300	mV
Charge Control	36	Termination Cfg.	10	TCA Clear %	I1	-1	100	95	%
Charge Control	36	Termination Cfg.	12	FC Clear %	I1	-1	100	98	%
Charge Control	37	Cell Balancing Cfg	0	Min Cell Deviation	U2	0	65535	1750	s/mAh
Charge Control	38	Charging Faults	13	Over Charge Capacity	I2	0	4000	300	mAh
SBS Configuration	48	Data	0	Rem Cap Alarm	I2	0	700	300	mAh
SBS Configuration	48	Data	2	Rem Energy Alarm	I2	0	1000	432	10mW
SBS Configuration	48	Data	4	Rem Time Alarm	U2	0	30	10	min
SBS Configuration	48	Data	6	Init Battery Mode	H2	0x0000	0xffff	0x0081	
SBS Configuration	48	Data	8	Design Voltage	I2	7000	18000	14400	mV
SBS Configuration	48	Data	10	Spec Info	H2	0x0000	0xffff	0x0031	
SBS Configuration	48	Data	12	Manuf Date	U2	0	65535	0	Day + Mo*32 + (Yr - 1980)*256
SBS Configuration	48	Data	14	Ser. Num.	H2	0x0000	0xffff	0x0001	
SBS Configuration	48	Data	16	Cycle Count	U2	0	65535	0	Count
SBS Configuration	48	Data	18	CC Threshold	I2	100	32767	4400	mAh
SBS Configuration	48	Data	21	CF MaxError Limit	U1	0	100	100	%
SBS Configuration	48	Data	22	Design Capacity	I2	0	65535	4400	mAh
SBS Configuration	48	Data	24	Design Energy	I2	0	65535	6336	10mWh
SBS Configuration	48	Data	26	Manuf Name	S12			Texas Inst.	
SBS Configuration	48	Data	38	Device Name	S8			bq20z70	
SBS Configuration	48	Data	46	Device Chemistry	S5			LION	
SBS Configuration	49	Configuration	0	TDA Set %	I1	-1	100	6	%
SBS Configuration	49	Configuration	1	TDA Clear %	I1	-1	100	8	%
SBS Configuration	49	Configuration	2	FD Set %	I1	-1	100	2	%
SBS Configuration	49	Configuration	3	FD Clear %	I1	-1	100	5	%
SBS Configuration	49	Configuration	4	TDA Set Volt Threshold	I2	0	16800	5000	mV
SBS Configuration	49	Configuration	6	TDA Set Volt Time	U1	0	60	0	s
SBS Configuration	49	Configuration	7	TDA Clear Volt	I2	0	16800	5500	mV
System Data	58	Manufacturer Info	0	Manuf. Info	S9			12345678	
Configuration	64	Registers	0	Operation Cfg A	H2	0x0000	0x033b	0x0329	
Configuration	64	Registers	2	Operation Cfg B	H2	0x0000	0x3eff	0x2440	
Configuration	64	Registers	4	Operation Cfg C	H2	0x0000	0x0001	0x0000	

Table C-138. DATAFLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
Configuration	64	Registers	6	Permanent Fail Cfg	H2	0x0000	0x4dff	0x0000	
Configuration	64	Registers	8	Non-Removable Cfg	H2	0x0000	0x3027	0x0000	
Power	68	Power	0	Flash Update OK Voltage	I2	6000	20000	7500	mV
Power	68	Power	2	Shutdown Voltage	I2	5000	20000	7000	mV
Power	68	Power	5	Charger Present	I2	0	23000	3000	mV
Power	68	Power	16	Wake Current Reg	H1	0x00	0xff	0x00	
Gas Gauging	80	IT Cfg	0	Load Select	U1	0	255	3	
Gas Gauging	80	IT Cfg	1	Load Mode	U1	0	255	0	
Gas Gauging	80	IT Cfg	45	Term Voltage	I2	-32768	32767	12000	mV
Gas Gauging	80	IT Cfg	60	User Rate-mA	I2	2000	9000	0	MilliAmp
Gas Gauging	80	IT Cfg	62	User Rate-mW	I2	3000	14000	0	10mW
Gas Gauging	80	IT Cfg	64	Reserve Cap-mAh	I2	0	9000	0	mAh
Gas Gauging	80	IT Cfg	66	Reserve Cap-mWh	I2	0	14000	0	10mWh
Gas Gauging	81	Current Thresholds	0	Dsg Current Threshold	I2	0	2000	50	mA
Gas Gauging	81	Current Thresholds	2	Chg Current Threshold	I2	0	2000	25	mA
Gas Gauging	81	Current Thresholds	4	Quit Current	I2	0	1000	10	mA
Gas Gauging	82	State	0	Qmax Cell0	I2	0	32767	4400	mAh
Gas Gauging	82	State	2	Qmax Cell1	I2	0	32767	4400	mAh
Gas Gauging	82	State	4	Qmax Cell2	I2	0	32767	4400	mAh
Gas Gauging	82	State	6	Qmax Cell3	I2	0	32767	4400	mAh
Gas Gauging	82	State	8	Qmax Pack	I2	0	32767	4400	mAh
Gas Gauging	82	State	12	Update Status	H1	0x0	0x3	0x0	
Gas Gauging	82	State	25	Delta Voltage	I2	-32768	32767	0	mV
Ra Table	88	R_a0	0	Cell0 R_a flag	H2	0x0000	0x0000	0xff55	
Ra Table	88	R_a0	2	Cell0 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	88	R_a0	4	Cell0 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	88	R_a0	6	Cell0 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	88	R_a0	8	Cell0 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	88	R_a0	10	Cell0 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	88	R_a0	12	Cell0 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	88	R_a0	14	Cell0 R_a 6	I2	333	333	176	2^-10ohm
Ra Table	88	R_a0	16	Cell0 R_a 7	I2	338	338	204	2^-10ohm
Ra Table	88	R_a0	18	Cell0 R_a 8	I2	345	345	222	2^-10ohm
Ra Table	88	R_a0	20	Cell0 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	88	R_a0	22	Cell0 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	88	R_a0	24	Cell0 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	88	R_a0	26	Cell0 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	88	R_a0	28	Cell0 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	88	R_a0	30	Cell0 R_a 14	I2	366	366	1458	2^-10ohm
Ra Table	89	R_a1	0	Cell1 R_a flag	H2	0x0	0x0	0xff55	
Ra Table	89	R_a1	2	Cell1 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	89	R_a1	4	Cell1 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	89	R_a1	6	Cell1 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	89	R_a1	8	Cell1 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	89	R_a1	10	Cell1 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	89	R_a1	12	Cell1 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	89	R_a1	14	Cell1 R_a 6	I2	333	333	176	2^-10ohm

Table C-138. DATAFLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
Ra Table	89	R_a1	16	Cell1 R_a 7	I2	338	338	204	2^-10ohm
Ra Table	89	R_a1	18	Cell1 R_a 8	I2	345	345	222	2^-10ohm
Ra Table	89	R_a1	20	Cell1 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	89	R_a1	22	Cell1 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	89	R_a1	24	Cell1 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	89	R_a1	26	Cell1 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	89	R_a1	28	Cell1 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	89	R_a1	30	Cell1 R_a 14	I2	366	366	1458	2^-10ohm
Ra Table	90	R_a2	0	Cell2 R_a flag	H2	0x0000	0x0000	0xff55	
Ra Table	90	R_a2	2	Cell2 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	90	R_a2	4	Cell2 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	90	R_a2	6	Cell2 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	90	R_a2	8	Cell2 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	90	R_a2	10	Cell2 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	90	R_a2	12	Cell2 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	90	R_a2	14	Cell2 R_a 6	I2	333	333	176	2^-10ohm
Ra Table	90	R_a2	16	Cell2 R_a 7	I2	338	338	204	2^-10ohm
Ra Table	90	R_a2	18	Cell2 R_a 8	I2	345	345	222	2^-10ohm
Ra Table	90	R_a2	20	Cell2 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	90	R_a2	22	Cell2 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	90	R_a2	24	Cell2 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	90	R_a2	26	Cell2 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	90	R_a2	28	Cell2 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	90	R_a2	30	Cell2 R_a 14	I2	366	366	1458	2^-10ohm
Ra Table	91	R_a3	0	Cell3 R_a flag	H2	0x0000	0x0000	0xff55	
Ra Table	91	R_a3	2	Cell3 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	91	R_a3	4	Cell3 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	91	R_a3	6	Cell3 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	91	R_a3	8	Cell3 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	91	R_a3	10	Cell3 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	91	R_a3	12	Cell3 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	91	R_a3	14	Cell3 R_a 6	I2	333	333	176	2^-10ohm
Ra Table	91	R_a3	16	Cell3 R_a 7	I2	338	338	204	2^-10ohm
Ra Table	91	R_a3	18	Cell3 R_a 8	I2	345	345	222	2^-10ohm
Ra Table	91	R_a3	20	Cell3 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	91	R_a3	22	Cell3 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	91	R_a3	24	Cell3 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	91	R_a3	26	Cell3 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	91	R_a3	28	Cell3 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	91	R_a3	30	Cell3 R_a 14	I2	366	366	1458	2^-10ohm
Ra Table	92	R_a0x	0	xCell0 R_a flag	H2	0xffff	0xffff	0xffff	
Ra Table	92	R_a0x	2	xCell0 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	92	R_a0x	4	xCell0 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	92	R_a0x	6	xCell0 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	92	R_a0x	8	xCell0 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	92	R_a0x	10	xCell0 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	92	R_a0x	12	xCell0 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	92	R_a0x	14	xCell0 R_a 6	I2	333	333	176	2^-10ohm
Ra Table	92	R_a0x	16	xCell0 R_a 7	I2	338	338	204	2^-10ohm

Table C-138. DATAFLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
Ra Table	92	R_a0x	18	xCell0 R_a 8	I2	345	345	222	2^-10ohm
Ra Table	92	R_a0x	20	xCell0 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	92	R_a0x	22	xCell0 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	92	R_a0x	24	xCell0 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	92	R_a0x	26	xCell0 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	92	R_a0x	28	xCell0 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	92	R_a0x	30	xCell0 R_a 14	I2	366	366	1458	2^-10ohm
Ra Table	93	R_a1x	0	xCell1 R_a flag	H2	0xffff	0xffff	0xffff	
Ra Table	93	R_a1x	2	xCell1 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	93	R_a1x	4	xCell1 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	93	R_a1x	6	xCell1 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	93	R_a1x	8	xCell1 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	93	R_a1x	10	xCell1 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	93	R_a1x	12	xCell1 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	93	R_a1x	14	xCell1 R_a 6	I2	333	333	176	2^-10ohm
Ra Table	93	R_a1x	16	xCell1 R_a 7	I2	338	338	204	2^-10ohm
Ra Table	93	R_a1x	18	xCell1 R_a 8	I2	345	345	222	2^-10ohm
Ra Table	93	R_a1x	20	xCell1 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	93	R_a1x	22	xCell1 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	93	R_a1x	24	xCell1 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	93	R_a1x	26	xCell1 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	93	R_a1x	28	xCell1 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	93	R_a1x	30	xCell1 R_a 14	I2	366	366	1458	2^-10ohm
Ra Table	94	R_a2x	0	xCell2 R_a flag	H2	0xffff	0xffff	0xffff	
Ra Table	94	R_a2x	2	xCell2 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	94	R_a2x	4	xCell2 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	94	R_a2x	6	xCell2 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	94	R_a2x	8	xCell2 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	94	R_a2x	10	xCell2 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	94	R_a2x	12	xCell2 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	94	R_a2x	14	xCell2 R_a 6	I2	333	333	176	2^-10ohm
Ra Table	94	R_a2x	16	xCell2 R_a 7	I2	338	338	204	2^-10ohm
Ra Table	94	R_a2x	18	xCell2 R_a 8	I2	345	345	222	2^-10ohm
Ra Table	94	R_a2x	20	xCell2 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	94	R_a2x	22	xCell2 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	94	R_a2x	24	xCell2 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	94	R_a2x	26	xCell2 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	94	R_a2x	28	xCell2 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	94	R_a2x	30	xCell2 R_a 14	I2	366	366	1458	2^-10ohm
Ra Table	95	R_a3x	0	xCell3 R_a flag	H2	0xffff	0xffff	0xffff	
Ra Table	95	R_a3x	2	xCell3 R_a 0	I2	183	183	160	2^-10ohm
Ra Table	95	R_a3x	4	xCell3 R_a 1	I2	181	181	166	2^-10ohm
Ra Table	95	R_a3x	6	xCell3 R_a 2	I2	198	198	153	2^-10ohm
Ra Table	95	R_a3x	8	xCell3 R_a 3	I2	244	244	151	2^-10ohm
Ra Table	95	R_a3x	10	xCell3 R_a 4	I2	254	254	145	2^-10ohm
Ra Table	95	R_a3x	12	xCell3 R_a 5	I2	261	261	152	2^-10ohm
Ra Table	95	R_a3x	14	xCell3 R_a 6	I2	333	333	176	2^-10ohm
Ra Table	95	R_a3x	16	xCell3 R_a 7	I2	338	338	204	2^-10ohm
Ra Table	95	R_a3x	18	xCell3 R_a 8	I2	345	345	222	2^-10ohm

Table C-138. DATAFLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units
Ra Table	95	R_a3x	20	xCell3 R_a 9	I2	350	350	254	2^-10ohm
Ra Table	95	R_a3x	22	xCell3 R_a 10	I2	382	382	315	2^-10ohm
Ra Table	95	R_a3x	24	xCell3 R_a 11	I2	429	429	437	2^-10ohm
Ra Table	95	R_a3x	26	xCell3 R_a 12	I2	502	502	651	2^-10ohm
Ra Table	95	R_a3x	28	xCell3 R_a 13	I2	545	545	1001	2^-10ohm
Ra Table	95	R_a3x	30	xCell3 R_a 14	I2	366	366	1458	2^-10ohm
PF Status	96	Device Status Data	0	PF Flags 1	H2	0x0000	0x4dff	0x0000	
PF Status	96	Device Status Data	28	PF Flags 2	H2	0x0000	0x0dff	0x0000	
Calibration	104	Data	0	CC Gain	F4	0.1	4	0.9419	
Calibration	104	Data	4	CC Delta	F4	29826	1193046	280932.625	
Calibration	104	Data	8	Ref Voltage	I2	0	32767	24500	50uV
Calibration	104	Data	12	AFE Pack Gain	I2	0	32767	22050	µV/cnt
Calibration	104	Data	14	CC Offset	I2	-32768	32767	-1667	
Calibration	104	Data	16	Board Offset	I2	-32768	32767	0	
Calibration	104	Data	18	Int Temp Offset	I1	-128	127	0	
Calibration	104	Data	19	Ext1 Temp Offset	I1	-128	127	0	
Calibration	104	Data	20	Ext2 Temp Offset	I1	-128	127	0	
Calibration	105	Config	0	CC Current	I2	0	32767	3000	mA
Calibration	105	Config	2	Voltage Signal	I2	0	32767	16800	mV
Calibration	105	Config	4	Temp Signal	I2	0	32767	2980	0.1°C
Calibration	105	Config	6	CC Offset Time	U2	0	65535	250	s
Calibration	105	Config	8	ADC Offset Time	U2	0	65535	32	s
Calibration	105	Config	10	CC Gain Time	U2	0	65535	250	s
Calibration	105	Config	12	Voltage Time	U2	0	65535	1984	ms
Calibration	105	Config	14	Temperature Time	U2	0	65535	32	s
Calibration	105	Config	17	Cal Mode Timeout	U2	0	65535	38400	1/128 s
Calibration	106	Temp Model	0	Ext Coef 1	I2	-32768	32767	-28285	s
Calibration	106	Temp Model	2	Ext Coef 2	I2	-32768	32767	20848	s
Calibration	106	Temp Model	4	Ext Coef 3	I2	-32768	32767	-7537	s
Calibration	106	Temp Model	6	Ext Coef 4	I2	-32768	32767	4012	s
Calibration	106	Temp Model	8	Ext Min AD	I2	-32768	32767	0	s
Calibration	106	Temp Model	10	Ext Max Temp	I2	-32768	32767	4012	s
Calibration	106	Temp Model	12	Int Coef 1	I2	-32768	32767	0	s
Calibration	106	Temp Model	14	Int Coef 2	I2	-32768	32767	0	s
Calibration	106	Temp Model	16	Int Coef 3	I2	-32768	32767	-11136	s
Calibration	106	Temp Model	18	Int Coef 4	I2	-32768	32767	5754	s
Calibration	106	Temp Model	20	Int Min AD	I2	-32768	32767	0	s
Calibration	106	Temp Model	22	Int Max Temp	I2	-32768	32767	5754	s
Calibration	107	Current	0	Filter	U1	0	255	239	
Calibration	107	Current	1	Deadband	U1	0	255	3	mA
Calibration	107	Current	2	CC Deadband	U1	0	255	34	294 nV

Glossaryreferences to non-existent LED, POV, and PUV features.

ADC	Analog to Digital Converter
AFE	Analog Front End
bit	a single bit in a SBS command or Dataflash value which can be changed by user
CC	Coulomb Counter
CHG FET	charge FET, connected to CHG pin of bq29330; used by bq29330 to enable or disable charging
COV	Cell Over Voltage
CPU	Central Processing Unit
CUV	Cell Under Voltage
DF	Dataflash
DSG	flag set by bq20z70 to indicate charge (DSG= 0) or discharge (DSG=1)
DSG FET	discharge FET, connected to DSG pin of bq29330; used by bq29330 to enable or disable discharging
FAS	Full Access Security
FC	Fully Charged
FCHG	Fast Charge
FCTMO	Fast Charge Timeout
FD	Fully Discharged
flag	a single bit in a SBS command or Dataflash value which is set by bq20z70 or bq29330 and indicates a status change
IC	Integrated Circuit
Li-Ion	Lithium-Ion
NR	Non Removable
OC	Over Current
OCA	Over Charge Alarm
OCV	Open Circuit Voltage
OTC	Over Temperature Charging
OTD	Over Temperature Discharging
PCHG	Pre-Charge
PEC	Packet Error Checking
PF	Permanent Fail

PRES	System Present Flag
Qmax	Maximum Chemical Capacity
RCA	Remaining Capacity Alarm
RSOC	RelativeStateOfCharge
SBS	Smart Battery System
SCC	Short Circuit Charge
SCD	Short Circuit Discharge
SMBus	System Management Bus
SOC	Safety Over Current
SOT	Safety Over Temperature
SS	Sealed mode flag
TCA	Terminate Charge Alarm
TDA	Terminate Discharge Alarm
ZVCHG FET	pre- charge FET, connected to ZVCHG pin of bq29330; depending on configuration it is used for pre charging and/or zero volt charging
XDSG	Discharge Fault flag

Revision History

Changes from Original (June 2006) to A Revision **Page**

- Deleted references to non-existent LED, POV, and PUV features. 6
- Changed Suspend Temp Low offset 34
- Changed Suspend Temp High offset 34
- Deleted reference to non-existent [PUV] flag 35
- Deleted reference to non-existent TCA Set% and FC Set% dataflash values. 36
- Deleted reference to non-existent Maintenance Current dataflash values. 36
- Deleted references to TCA Set% and FC Set% 37
- Changed CF Max Error Limit offset value from (19) to (20) 53
- Changed the OC Discharge recovery threshold value 82
- Changed FET Fail Time offset 92
- Deleted reference to non-existent Temp Hys dataflash value 94
- Changed Suspend Temp Low offset from 8 to 6 96
- Changed Suspend Temp High offset from 10 to 8 97
- Changed reference from non-existent AFE_P flag to RSVD flag. 127
- Deleted non-existent AFE Corr (Offset 10) dataflash value description. 128
- Changed Int Temp Offset from 17 to 18. 129
- Changed Ext1 Temp Offset from 18 to 19. 129
- Changed Ext2 Temp Offset from 19 to 20. 130
- Deleted references to non-existent LED, POV, and PUV features. 141
- Deleted references to non-existent LED, POV, and PUV features. 142
- Deleted references to non-existent LED, POV, and PUV features. 143

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Index

D

P

Q

R

S

T

U

V

W

X

Z

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
Low Power Wireless	www.ti.com/lpw	Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265