

**bq20z60-R1/bq20z65-R1**

# **Technical Reference**



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<b>1</b>	<b>Preface</b>	<b>7</b>
1.1	Read This First	7
1.2	Notational Conventions	7
<b>2</b>	<b>Detailed Description</b>	<b>9</b>
2.1	JEITA Temperature Ranges	9
2.2	1st Level Protection Features	10
2.2.1	Cell Overvoltage (COV) and Cell Undervoltage (CUV)	10
2.2.2	Charge and Discharge Overcurrent	13
2.2.3	Short-Circuit Protection	18
2.2.4	Overtemperature Protection	19
2.2.5	Host Watchdog	21
2.2.6	AFE Watchdog	21
2.3	2nd Level Protection Features	21
2.3.1	2nd Level (Permanent) Failure Actions	22
2.3.2	Time-Limit-Based Protection	23
2.3.3	Limit-Based Protection	25
2.3.4	Clearing Permanent Failure	27
2.4	Gas Gauging	27
2.4.1	Impedance Track Configuration	27
2.4.2	Gas Gauge Modes	28
2.4.3	Qmax	30
2.5	Charge Control	32
2.5.1	Charge Control SMBus Broadcasts	32
2.5.2	Cell Balancing	32
2.5.3	Charge-Inhibit Mode	33
2.5.4	Charge-Suspend Mode	35
2.5.5	Charging and Temperature Ranges	37
2.5.6	Precharge	40
2.5.7	Primary Charge Termination	41
2.5.8	Charging Faults	42
2.5.9	Discharge and Charge Alarms	45
2.6	Discharge-Inhibit Mode	45
2.7	LED Display	46
2.7.1	Display Activation	46
2.7.2	Display Configuration	47
2.7.3	Display Format	48
2.7.4	Permanent Failure Error Codes	49
2.7.5	LED Current Configuration	50
2.8	Device Operating Mode	50
2.8.1	Normal Mode	50
2.8.2	Battery Pack Removed Mode/System Present Detection	51
2.8.3	Sleep Mode	51
2.8.4	Wake Function	52
2.8.5	Shutdown Mode	53
2.8.6	Ship Mode	53

2.9	Security (Enables and Disables Features)	53
2.10	Calibration	56
2.10.1	Coulomb-Counter Dead Band	56
2.10.2	Autocalibration	56
2.11	Communications	56
2.11.1	SMBus On and Off States	56
2.11.2	Packet Error Checking	56
2.11.3	bq20z60-R1/bq20z65-R1 Slave Address	56
2.11.4	Broadcasts to Smart Charger and Smart Battery Host	57
<b>A</b>	<b>Standard SBS Commands</b>	<b>59</b>
A.1	ManufacturerAccess (0x00)	59
A.1.1	System Data	59
A.1.2	System Control	61
A.1.3	Extended SBS Commands	65
A.2	RemainingCapacityAlarm (0x01)	66
A.3	RemainingTimeAlarm (0x02)	66
A.4	BatteryMode (0x03)	67
A.5	AtRate (0x04)	68
A.6	AtRateTimeToFull (0x05)	69
A.7	AtRateTimeToEmpty (0x06)	69
A.8	AtRateOK (0x07)	69
A.9	Temperature (0x08)	70
A.10	Voltage (0x09)	70
A.11	Current (0x0a)	70
A.12	AverageCurrent (0x0b)	71
A.13	MaxError (0x0c)	71
A.14	RelativeStateOfCharge (0x0d)	71
A.15	AbsoluteStateOfCharge (0x0e)	72
A.16	RemainingCapacity (0x0f)	72
A.17	FullChargeCapacity (0x10)	73
A.18	RunTimeToEmpty (0x11)	73
A.19	AverageTimeToEmpty (0x12)	73
A.20	AverageTimeToFull (0x13)	74
A.21	ChargingCurrent (0x14)	74
A.22	ChargingVoltage (0x15)	74
A.23	BatteryStatus (0x16)	75
A.24	CycleCount (0x17)	76
A.25	DesignCapacity (0x18)	76
A.26	DesignVoltage (0x19)	76
A.27	SpecificationInfo (0x1a)	77
A.28	ManufactureDate (0x1b)	77
A.29	SerialNumber (0x1c)	78
A.30	ManufacturerName (0x20)	78
A.31	DeviceName (0x21)	78
A.32	DeviceChemistry (0x22)	79
A.33	ManufacturerData (0x23)	79
A.34	Authenticate (0x2f)	80
A.35	CellVoltage4..1 (0x3c..0x3f)	80
A.36	SBS Command Values	80
<b>B</b>	<b>Extended SBS Commands</b>	<b>83</b>
B.1	AFEDData (0x45)	83
B.2	FETControl (0x46)	83
B.3	StateOfHealth (0x4f)	84

B.4	SafetyAlert (0x50)	85
B.5	SafetyStatus (0x51)	85
B.6	PFAAlert (0x52)	86
B.7	PFStatus (0x53)	87
B.8	OperationStatus (0x54)	88
B.9	ChargingStatus (0x55)	88
B.10	ResetData (0x57)	89
B.11	WDRResetData (0x58)	89
B.12	PackVoltage (0x5a)	89
B.13	AverageVoltage (0x5d)	89
B.14	TS1Temperature (0x5e)	90
B.15	TS2Temperature (0x5f)	90
B.16	UnSealKey (0x60)	90
B.17	FullAccessKey (0x61)	90
B.18	PFKey (0x62)	91
B.19	AuthenKey3 (0x63)	91
B.20	AuthenKey2 (0x64)	91
B.21	AuthenKey1 (0x65)	91
B.22	AuthenKey0 (0x66)	92
B.23	SafetyAlert2 (0x68)	92
B.24	SafetyStatus2 (0x69)	92
B.25	PFAAlert2 (0x6a)	93
B.26	PFStatus2 (0x6b)	93
B.27	ManufBlock1..4 (0x6c..0x6f)	94
B.28	ManufacturerInfo (0x70)	95
B.29	SenseResistor (0x71)	95
B.30	TempRange (0x72)	95
B.31	LifetimeData1 (0x73)	96
B.32	LifetimeData2 (0x74)	97
B.33	DataFlashSubClassID (0x77)	97
B.34	DataFlashSubClassPage1..8 (0x78..0x7f)	98
B.35	Extended SBS Command Values	98
<b>C</b>	<b>Data Flash</b>	<b>101</b>
C.1	Accessing Data Flash	101
C.1.1	Data Flash Interface	101
C.1.2	Reading a SubClass	102
C.1.3	Writing a SubClass	102
C.1.4	Example	102
C.2	1st Level Safety Class	103
C.2.1	Voltage (Subclass 0)	103
C.2.2	Current (Subclass 1)	108
C.2.3	Temperature (Subclass 2)	114
C.2.4	Host Comm (Subclass 4)	118
C.3	2nd Level Safety	118
C.3.1	Voltage (Subclass 16)	118
C.3.2	Current (Subclass 17)	125
C.3.3	Temperature (Subclass 18)	126
C.3.4	FET Verification (Subclass 19)	130
C.3.5	AFE Verification (Subclass 20)	131
C.3.6	Fuse Verification (Subclass 21)	132
C.4	Charge Control	134
C.4.1	Charge Temp Cfg (Subclass 32)	134
C.4.2	Pre-Charge Cfg (Subclass 33)	136

C.4.3	Charge Cfg (Subclass 34)	137
C.4.4	Termination Cfg. (Subclass 36)	143
C.4.5	Cell Balancing Cfg (Subclass 37)	145
C.4.6	Charging Faults (Subclass 38)	146
C.5	SBS Configuration	152
C.5.1	Data (Subclass 48)	152
C.5.2	Configuration (Subclass 49)	157
C.6	System Data	160
C.6.1	Manufacturer Data (Subclass 56)	160
C.6.2	Manufacturer Info (Subclass 58)	161
C.6.3	Manuf. Block 2 (Offset 53)	161
C.6.4	Manuf. Block 3 (Offset 74)	162
C.6.5	Manuf. Block 4 (Offset 95)	162
C.6.6	Lifetime Data (Subclass 59)	162
C.6.7	Lifetime Temp Samples (Subclass 60)	169
C.7	Configuration	169
C.7.1	Registers (Subclass 64)	169
C.7.2	AFE (Subclass 65)	178
C.8	LED Support	179
C.8.1	LED Cfg (Subclass 67)	179
C.9	Power	184
C.9.1	Power (Subclass 68)	184
C.10	Gas Gauging	188
C.10.1	IT Cfg (Subclass 80)	188
C.10.2	Current Thresholds (Subclass 81)	191
C.10.3	State (Subclass 82)	193
C.11	Ra Table	195
C.11.1	R_a0 (Subclass 88)	195
C.11.2	R_a1 (Subclass 89)	196
C.11.3	R_a2 (Subclass 90)	197
C.11.4	R_a3 (Subclass 91)	198
C.11.5	R_a0x (Subclass 92)	199
C.11.6	R_a1x (Subclass 93)	200
C.11.7	R_a2x (Subclass 94)	201
C.11.8	R_a3x (Subclass 95)	202
C.12	PF Status	203
C.12.1	Device Status Data (Subclass 96)	203
C.12.2	AFE Regs (Subclass 97)	208
C.13	Calibration	208
C.13.1	Data (Subclass 104)	208
C.13.2	Config (Subclass 105)	210
C.13.3	Temp Model (Subclass 106)	212
C.13.4	Current (Subclass 107)	213
C.14	Data Flash Values	214
<b>D</b>	<b>Glossary</b>	<b>227</b>
<b>Index</b>		<b>229</b>

## 1.1 Read This First

This manual discusses modules and peripherals of the bq20z60-R1/bq20z65-R1 and its use to build a complete battery pack gas gauge and protection solution.

## 1.2 Notational Conventions

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

- SBS commands are set in italic, e.g., *Voltage*
- SBS bits and flags are capitalized, set in italic and enclosed with square brackets, e.g., *[LED1]*
- Data flash values are set in bold italic e.g., ***COV Threshold***
- All data flash bits and flags are capitalized, set in bold italic and enclosed with square brackets, e.g., ***[NR]***

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

The reference format for SBS commands is SBS:Command Name(Command No.)[Flag], or SBS:ManufacturerAccess(0x00):Manufacturer Access Command(MA No.), for example:

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

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

DF:1st Level Safety:Voltage(0):COV Threshold(0), or

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





## Detailed Description

### 2.1 JEITA Temperature Ranges

The bq20z60-R1/bq20z65-R1 follows the JEITA guidelines which specify that charging voltage and charging current depend on the temperature. Temperature ranges are used for specifying both what the charging voltage and charging current should be.

There are three temperature ranges in which charging is allowed and they are defined as:

- T1 – T2: Low charging temperature range ( $T1 \leq \text{Temperature} < T2$ )
- T2 – T3: Standard charging temperature range ( $T2 \leq \text{Temperature} < T3$ )
- T3 – T4: High charging temperature range ( $T3 \leq \text{Temperature} < T4$ )

For added flexibility the standard temperature range is divided into 2 sub-ranges: standard range 1 and standard range 2. An additional temperature value (T2a) is needed to specify these 2 ranges. These temperature ranges will be configurable in the gas gauge through the following data flash constants.

- **JT1**: Lower bound of low charging temperature range, in °C.
- **JT2**: Upper bound of low charging temperature range and lower bound of standard charging temperature range 1, in °C.
- **JT2a**: Upper bound of standard charging temperature range 1 and lower bound of standard charging temperature range 2, in °C
- **JT3**: Upper bound of standard charging temperature range 2 and lower bound of high charging temperature range, in °C.
- **JT4**: Upper bound of high charging temperature range, in °C.

Additional temperature parameters are defined for discharging.

- **OT1D and OT2D**: The temperature at which discharge will be suspended.
- **Hi Dsg Start Temp**: If the temperature is above **Hi Dsg Start Temp** when starting discharge then discharge is not started.

The bq20z60-R1/bq20z65-R1 implements hysteresis for the temperature ranges above using the DF variable (**Temp Hys**). This variable specifies the number of degrees of hysteresis that should be used before switching charging temperature ranges.

**Table 2-1. Temperature Ranges in bq20z60-R1/bq20z65-R1**

Flag	JEITA Temperature Range	Charging Mode
TR1	Temp < JT1	Charge Suspend or Charge Inhibit
TR2	JT1 < Temp < JT2	Low Temp Charge
TR3	JT2 < Temp < JT2a	Std Temp Charge 1
TR4	JT2a < Temp < JT3	Std Temp Charge 2
TR5	JT3 < Temp < JT4	High Temp Charge or Charge Inhibit
TR6	JT4 < Temp	Charge Suspend or Charge Inhibit

The active temperature range is indicated using a set of flags. Since hysteresis is implemented for the temperature ranges, determining the active temperature range depends on the previous state, in addition to the actual temperature. These flags reside in a status register called *TempRange*.

## 2.2 1st Level Protection Features

The bq20z60-R1/bq20z65-R1 supports a wide range of battery and system protection features that are easily configured or enabled via the integrated data flash.

### 2.2.1 Cell Overvoltage (COV) and Cell Undervoltage (CUV)

The bq20z60-R1/bq20z65-R1 can detect cell overvoltage/undervoltage and protect battery cells from damage from battery cell overvoltage/undervoltage. If the over/undervoltage remains over an adjustable time period, the bq20z60-R1/bq20z65-R1 goes into overvoltage/undervoltage condition and switches off the CHG/DSG FET. The bq20z60-R1/bq20z65-R1 recovers from a cell overvoltage condition if all the cell voltages drop below the cell overvoltage recovery threshold. The bq20z60-R1/bq20z65-R1 recovers from cell undervoltage condition if all the cell voltages rise above the cell undervoltage recovery threshold. An additional charge current detection requirement for cell undervoltage recovery can be enabled by setting the **CUV\_RECOV\_CHG** bit in the **Operation Cfg C** register to a 1.

Per JEITA guidelines, the cell overvoltage threshold changes depending on the temperature. Three cell overvoltage thresholds are specified, one for each operating temperature range.

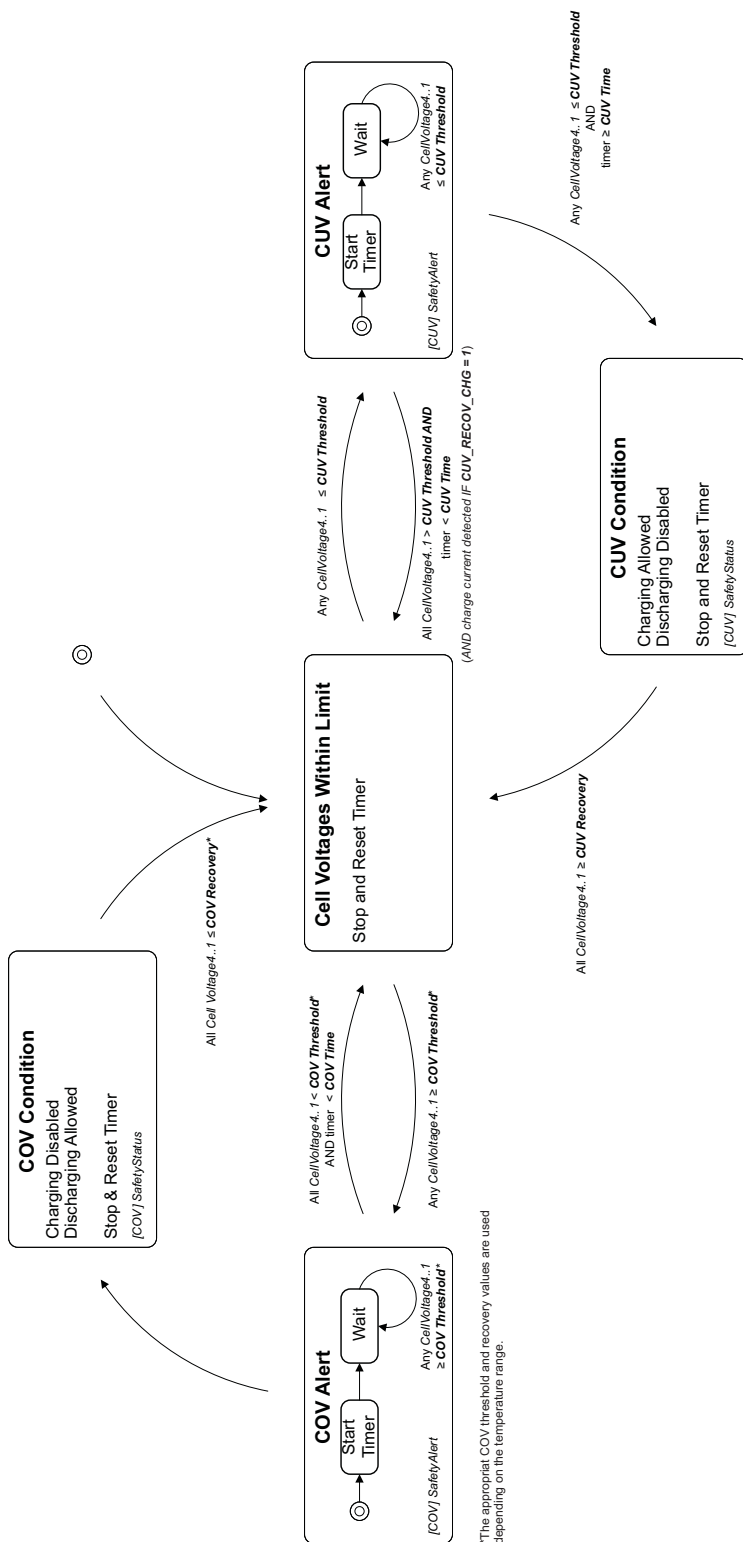


Figure 2-1. COV and CUV

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

Condition:		COV Alert	COV Condition	Normal	CUV Alert	CUV Condition
<b>Flags:</b>	<i>BatteryStatus</i>		[TCA]			[TDA], [FD]
	<i>SafetyAlert</i>	[COV]			[CUV]	
	<i>SafetyStatus</i>		[COV]			[CUV]
	<i>OperationStatus</i>					[XDSG]
<b>FET:</b>		Normal	CHG FET disabled, enabled during discharge	Normal	Normal	DSG FET disabled, enabled during charge
<b>SBS Command:</b>	<i>ChargingCurrent</i>	Charging algorithm	0	Charging algorithm	Charging algorithm	Charging algorithm
	<i>ChargingVoltage</i>	Charging algorithm	0	Charging algorithm	Charging algorithm	Charging algorithm

The bq20z60-R1/bq20z65-R1 indicates cell overvoltage by setting the [COV] flag in *SafetyAlert* if any *CellVoltage4..1* reaches or surpasses the cell overvoltage limit (**LT COV Threshold**, **ST COV Threshold**, or **HT COV Threshold**, depending on the current temperature range). The bq20z60-R1/bq20z65-R1 goes into cell overvoltage condition and changes the [COV] flag in *SafetyAlert* to the [COV] flag in *SafetyStatus* if any of *CellVoltage4..1* stays above cell overvoltage for a minimum time period of **COV Time**. This function is disabled if **COV Time** is set to zero.

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

The bq20z60-R1/bq20z65-R1 recovers from a cell overvoltage condition if all *CellVoltages4..1* are equal to or lower than the appropriate COV Recovery limit (**LT COV Recovery**, **ST COV Recovery**, or **HT COV Recovery**). On recovery the [COV] flag in *SafetyStatus* is reset, [TCA] flag in *BatteryStatus* is reset, and *ChargingCurrent* and *ChargingVoltage* are set back to appropriate values per the charging algorithm.

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

The bq20z60-R1/bq20z65-R1 indicates cell undervoltage by setting the [CUV] flag in *SafetyAlert* if any *CellVoltage4..1* reaches or drops below the **CUV Threshold** limit during discharging. The bq20z60-R1/bq20z65-R1 goes into cell undervoltage condition and changes the [CUV] flag in *SafetyAlert* to the [CUV] flag in *SafetyStatus* if any of *CellVoltage4..1* stays below **CUV Threshold** limit for a minimum time period of **CUV Time**. This function is disabled if **CUV Time** is set to zero.

In a cell undervoltage condition, discharging is disabled and DSG FET is turned off, the [CUV] flag in *SafetyAlert* is reset, the [TDA] and [FD] flags in *BatteryStatus* and the [CUV] flag in *SafetyStatus* are set.

The bq20z60-R1/bq20z65-R1 recovers from cell undervoltage condition if all *CellVoltages4..1* are equal to or higher than **CUV Recovery** limit (and charge current detected if **CUV\_RECOV\_CHG** is set). 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 values per the charging algorithm.

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

#### Related Variables:

- DF:1st Level Safety:Voltage(0): LT COV Threshold(0)
- DF:1st Level Safety:Voltage(0): ST COV Threshold(4)
- DF:1st Level Safety:Voltage(0): HT COV Threshold(8)
- DF:1st Level Safety:Voltage(0):COV Time(12)
- DF:1st Level Safety:Voltage(0): LT COV Recovery(2)
- DF:1st Level Safety:Voltage(0): ST COV Recovery(6)
- DF:1st Level Safety:Voltage(0): HT COV Recovery(10)
- DF:1st Level Safety:Voltage(0):CUV Threshold(13)
- DF:1st Level Safety:Voltage(0):CUV Time(15)

- DF:1st Level Safety:Voltage(0):CUV Recovery(16)
- DF:Charge Control:Charge Cfg(34):LT Chg Current1(2)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA],[FD],[DSG]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[CUV],[COV]
- SBS:SafetyStatus(0x51)[CUV],[COV]
- SBS:OperationStatus(0x54)[XDSG]

### 2.2.2 Charge and Discharge Overcurrent

The bq20z60-R1/bq20z65-R1 has two independent tiers (levels) of overcurrent protection for charge and discharge. These two tiers require the *Current* value to be greater than or equal to a programmed OC Threshold in either charge or discharge state for a period greater than OC Time Limit. If the OC Time Limit for any of the overcurrent protections is set to 0, that specific feature is disabled.

**Table 2-3. Charge and Discharge Overcurrent**

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

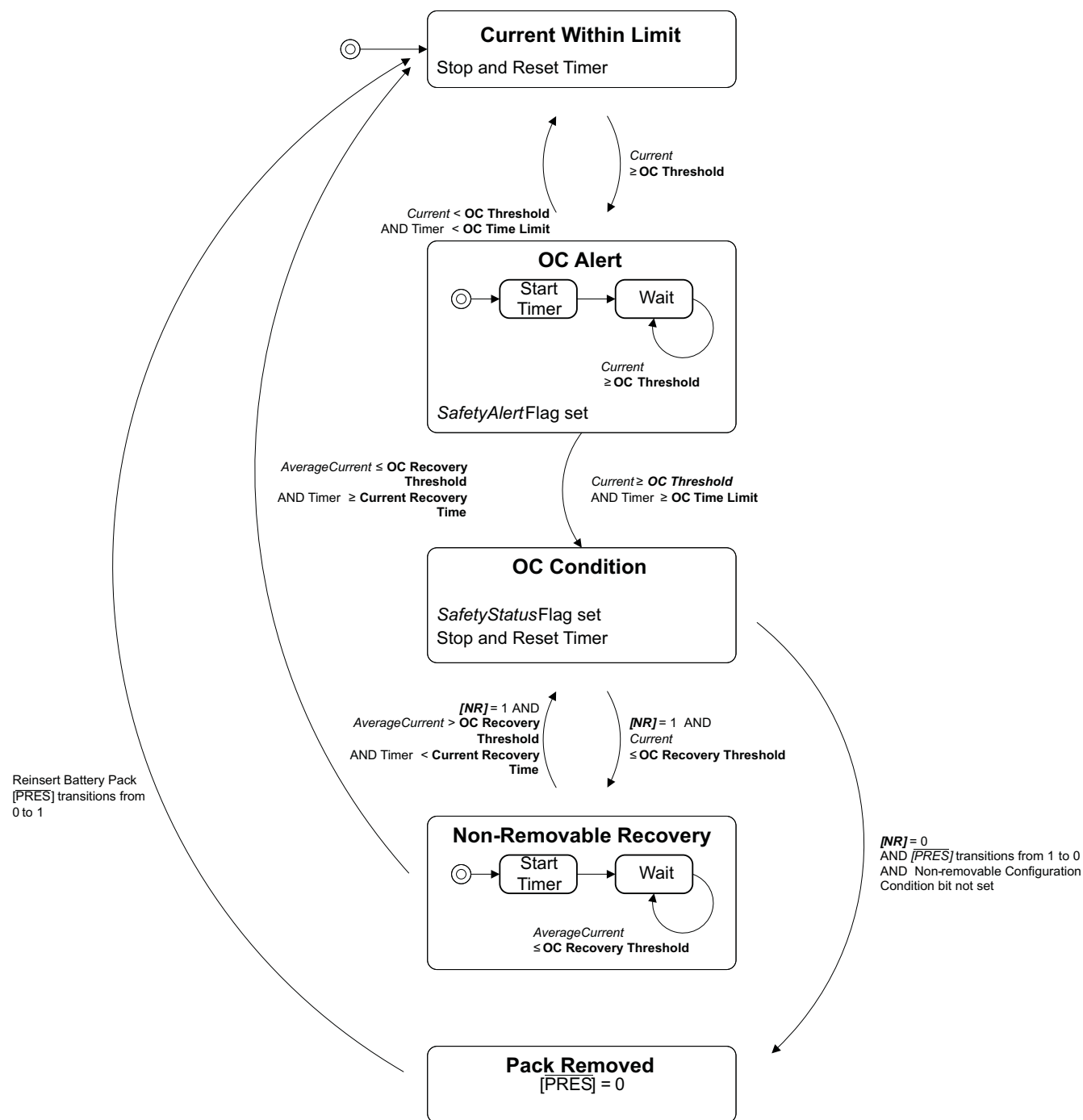


Figure 2-2. OC Protection

For the first two tiers of overcurrent protection, the specific flag in *SafetyAlert* is set if *Current* exceeds the OC Threshold. The bq20z60-R1/bq20z65-R1 changes the specific flag in *SafetyAlert* to the specific flag in *SafetyStatus* if the *Current* stays above the OC Threshold limit for at least OC Time Limit period. This function is disabled if the OC Time Limit is set to zero. The *SafetyStatus* flag is reset if the *Current* falls below the OC Recovery Threshold.

If the timer of any tier expires during charging, the CHG FET is turned off and ZVCHG FET (if used) is turned off. When this occurs, the OC Time Limit timer is started from 0, *ChargingCurrent* and *ChargingVoltage* are set to 0, the [TCA] flag in *BatteryStatus* is set, and the appropriate *SafetyStatus* tier flag is set.

However, when the bq20z60-R1/bq20z65-R1 has either of [OCC] or [OCC2] flags in *SafetyStatus* set, the CHG FET are turned on again during discharge ( $Current \leq (-)Dsg \text{ Current Threshold}$ ). This prevents overheating of the CHG FET body diode during discharge. No other flags change state until full recovery is reached. This action is not affected by the setting of the [NR] bit.

If the timer of either of the first two tiers expires during discharging, the DSG FET is turned off and the ZVCHG FET (if used) is turned on. When this occurs, the OC Time Limit timer is started from 0, *ChargingCurrent* is set to **Pre-chg Current**, [XDSG1] flag is set, [TDA] flag is set, and [OCD] tier flag is set.

When the AFE detects a discharge-overcurrent fault, the charge and discharge FETs are turned off. When the bq20z60-R1/bq20z65-R1 identifies the overcurrent condition and the OC Time Limit timer is started from 0, [TDA] flag is set, *ChargingCurrent* is set to 0, and [AOCD] is set.

However, when the bq20z60-R1/bq20z65-R1 has any [OCD], [OCD2], [AOCD] set, the DSG FET is turned on again during charging ( $Current \geq Chg \text{ Current Threshold}$ ). 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 2-4. Overcurrent Conditions**

Protection	Condition	Flags				FET	Charging Current	Charging Voltage
		<i>SafetyAlert</i>	<i>SafetyStatus</i>	<i>BatteryStatus</i>	<i>OperationStatus</i>			
Tier-1 Charge	OC alert	[OCC]				Normal	Charging algorithm	Charging algorithm
	OC condition		[OCC]	[TCA]		CHG FET disabled, enabled during discharge	0	0
Tier-2 Charge	OC alert	[OCC2]				Normal	Charging algorithm	Charging algorithm
	OC condition		[OCC2]	[TCA]		CHG FET disabled, enabled during discharge	0	0
Tier-1 Discharge	OC alert	[OCD]				Normal	Charging algorithm	Charging algorithm
	OC condition		[OCD]	[TDA]	[XDSG1]	DSG FET disabled, enabled during charge	<b>Pre-chg Current</b>	Charging algorithm
Tier-2 Discharge	OC Alert	[OCD2]				Normal	Charging algorithm	Charging algorithm
	OC condition		[OCD2]	[TDA]	[XDSG1]	DSG FET disabled, enabled during charge	<b>Pre-chg Current</b>	Charging algorithm
Tier-3 Discharge	OC condition		[AOCD]	[TDA]	[XDSG1]	CHG FET and DSG FET disabled	0	Charging algorithm

The bq20z60-R1/bq20z65-R1 can individually configure each overcurrent-protection feature to recover via two different methods, based on the state of the [NR] bit.

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

**Non-Removable Battery Mode Recovery**, where [NR] = 1. The state of **Non-Removable Cfg** has no consequence. This recovery requires *AverageCurrent* to be  $\leq$  the recovery threshold and for the OC Time Limit timer  $\geq$  **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] in *BatteryStatus* 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.

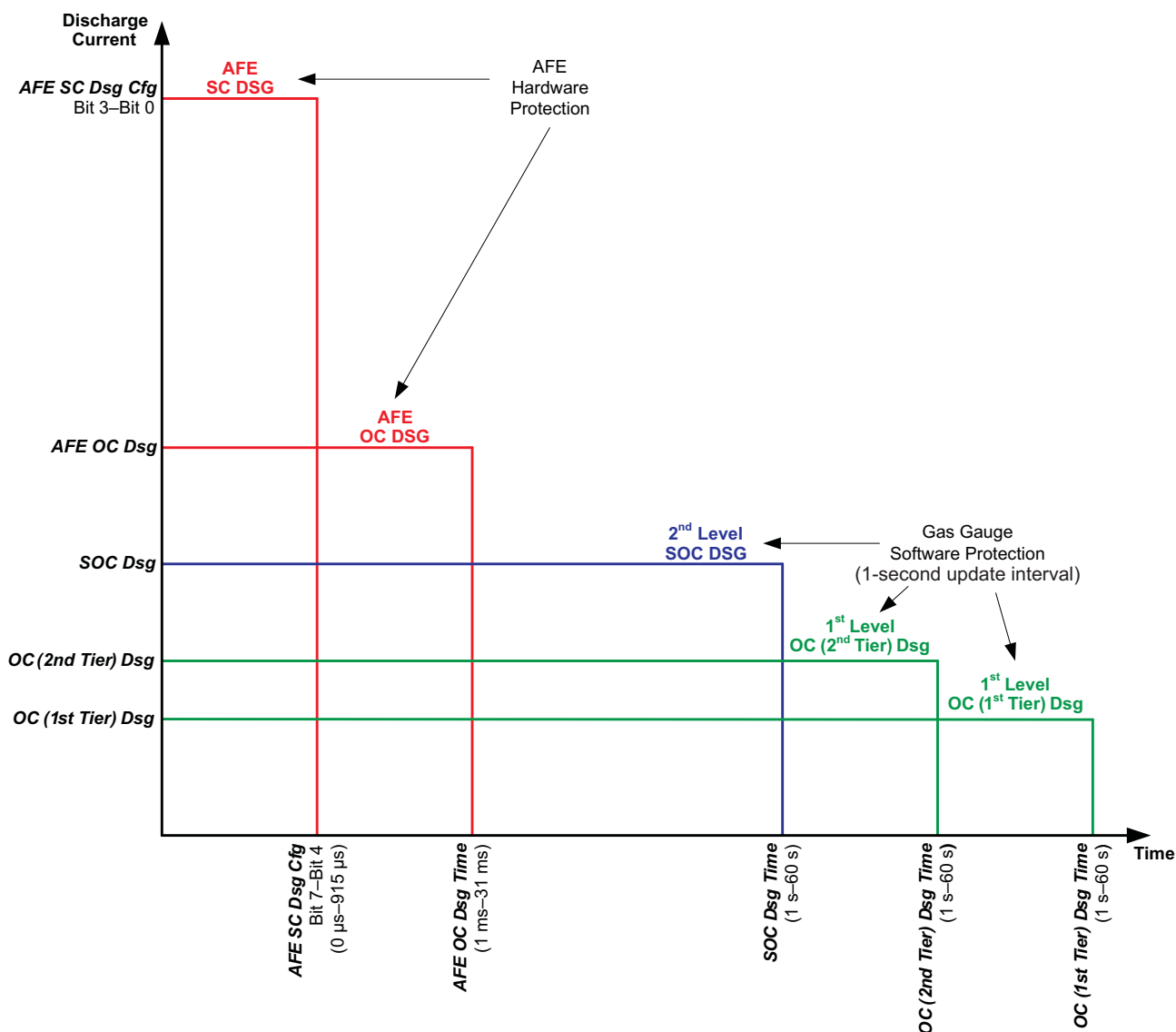


Figure 2-3. Overcurrent Protection Levels



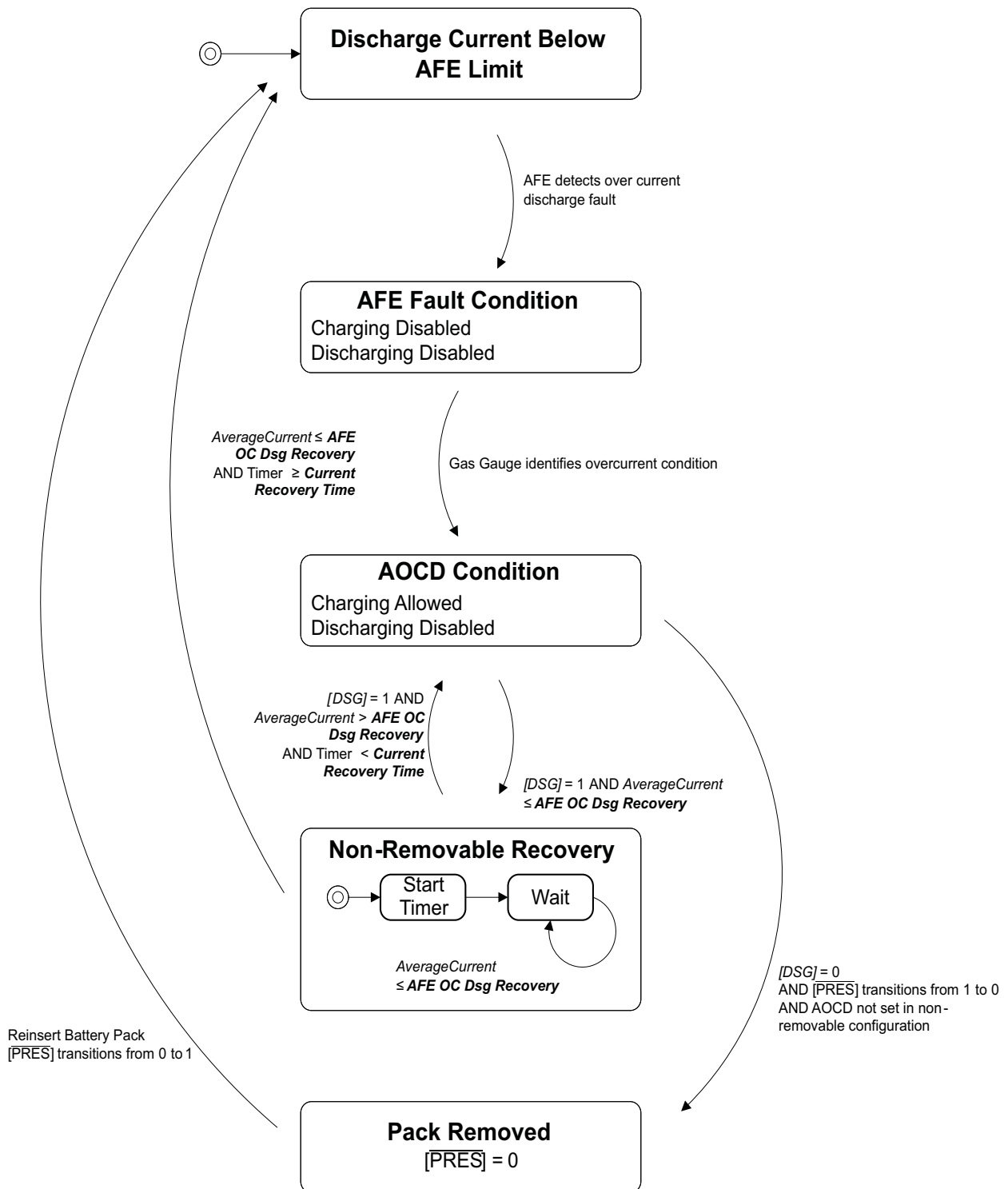


Figure 2-4. AFE Discharge Overcurrent Protection

**Related Variables:**

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

- DF:1st Level Safety:Current(1):OC(1st Tier) Dsg(5)
- DF:1st Level Safety:Current(1):OC(1st Tier) Dsg Time(7)
- DF:1st Level Safety:Current(1):OC Dsg Recovery(8)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Chg(10)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Chg Time(12)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Dsg(13)
- DF:1st Level Safety:Current(1):OC(2nd Tier) Dsg Time(15)
- DF:1st Level Safety:Current(1):Current Recovery Time(16)
- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- DF:1st Level Safety:Current(1):AFE OC Dsg Time(18)
- DF:1st Level Safety:Current(1):AFE OC Dsg Recovery(19)
- DF:Charge Control:Charge Cfg(33):Pre-chg Current (4)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- DF:Configuration:Registers(64):Non-Removable Cfg(8)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyAlert(0x50)
- SBS:SafetyStatus(0x51)
- SBS:OperationStatus(0x54)[XDSDGI]

### 2.2.3 Short-Circuit Protection

The bq20z60-R1/bq20z65-R1 short-circuit protection is controlled by the AFE, but is recovered by the gas gauge. This allows different recovery methods to accommodate various applications.

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

When the AFE detects a short-circuit-in-charge or short-circuit-in-discharge fault, the charge and discharge FETs are turned off. The bq20z60-R1/bq20z65-R1 identifies the short-circuit condition (charge or discharge current direction) and the internal *Current\_Fault* timer is started from 0, either [TCA] or [TDA] in *BatteryStatus* is set, *ChargingCurrent* and *ChargingVoltage* are set to 0 (only if in charge mode), and either [SCC] or [SCD] is set. If the short-circuit condition is in discharge, then [XDSDG] flag is also set.

Each bq20z60-R1/bq20z65-R1 short-circuit protection feature can be individually configured to recover via two different methods, based on the setting of the [NR] bit.

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

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

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

**Table 2-5. Short-Circuit Protection**

Short Circuit	Condition	Flags set	FET	Charging Current	Charging Voltage	Clear Threshold
Charge	<b>AFE SC Chg Cfg</b>	[SCC] <i>SafetyStatus</i> , [TCA] <i>BatteryStatus</i>	CHG FET disabled, enabled during discharge	0	0	<b>AFE SC Recovery</b>
Discharge	<b>AFE SC Dsg Cfg</b>	[SCD] <i>SafetyStatus</i> , [TDA] <i>BatteryStatus</i> , [XDSG] <i>OperationStatus</i>	DSG FET disabled, enabled during charge	0	per charging algorithm	

**Related Variables:**

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

**2.2.4 Overtemperature Protection**

The bq20z60-R1/bq20z65-R1 has overtemperature protection for both charge and discharge conditions with separate thresholds and alarms for the 2 temperature sensors TS1 and TS2.

The bq20z60-R1/bq20z65-R1 sets the overtemperature charging [OT1C] flag in *SafetyAlert* if the pack temperature measured on TS1 reaches or surpasses the **OT1 Chg Threshold** during charging. The bq20z60-R1/bq20z65-R1 changes [OT1C] in *SafetyAlert* to an overtemperature charging condition if the temperature on TS1 stays above the **OT1 Chg Threshold** limit for a time period of **OT1 Chg Time**. This function is disabled if **OT1 Chg Time** is set to zero. Similarly, the bq20z60-R1/bq20z65-R1 sets the overtemperature charging [OT2C] flag in *SafetyAlert2* if the pack temperature measured on TS2 reaches or surpasses the **OT2 Chg Threshold** during charging. The bq20z60-R1/bq20z65-R1 changes [OT2C] in *SafetyAlert2* to an overtemperature charging condition if the temperature on TS2 stays above the **OT2 Chg Threshold** limit for a time period of **OT2 Chg Time**. This function is disabled if **OT2 Chg Time** is set to zero.

If [OTFET] is set and the bq20z60-R1/bq20z65-R1 is in overtemperature charging condition, charging is disabled and the CHG FET is turned off, the ZVCHG FET is turned off if configured for use, *ChargingCurrent* and *ChargingVoltage* are set to zero, the [OT1C] flag in *SafetyAlert* (or [OTC2] in *SafetyAlert2*) is cleared, and [TCA] in *BatteryStatus* and the [OT1C] flag in *SafetyStatus* (or [OTC2] in *SafetyStatus2*) are set.

The bq20z60-R1/bq20z65-R1 recovers from an [OT1C] condition if *TS1Temperature* is equal to or below the **OT1 Chg Recovery** limit. The bq20z60-R1/bq20z65-R1 recovers from an [OTC2] condition if *TS2Temperature* is equal to or below the **OT2 Chg Recovery** limit. On recovery the [OT1C] flag in *SafetyStatus* (or [OTC2] flag in *SafetyStatus2*) is cleared, [OTA] and [TCA] in *BatteryStatus* are cleared, *ChargingCurrent* and *ChargingVoltage* are set back to their appropriate values per the charging algorithm, and the CHG FET returns to its previous state.

In an [OT1C] or [OT2C] condition, the CHG FET is turned on during discharging to prevent overheating of the CHG FET body diode.

The bq20z60-R1/bq20z65-R1 sets the overtemperature discharging [OT1D] flag in *SafetyAlert* if the pack temperature measured on TS1 reaches or surpasses the **OT1 Dsg Threshold** during discharging. The bq20z60-R1/bq20z65-R1 changes [OT1D] *SafetyAlert* to an overtemperature discharging condition if the temperature on TS1 stays above the **OT1 Dsg Threshold** limit for a time period of **OT1 Dsg Time**. This function is disabled if **OT1 Dsg Time** is set to zero. Similarly, the bq20z60-R1/bq20z65-R1 sets the

overtemperature discharging *[OT2D]* flag in *SafetyAlert2* if the measured temperature on TS2 reaches or surpasses the **OT2 Dsg Threshold** during discharging. The bq20z60-R1/bq20z65-R1 changes *[OT2D]* in *SafetyAlert2* to an overtemperature discharging condition if the temperature on TS2 reaches or surpasses the **OT2 Dsg Threshold** limit for a time period of **OT2 Dsg Time**. This function is disabled if **OT2 Dsg Time** is set to zero.

If *[OTFET]* is set and bq20z60-R1/bq20z65-R1 is in an overtemperature discharging condition, discharging is disabled and the DSG FET is turned off, *ChargingCurrent* is set to zero, the *[OT1D]* flag in *SafetyAlert* (or *[OT2D]* in *SafetyAlert2*) is cleared, *[TDA]* is set, *[XDSG]* flag is set and the *[OT1D]* flag in *SafetyStatus* (or *[OT2D]* flag in *SafetyStatus2*) is set.

The bq20z60-R1/bq20z65-R1 recovers from an *[OT1D]* condition if *TS1Temperature* is equal to or below the **OT1 Dsg Recovery** limit. The bq20z60-R1/bq20z65-R1 recovers from an *[OT2D]* condition if *TS2Temperature* is equal to or below the **OT2 Dsg Recovery** limit. On recovery, *[OT1D]* flag in *SafetyStatus* (or *[OT2D]* flag in *SafetyStatus2*) is cleared, *[TDA]* and *[OTA]* are cleared, *ChargingCurrent* is set back to the appropriate value per the charging algorithm, *[XDSG]* is cleared, and the DSG FET is allowed to switch on again.

In an overtemperature discharging condition, the DSG FET is turned on during charging to prevent overheating of the DSG FET body diode

**Table 2-6. Overtemperature Protection**

	Alert Threshold	Alert Time Limit	SafetyAlert Flags set	Overtemp Condition	Recovery Threshold
Charge	<b>OT1 Chg Threshold, OT2 Chg Threshold</b>	<b>OT1 Chg Time, OT2 Chg Time</b>	<i>[OT1C], [OT2C]</i>	<i>[OT1C]</i> <i>SafetyStatus</i> Flag (or <i>[OT2C]</i> <i>SafetyStatus2</i> Flag) set, <i>[TCA]</i> and <i>[OTA]</i> <i>BatteryStatus</i> set, <i>ChargingCurrent</i> = 0, <i>ChargingVoltage</i> = 0, if <i>[OTFET]</i> is set then CHG FET is turned off	<b>OT1 Chg Recovery, OT2 Chg Recovery</b>
Discharge	<b>OT1 Dsg Threshold, OT2 Dsg Threshold</b>	<b>OT1 Dsg Time, OT2 Dsg Time</b>	<i>[OT1D], [OT2D]</i>	<i>[OT1D]</i> <i>SafetyStatus</i> Flag (or <i>[OT2D]</i> <i>SafetyStatus2</i> Flag) set, <i>[TDA]</i> and <i>[OTA]</i> <i>BatteryStatus</i> set, <i>ChargingCurrent</i> = 0, if <i>[OTFET]</i> is set then <i>[XDSG]</i> set and DSG FET off	<b>OT1 Dsg Recovery, OT2 Dsg Recovery</b>

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT1 Chg Threshold(0)
- DF:1st Level Safety:Temperature(2):OT1 Chg Time(2)
- DF:1st Level Safety:Temperature(2):OT1 Chg Recovery(3)
- DF:1st Level Safety:Temperature(2):OT2 Chg Threshold(5)
- DF:1st Level Safety:Temperature(2):OT2 Chg Time(7)
- DF:1st Level Safety:Temperature(2):OT2 Chg Recovery(8)
- DF:1st Level Safety:Temperature(2):OT1 Dsg Threshold(10)
- DF:1st Level Safety:Temperature(2):OT1 Dsg Time(12)
- DF:1st Level Safety:Temperature(2):OT1 Dsg Recovery(13)
- DF:1st Level Safety:Temperature(2):OT2 Dsg Threshold(15)
- DF:1st Level Safety:Temperature(2):OT2 Dsg Time(17)
- DF:1st Level Safety:Temperature(2):OT2 Dsg Recovery(18)
- DF:Configuration:Registers(64):Operation Cfg B(2)[OTFET]
- SBS:TS1Temperature(0x5e)
- SBS:TS2Temperature(0x5f)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA], [OTA]
- SBS:SafetyAlert(0x50)[OT1C],[OT1D]
- SBS:SafetyStatus(0x51)[OT1C],[OT1D]
- SBS:SafetyAlert2(0x68)[OT2C],[OT2D]

- SBS:SafetyStatus2(0x69)[OT2C],[OT2D]
- SBS:OperationStatus(0x54)[XDSG]

### 2.2.5 Host Watchdog

The bq20z60-R1/bq20z65-R1 can be configured to require the host system to communicate with the battery periodically, else the battery disables charging and discharging. The Host Watchdog function is only active in Normal Power mode and is disabled if **Host Watchdog Timeout** is set to 0.

If the bq20z60-R1/bq20z65-R1 does not receive any valid SMBus communications for **Host Watchdog Timeout** period of time, the FETs are turned off, *ChargingVoltage* and *ChargingCurrent* are set to 0, [TCA] and [TDA] in *BatteryStatus*, [XDSG] in *OperationStatus*, and [HWDG] in *SafetyStatus* are all set.

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

#### Related Variables:

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

### 2.2.6 AFE Watchdog

The AFE automatically turns off the CHG FET, DSG FET and ZVCHG FET (if used), if it does not receive the appropriate frequency on the WDI input from gas gauge. The gas gauge has no warning that this is about to happen, but it can report the occurrence once the bq20z60-R1/bq20z65-R1 is able to interrogate the AFE.

When the XALERT signal is triggered, the bq20z60-R1/bq20z65-R1 reads the STATUS register of the AFE. If [WDF] is set, the bq20z60-R1/bq20z65-R1 also sets [WDF] in *SafetyStatus*, and periodic verification of the AFE RAM is undertaken. If verification of the AFE RAM fails, then the FETs turn off. Verification of the AFE RAM continues once every second. If the periodic verification passes, then [WDF] in *SafetyStatus* is cleared and the FETs return to normal operation.

#### Related Variable:

- SBS:SafetyStatus(0x51)[WDF]

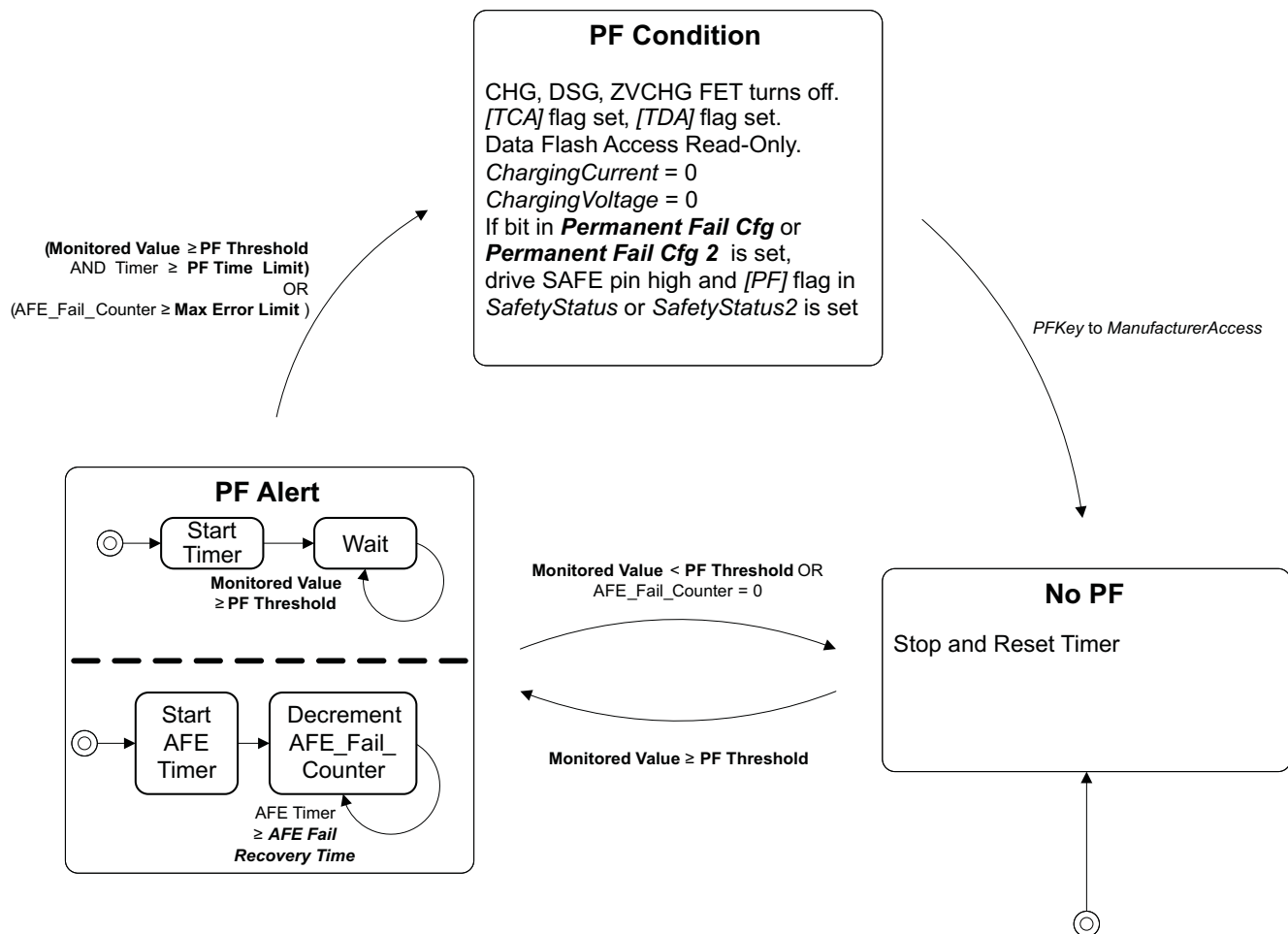
## 2.3 2nd Level Protection Features

The bq20z60-R1/bq20z65-R1 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, the appropriate *PFAAlert* flag is set. If the PF Threshold condition is cleared within the PF time limit, the appropriate *PFAAlert* flag is cleared. But if the PF Threshold condition continues over the PF Time Limit, then the bq20z60-R1/bq20z65-R1 goes into a permanent failure condition and the *PFStatus* flag is set, and the *PFAAlert* flag is cleared.

When any NEW cause of a permanent failure is set in *PFStatus* function, the NEW cause is added to **Saved PF Flags 1..2**. This allows **Saved PF Flags 1..2** to show ALL permanent failure conditions that have occurred.

On the first occasion of a permanent failure indicated by *PFStatus* or *PFStatus2* change from 0x00, the *PFStatus* and *PFStatus2* value is stored in **Saved 1st PF Flags 1..2**.


**Figure 2-5. 2nd Level Protection**

### 2.3.1 2nd Level (Permanent) Failure Actions

When the *PFStatus* or *PFStatus2* 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.
- The [TCA] and [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 *Saved PF Flags 1* or *Saved PF Flags 2* is set.
- If the appropriate bit in **Permanent Fail Cfg** is set, then 0x3672 is programmed to **Fuse Flag**, and the SAFE pin is driven and latched high. The [PF] flag in *SafetyStatus* is also set.

#### Related Variables:

- DF:Configuration:Registers(64):Permanent Fail Cfg 1(6), Permanent Fail Cfg 2(8)
- DF:PF Status:Device Status Data(96):Saved PF Flags 1(0), Saved PF Flags 2(2)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)
- DF:PF Status:Device Status Data(96):Saved 1st PF Flags 1(32), Saved 1st PF Flags 2(34)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]



- SBS:SafetyStatus(0x51)[PF]
- SBS:PFStatus(0x53)

### 2.3.2 Time-Limit-Based Protection

The bq20z60-R1/bq20z65-R1 reports a 2nd level protection alert by setting the appropriate flag in the *PFAlert* or *PFAlert2* register if the monitored value goes beyond the Protection Threshold. If the monitored value stays beyond the Protection Threshold over the Max Alert duration, the bq20z60-R1/bq20z65-R1 reports a 2nd level permanent failure, clears the appropriate *PFAlert* flag, and sets the appropriate *PFStatus* flag. See [Table 2-7](#) for all Protection Thresholds and Max Alert durations.

**Safety Overvoltage Protection**— The bq20z60-R1/bq20z65-R1 monitors the individual cell voltages for extreme values.

**Safety Undervoltage Protection**— The bq20z60-R1/bq20z65-R1 monitors the individual cell voltages for extreme undervoltage values. Additionally, the bq20z60-R1/bq20z65-R1 can check cell voltages upon wakeup from shutdown mode while the charge and precharge FETs are turned off (to detect copper deposition).

**Cell Imbalance Fault**— Two methods of cell imbalance detection are implemented to provide CIM detection both while charging and at rest. Two safety CIM flags are used, one for each detection methods. *CIM\_A* reflects faults detected using the active CIM detection and *CIM\_R* reflects faults detected using the at rest CIM detection. These flags and the bits associated with them are shown in [Table 2-7](#).

#### At Rest Detection

The at rest detection mechanism starts detection if all of following conditions are reached:

- Any (*CellVoltage4..1*) > **Rest CIM Check Voltage**
- $|Current| \leq \text{Rest CIM Current}$  for **CIM Battery Rest Time**  
The bq20z60-R1/bq20z65-R1 sets [*CIM\_R*] in *PFAlert* if the following condition is met:
- Max difference between any (*CellVoltage4..1*) > **Rest CIM Fail Voltage**  
If the above condition remains active for more than **Rest CIM Time**, the device goes into permanent fail condition and moves [*CIM\_R*] from *PFAlert* to *PFStatus*. Set **Rest CIM Time** to 0 to disable this CIM detection.

#### Active Detection

The active detection method during charging is activated when the following conditions are met:

- Any (*CellVoltage4..1*) > **Active CIM Check Voltage**
- $Current \geq \text{Charge Threshold Current}$   
The bq20z60-R1/bq20z65-R1 sets [*CIM\_A*] in *PFAlert2* if the following condition is met:
- Max difference between any (*CellVoltage4..1*) > **Active CIM Fail Voltage**  
If above condition remains active for more than **Active CIM Time**, the bq20z60-R1/bq20z65-R1 goes into permanent fail condition and moves [*CIM\_A*] from *PFAlert2* to *PFStatus2*. Set **Active CIM Time** to 0 to disable this CIM detection.

**2nd Level Protection IC Input**— The  $\overline{PFIN}$  input of the bq20z60-R1/bq20z65-R1 can be used to determine the state of an external protection device such as the bq294xx. The bq20z60-R1/bq20z65-R1 watches for the  $\overline{PFIN}$  pin being driven low by an external device.

**Safety Overcurrent Protection**— The bq20z60-R1/bq20z65-R1 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 bq20z60-R1/bq20z65-R1 monitors the pack temperature during charging and discharging. The overtemperature thresholds and time limits can be set independently for charging and discharging. Additionally, the two temperature sensors (TS1 and TS2) have separate alarms, thresholds, and time limits.

**Open Thermistor**— The bq20z60-R1/bq20z65-R1 monitors the thermistor temperature readings and can detect open thermistors by their unusually low readings. Two separate safety flags are used one for each thermistor.

**Charge and Zero-Volt Charge FET Fault Protection**— The bq20z60-R1/bq20z65-R1 monitors if there is, at any time, an attempt to turn off the CHG FET or ZVCHG FET or if the CHG bit in the AFE OUTPUT register is set and the current still continues to flow.

**Discharge FET Fault Protection**— The bq20z60-R1/bq20z65-R1 monitors if there is, at any time, an attempt to turn off the DSG FET or if the DSG bit in the AFE OUTPUT register is set and the current still continues to flow.

**Fuse State Detection**— The bq20z60-R1/bq20z65-R1 can detect if an attempt has been made to blow the fuse, but the attempt has failed. The bq20z60-R1/bq20z65-R1 monitors if the **Fuse Flag** is set to 0x3672 and current is still flowing.

**Table 2-7. Time-Limit-Based 2<sup>nd</sup> Level Protection**

Protection	Conditions	Monitored Value	PF Threshold	PF Time Limit	PFAAlert Flag, PFStatus Flag	Permanent Fail Cfg Flag
Safety overvoltage	–	Voltage	LT SOV Threshold, or ST SOV Threshold, or HT SOV Threshold	SOV Time	[SOV]	[XSOV]
Safety undervoltage	–	Voltage	SUV Threshold	SUV Time	[SUV]	[XSUV]
Cell imbalance fault (at rest)	<ul style="list-style-type: none"> <li>Any (CellVoltage4..1) &gt; <b>Rest CIM Check Voltage</b></li> <li> Current  ≤ <b>Rest CIM Current</b> for <b>CIM Battery Rest Time</b></li> </ul>	Max difference Any CellVoltage4..1	<b>Rest CIM Fail Voltage</b>	<b>Rest CIM Time</b>	[CIM_R]	[XCIM_R]
Cell imbalance fault (active)	<ul style="list-style-type: none"> <li>Any (CellVoltage4..1) &gt; <b>Active CIM Check Voltage</b></li> <li> Current  ≥ <b>Charge Detection Current</b></li> </ul>	Max difference Any CellVoltage4..1	<b>Active CIM Fail Voltage</b>	<b>Active CIM Time</b>	[CIM_A]	[XCIM_A]
2nd level protection IC input	–	PFIN pin	PFIN pin low	<b>PFIN Detect Time</b>	[PFIN]	[XPFIN]
Safety overcurrent charge	Current > 0	Current	<b>SOC Chg</b>	<b>SOC Chg Time</b>	[SOCC]	[XSOCC]
Safety overcurrent discharge	Current < 0	Current	<b>SOC Dsg</b>	<b>SOC Dsg Time</b>	[SOCD]	[XSOCD]
Safety overtemperature chg	Current > 0	TS1Temperature	<b>SOT1 Chg Threshold</b>	<b>SOT1 Chg Time</b>	[SOT1C]	[XSOT1C]
		TS2Temperature	<b>SOT2 Chg Threshold</b>	<b>SOT2 Chg Time</b>	[SOT2C]	[XSOT2C]
Safety overtemperature dsg	Current < 0	TS1Temperature	<b>SOT1 Dsg Threshold</b>	<b>SOT1 Dsg Time</b>	[SOT1D]	[XSOT1D]
		TS2Temperature	<b>SOT2 Dsg Threshold</b>	<b>SOT2 Dsg Time</b>	[SOT2D]	[XSOT2D]
Open thermistor 1	–	TS1Temperature	<b>Open Thermistor</b>	<b>Open Time</b>	[SOPT1]	[XSOPT1]
Open thermistor 2	–	TS2Temperature	<b>Open Thermistor</b>	<b>Open Time</b>	[SOPT2]	[XSOPT2]
Charge and zero-volt charge FET fault	(CHG FET or ZVCHG FET turn off attempt or CHG Flag in AFE OUTPUT register set) and Current > 0	Current	<b>FET Fail Limit</b>	<b>FET Fail Time</b>	[CFETF]	[XCFETF]
Discharge FET fault	(DSG FET turn off attempt or DSG Flag in AFE OUTPUT register set) and Current < 0	(–)Current	<b>FET Fail Limit</b>	<b>FET Fail Time</b>	[DFETF]	[XDFETF]
Fuse state	<b>Fuse Flag</b> = 0x3672	Current	<b>Fuse Fail Limit</b>	<b>Fuse Fail Time</b>	[FBF]	[XFBF]



**Related Variables:**

- DF:2nd Level Safety:Voltage(16): LT SOV Threshold(0)
- DF:2nd Level Safety:Voltage(16): ST SOV Threshold(2)
- DF:2nd Level Safety:Voltage(16): HT SOV Threshold(4)
- DF:2nd Level Safety:Voltage(16): SOV Time(6)
- DF:2nd Level Safety:Voltage(16):SUV Threshold(7)
- DF:2nd Level Safety:Voltage(16):SUV Time(9)
- DF:2nd Level Safety:Voltage(16):Rest CIM Current(12)
- DF:2nd Level Safety:Voltage(16):Rest CIM Fail Voltage(13)
- DF:2nd Level Safety:Voltage(16):Rest CIM Time(15)
- DF:2nd Level Safety:Voltage(16):CIM Battery Rest Time(16)
- DF:2nd Level Safety:Voltage(16): Rest CIM Check Voltage(18)
- DF:2nd Level Safety:Voltage(16): Active CIM Fail Voltage(20)
- DF:2nd Level Safety:Voltage(16): Active CIM Time(22)
- DF:2nd Level Safety:Voltage(16): Active CIM Check Voltage(23)
- DF:2nd Level Safety:Voltage(16):PFIN Detect Time(25)
- 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):SOT1 Chg Threshold(0)
- DF:2nd Level Safety:Temperature(18):SOT1 Chg Time(2)
- DF:2nd Level Safety:Temperature(18):SOT2 Chg Threshold(3)
- DF:2nd Level Safety:Temperature(18):SOT2 Chg Time(5)
- DF:2nd Level Safety:Temperature(18):SOT1 Dsg Threshold(6)
- DF:2nd Level Safety:Temperature(18):SOT1 Dsg Time(8)
- DF:2nd Level Safety:Temperature(18):SOT2 Dsg Threshold(9)
- DF:2nd Level Safety:Temperature(18):SOT2 Dsg Time(11)
- DF:2nd Level Safety:Temperature(18):Open Thermistor(12)
- DF:2nd Level Safety:Temperature(18):Open Time(14)
- DF:2nd Level Safety:FET Verification(19):FET Fail Limit(0)
- DF:2nd Level Safety:FET Verification(19):FET Fail Time(2)
- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Limit(0)
- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Time(2)
- DF:Configuration:Registers(64):Permanent Fail Cfg 1(6), Permanent Fail Cfg 2(8)
- DF:PF Status:Device Status Data(96):Saved PF Flags 1(0), Saved PF Flags 2(2)
- SBS:TS1Temperature(0x5e)
- SBS:TS2Temperature(0x5f)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:PFStatus(0x53)

### 2.3.3 Limit-Based Protection

The bq20z60-R1/bq20z65-R1 reports a 2nd level permanent failure and sets the appropriate *PFStatus* flag if the internal error counter reaches the maximum error limit. The internal error counter is incremented by one if the error happens and reset to zero (0) for every good communication cycle.

**AFE Communication Fault Protection**— The gas gauge in the bq20z60-R1/bq20z65-R1 periodically validates its read and write communications with the AFE. 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 bq20z60-R1/bq20z65-R1 reports an [AFE\_C] permanent failure. The AFE\_Fail\_Counter is reset to zero (0) for every good communication cycle. 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 AFE VCELL output. The AFE offset values are verified by reading the values twice and confirming that the readings are within acceptable limits. The maximum difference between two readings is set with **AFE Init Limit**. The maximum number of read retries, if offset and gain value verification fails and an [AFE\_C] fault is declared, is set in **AFE Fail Limit**.

**Periodic AFE Verification**— The gas gauge in the bq20z60-R1/bq20z65-R1 periodically (**AFE Check Time**) compares certain RAM content of the AFE with that of the data flash and the expected control-bit states. This function is disabled if **AFE Check Time** is set to 0. If an error is detected, the internal AFE\_Fail\_Counter is incremented. If the internal AFE\_Fail\_Counter reaches the **AFE Fail Limit**, the bq20z60-R1/bq20z65-R1 reports a permanent failure.

**AFE Init Verification**— After a full reset, the bq20z60-R1/bq20z65-R1 gas gauge and the AFE offset and gain values are read twice and compared. The **AFE Init Limit** sets the maximum difference in A/D counts of two successful readings of offset and gain, which the bq20z60-R1/bq20z65-R1 still considers as the same value. If the gain and offset values are still not considered the same after **AFE Init Retry Limit** comparison retries, the bq20z60-R1/bq20z65-R1 reports a permanent failure error.

**Data Flash Failure**— The bq20z60-R1/bq20z65-R1 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 2-8. Error-Based 2nd Level Protection**

Protection	Monitored Value	Fail Recovery	Max Error Limit (Set to 0 to Disable Protection)	PFAAlert Flag, PFStatus Flag	Permanent Fail Cfg Flag
AFE communication fault	Periodic communication with the AFE	AFE_Fail_Counter is reset to zero (0) per each <b>AFE Fail Recovery Time</b> period	<b>AFE Fail Limit</b>	[AFE_C]	[XAFE_C]
Periodic AFE verification	Check RAM of the AFE with <b>AFE Check Time</b> period	Decrement of internal AFE_Fail_Counter by one per <b>AFE Fail Recovery Time</b> period.	<b>AFE Fail Limit</b>	[AFE_P]	[XAFE_P]
AFE initialization	Initial gain and offset values from the AFE after full reset	–	<b>AFE Init Retry Limit</b>	[AFE_C]	[XAFE_C]
Data flash failure	Data flash	–	False flash checksum after reset, data flash write not verified, data flash erase not verified	[DFF]	[XDFF]

**Related Variables:**

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

### 2.3.4 Clearing Permanent Failure

A bq20z60-R1/bq20z65-R1 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)

## 2.4 Gas Gauging

The bq20z60-R1/bq20z65-R1 features Impedance Track™ (IT) gauging algorithm and is capable of supporting a maximum battery pack capacity of 32Ah. The gas gauge measures individual cell voltages, pack voltage, temperature, and current using features of the AFE. The bq20z60-R1/bq20z65-R1 determines battery state of charge by analyzing individual cell voltages when a time exceeding 35 minutes has passed since the last charge or discharge activity of the battery. The bq20z60-R1/bq20z65-R1 measures charge and discharge activity by monitoring the voltage across a small-value series sense resistor (10 mΩ typ.) between the cell stack negative terminal and the negative terminal of the battery pack. The battery state of charge is subsequently adjusted during load or charger application using the integrated charge passed through the battery.

### 2.4.1 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  $I \times R$  drop near the end of discharge, the bq20z60-R1/bq20z65-R1 must be configured for whatever current (or power) will flow in the future. While it cannot be exactly known, the bq20z60-R1/bq20z65-R1 can use load history such as the average current of the present discharge to make a sufficiently accurate prediction. The bq20z60-R1/bq20z65-R1 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 (0 to 3, and method 7) result in only minor differences in accuracy. However, methods 4 to 6, where an estimate is arbitrarily assigned by the user, can result in significant error if a fixed estimate is far from the actual load. For highly variable loads, selection 7 will give the most conservative estimate and is preferable.

Constant Current ( <b>Load Mode</b> = 0)	Constant Power ( <b>Load Mode</b> = 1)
0 = <b>Avg I Last Run</b>	<b>Avg P Last Run</b>
1 = Present average discharge current	Present average discharge power
2 = <i>Current</i>	<i>Current</i> × <i>Voltage</i>
3 = <i>AverageCurrent</i> (default)	<i>AverageCurrent</i> × <i>average Voltage</i>
4 = <b>Design Capacity</b> / 5	<b>Design Energy</b> / 5
5 = <i>AtRate</i> (mA)	<i>AtRate</i> (10 mW)
6 = <b>User Rate-mA</b>	<b>User Rate-mW</b>
7 = <b>Max Avg I Last Run</b>	<b>Max Avg P Last Run</b>

**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 bq20z60-R1/bq20z65-R1 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 bq20z60-R1/bq20z65-R1 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 the *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 the **[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(59)
- DF:Gas Gauging:IT Cfg(80):User Rate-mA(76)
- DF:Gas Gauging:IT Cfg(80):User Rate-mW(78)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(80)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(82)
- DF:Gas Gauging:State(82):Avg I Last Run(21)
- DF:Gas Gauging:State(82):Avg P Last Run(23)
- DF:Gas Gauging:State(82):Delta Voltage(25)
- DF:Gas Gauging:State(82):Max I Last Run(31)
- DF:Gas Gauging:State(82):Max P Last Run(33)
- SBS:BatteryMode(0x03)[CapM]
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:OperationStatus(0x54)[LDMD]

### 2.4.2 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.

In order to prevent abnormally fast resistance change, resistance change is limited to old value +/- Ra Max Delta (mOhm). Recommended setting is 15% of 4 Ra grid point value, after optimized values of Ra are obtained from optimization cycle.

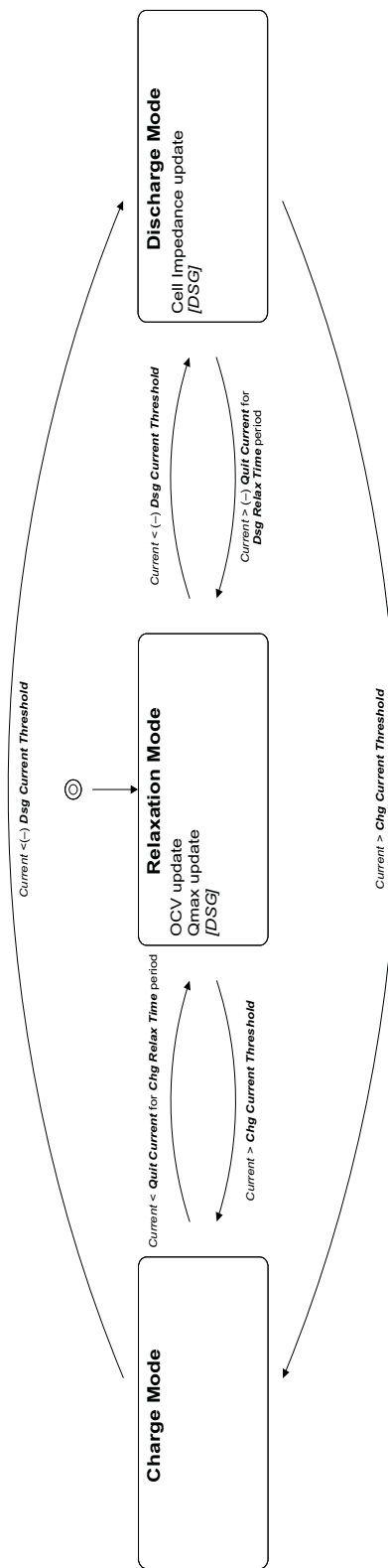
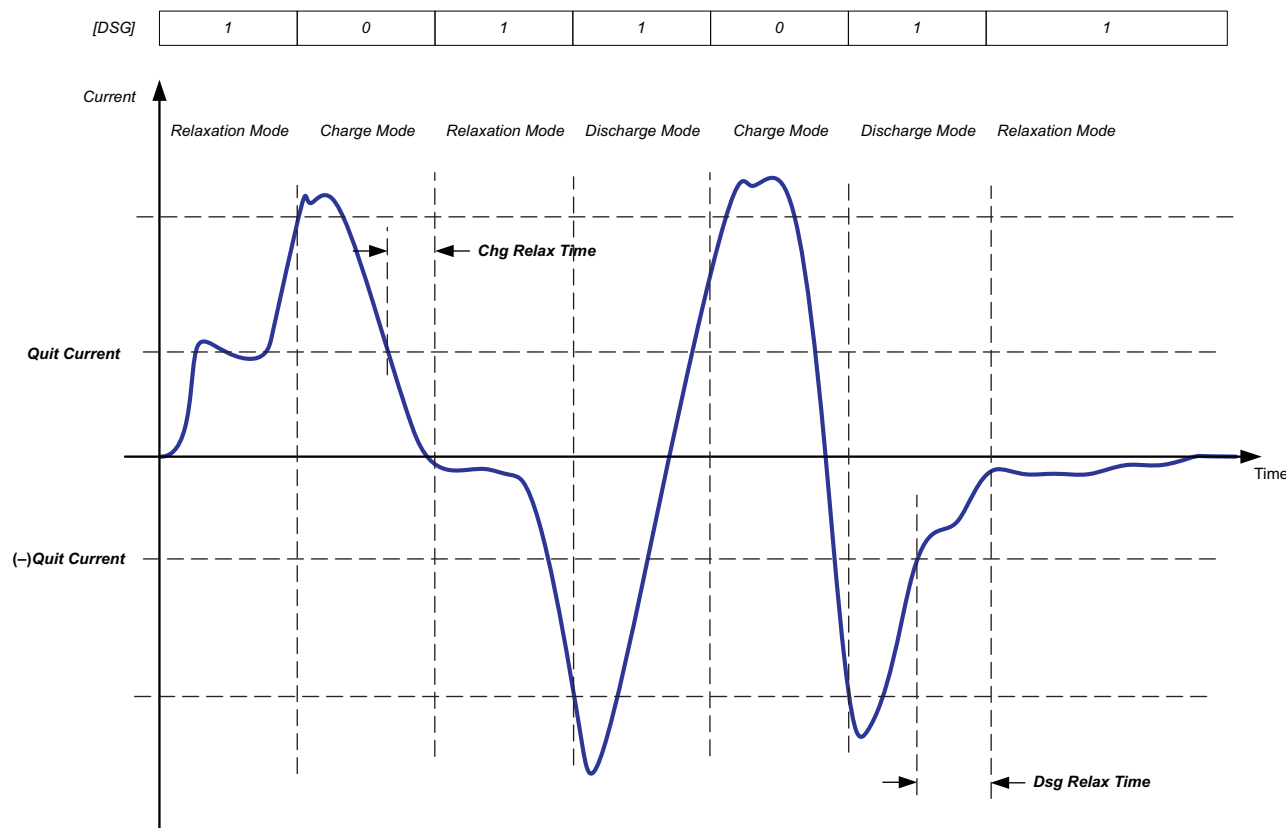


Figure 2-6. Gas Gauge Operating Modes

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



**Figure 2-7. 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)
- DF:Gas Gauging:Current Thresholds(81):Dsg Relax Time(6)
- DF:Gas Gauging:Current Thresholds(81):Chg Relax Time(7)
- SBS:Current(0x0a)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:OperationStatus(0x54)[VOK],[R\_DIS],[QEN]

### 2.4.3 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 bq20z60-R1/bq20z65-R1 acquires and updates the battery-impedance profile during normal battery usage. It uses this profile, along with state-of-charge and the *Q<sub>max</sub>* values, to determine *FullChargeCapacity* and *RelativeStateOfCharge* specifically for the present load and temperature. *FullChargeCapacity* reports a capacity or energy available from a fully charged battery reduced by **Reserve Cap-mAh** or **Reserve Cap-mWh** under the present load and present temperature until *Voltage* reaches the **Term Voltage**.

**Related Variables:**

- DF:Gas Gauging:IT Config(80):Term Voltage(59)
- SBS:Voltage(0x09)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:FullChargeCapacity(0x10)

### 2.4.3.1 Q<sub>max</sub> Initial Values

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

See the *Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm in bq20zxx Product Family* application report ([SLUA364B](#)) for further details.

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:Gas Gauging:State(82):Q<sub>max</sub> Cell 0(0)
- DF:Gas Gauging:State(82):Q<sub>max</sub> Cell 1(2)
- DF:Gas Gauging:State(82):Q<sub>max</sub> Cell 2(4)
- DF:Gas Gauging:State(82):Q<sub>max</sub> Cell 3(6)
- DF:Gas Gauging:State(82):Q<sub>max</sub> Pack(8)
- SBS:DesignCapacity(0x18)

### 2.4.3.2 Q<sub>max</sub> Update Conditions

The bq20z60-R1/bq20z65-R1 updates the no-load full capacity (Q<sub>MAX</sub>) when two open circuit voltage (OCV) readings are taken. These OCV readings are affected by the setting of **[CHGOCV\_DIS]** and taken when the battery is in a relaxed state before and after charge or discharge activity. A relaxed state is achieved if the battery voltage has a dV/dt of < 4 μV/s. Typically it takes 2 hours in a charged state and 5 hours in a discharged state to ensure that the dV/dt condition is satisfied. If 5 hours is exceeded, a reading is taken even if the dV/dt condition was not satisfied. A Q<sub>MAX</sub> 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 in the range of 3737 mV to 3800 mV for the default LION chemistry. (See the *Support of Multiple Li-Ion Chemistries With Impedance Track Gas Gauges* application note ([SLUA372](#)) for the voltage ranges of other chemistries.)

**Offset Error**— If offset error accumulated during time passed from previous OCV reading exceeds 1% of *Design Capacity*, update is disqualified. Offset error current is calculated as **CC Deadband** / sense resistor value.

**Related Variables:**

- DF:Calibration:Current(107):CC Deadband(2)
- SBS:Temperature(0x08)
- SBS:RelativeStateOfCharge(0x0d)
- SBS:AbsoluteStateOfCharge(0x0e)
- SBS:DesignCapacity(0x18)



- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:OperationStatus(0x54)[VOK],[QEN]

Due to variations in charging voltages and taper current, chemical state of charge at the end of charge is not always 100%. To account for the difference in state of charge achieved by different charges, the gas-gauge learns actual depth of discharge after charge termination and relaxation for more than 30 minutes. These values are store in dataflash individually for each cell as follows:

- Cell 0 Chg DOD at EOC = 0
- Cell 1 Chg DOD at EOC = 0
- Cell 2 Chg DOD at EOC = 0
- Cell 3 Chg DOD at EOC = 0

Units of DOD are in an internal format. To convert it to %, the internal units should be divided by 163.84.

## 2.5 Charge Control

The bq20z60-R1/bq20z65-R1 can report to a smart charger the appropriate charging current needed for constant-current charging and the charging voltage needed for constant-voltage charging per the charging algorithm by using the *ChargingCurrent* and *ChargingVoltage* functions. The actual charging status of the bq20z60-R1/bq20z65-R1 is indicated with flags and can be read out with the *ChargingStatus* function.

### Related Variables:

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

### 2.5.1 Charge Control SMBus Broadcasts

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

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

### Related Variables:

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

### 2.5.2 Cell Balancing

The bq20z60-R1/bq20z65-R1 can determine the chemical state of charge of each cell using the Impedance Track algorithm. The cell balancing algorithm used in the bq20z60-R1/bq20z65-R1 decreases the differences in imbalanced cells in a fully charged state gradually, which prevents fully charged cells from becoming overcharged causing excessive degradation. This increases overall pack energy by preventing premature charge termination. More information can be found in the *Cell Balancing Using the bq20zxx* application report ([SLUA340B](#)).



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 AFE. 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.

Cell balancing is active after a Qmax update has occurred with the FC bit set and OCV taken. This state can be determined by the Update Status being set to 0x0E.

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:

$$\text{Min Cell Deviation} = R / (\text{duty\_cycle} \times V\_avg) \times 3.6 \text{ s/mAh}$$

Where:

R = internal bypass FET resistance of 500  $\Omega$  (typ.) + 2 series input filter resistors,  $R_X$ . For example: if input filter  $R_X$  value is 100  $\Omega$ ,  $R = 500 + 2 \times R_X = 700 \Omega$ .

$V\_avg = 3.6 \text{ V}$

duty\_cycle = 0.4 typ.

#### Related Variables:

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

### 2.5.3 Charge-Inhibit Mode

If the bq20z60-R1/bq20z65-R1 is in discharge mode or relaxation mode (*[DSG] = 1*), the bq20z60-R1/bq20z65-R1 goes into charge-inhibit mode and sets the *ChargingCurrent* and *ChargingVoltage* values to 0 to inhibit charging if:

- *Temperature* < **JT1** limit OR
- *Temperature* > **JT3** limit

In charge-inhibit mode, the *[XCHG]* flag in *ChargingStatus* is set. If the **[CHGIN]** bit in **Operation Cfg B** is set, the CHG FET and ZVCHG FET (if used) are also turned off when the bq20z60-R1/bq20z65-R1 is in charge-inhibit mode.

The bq20z60-R1/bq20z65-R1 allows charging to resume when:

- *Temperature*  $\geq$  **JT1 + Temp Hys** AND
- *Temperature*  $\leq$  **JT3 – Temp Hys**

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

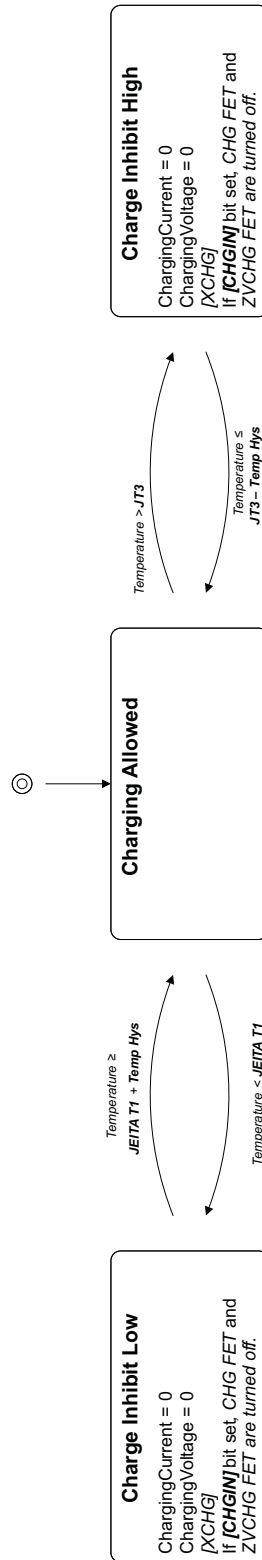


Figure 2-8. Charge Inhibit

**Related Variables:**

- DF:Charge Control:Charge Temp Cfg(32):JT1(0)
- DF:Charge Control:Charge Temp Cfg(32):JT3(6)
- DF:Charge Control:Charge Temp Cfg(32):Temp Hys(10)
- 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]

### 2.5.4 Charge-Suspend Mode

The bq20z60-R1/bq20z65-R1 suspends charging when:

- *Temperature* < **JT1**, OR
- *Temperature* > **JT4**

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

The bq20z60-R1/bq20z65-R1 resumes charging if:

- *Temperature* ≥ **JT1** + **Temp Hys**, AND
- *Temperature* ≤ **JT3** – **Temp Hys**.

On resuming, the bq20z60-R1/bq20z65-R1 clears the *[CHGSUSP]* status flag and sets *ChargingCurrent* according to the appropriate charging mode entered, and the CHG and ZVCHG FETs (if used) return to their previous state.

The bq20z60-R1/bq20z65-R1 also leaves the 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).

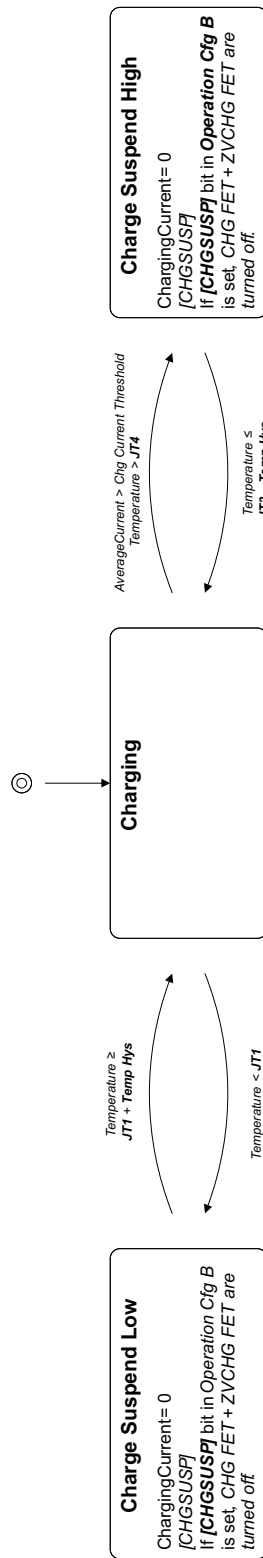


Figure 2-9. Charge Suspend

**Related Variables:**

- DF:Charge Control:Charge Temp Cfg(32):JT1(0)
- DF:Charge Control:Charge Temp Cfg(32):JT3(6)
- DF:Charge Control:Charge Temp Cfg(32):JT4(8)
- DF:Charge Control:Charge Temp Cfg(32):Temp Hys(10)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGSUSP],[NR]
- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- SBS:Temperature(0x08)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[CHGSUSP]

### 2.5.5 Charging and Temperature Ranges

The bq20z60-R1/bq20z65-R1 requests different charging current and charging voltage for each of the temperature ranges defined in [Section 2.1](#), through the *ChargingVoltage* and *ChargingCurrent* commands.

Additionally, the charging current can be set differently depending on the cell voltage. Three ranges of cell voltage are defined using two cell voltage thresholds: **Cell Voltage Threshold 1** and **Cell Voltage Threshold 2** (see [Table 2-9](#)). During charging, as cell voltage increases, *ChargingCurrent* is set to the appropriate value when cell voltage crosses one of the cell voltage thresholds. However, if cell voltage decreases below the threshold, *ChargingCurrent* is not set back to the previous value unless a discharge or relax state is detected. This is done to avoid the situation where the charging current is being changed back and forth due to the voltage drop that results from changing the charging current value.

**Table 2-9. Cell Voltage Ranges**

Condition	Cell Voltage Range
$\max(\text{CellVoltage4..1}) < \text{Cell Voltage Threshold 1}$	CVR1
$\text{Cell Voltage Threshold 1} < \max(\text{CellVoltage4..1}) < \text{Cell Voltage Threshold 2}$	CVR2
$\text{Cell Voltage Threshold 2} < \max(\text{CellVoltage4..1})$	CVR3

The dependency of the *Charging Voltage* and *Charging Current* on temperature range and cell voltage range is summarized in [Table 2-10](#) and illustrated in [Figure 2-10](#) and [Figure 2-11](#).

**Table 2-10. Charging Voltage and Charging Current Dependency on Temperature Range and Cell Voltage Range**

Temp Range	Cell Voltage	Charging Voltage	Charging Current
TR1	–	0	0
TR2	CVR1	<i>LT Chg Voltage</i>	<i>LT Chg Current1</i>
	CVR2		<i>LT Chg Current2</i>
	CVR3		<i>LT Chg Current3</i>
TR2A	CVR1	<i>ST1 Chg Voltage</i>	<i>ST1 Chg Current1</i>
	CVR2		<i>ST1 Chg Current2</i>
	CVR3		<i>ST1 Chg Current3</i>
TR3	CVR1	<i>ST2 Chg Voltage</i>	<i>ST2 Chg Current1</i>
	CVR2		<i>ST2 Chg Current2</i>
	CVR3		<i>ST2 Chg Current3</i>
TR4	CVR1	<i>HT Chg Voltage</i>	<i>HT Chg Current1</i>
	CVR2		<i>HT Chg Current2</i>
	CVR3		<i>HT Chg Current3</i>
TR5	–	0	0

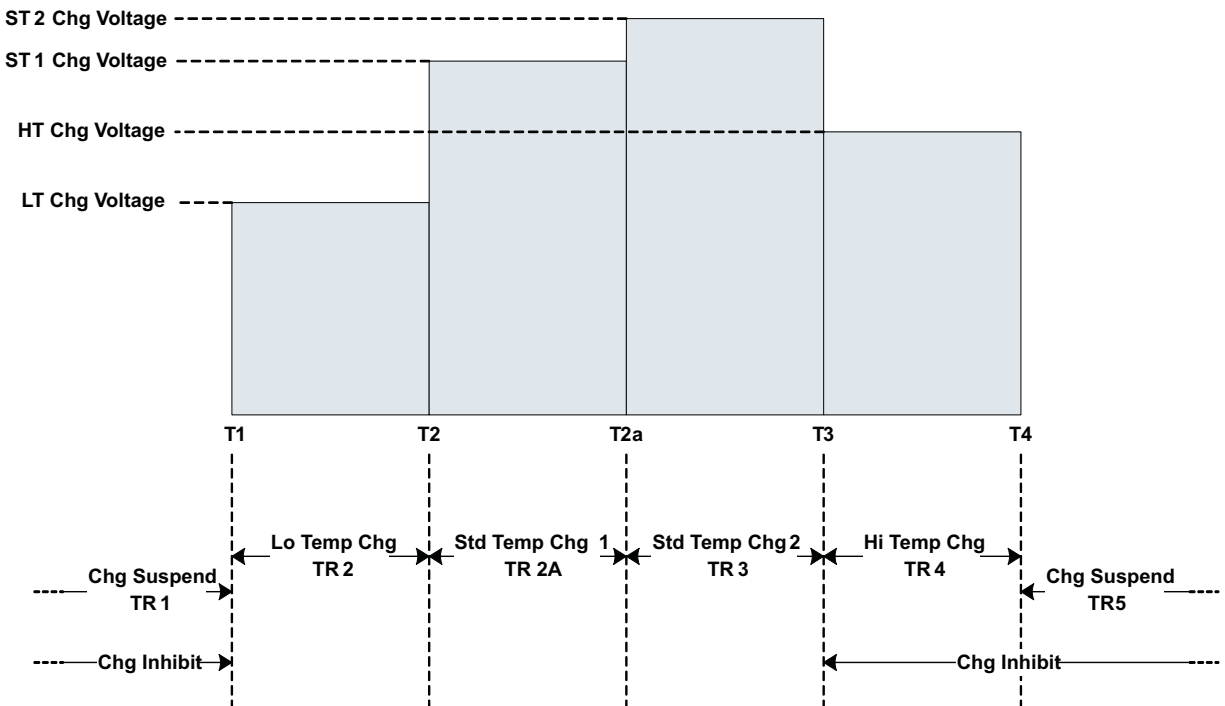


Figure 2-10. Temp Ranges and Charge Voltage for JEITA With Enhancements for More Complex Charging Profiles

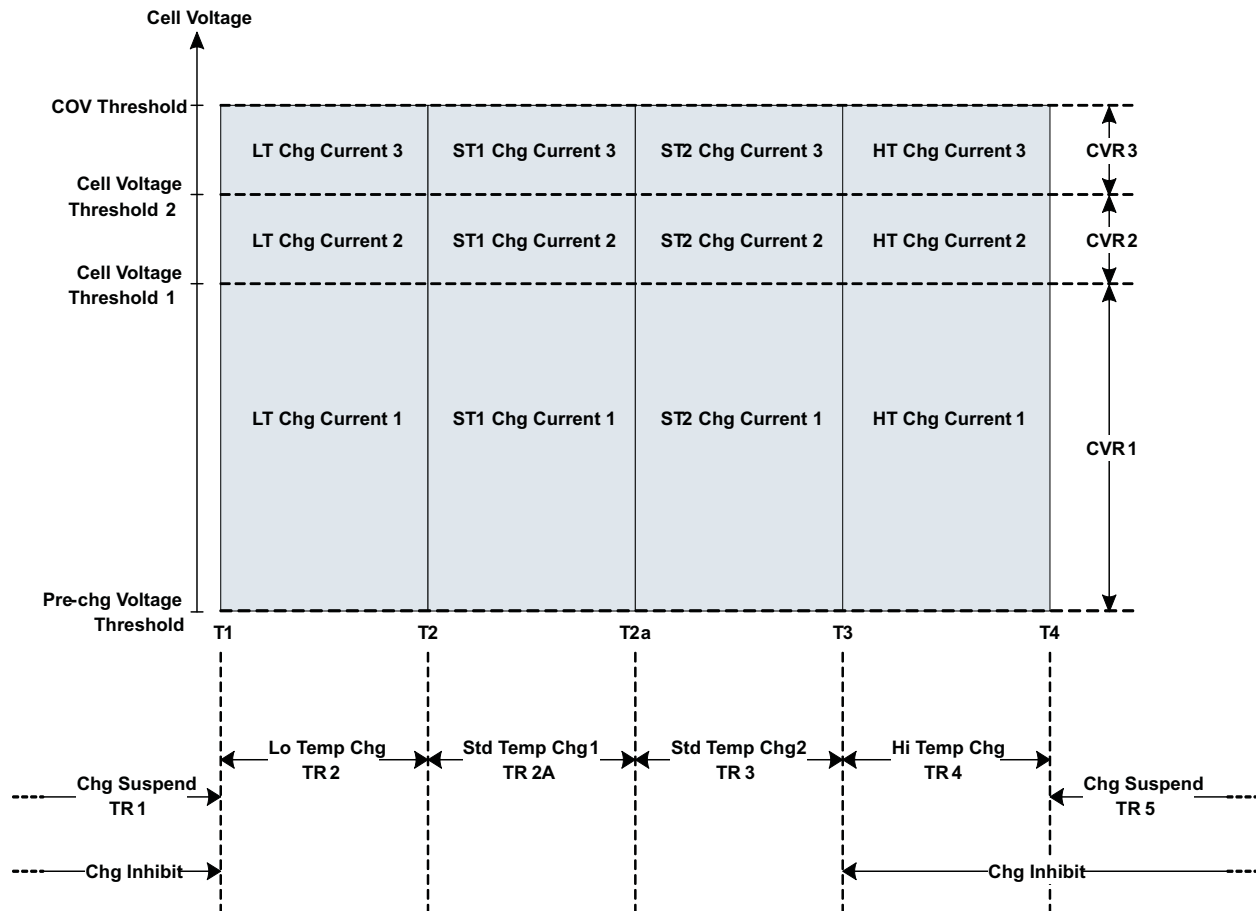


Figure 2-11. Temp Ranges and Charge Current for JEITA With Enhancements for More Complex Charging Profiles

### 2.5.5.1 Low Temperature Charging

The bq20z60-R1/bq20z65-R1 enters this mode when the *Temperature* function reports a temperature in the TR2 range ( $JT1 < Temperature < JT2$ ). In this mode [*LTCHG*] flag in *ChargingStatus* is set, the *ChargingVoltage* is set to *LT Chg Voltage*, and the *ChargingCurrent* is set to **LT Chg Current1**, **LT Chg Current2**, or **LT Chg Current3** depending on the active cell voltage range. The charging current dataflash values for low temp charging should be set to low current values similar to precharge mode. The bq20z60-R1/bq20z65-R1 leaves this mode and clears the [*LTCHG*] flag if the *Temperature* goes below *JT1* or above  $JT2 + Temp Hys$ .

### 2.5.5.2 Standard Temperature Charging 1

The bq20z60-R1/bq20z65-R1 enters this mode when the *Temperature* function reports a temperature in the TR2A range ( $JT2 < Temperature < JT2a$ ). In this mode the [*ST1CHG*] flag in *ChargingStatus* is set, *ChargingVoltage* is set to **ST1 Chg Voltage**, and the *ChargingCurrent* is set to **ST1 Chg Current**, **ST1 Chg Current 2**, or **ST1 Chg Current 3** depending on the active cell voltage range. The bq20z60-R1/bq20z65-R1 leaves this mode and clears the [*ST1CHG*] flag if the *Temperature* goes below *JT2* or above *JT2a*.

### 2.5.5.3 Standard Temperature Charging 2

The bq20z60-R1/bq20z65-R1 enters this mode when the *Temperature* function reports a temperature in

the TR3 range (**JT2a** < Temperature < **JT3**). In this mode the **[ST2CHG]** flag in **ChargingStatus** is set, **ChargingVoltage** is set to **ST2 Chg Voltage**, and the **ChargingCurrent** is set to **ST2 Chg Current 1** or **ST2 Chg Current 2** or **ST2 Chg Current 3** depending on the active cell voltage. The bq20z60-R1/bq20z65-R1 leaves this mode and clears the **[ST2CHG]** flag if the **Temperature** goes below **JT2a – Temp Hys** or above **JT3**.

#### 2.5.5.4 High Temperature Charging

The bq20z60-R1/bq20z65-R1 enters this mode when the **Temperature** function reports a temperature in the TR4 range (**JT3** < Temperature < **JT4**). In this mode the **[HTCHG]** flag in **ChargingStatus** is set, **ChargingVoltage** is set to **HT Chg Voltage**, and the **ChargingCurrent** is set to **HT Chg Current1**, **HT Chg Current2**, or **HT Chg Current3** depending on the active cell voltage. The bq20z60-R1/bq20z65-R1 leaves this mode and clears the **[HTCHG]** flag if the **Temperature** goes below **JT3 – Temp Hys** or above **JT4**.

##### Related Variables:

- DF:Charge Control:Charge Temp Cfg(32):JT1(0)
- DF:Charge Control:Charge Temp Cfg(32):JT2(2)
- DF:Charge Control:Charge Temp Cfg(32):JT2a(4)
- DF:Charge Control:Charge Temp Cfg(32):JT3(6)
- DF:Charge Control:Charge Temp Cfg(32):JT4(8)
- DF:Charge Control:Charge Temp Cfg(32):Temp Hys(10)
- DF:Charge Control:Charge Cfg(34):LT Charge Voltage(0)
- DF:Charge Control:Charge Cfg(34):LT Charge Current 1(2)
- DF:Charge Control:Charge Cfg(34):LT Charge Current 2(4)
- DF:Charge Control:Charge Cfg(34):LT Charge Current 3(6)
- DF:Charge Control:Charge Cfg(34):ST1 Charge Voltage(8)
- DF:Charge Control:Charge Cfg(34):ST1 Charge Current 1(10)
- DF:Charge Control:Charge Cfg(34):ST1 Charge Current 2(12)
- DF:Charge Control:Charge Cfg(34):ST1 Charge Current 3(14)
- DF:Charge Control:Charge Cfg(34):ST2 Charge Voltage(16)
- DF:Charge Control:Charge Cfg(34):ST2 Charge Current 1(18)
- DF:Charge Control:Charge Cfg(34):ST2 Charge Current 2(20)
- DF:Charge Control:Charge Cfg(34):ST2 Charge Current 3(22)
- DF:Charge Control:Charge Cfg(34):HT Charge Voltage(24)
- DF:Charge Control:Charge Cfg(34):HT Charge Current 1(26)
- DF:Charge Control:Charge Cfg(34):HT Charge Current 2(28)
- DF:Charge Control:Charge Cfg(34):HT Charge Current 3(30)
- DF:Charge Control:Charge Cfg(34):Cell Voltage Threshold 1(32)
- DF:Charge Control:Charge Cfg(34):Cell Voltage Threshold 2(34)
- SBS:Temperature(0x08)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:ChargingStatus(0x55)[LTCHG] , [ST1CHG] , [ST2CHG], [HTCHG]

#### 2.5.6 Precharge

The bq20z60-R1/bq20z65-R1 enters precharge mode during charging if any cell voltage goes below **Pre-chg Voltage Threshold** limit or if any of the **SafetyStatus** flags, **[CUV]**, **[OCD]**, or **[OCD2]** is set.

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



**Table 2-11. Precharge FET**

ZVCHG1	ZVCHG0	FET USED
0	0	ZVCHG FET
0	1	CHG FET
1	0	GPOD Pin (on the AFE when used with bq20z60)
1	1	No Action

In precharge mode, the *[PCHG]* flag is set, the *ChargingVoltage* is set to **Pre-chg Current**, and *ChargingVoltage* is set per the charging algorithm.

The bq20z60-R1/bq20z65-R1 leaves precharge mode and clears the *[PCHG]* flag if all cell voltages reach or rise above **Pre-chg Recovery Voltage**. Precharge mode is also exited if charge suspend mode is entered, any fault condition is detected, or the pack is removed in removable mode.

**Related Variables:**

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

**2.5.7 Primary Charge Termination**

The bq20z60-R1/bq20z65-R1 determines charge termination if:

- Average Charge Current < **Taper Current** during two consecutive **Current Taper Window** time periods, AND
- The accumulated change in capacity must be > 0.25 mAh per period during two consecutive **Current Taper Window** time periods, AND
- Taper voltage condition is met. Taper voltage condition is either cell voltage-based or pack voltage-based depending on the bit *[CELL\_TAPER]* in **Operation Cfg C**.
  - *[CELL\_TAPER]* = 1: Max (*CellVoltage4..1*) + **Taper Voltage** ≥ *ChargingVoltage* / number of cells
  - *[CELL\_TAPER]* = 0: *Voltage* + **Taper Voltage** ≥ *ChargingVoltage*

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

The following parameters change the behavior of bq20z60-R1/bq20z65-R1 on charge termination:

**Table 2-12. Primary Charge Termination**

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

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):Maintenance Current(0)
- DF:Charge Control:Termination Cfg.(36):Taper Current(2)
- DF:Charge Control:Termination Cfg.(36):Taper Voltage(6)
- DF:Charge Control:Termination Cfg.(36):Current Taper Window(8)
- DF:Charge Control:Termination Cfg.(36):TCA Set %(9)
- DF:Charge Control:Termination Cfg.(36):FC Set %(11)
- DF:Configuration:Registers(64):Operation Cfg B(2)[CHGFET],[CSYNC]
- DF:Configuration:Registers(64):Operation Cfg C(4)[RSOCL]
- DF:Gas Gauging:Current Thresholds(81):Quit Current(4)
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:RemainingCapacity(0x0f)
- SBS:FullChargeCapacity(0x10)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA],[FC]
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:ChargingStatus(0x55)[MCHG]

### 2.5.8 Charging Faults

The bq20z60-R1/bq20z65-R1 can report charging faults in the *ChargingStatus* register. When the [OCHG] bit in **Charge Fault Cfg** is set, the CHG FET is turned OFF and the ZVCHG FET is turned ON if the [ZVCHG1], [ZVCHG0] bits in **Operation Cfg A** are set appropriately. If the ZVCHG FET is not used the CHG FET remains ON, regardless of the bits set in **Charge Fault Cfg**, because it acts as the ZVCHG FET.

On occurrence of a charging fault, the bq20z60-R1/bq20z65-R1:

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

On recovery, the bq20z60-R1/bq20z65-R1:

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

#### Precharge Mode Timeout

When *Current* ≥ **Chg Current Threshold**, the bq20z60-R1/bq20z65-R1 starts the Precharge Timer. The Precharge Timer is suspended when precharge mode is not active ([PCHG] = 0). Set **Precharge Timeout** [PCMTO] to zero to disable this feature.

The bq20z60-R1/bq20z65-R1 goes into precharge mode charging timeout [PCMTO] if:

- Precharge timer ≥ **Precharge Timeout**

The bq20z60-R1/bq20z65-R1 recovers if:

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

#### Charge Mode Timeout

When *Current* is  $\geq$  **Chg Current Threshold**, the bq20z60-R1/bq20z65-R1 starts the Charge Timer. The Charge Timer is suspended when charge is not active ( $[LTCHG] = 0$ ,  $[ST1CHG] = 0$ ,  $[ST2CHG] = 0$ , and  $[HTCHG] = 0$ , or when  $[DSG] = 1$ ). The Charge Timer is reset when an amount of discharge greater than **Over Charge Recovery** is detected or if the pack is removed and reinserted when  $[NR] = 0$ . Set **Charge Timeout** to 0 to disable this feature.

The bq20z60-R1/bq20z65-R1 goes into charge mode charging timeout if:

- Charge timer  $\geq$  **Charge Timeout**

The bq20z60-R1/bq20z65-R1 recovers if:

- $Current \leq (-)Dsg \text{ Current Threshold}$  OR
- Pack is removed and reinserted if  $[NR] = 0$

### Overcharging Voltage

The bq20z60-R1/bq20z65-R1 goes into overcharging voltage mode if:

- $Voltage \geq ST2 \text{ Chg Voltage} + \text{Over Charging Voltage}$  for minimum **Over Charging Volt Time** period.

The bq20z60-R1/bq20z65-R1 recovers, if:

- $Voltage \leq ST2 \text{ Chg Voltage}$

### Overcharging Current

The bq20z60-R1/bq20z65-R1 goes into overcharging current mode if:

- $Current \geq ChargingCurrent + \text{Over Charging Current}$  for minimum **Over Charging Curr Time** period.

The bq20z60-R1/bq20z65-R1 recovers, if:

- $AverageCurrent \leq \text{Over Charging Curr Recov}$

### Overcharge

The bq20z60-R1/bq20z65-R1 goes into overcharge mode if the battery pack is charged in excess of *FullChargeCapacity* by **Over Charge Capacity**.

The bq20z60-R1/bq20z65-R1 recovers if any of the following conditions are met:

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

### Battery Depleted

The bq20z60-R1/bq20z65-R1 goes into battery depleted mode if:

- $Voltage \leq \text{Depleted Voltage}$  for **Depleted Voltage Time** and charger is present

The bq20z60-R1/bq20z65-R1 recovers, if:

- $Voltage > \text{Depleted Voltage Recovery}$

**Table 2-13. Charging Faults**

Charge Fault	Fault Condition	Recovery Condition	ChargingStatus Flag, Charge Fault Configuration Flag
Precharge Timeout	Precharge Timer $\geq$ <b>Precharge Timeout</b>	$Current \leq (-)Dsg \text{ Current Threshold}$ , OR pack removed and reinserted if $[NR] = 0$	[PCMTO]
Charge Timeout	Charge Timer $\geq$ <b>Charge Timeout</b>		[CMT0]
Overcharging Voltage	$Voltage \geq ST2 \text{ Chg Voltage} +$ <b>Over Charging Voltage</b> for minimum <b>Over Charging Volt Time</b>	$Voltage \leq ST2 \text{ Chg Voltage}$	[OCHGV]
Overcharging Current	$Current \geq ChargingCurrent +$ <b>Over Charging Current</b> for minimum <b>Over Charging Curr Time</b>	$AverageCurrent \leq \text{Over Charging CurrRecov}$	[OCHGI]

**Table 2-13. Charging Faults (continued)**

Charge Fault	Fault Condition	Recovery Condition	ChargingStatus Flag, Charge Fault Configuration Flag
Overcharge	$RemainingCapacity - FullChargeCapacity \geq$ <b>Over Charge Capacity</b>	Pack removed and reinserted if <b>[NR]</b> = 0, OR continuous amount of discharge of <b>Over Charge Recovery</b> if <b>[NR]</b> = 1, OR $RemainingCapacity \leq$ <b>FC Clear %</b>	[OC]
Battery Depleted	$Voltage \leq$ <b>Depleted Voltage</b> for minimum <b>Depleted Voltage Time</b>	$Voltage >$ <b>Depleted Voltage Recovery</b>	[XCHGLV]

**Related Variables:**

- DF:Charge Control:Charge Cfg(34):ST2 Chg Voltage(16)
- DF:Charge Control:Termination Cfg.(36):FC Clear %(12)
- DF:Charge Control:Charging Faults(38):Over Charging Voltage(0)
- DF:Charge Control:Charging Faults(38):Over Charging Volt Time(2)
- DF:Charge Control:Charging Faults(38):Over Charging Current(3)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Recov(6)
- DF:Charge Control:Charging Faults(38):Depleted Voltage(8)
- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- DF:Charge Control:Charging Faults(38):Depleted Recovery(11)
- DF:Charge Control:Charging Faults(38):Over Charge Capacity(13)
- DF:Charge Control:Charging Faults(38):Over Charge Recovery(15)
- DF:Charge Control:Charging Faults(38):Charge Timeout(17)
- DF:Charge Control:Charging Faults(38):Precharge Timeout(19)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:Voltage(0x09)
- SBS:Current(0x0a)
- SBS:AverageCurrent(0x0b)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TDA],[TCA],[OCA]
- SBS:ChargingStatus(0x55)[LTCHG],[STCHG],[HTCHG]

## 2.5.9 Discharge and Charge Alarms

The bq20z60-R1/bq20z65-R1 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
<i>RelativeStateOfCharge</i>	$\leq$ TDA Set % and discharging	[TDA] is set.
	$\geq$ TDA Clear %	[TDA] is cleared.
	$\leq$ FD Set %	[FD] is set.
	$\geq$ FD Clear %	[FD] is cleared.
	$\geq$ TCA Set %	[TCA] is set.
	$\leq$ TCA Clear %	[TCA] is cleared.
	$\geq$ FC Set %	[FC] is set.
	$\leq$ FC Clear %	[FC] is cleared.

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

	Threshold	BatteryStatus Flag
<i>Voltage</i>	$\leq$ TDA Volt Threshold for a period of TDA Volt Time and discharging	[TDA] is set.
	$\geq$ TDA Clear Volt	[TDA] is cleared.
	$\leq$ FD Volt Threshold for a period of FD Volt Time	[FD] is set.
	$\geq$ FD Clear Volt	[FD] is cleared.

### Related Variables:

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

## 2.6 Discharge-Inhibit Mode

The bq20z60-R1/bq20z65-R1 prevents discharging if *Temperature* > **Hi Dsg Start Temp**. When this happens, the bq20z60-R1/bq20z65-R1 goes into discharge inhibit mode. In discharge inhibit mode, discharging is disabled, and *[XDSG]*, *[DSGIN]* in *OperationStatus* and *[TDA]* in *BatteryStatus* are set. The bq20z60-R1/bq20z65-R1 returns to normal mode and allows discharging if *Temperature* becomes less than or equal **Hi Dsg Start Temp**.

### Related Variables:

- DF:1st Level Safety:Temperature(2):Hi Dsg Start Temp(20)
- SBS:Temperature(0x08)

- SBS:BatteryStatus(0x16)[TDA]
- SBS:OperationStatus(0x54)[XDSG],[DCHGIN]

## 2.7 LED Display

### 2.7.1 Display Activation

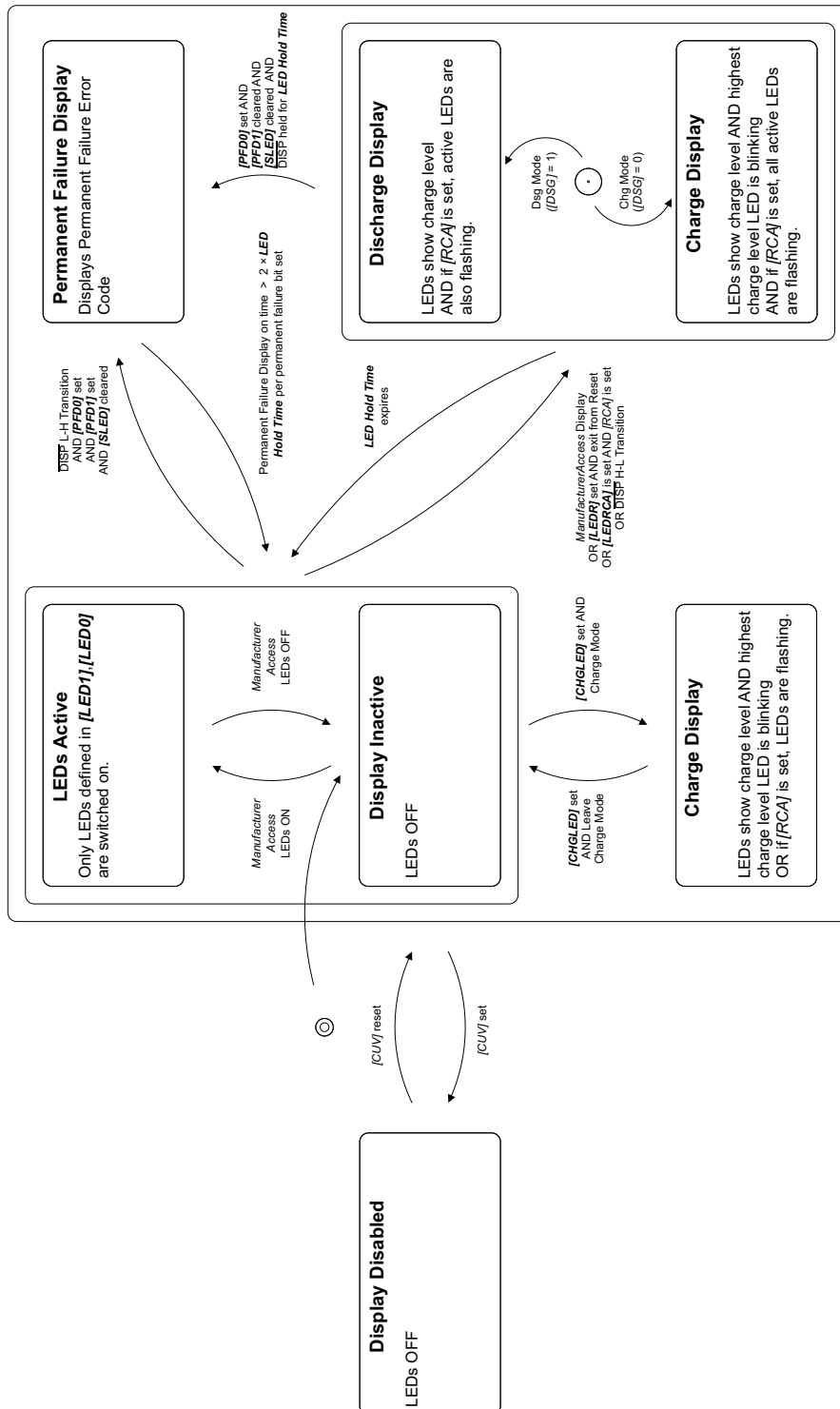


Figure 2-12. Display Activation



The LED display is activated with a High to Low (H-L) transition at the  $\overline{\text{DISP}}$  pin. The following flags configure additional display activation settings. If *[CUV]* or *[PUV]* flags are set, the display is disabled.

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

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

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

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

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

#### Related Variables:

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

## 2.7.2 Display Configuration

The following parameters configures the display in various ways.

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

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

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

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

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

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

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

#### Related Variables:

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

### 2.7.3 Display Format

The bq20z60-R1/bq20z65-R1 can show state of charge using the LED display. Predefined levels for 3, 4 or 5 LEDs or user configurable levels can be selected. State of charge levels can be configured for charging and discharging.

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

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



**Table 2-14. Display Charge Level Threshold**

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

**Related Variables:**

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

**2.7.4 Permanent Failure Error Codes**

When a permanent failure occurs, the type of permanent failure error can be shown on the display. The table below shows available error codes. The permanent failure display requires proper setting of **[PFD1]** and **[PFD0]** bits. The permanent failure code display is disabled if **[SLED]** bit is set. The LED Flash Period and LED Blink Period are fixed for these errors and not affected by the LED Data Flash settings.

<i>PfStatus</i>	<b>LED3</b>	<b>LED2</b>	<b>LED1</b>
<i>[SOPT2]</i>	Flashing with LED Flash Period	Off	Flashing with LED Blink Period
<i>[SOT2D]</i>	On	Off	Flashing with LED Blink Period
<i>[SOT2C]</i>	Off	Off	Flashing with LED Blink Period
<i>[CIM_A]</i>	Flashing with LED Flash Period	Flashing with LED Blink Period	Flashing with LED Flash Period
<i>[FBF]</i>	On	Flashing with LED Blink Period	Flashing with LED Flash Period
<i>[VSHUT]</i>	Off	Flashing with LED Blink Period	Flashing with LED Flash Period
<i>[SUV]</i>	Flashing with LED Flash Period	Flashing with LED Blink Period	On
<i>[SOPT1]</i>	On	Flashing with LED Blink Period	On
<i>[SOCD]</i>	Off	Flashing with LED Blink Period	On
<i>[SOCC]</i>	Flashing with LED Flash Period	Flashing with LED Blink Period	Off
<i>[AFE_P]</i>	On	Flashing with LED Blink Period	Off
<i>[AFE_C]</i>	Off	Flashing with LED Blink Period	Off
<i>[DFF]</i>	Flashing with LED Blink Period	Flashing with LED Flash Period	Flashing with LED Flash Period

<i>PFStatus</i>	<b>LED3</b>	<b>LED2</b>	<b>LED1</b>
<i>[DFETF]</i>	Flashing with LED Blink Period	On	Flashing with LED Flash Period
<i>[CFETF]</i>	Flashing with LED Blink Period	Off	Flashing with LED Flash Period
<i>[CIM_R]</i>	Flashing with LED Blink Period	Flashing with LED Flash Period	On
<i>[SOT1D]</i>	Flashing with LED Blink Period	On	On
<i>[SOT1C]</i>	Flashing with LED Blink Period	Off	On
<i>[SOV]</i>	Flashing with LED Blink Period	Flashing with LED Flash Period	Off
<i>[PFIN]</i>	Flashing with LED Blink Period	On	Off
None	Flashing with LED Blink Period	Off	Off

**Related Variables:**

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

### 2.7.5 LED Current Configuration

The sink current setting of the LED inputs to the bq20z60-R1/bq20z65-R1 can be programmed with the following settings. All of the LEDs are programmed with the same current level.

**Table 2-15. LED Current Configuration**

<b>ILED1</b>	<b>ILED0</b>	<b>Sink Current</b>
0	0	0 mA
0	1	3 mA
1	0	4 mA
1	1	5 mA (default)

**Related Variables:**

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

## 2.8 Device Operating Mode

The bq20z60-R1/bq20z65-R1 has several device power modes. During these modes, the bq20z60-R1/bq20z65-R1 modifies its operation to minimize power consumption from the battery.

### 2.8.1 Normal Mode

During normal operation, the bq20z60-R1/bq20z65-R1 takes *Current*, *Voltage*, and *Temperature* measurements, performs calculations, updates SBS data, and makes protection and status decisions at 1-second intervals. Between these periods of activity, the bq20z60-R1/bq20z65-R1 is in a reduced-power state.

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

If the *[NR]* bit is set, the  $\overline{PRES}$  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]

## 2.8.2 Battery Pack Removed Mode/System Present Detection

### 2.8.2.1 Battery Pack Removed

The bq20z60-R1/bq20z65-R1 detects the Battery Pack Removed mode if the **[NR]** bit is set to 0 AND the  $\overline{\text{PRES}}$  input is high ( $[\text{PRES}] = 0$ ).

On entry to the Battery Pack Removed mode, the  $[\text{TCA}]$  and  $[\text{TDA}]$  flags in *BatteryStatus* 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 bq20z60-R1/bq20z65-R1 exits the Battery Pack Removed state if the **[NR]** flag is set to 0 AND the  $\overline{\text{PRES}}$  input is low ( $[\text{PRES}] = 1$ ). When this occurs, the  $[\text{TCA}]$  and  $[\text{TDA}]$  flags in *BatteryStatus* are reset.

#### Related Variables:

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

### 2.8.2.2 System Present

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

#### Related Variables:

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

### 2.8.3 Sleep Mode

In Sleep mode, the bq20z60-R1/bq20z65-R1 measures *Voltage* and *Temperature* in **Sleep Voltage Time** intervals and *Current* at **Sleep Current Time** intervals. At each interval the bq20z60-R1/bq20z65-R1 performs calculations, updates SBS data, and makes protection and status decisions. Between these periods of activity, the bq20z60-R1/bq20z65-R1 is in a reduced-power state.

The bq20z60-R1/bq20z65-R1 enters Sleep mode when the following conditions exist:

- If the **[NR]** bit is set to 0,  $[\text{PRES}]$  must also be set to 0 for the bq20z60-R1/bq20z65-R1 to enter sleep. AND one of the following conditions:
- ( $|\text{Current}| \leq \text{Sleep Current}$ ) AND (SMBus is low for **Bus Low Time**) AND (the **[SLEEP]** bit is set)  
OR
- ( $|\text{Current}| \leq \text{Sleep Current}$ ) AND (*ManufacturerAccess* Sleep command is received) AND (the **[SLEEP]** bit is set).

Entry to Sleep mode is blocked if any of the *PFStatus* flags is 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 the **[NRCHG]** setting. If **[NR]** = 1, the CHG FET is turned off, and the ZVCHG FET is turned off (if used). However, if **[NRCHG]** is set, then the CHG FET remains on.

Also, on entry to Sleep mode, the autocalibration of the ADC begins. However, if *Temperature*  $\leq$  **Cal Inhibit Temp Low** or *Temperature*  $\geq$  **Cal Inhibit Temp High**, autocalibration is not started on entry to sleep mode. The activation of autocalibration is not affected by the state of **[SLEEP]**, **Sleep Voltage Time**, **Sleep Current Time**, or *Current*.

Additionally, if sleep mode is entered in response to *ManufacturerAccess* Sleep command, then the ADC autocalibration is not performed.

The bq20z60-R1/bq20z65-R1 exits Sleep mode when one or more of the following conditions exist:

- If the **[NR]** bit is set to 0 and  $[\text{PRES}]$  is set to 1.

- $|Current| > Sleep\ Current$
- SMBC or SMBD input transitions high
- Any current related flag is set in *SafetyStatus*
- *[OC]*, *[CMTO]*, *[OCHGV]*, *[OCHGI]*, and *[XCHGLV]* flags in *ChargingStatus* are set
- Wake function enabled by setting **Wake Current Reg** and a voltage across SRP and SRN is detected

The bq20z60-R1/bq20z65-R1 exits Sleep mode if the absolute value of *Current* is greater than **Sleep Current**, OR the SMBC or SMBD input transitions high, OR any *OperationStatus*, *ChargingStatus*, or *SafetyStatus* flags change state.

In addition, if **[NR]** is cleared, the bq20z60-R1/bq20z65-R1 exits Sleep mode when *[PRES]* = 1.

**Related Variables:**

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

## 2.8.4 Wake Function

The bq20z60-R1/bq20z65-R1 can exit sleep mode, if enabled, by the presence of a voltage across SRP and SRN. The level of the current signal needed is programmed in **Wake Current Reg**.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	IWAKE	RSNS1	RSNS0

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

**Figure 2-13. Wake Current Reg**

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

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

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

**Table 2-16. 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]
- DF:Power:Power(68):Wake Current Reg(19)
- SBS:Current(0x0a)

### 2.8.5 Shutdown Mode

The bq20z60-R1/bq20z65-R1 enters Shutdown mode if the following conditions are met:

- **[SHUTV]** in **Operation Cfg C** is set to 0 AND  $Voltage \leq \text{Shutdown Voltage}$  AND  $Current \leq 0$  for a period of **Cell Shutdown Time**  
OR
- **[SHUTV]** in **Operation Cfg C** is set to 1 AND  $\text{Min}(\text{CellVoltage4..1}) \leq \text{Cell Shutdown Voltage}$  AND  $Current \leq 0$  for a period of **Shutdown Time**  
OR
- (*ManufacturerAccess* shutdown command received AND  $Current = 0$ ) AND  $PackVoltage < \text{Charger Present}$  threshold.

When the bq20z60-R1/bq20z65-R1 meets these conditions, the CHG, DSG, and ZVCHG FETs are turned off, and the AFE is commanded to shut down. In Shutdown mode, the bq20z60-R1/bq20z65-R1 is completely powered down because its supply is removed.

To exit Shutdown mode, the PACK voltage must be greater than its minimum operating voltage. When this occurs, the AFE returns power to the bq20z60-R1/bq20z65-R1, the **[WAKE]** flag is set, and the AFE is configured. The **[WAKE]** flag is cleared after approximately 1 s when all SBS parameters have been measured and updated.

#### Related Variables:

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

### 2.8.6 Ship Mode

While in sealed mode, the bq20z60-R1/bq20z65-R1 enters ship mode if *ManufacturerAccess* (MAC) shutdown command (0x0010) is received 2 consecutive times AND  $PackVoltage < \text{Charger Present}$  threshold AND no safety conditions. The 2 MAC writes cannot have any other MAC commands following or between them. After the bq20z60-R1/bq20z65-R1 receives the 2 consecutive MAC (0x0010) commands, the CHG, DSG, and ZVCHG FETs are turned off after **Sealed Ship Delay** time period. After the passage of another **Sealed Ship Delay** period, ship mode is entered (i.e. after a time period which 2 times **Sealed Ship Delay**). For example, if **Sealed Ship Delay** is set to 5 seconds, then 5 seconds after receiving the 2 MAC (0x0010) commands the FETs will turn off, and 10 seconds after receiving the 2 commands, the bq20z60-R1/bq20z65-R1 will enter ship mode.

#### Related Variables:

- DF:Power:Power(68):Charger Present(8)
- DF:Power:Power(68):Sealed Ship Delay(20)
- SBS:PackVoltage(0x5a)

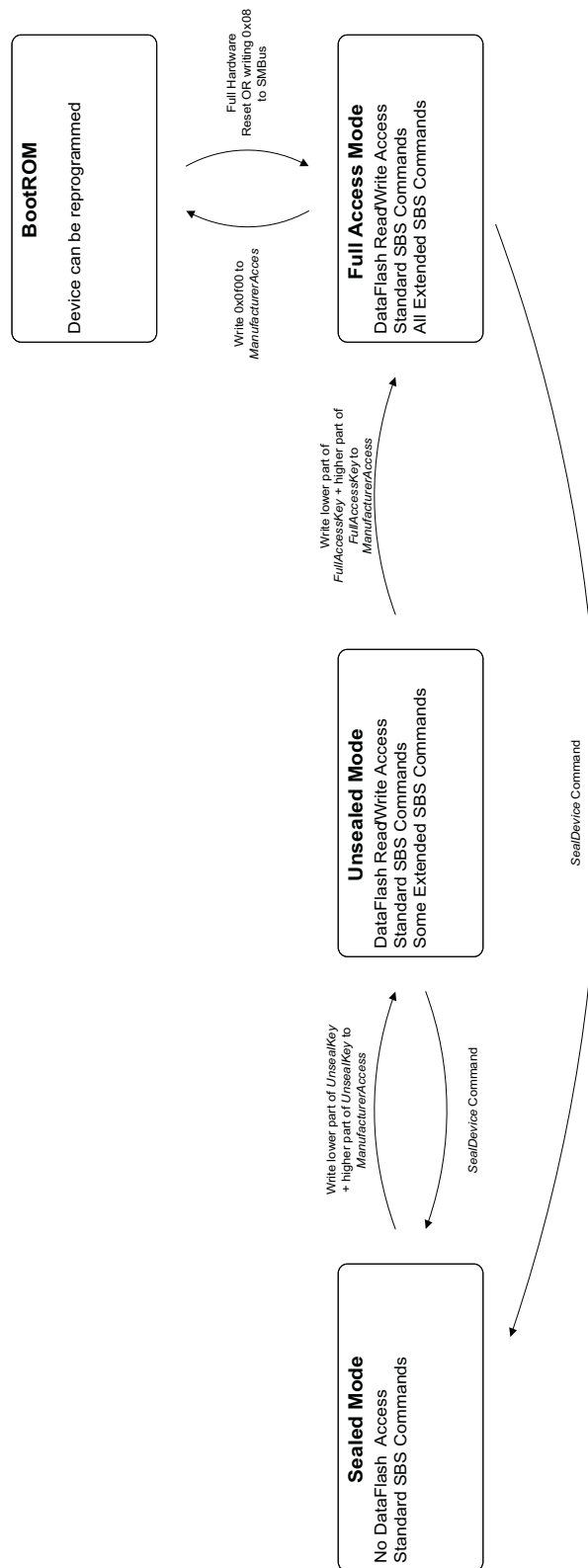
## 2.9 Security (Enables and Disables Features)

There are three levels of secured operation within the bq20z60-R1/bq20z65-R1. 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 bq20z60-R1/bq20z65-R1 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 bq20z60-R1/bq20z65-R1 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 two-step command performed by writing the first word of the *UnSealKey* to *ManufacturerAccess* followed by the second word of *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 bq20z60-R1/bq20z65-R1 to allow full access to all SBS commands and data flash. The bq20z60-R1/bq20z65-R1 is shipped from TI in this mode. The keys for Unsealed to Full Access can be read and changed via the extended SBS block command *FullAccessKey* when in Full Access mode. Changing from Unsealed to Full Access is performed by using the *ManufacturerAccess* command, by writing the first word of *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.

**Related Variables:**

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



**Figure 2-14. Security**



## 2.10 Calibration

### 2.10.1 Coulomb-Counter Dead Band

The bq20z60-R1/bq20z65-R1 does not accumulate charge or discharge for gas gauging when the current input is below the dead-band current threshold. The threshold is programmed in **CC Deadband** (coulomb-counter dead band) and should be set sufficiently high to prevent false signal detection with no charge or discharge flowing through the sense resistor.

**Related Variable:**

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

### 2.10.2 Autocalibration

The bq20z60-R1/bq20z65-R1 provides an autocalibration feature to cancel the voltage offset error across SRP and SRN for maximum charge measurement accuracy. The bq20z60-R1/bq20z65-R1 performs autocalibration when the SMBus lines stay low continuously for a minimum of 5 s and *Temperature* is within bounds of **Cal Inhibit Temp Low** and **Cal Inhibit Temp High**.

**Related Variables:**

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

## 2.11 Communications

The bq20z60-R1/bq20z65-R1 uses SMBus v1.1 with master mode and packet error checking (PEC) options per the SBS specification.

### 2.11.1 SMBus On and Off States

The bq20z60-R1/bq20z65-R1 detects an SMBus off state when SMBC and SMBD are logic-low for  $\geq 2$  seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

### 2.11.2 Packet Error Checking

The bq20z60-R1/bq20z65-R1 can receive or transmit data with or without PEC.

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

In the write-word protocol, the bq20z60-R1/bq20z65-R1 receives the PEC after the last byte of data from the host. If the host does not support PEC, the last byte of data is followed by a stop condition. After receipt of the PEC, the bq20z60-R1/bq20z65-R1 compares the value to its calculation. If the PEC is correct, the bq20z60-R1/bq20z65-R1 responds with an ACKNOWLEDGE. If it is not correct, the bq20z60-R1/bq20z65-R1 responds with a NOT ACKNOWLEDGE and sets an error code. If the host supports PEC, the **[HPE]** bit should be set to 1.

In the read-word and block-read in master mode, the host generates an ACKNOWLEDGE after the last byte of data sent by the bq20z60-R1/bq20z65-R1. The bq20z60-R1/bq20z65-R1 then sends the PEC, and the host, acting as a master receiver, generates a NOT ACKNOWLEDGE and a stop condition.

**Related Variable:**

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

### 2.11.3 bq20z60-R1/bq20z65-R1 Slave Address

The bq20z60-R1/bq20z65-R1 uses address 0x16 on the SMB for communication.



#### 2.11.4 Broadcasts to Smart Charger and Smart Battery Host

The bq20z60-R1/bq20z65-R1 can broadcast messages to the smart battery charger and smart battery host. This can be enabled with the **[BCAST]** bit.

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

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

**Related Variable:**

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



## Standard SBS Commands

The bq20z60-R1/bq20z65-R1 SBS command set meets the SBD v1.1 specification. All SBS values are updated in 1-second intervals.

### A.1 ManufacturerAccess (0x00)

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

**Table A-1. ManufacturerAccess**

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

#### A.1.1 System Data

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

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

Returns the IC part number.

**Table A-2. Device Type**

Manufacturer Access	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0001	R	Device Type	Hex	2	–	–	0x0600	–

##### 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	–	–	–	–

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

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

**Table A-4. Hardware Version**

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

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

This function is only available when the bq20z60-R1/bq20z65-R1 is in unsealed mode or full access mode, indicated by the *[SS]* and *[FAS]* flags. A write to this command forces the bq20z60-R1/bq20z65-R1 to generate a checksum of the full data flash (DF) array. The generated checksum is then returned within 45 ms.

---

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

---

**Table A-5. DF Checksum**

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

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

This function is available while the bq20z60-R1/bq20z65-R1 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
<b>High Byte</b>	FET1	FET0	PF1	PF0	STATE3	STATE2	STATE1	STATE0
<b>Low Byte</b>	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 is indicated by STATE3..STATE0

- 0,0 = Fuse is blown if enabled via DF:Configuration:Register(64):Permanent Fail Cfg(6), Permanent Fail Cfg 2(8)
- 0,1 = Cell imbalance failure
- 1,0 = Safety voltage failure
- 1,1 = FET failure

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

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

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

Returns the OCV table chemistry ID of the battery. The default table ID is 0x0100. For a list of OCV chemistry IDs, see the *Support of Multiple Li-Ion Chemistries With Impedance Track Gas Gauges* application note ([SLUA372](#)).

**Table A-6. Chemistry ID**

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

### A.1.2 System Control

The commands in this section cause the bq20z60-R1/bq20z65-R1 to take actions when written. No data is returned.

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

Instructs the bq20z60-R1/bq20z65-R1 to verify and enter shutdown mode (when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode). This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode. Shutdown is not entered unless the *PackVoltage* < **Charger Present** and *Current* ≤ 0.

In sealed mode, if the shutdown command (0x0010) is received 2 consecutive times, the bq20z60-R1/bq20z65-R1 enters ship mode. The 2 MAC writes cannot have any other MAC commands following or between them. For bq20z60-R1/bq20z65-R1 to enter ship mode, *PackVoltage* must be less than **Charger Present** threshold AND there are no safety conditions.

#### Related Variables:

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

### A.1.2.2 Sleep (0x0011)

Instructs the bq20z60-R1/bq20z65-R1 to verify and enter sleep mode if no other command is sent after the *Sleep* command. Any SMB transition wakes up the bq20z60-R1/bq20z65-R1. It takes about 1 minute before the device goes to sleep. This command is only available when the bq20z60-R1/bq20z65-R1 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 bq20z60-R1/bq20z65-R1 to limit access to the extended SBS functions and data flash space, sets the [SS] flag, and clears the [FAS] flag.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

See *Security*, [Section 2.9](#), for detailed information.

**Related Variable:**

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

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

This command forces the bq20z60-R1/bq20z65-R1 to begin the Impedance Track algorithm, changes **Update Status**, and sets the [QEN] flag.

This command is only available when the bq20z60-R1/bq20z65-R1 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 bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variable:**

- 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 bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variable:**

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

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

Activates all configured LEDs to stay on.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variables:**

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

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

Deactivates all configured LEDs.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variables:**

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

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

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

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variable:**

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

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

Places the bq20z60-R1/bq20z65-R1 into calibration mode. See the *Data Flash Programming and Calibrating the bq20zxx Family of Gas Gauges*, application report ([SLUA379A](#)) for further details.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variable:**

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

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

The bq20z60-R1/bq20z65-R1 undergoes a full reset. The bq20z60-R1/bq20z65-R1 holds the clock line down for a few milliseconds to complete the reset

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variable:**

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

**A.1.2.12 BootROM (0x0f00)**

The bq20z60-R1/bq20z65-R1 goes into BootROM mode.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Full Access mode.

**Related Variable:**

- SBS:OperationStatus(0x54)[FAS]

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

This two-step command must be written to *ManufacturerAccess* in following order: first word of the *PFKey* first, followed by the second word of the *PFKey*. If the command fails, 4 seconds must pass before the command can be reissued.

This command instructs the bq20z60-R1/bq20z65-R1 to clear the *PFStatus*, clear the *[PF]* flag, clear the **Fuse Flag**, reset the SAFE pin, and unlock the data flash for writes.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed or Full Access mode.

**Related Variables:**

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



---

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

---

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

Instructs the bq20z60-R1/bq20z65-R1 to enable access to the SBS functions and data flash space and clear the *[SS]* flag. This two-step command must be written to *ManufacturerAccess* in the following order: first word of the *UnSealKey* first, followed by the second word of the *UnSealKey*. If the command fails, 4 seconds must pass before the command can be reissued.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Sealed mode.

See *Security*, [Section 2.9](#), for detailed information.

**Related Variables:**

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

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

Instructs the bq20z60-R1/bq20z65-R1 to enable full access to all SBS functions and data flash space and set the *[FAS]* flag. This two-step command must be written to *ManufacturerAccess* in the following order: first word of the *FullAccessKey* first, followed by the second word of the *FullAccessKey*.

This command is only available when the bq20z60-R1/bq20z65-R1 is in Unsealed mode.

See *Security*, [Section 2.9](#), for detailed information.

**Related Variables:**

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

### A.1.3 Extended SBS Commands

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

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

- 0x0046 = SBS:FETControl(0x46) (Read Only)
- 0x0050 = SBS:SafetyAlert(0x50)
- 0x0051 = SBS:SafetyStatus(0x51)
- 0x0052 = SBS:PFAlert(0x52)
- 0x0053 = SBS:PFStatus(0x53)
- 0x0054 = SBS:OperationStatus(0x54)
- 0x0055 = SBS:ChargingStatus(0x55)
- 0x0057 = SBS:ResetData(0x57)
- 0x0058 = SBS:WDRResetData(0x58)
- 0x005a = SBS:PackVoltage(0x5a)
- 0x005d = SBS:AverageVoltage(0x5d)
- 0x0069 = SBS:SafetyStatus2(0x69)
- 0x006b = SBS:PFStatus2(0x6b)
- 0x006c = SBS:ManufBlock1(0x6c)
- 0x006d = SBS:ManufBlock2(0x6d)

0x006e = SBS:ManufBlock3(0x6e)  
0x006f = SBS:ManufBlock4(0x6f)  
0x0072 = SBS:TempRange(0x72)

## A.2 RemainingCapacityAlarm (0x01)

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

If *RemainingCapacity* < *RemainingCapacityAlarm*, the [RCA] flag is set and the bq20z60-R1/bq20z65-R1 sends an *AlarmWarning* message to the SMBUS host.

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

0 = Remaining capacity alarm is disabled  
1..700 = Remaining capacity limit for [RCA] flag

**Table A-7. RemainingCapacityAlarm**

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

### Related Variables:

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

## A.3 RemainingTimeAlarm (0x02)

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

If *AverageTimeToEmpty* < *RemainingTimeAlarm*, the [RTA] flag is set and the bq20z60-R1/bq20z65-R1 sends an *AlarmWarning* message to the SMBus host.

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

0 = Remaining time alarm is disabled  
1..30 = Remaining time limit for [RTA] flag

**Table A-8. RemainingTimeAlarm**

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

### Related Variables:

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

## A.4 BatteryMode (0x03)

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

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	CapM	ChgM	AM	RSVD	RSVD	RSVD	PB	CC
<b>Low Byte</b>	CF	RSVD	RSVD	RSVD	RSVD	RSVD	PBS	ICC

LEGEND: High byte is read/write, low byte is read-only; RSVD = Reserved and **must** be programmed to 0

**Figure A-2. BatteryMode**

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

- 0 = Reports in mA or mAh (default)
- 1 = Reports in 10 mW or 10 mWh

The following functions are instantaneously updated after a *[CapM]* change:

SBS:RemainingCapacityAlarm(0x01)  
 SBS:AtRate(0x04)  
 SBS:RemainingCapacity(0x0f)  
 SBS:FullChargeCapacity(0x10)  
 SBS:DesignCapacity(0x18)

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

SBS:RemainingTimeAlarm(0x02)  
 SBS:AtRateTimeToEmpty(0x06)  
 SBS:AtRateOK(0x07)  
 SBS:RunTimeToEmpty(0x11)  
 SBS:AverageTimeToEmpty(0x12)  
 SBS:BatteryStatus(0x16)

**ChgM**— Enables or disables the bq20z60-R1/bq20z65-R1 transmission of *ChargingCurrent* and *ChargingVoltage* messages to the Smart Battery Charger.

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

**Related Variables:**

DF:Configuration:Registers(64):Operation Cfg B(2)[BCAST]  
 SBS:ChargingCurrent(0x14)  
 SBS:ChargingVoltage(0x15)

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

- 0 = Enable *AlarmWarning* broadcast to host and Smart Battery Charger by setting the **[BCAST]** bit in **Operation Cfg B** (default). The bq20z60-R1/bq20z65-R1 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. The bq20z60-R1/bq20z65-R1 does not master the SMBus, and *AlarmWarning* messages are not sent to the SMBus Host and the Smart Battery Charger for a period of no more than 65 seconds and no less than 45 seconds. *[AM]* is automatically cleared by the bq20z60-R1/bq20z65-R1 60 seconds after being set to 1, independent of the **[BCAST]** bit.

**Related Variable:**

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

---

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

---

**PB**— Sets the role of the battery pack. This flag is not used by the bq20z60-R1/bq20z65-R1 and should be set to 0.

**CC**— Enable or disable internal charge controller. This flag is not used by bq20z60-R1/bq20z65-R1 and should be set to 0.

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

- 0 = Battery OK
- 1 = Condition cycle requested

**Related Variables:**

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

SBS:MaxError(0x0c)

**PBS**— Primary battery support is not supported by bq20z60-R1/bq20z65-R1 and is fixed to 0.

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

## A.5 AtRate (0x04)

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

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

The default value for *AtRate* is zero.

**Table A-9. AtRate**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x04	R/W	AtRate	Signed integer	2	-32,768	32,767	0	mA or 10 mW

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

*AtRateTimeToFull* can report time based on constant current ( $[CapM] = 0$ ) or constant power ( $[CapM] = 1$ ), and updates within 1 second after the SMBus host sets the *AtRate* value. The bq20z60-R1/bq20z65-R1 automatically updates *AtRateTimeToFull* based on the *AtRate* function at 1-second intervals.

- 0..65,534 = predicted time to full charge, based on *AtRate*
- 65,535 = no charge or discharge (*AtRate* is 0)

**Table A-10. AtRateTimeToFull**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x05	R	AtRateTimeToFull	Unsigned integer	2	0	65,535	–	min

**Related Variables:**

- SBS:AtRate(0x04)
- SBS:BatteryMode(0x03)[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 65,534, if the battery is discharged at the *AtRate* value. A value of 65,535 indicates that *AtRate* = 0.

*AtRateTimeToEmpty* can report time based on constant current ( $[LDMD] = 0$ ), or constant power ( $[LDMD] = 1$ ), and is updated within 1 second after the SMBus host sets the *AtRate* value. The bq20z60-R1/bq20z65-R1 updates *AtRateTimeToEmpty* at 1-second intervals.

- 0..65,534 = predicted remaining operating time, based on *AtRate*
- 65,535 = no charge or discharge (*AtRate* is 0)

**Table A-11. AtRateTimeToEmpty**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x06	R	AtRateTimeToEmpty	Unsigned integer	2	0	65,535	–	min

**Related Variables:**

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

**A.8 AtRateOK (0x07)**

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

The bq20z60-R1/bq20z65-R1 updates this value within 1 second after the SMBus host sets the *AtRate* function value. The bq20z60-R1/bq20z65-R1 updates *AtRateOK* at 1-second intervals.

If *AtRate* function returns  $\geq 0$ , *AtRateOK* always returns TRUE.

- 0 = FALSE bq20z60-R1/bq20z65-R1 **cannot** deliver energy for 10 seconds, based on discharge rate indicated in *AtRate*
- 1..65,535 = TRUE bq20z60-R1/bq20z65-R1 can deliver energy for 10 seconds, based on discharge rate indicated in *AtRate*

**Table A-12. AtRateOK**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x07	R	AtRateOK	Unsigned integer	2	0	65,535	–	min

**Related Variable:**

- 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 bq20z60-R1/bq20z65-R1. It has a range of 0 to 6553.5 K.

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

**Table A-13. Temperature**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x08	R	Temperature	Unsigned integer	2	0	65,535	–	0.1 K

**Related Variable:**

- 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 20,000 mV.

**Table A-14. Voltage**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x09	R	Voltage	Unsigned integer	2	0	20,000	–	mV

### A.11 Current (0x0a)

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

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

**Table A-15. Current**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0a	R	Current	Signed integer	2	–32,768	32,767	–	mA

**Related Variable:**

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

---

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

---

**A.12 AverageCurrent (0x0b)**

This read-word function returns a signed integer value that approximates a 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 14.5 s. During the time after a reset and before 14.5 s has elapsed, the reported *AverageCurrent* = *Current* function value.

**Table A-16. AverageCurrent**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0b	R	AverageCurrent	Signed integer	2	–32,768	32,767	–	mA

**Related Variables:**

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

**A.13 MaxError (0x0c)**

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

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

Event	MaxError Setting
Full reset	Set to 100%
QMAX and Ra table update	Set to 1%
QMAX update	Set to 3%
Ra table update	Set to 5%

**Table A-17. MaxError**

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

**Related Variable:**

- SBS:CycleCount(0x17)

**A.14 RelativeStateOfCharge (0x0d)**

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

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



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

**Table A-18. RelativeStateOfCharge**

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

**Related Variables:**

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

**A.15 AbsoluteStateOfCharge (0x0e)**

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

**CapM AbsoluteStateOfCharge Calculation**

0 = *RemainingCapacity* / **Design Capacity**

1 = *RemainingCapacity* / **Design Energy**

---

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

---

**Table A-19. AbsoluteStateOfCharge**

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

**Related Variables:**

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

**A.16 RemainingCapacity (0x0f)**

This read- or write-word function returns an unsigned integer value, with a range of 0 to 65,535, of the predicted charge or energy remaining in the battery. This value is expressed in either charge (mAh) or energy (10 mWh), depending on the setting of the *[CapM]* flag.

**Table A-20. RemainingCapacity**

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



**Related Variable:**

- SBS:BatteryMode(0x03)[CapM]

**A.17 FullChargeCapacity (0x10)**

This read-word function returns an unsigned integer value of the predicted pack capacity when it is fully charged. This value is expressed in either charge (mAh) or power (10 mWh) depending on setting of [CapM] flag. The maximum charge capacity is limited to 32Ah.

**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	32,767	–	mAh or 10 mWh

**Related Variable:**

- 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 minutes. A value of 65,535 indicates that the battery is not being discharged.

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

- 0..65,534 = Predicted remaining battery life, based on *Current*
- 65,535 = Battery is not being discharged

**Table A-22. RunTimeToEmpty**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x11	R	RunTimeToEmpty	Unsigned integer	2	0	65,534	–	min

**Related Variable:**

- SBS:BatteryMode(0x03)[CapM]

**A.19 AverageTimeToEmpty (0x12)**

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

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

- 0..65,534 = Predicted remaining battery life, based on *AverageCurrent*
- 65,535 = Battery is not being discharged

**Table A-23. AverageTimeToEmpty**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x12	R	AverageTimeToEmpty	Unsigned integer	2	0	65,534	–	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 65,534. A value of 65,535 indicates that the battery is not being charged.

- 0..65,534 = Predicted remaining time until full charge
- 65,535 = Battery is not being charged

**Table A-24. AverageTimeToFull**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x13	R	AverageTimeToFull	Unsigned integer	2	0	65,534	–	min

**Related Variable:**

- SBS:AverageCurrent(0x0b)

**A.21 ChargingCurrent (0x14)**

This read-word function returns an unsigned integer value of the desired charging current, in mA, with a range of 0 to 65,534. A value of 65,535 indicates that a charger should operate as a voltage source outside its maximum regulated current range.

- 0..65,534 = Desired charging current in mA
- 65,535 = Charger should operate as voltage source outside its maximum regulated current range.

**Table A-25. ChargingCurrent**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x14	R	ChargingCurrent	Unsigned integer	2	0	65,534	–	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 65,534. A value of 65,535 indicates that the charger should operate as a current source outside its maximum regulated voltage range.

- 0..65,534 = Desired charging voltage in mV
- 65,535 = cCharger should operate as current source outside its maximum regulated voltage range.

**Table A-26. ChargingVoltage**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x15	R	ChargingVoltage	Unsigned integer	2	0	65,534	–	mV

### A.23 BatteryStatus (0x16)

This read-word function returns the status of the bq20z60-R1/bq20z65-R1-based battery.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	OCA	TCA	RSVD	OTA	TDA	RSVD	RCA	RTA
<b>Low Byte</b>	INIT	DSG	FC	FD	EC3	EC2	EC1	EC0

LEGEND: All values read-only; RSVD = Reserved

**Figure A-3. BatteryStatus**

**OCA**— 1 = Over Charged Alarm

**TCA**— 1 = Terminate Charge Alarm

**OTA**— 1 = Over Temperature Alarm

**TDA**— 1 = Terminate Discharge Alarm

**RCA**— Remaining Capacity Alarm

1 = Remaining Capacity Alarm is set

See: [SBS:RemainingCapacityAlarm\(0x01\)](#)

**RTA**— Remaining Time Alarm

1 = Remaining Time Alarm is set

See: [SBS:RemainingTimeAlarm\(0x02\)](#)

**INIT**— 1 = Initialization. The INIT flag is always set in normal operation.

**DSG**— Discharging

0 = bq20z60-R1/bq20z65-R1 is in charging mode

1 = bq20z60-R1/bq20z65-R1 is in discharging mode or relaxation mode, or valid charge termination has occurred.

See: *Gas Gauging*, [Section C.10](#)

**FC**— 1 = Fully Charged

**FD**— 1 = Fully Discharged

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

0,0,0,0 = OK	bq20z60-R1/bq20z65-R1 processed the function code with no errors detected.
0,0,0,1 = BUSY	bq20z60-R1/bq20z65-R1 is unable to process the function code at this time.
0,0,1,0 = Reserved	bq20z60-R1/bq20z65-R1 detected an attempt to read or write to a function code reserved by this version of the specification, or bq20z60-R1/bq20z65-R1 detected an attempt to access an unsupported optional manufacturer function code.
0,0,1,1 = Unsupported	bq20z60-R1/bq20z65-R1 does not support this function code as defined in this version of the specification.
0,1,0,0 = AccessDenied	bq20z60-R1/bq20z65-R1 detected an attempt to write to a read-only function code.
0,1,0,1 = Over/Underflow	bq20z60-R1/bq20z65-R1 detected a data overflow or underflow.

- 0,1,1,0 = BadSize      bq20z60-R1/bq20z65-R1 detected an attempt to write to a function code with an incorrect data block.
- 0,1,1,1 = UnknownError      bq20z60-R1/bq20z65-R1 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 the data flash value **Cycle Count**, which is updated each time this variable is incremented. One cycle count is the accumulated discharge of **CC Threshold**.

When the bq20z60-R1/bq20z65-R1 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	65,535	0	–

### Related Variables:

- DF:SBS Configuration:Data(48)Cycle Count(16)
- DF:SBS Configuration:Data(48)CC Threshold(18)

## A.25 DesignCapacity (0x18)

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

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

When the bq20z60-R1/bq20z65-R1 is in unsealed or full-access mode, this block is R/W. The maximum capacity is 32Ah.

**Table A-28. DesignCapacity**

SBS Cmd.	Mode	Name	CapM	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x18	R/W	DesignCapacity	0	Unsigned integer	2	0	32,767	4400	mAh
			1	Unsigned integer	2	0	32,767	6336	10 mWh

### Related Variables:

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

## A.26 DesignVoltage (0x19)

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

When the bq20z60-R1/bq20z65-R1 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	18,000	14,400	mV

**Related Variables:**

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

**A.27 SpecificationInfo (0x1a)**

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

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

$$\text{IPScale} \times 0x1000 + \text{VScale} \times 0x0100 + \text{SpecID\_H} \times 0x0010 + \text{SpecID\_L}$$

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

When the bq20z60-R1/bq20z65-R1 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 $10^{\text{IPScale}}$ )				VScale (0) (multiplies voltage by $10^{\text{VScale}}$ )				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:

$$(\text{Year} - 1980) \times 512 + \text{month} \times 32 + \text{day}$$

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

When the bq20z60-R1/bq20z65-R1 is in unsealed or full-access mode, this block is R/W.

**Table A-31. ManufactureDate**

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

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

**Figure A-5. ManufacturerDate**

**Related Variables:**

- DF:SBS Configuration:Data(48):Manuf Date(12)
- SBS:OperationStatus(0x54)[SS],[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 bq20z60-R1/bq20z65-R1 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 20 characters (20 data + length byte).

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

When the bq20z60-R1/bq20z65-R1 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	20 + 1	–	–	Texas Instruments	–

**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 20 characters (20 data + length byte).

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

When the bq20z60-R1/bq20z65-R1 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	20 + 1	–	–	bq20z60 or bq20z65	–

**Related Variables:**

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

**A.32 DeviceChemistry (0x22)**

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

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

When the bq20z60-R1/bq20z65-R1 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	–

**Related Variables:**

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

**A.33 ManufacturerData (0x23)**

This read-block function returns several configuration data flash elements with an absolute maximum length of 14 data + 1 length byte (stored in ManufacturerData Length). The ManufacturerData elements shown in [Table A-36](#) are stored in the ManufacturerData subclass.

When the bq20z60-R1/bq20z65-R1 is in Unsealed or full-access mode, this block is R/W.

**Table A-36. ManufacturerData**

Data	Byte	Name	Format
Manufacturer Data	0	Pack Lot Code	Hex
	1		
	2	PCB Lot Code	
	3		
	4	Firmware Version	
	5		
	6	Hardware Revision	
	7		
	8	Cell Revision	
bq20z60-R1/bq20z65-R1 Counter	10	Partial Reset Counter	
	11	Full Reset Counter	
	12	Watchdog Reset Counter	
	13	Check Sum	
	14	String Length Byte	

**Related Variables:**

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

### A.34 Authenticate (0x2f)

This read- or write-block function allows the host to authenticate a bq20z60-R1/bq20z65-R1-based battery using an SHA-1 authentication transform with a length of 20 data bytes + 1 length byte. See the *Using SHA-1 in bq20zxx Family of Gas Gauges* application report ([SLUA359](#)) for detailed information.

**Table A-37. Authenticate**

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

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

These read-word functions return an unsigned value of the calculated individual cell voltages, in mV, with a range of 0 to 65,535. *CellVoltage1* corresponds to the bottommost series cell element, whereas *CellVoltage4* corresponds to the topmost series cell element.

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

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x3c	R	CellVoltage4	Unsigned integer	2	0	65,535	–	mV
0x3d		CellVoltage3					–	
0x3e		CellVoltage2					–	
0x3f		CellVoltage1					–	

### 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	Integer	2	0	700 or 1000	300 or 432	mAh or 10 mWh
0x02	R/W	RemainingTimeAlarm	Unsigned integer	2	0	30	10	min
0x03	R/W	BatteryMode	Hex	2	0x0000	0xffff	–	–
0x04	R/W	AtRate	Integer	2	–32,768	32,767	0	mA or 10 mW
0x05	R	AtRateTimeToFull	Unsigned integer	2	0	65,535	–	min
0x06	R	AtRateTimeToEmpty	Unsigned integer	2	0	65,535	–	min
0x07	R	AtRateOK	Unsigned integer	2	0	65,535	–	–
0x08	R	Temperature	Unsigned integer	2	0	65,535	–	0.1 K
0x09	R	Voltage	Unsigned integer	2	0	20,000	–	mV
0x0a	R	Current	Integer	2	–32,768	32,767	–	mA
0x0b	R	AverageCurrent	Integer	2	–32,768	32,767	–	mA
0x0c	R	MaxError	Unsigned integer	1	0	100	–	%
0x0d	R	RelativeStateOfCharge	Unsigned integer	1	0	100	–	%
0x0e	R	AbsoluteStateOfCharge	Unsigned integer	1	0	100+	–	%



**Table A-39. SBS COMMANDS (continued)**

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x0f	R/W	RemainingCapacity	Unsigned integer	2	0	65,535	–	mAh or 10 mWh
0x10	R	FullChargeCapacity	Unsigned integer	2	0	32,767	–	mAh or 10 mWh
0x11	R	RunTimeToEmpty	Unsigned integer	2	0	65,534	–	min
0x12	R	AverageTimeToEmpty	Unsigned integer	2	0	65,534	–	min
0x13	R	AverageTimeToFull	Unsigned integer	2	0	65,534	–	min
0x14	R	ChargingCurrent	Unsigned integer	2	0	65,534	–	mA
0x15	R	ChargingVoltage	Unsigned integer	2	0	65,534	–	mV
0x16	R	BatteryStatus	Hex	2	0x0000	0xdbff	–	–
0x17	R/W	CycleCount	Unsigned integer	2	0	65,535	0	–
0x18	R/W	DesignCapacity	Integer	2	0	32,767	4400 or 6336	mAh or 10 mWh
0x19	R/W	DesignVoltage	Integer	2	7000	18,000	14,400	mV
0x1a	R/W	SpecificationInfo	Hex	2	0x0000	0xffff	0x0031	–
0x1b	R/W	ManufactureDate	Unsigned integer	2	–	65,535	0	–
0x1c	R/W	SerialNumber	Hex	2	0x0000	0xffff	0	–
0x20	R/W	ManufacturerName	String	20 + 1	–	–	Texas Instruments	–
0x21	R/W	DeviceName	String	20 + 1	–	–	bq20z60 or bq20z65	–
0x22	R/W	DeviceChemistry	String	4 + 1	–	–	LION	–
0x23	R/W	ManufacturerData	String	14 + 1	–	–	–	–
0x2f	R/W	Authenticate	String	20 + 1	–	–	–	–
0x3c	R	CellVoltage4	Unsigned integer	2	0	65,535	–	mV
0x3d	R	CellVoltage3	Unsigned integer	2	0	65,535	–	mV
0x3e	R	CellVoltage2	Unsigned integer	2	0	65,535	–	mV
0x3f	R	CellVoltage1	Unsigned integer	2	0	65,535	–	mV



## Extended SBS Commands

The extended SBS commands are only available when the bq20z60-R1/bq20z65-R1 device is in unsealed or full access mode, unless otherwise noted.

**Related Variables:**

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

### B.1 AFEData (0x45)

This read-block function returns a string of 11 data bytes + 1 length byte. The first 9 bytes are the AFE memory map followed by 2 bytes of the internal bq20z60-R1/bq20z65-R1 AFE\_Fail\_Counter.

**Table B-1. AFEData**

Data	Byte	Name	Format
AFE	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	
bq20z60-R1/bq20z65-R1	9	Internal AFE_Fail_Counter high byte	
	10	Internal AFE_Fail_Counter low byte	
	11	String Length Byte	

**Related Variables:**

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

### B.2 FETControl (0x46)

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

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>FETControl</b>	RSVD	RSVD	RSVD	OD	ZVCHG	CHG	DSG	RSVD

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

**Figure B-1. FETControl**

**OD**— AFE 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 does not turn off in discharge mode to protect the FET body diode.
- 1 = Turn ON CHG FET

**DSG**— Discharge FET Control

- 0 = Turn OFF DSG FET. DSG FET does not turn off in charge mode to protect the FET body diode.
- 1 = Turn ON DSG FET

### B.3 StateOfHealth (0x4f)

This read word function returns the state of health of the battery in % as well as information about the cell deterioration. The calculation formula depends on the *[CapM]* flag.

**CapM StateOfHealth**

- 0 =  $FullChargeCapacity / Design Capacity$
- 1 =  $FullChargeCapacity / Design Energy$

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	CLL	DetF	DetW
<b>Low Byte</b>	State of Health %							

LEGEND: All values read-only; RSVD = Reserved

#### Figure B-2. Operation Status

**CLL**— (Cell Life Limit) 1 = Capacity of the pack fallen below **Cell Life Limit** threshold

**DetW**— (Deterioration Warning) 1 = Capacity of the pack fallen below **Deterioration Warn Limit** threshold

**DetF**— (Deterioration Fault) 1 = Capacity of the pack fallen below **Deterioration Fault Limit** threshold

**Related Variables:**

- DF:SBS Configuration:Data(48):Design Capacity(22)
- DF:SBS Configuration:Data(48):Design Energy(24)
- DF: SBS Configuration:Data(48):Deterioration Warn Limit(73)
- DF: SBS Configuration:Data(48):Deterioration Fault Limit(74)
- DF: SBS Configuration:Data(48):Cell Life Limit(75)
- SBS:FullChargeCapacity(0x10)
- SBS:BatteryMode(0x03)[CapM]

## B.4 SafetyAlert (0x50)

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

See *1st Level Protection Features*, [Section 2.2](#), for further details.

### Related Variable:

- SBS:SafetyStatus(0x51)

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	OT1D	OT1C	OCD	OCC	OCD2	OCC2	RSVD	RSVD
<b>Low Byte</b>	CUV	COV	PF	HWDG	WDF	AOCD	SCC	SCD

LEGEND: All values read-only

**Figure B-3. SafetyAlert**

**OT1D**— 1 = Discharge overtemperature on TS1 alert

**OT1C**— 1 = Charge overtemperature on TS1 alert

**OCD**— 1 = Discharge overcurrent alert

**OCC**— 1 = Charge overcurrent alert

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

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

**CUV**— 1 = Cell undervoltage alert

**PF**— 1 = Permanent failure alert

**COV**— 1 = Cell overvoltage alert

**HWDG**— 1 = Host watchdog alert

**WDF**— 1 = AFE watchdog alert

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

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

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

## B.5 SafetyStatus (0x51)

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

See *1st Level Protection Features*, [Section 2.2](#), for further details.

### Related Variables:

- SBS:SafetyAlert(0x50)

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	OT1D	OT1C	OCD	OCC	OCD2	OCC2	RSVD	RSVD
<b>Low Byte</b>	CUV	COV	PF	HWDG	WDF	AOCD	SCC	SCD

LEGEND: All values read-only; RSVD = Reserved

**Figure B-4. SafetyStatus**

- OT1D**— 1 = Discharge overtemperature on TS1 condition
- OT1C**— 1 = Charge overtemperature on TS1 condition
- OCD**— 1 = Discharge overcurrent condition
- OCC**— 1 = Charge overcurrent condition
- OCD2**— 1 = Tier-2 discharge overcurrent condition
- OCC2**— 1 = Tier-2 charge overcurrent condition
- CUV**— 1 = Cell undervoltage condition
- COV**— 1 = Cell overvoltage condition
- PF**— 1 = Permanent failure condition.
- HWDG**— 1 = Host watchdog condition
- WDF**— 1 = AFE watchdog condition
- AOCD**— 1 = AFE discharge overcurrent condition
- SCC**— 1 = Charge short-circuit condition
- SCD**— 1 = Discharge short-circuit condition

## B.6 PFAAlert (0x52)

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

See *2nd Level Protection Features*, [Section 2.3](#), for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	FBF	RSVD	SUV	SOPT1	SOCD	SOCC	AFE_P	ACE_C
<b>Low Byte</b>	DFF	DFETF	CFETF	CIM_R	SOT1D	SOT1C	SOV	PFIN

LEGEND: All values read-only; RSVD = Reserved

**Figure B-5. PFAAlert**

- FBF**— 1 = Fuse Blow Failure alert
- SUV**— 1 = Safety Undervoltage permanent failure alert
- SOPT1**— 1 = Open Thermistor, TS1, permanent failure alert
- SOCD**— 1 = Discharge Safety Overcurrent permanent failure alert
- SOCC**— 1 = Charge Safety-Overcurrent permanent failure alert
- AFE\_P**— 1 = Periodic AFE Communications permanent failure alert
- AFE\_C**— 1 = Permanent AFE Communications failure alert
- DFF**— 1 = Data Flash Fault permanent failure alert
- DFETF**— 1 = Discharge-FET-Failure permanent failure alert
- CFETF**— 1 = Charge-FET-Failure permanent failure alert
- CIM\_R**— 1 = Cell-Imbalance (At Rest method) permanent failure alert
- SOT1D**— 1 = Discharge Safety Overtemperature on TS1 permanent failure alert
- SOT1C**— 1 = Charge Safety Overtemperature on TS1 permanent failure alert

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

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

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- SBS:PFAlert2(0x6a)
- SBS:PFStatus(0x53)
- SBS:PFStatus2(0x6b)

## B.7 PFStatus (0x53)

The permanent failure status register indicates the source of the bq20z60-R1/bq20z65-R1 permanent-failure condition.

Any new permanent failure is added to **Saved PF Flags 1..2** register to show all permanent failures that have occurred.

See *2nd Level Protection Features*, [Section 2.3](#), for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	FBF	RSVD	SUV	SOPT1	SOCD	SOCC	AFE_P	AFE_C
<b>Low Byte</b>	DFF	DFETF	CFETF	CIM_R	SOT1D	SOT1C	SOV	PFIN

LEGEND: All values read-only; RSVD = Reserved

**Figure B-6. PFStatus**

**FBF**— 1 = Fuse Blow Failure

**SUV**— 1 = Safety Undervoltage permanent failure

**SOPT1**— 1 = Open Thermistor on TS1 permanent failure

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

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

**AFE\_P**— 1 = Periodic AFE Communications permanent failure

**AFE\_C**— 1 = Permanent AFE Communications failure

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

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

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

**CIM\_R**— 1 = Cell-Imbalance (At Rest method) permanent failure

**SOT1D**— 1 = Discharge Safety Overtemperature on TS1 permanent failure

**SOT1C**— 1 = Charge Safety Overtemperature on TS1 permanent failure

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

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

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg 1(6),Permanent Fail Cfg 2(8)
- DF:PF Status:Device Status Data(96):Saved PF Flags 1(0),Saved PF Flags 2(2)
- DF:PF Status:Device Status Data(96):Saved 1st PF Flag 1(32), Saved 1st PF Flag 2(34)
- SBS:PFAlert(0x52)
- SBS:PFAlert2(0x6a)

- SBS:PFStatus2(0x6b)

## B.8 OperationStatus (0x54)

This read-word function returns the current operation status of the bq20z60-R1/bq20z65-R1.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	PRES	FAS	SS	CSV	RSVD	LDMD	RSVD	RSVD
<b>Low Byte</b>	WAKE	DSG	XDSG	XDSGI	DSGIN	R_DIS	VOK	QEN

LEGEND: All values read-only; RSVD = Reserved

**Figure B-7. OperationStatus**

**PRES**— 1 = PRES is low, indicating that the system is present (battery inserted).

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

**SS**— 1 = Sealed security mode

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

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

**WAKE**— 1 = bq20z60-R1/bq20z65-R1 WAKE mode

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

**XDSG**— 1 = Discharge fault

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

**DSGIN**— 1 = Discharge inhibited due to a high temperature issue

**R\_DIS**— 1 = Ra Table resistance updates are disabled

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

**QEN**— 1 = QMAX updates are enabled

## B.9 ChargingStatus (0x55)

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

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	XCHG	CHSUSP	PCHG	MCHG	LTCHG	ST1CHG	ST2CHG	HTCHG
<b>Low Byte</b>	RSVD	CB	PCMTO	CMTO	OCHGV	OCHGI	OC	XCHGLV

LEGEND: All values read-only

**Figure B-8. ChargingStatus**

**XCHG**— 1 = Charging disabled

**CHGSUSP**— 1 = Charging suspended

**PCHG**— 1 = Precharging

**MCHG**— 1 = Maintenance charging

**LTCHG**— 1 = Low temperature charging

**ST1CHG**— 1 = Standard temperature charging 1

**ST2CHG**— 1 = Standard temperature charging 2

**HTCHG**— 1 = High temperature charging



- CB**— 1 = Cell balancing in progress
- PCMTO**— 1 = Precharge timeout fault
- CMTO**— 1 = Charge timeout fault
- OCHGV**— 1 = Overcharge voltage fault
- OCHGI**— 1 = Overcharge current fault
- OC**— 1 = Overcharge fault
- XCHGLV**— 1 = Battery is depleted

### B.10 ResetData (0x57)

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

**Table B-2. ResetData**

SBS Cmd.	Mode	Name	Byte	Contents	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x57	R	ResetData	Low byte	Partial resets	Unsigned integer	1	0	255	–	–
			High byte	Full resets	Unsigned integer	1	0	255	–	–

### B.11 WDRResetData (0x58)

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

**Table B-3. WDRResetData**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x58	R	WDRResetData	Unsigned integer	2	0	65,535	–	–

### B.12 PackVoltage (0x5a)

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

**Table B-4. PackVoltage**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5a	R	PackVoltage	Unsigned integer	2	0	65,535	–	mV

### B.13 AverageVoltage (0x5d)

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

**Table B-5. AverageVoltage**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5d	R	AverageVoltage	Unsigned integer	2	0	65,535	–	mV

**Related Variable:**

- SBS:Voltage(0x09)

### B.14 TS1Temperature (0x5e)

This read-block function returns the TS1 temperature reading. In addition to being accessible in full-access and unsealed modes, this command is also accessible in sealed mode.

**Table B-6. TS1Temperature**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5e	R	TS1Temperature	Integer	2	-400	1200	–	0.1°C

### B.15 TS2Temperature (0x5f)

This read-block function returns the TS2 temperature reading. In addition to being accessible in full-access and unsealed modes, this command is also accessible in sealed mode.

**Table B-7. TS2Temperature**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5f	R	TS2Temperature	Integer	2	-400	1200	–	0.1°C

### B.16 UnSealKey (0x60)

This read- or write-block command allows the user to change the unseal key for the sealed-to-unsealed security-state transition. This function is only available when the bq20z60-R1/bq20z65-R1 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

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

**Table B-8. UnSealKey**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x60	R/W	UnSealKey	Hex	4	0x0000 0000	0xffff ffff	–	–

**Related Variable:**

- SBS:OperationStatus(0x54)[FAS]

### B.17 FullAccessKey (0x61)

This read- or write-block command allows the user to change the full-access security key for the unsealed-to-full access security-state transition. This function is only available when the bq20z60-R1/bq20z65-R1 is in the Full Access mode, indicated by a cleared *[FAS]* flag.

The order of the bytes, when entered in *ManufacturerAccess*, is the reverse of what is written to or read from the part. For example, if the first and second words of the *FullAccessKey* block-read return 0x1234 and 0x5678, then in *ManufacturerAccess*, 0x3412 and 0x7856 should be entered to put the part in full access mode.

**Table B-9. FullAccessKey**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x61	R/W	FullAccessKey	Hex	4	0x0000 0000	0xffff ffff	–	–

**Related Variable:**

- SBS:OperationStatus(0x54)[FAS]

**B.18 PFKey (0x62)**

This read- or write-block command allows the user to change the Permanent Failure Clear key. This function is only available when the bq20z60-R1/bq20z65-R1 is in the full-access mode, indicated by a cleared [FAS] flag.

The order of the bytes, when entered in *ManufacturerAccess*, is the reverse of what is written to or read from the part. For example, if the first and second words of the *PFKey* block-read return 0x1234 and 0x5678, then in *ManufacturerAccess*, 0x3412 and 0x7856 should be entered to clear a permanent failure.

**Table B-10. PFKey**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x62	R/W	PFKey	Hex	4	0x0000 0000	0xffff ffff	–	–

**Related Variable:**

- SBS:OperationStatus(0x54)[FAS]

**B.19 AuthenKey3 (0x63)**

This read- or write-block command stores byte 12 to byte 15 of the 16-byte-long authentication key. This function is only available when the bq20z60-R1/bq20z65-R1 is in the full-access mode, indicated by a cleared [FAS] flag.

**Table B-11. AuthenKey3**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x63	R/W	AuthenKey3	Hex	4	0x0000 0000	0xffff ffff	0x1032 5476	–

**Related Variables:**

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

**B.20 AuthenKey2 (0x64)**

This read- or write-block command stores byte 8 to byte 11 of the 16-byte-long authentication key. This function is only available when the bq20z60-R1/bq20z65-R1 is in the full-access mode, indicated by a cleared [FAS] flag.

**Table B-12. AuthenKey2**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x64	R/W	AuthenKey2	Hex	4	0x0000 0000	0xffff ffff	0x98ab dcfe	–

**Related Variables:**

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

**B.21 AuthenKey1 (0x65)**

This read- or write-block command stores byte 4 to byte 7 of the 16-byte-long authentication key. This function is only available when the bq20z60-R1/bq20z65-R1 is in the full-access mode, indicated by a cleared [FAS] flag.

**Table B-13. AuthenKey1**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x65	R/W	AuthenKey1	Hex	4	0x0000 0000	0xffff ffff	0xdfce ab89	–

**Related Variables:**

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

**B.22 AuthenKey0 (0x66)**

This read- or write-block command stores byte 0 to byte 3 of the 16-byte-long authentication key. This function is only available when the bq20z60-R1/bq20z65-R1 is in the full-access mode, indicated by a cleared *[FAS]* flag.

**Table B-14. AuthenKey0**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x66	R/W	AuthenKey0	Hex	4	0x0000 0000	0xffff ffff	0x6745 2301	–

**Related Variables:**

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

**B.23 SafetyAlert2 (0x68)**

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

See *1st Level Protection Features*, Section 2.2, for further details.

**Table B-15. SafetyAlert2**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x68	R	SafetyAlert2	Hex	2	0x0000	0x0003	–	–

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	OT2D	OT2C

LEGEND: All values read-only. RSVD = Reserved

**Figure B-9. SafetyAlert2**

**OT2D**— 1 = Discharge overtemperature alert on TS2

**OT2C**— 1 = Charge overtemperature alert on TS2

**Related Variables:**

- SBS:SafetyStatus2(0x69)

**B.24 SafetyStatus2 (0x69)**

This read-word function returns indications of pending safety issues that have not reached the required time or value to trigger a *SafetyStatus* failure.

See *1st Level Protection Features*, Section 2.2, for further details.

**Table B-16. SafetyStatus2**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x69	R	SafetyStatus2	Hex	2	0x0000	0x0003	–	–

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	OT2D	OT2C

LEGEND: All values read-only. RSVD = Reserved

**Figure B-10. SafetyStatus2**

**OT2D**— 1 = Discharge overtemperature condition on TS2

**OT2C**— 1 = Charge overtemperature condition on TS2

**Related Variables:**

- SBS:SafetyAlert2(0x68)

## B.25 PFAAlert2 (0x6a)

This read-word function returns indications of pending safety issues that have not reached the required time or value to trigger a permanent failure.

See *2nd Level Protection Features*, Section 2.3, for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	SOPT2	SOT2D	SOT2C	CIM_A

LEGEND: All values read-only. RSVD = Reserved

**Figure B-11. PFAAlert2**

**CIM\_A**— 1 = Cell-Imbalance (Active method) permanent failur alert

**SOT2D**— 1 = Discharge Safety Overtemperature on TS2 permanent failure alert

**SOT2C**— 1 = Charge Safety Overtemperature in TS2 permanent failure alert

**SOPT2**— 1 = Open Thermistor on TS2 permanent failure alert

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- SBS:PFAAlert(0x52)
- SBS:PFStatus2(0x6b)

## B.26 PFStatus2 (0x6b)

The permanent failure status register indicates the source of the bq20z60-R1/bq20z65-R1 permanent failure condition.

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

See *2nd Level Protection Features*, Section 2.3, for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	SOPT2	SOT2D	SOT2C	CIM_A

LEGEND: All values read-only. RSVD = Reserved

**Figure B-12. PFStatus2**

- CIM\_A**— 1 = Cell-Imbalance (Active method) permanent failure
- SOT2D**— 1 = Discharge Safety Overtemperature on TS2 permanent failure
- SOT2C**— 1 = Charge Safety Overtemperature in TS2 permanent failure
- SOPT2**— 1 = Open Thermistor on TS2 permanent failure

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):Saved PF Flags2(2)
- DF:PF Status:Device Status Data(96): Saved 1st PF Flag 2(34)
- SBS:PFAlert(0x52)
- SBS:PFStatus(0x53)
- SBS:PFAlert2(0x6a)

### B.27 ManufBlock1..4 (0x6c..0x6f)

These read/write commands are used to access four 20-byte locations, **ManufBlock1..4** that contain manufacturer data. These commands are available in sealed and unsealed modes. See the bq20z60-R1/bq20z65-R1 data sheet (SLUS877, SLUS878) for allowable number of write cycles.

**Table B-17. ManufBlock1..4**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x6c	R/W	ManufBlock1	String	20	–	–	–	–
0x6d	R/W	ManufBlock2	String	20	–	–	–	–
0x6e	R/W	ManufBlock3	String	20	–	–	–	–
0x6f	R/W	ManufBlock4	String	20	–	–	–	–

**Related Variables:**

- DF:System Data:Manufacturer Info(58):Manuf. Block 1..4(32..95)

## B.28 ManufacturerInfo (0x70)

This read/write block function returns the data stored in **Manuf. Info** where byte 0 is the MSB with a maximum length of 31 data + 1 length byte. This command is also accessible in Sealed mode. See the bq20z60-R1/bq20z65-R1 data sheet (SLUS801A, SLUS800) for allowable number of write cycles.

**Table B-18. ManufacturerInfo**

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

### Related Variables:

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

## B.29 SenseResistor (0x71)

This read or write word command allows the user to change the sense resistor value used in  $\mu\Omega$ . The bq20z60-R1/bq20z65-R1 automatically updates the associated calibration data on receipt of a new sense resistor value.

**Table B-19. SenseResistor**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x71	R/W	SenseResistor	Unsigned integer	2	0	65,535	10,000	$\mu\Omega$

## B.30 TempRange (0x72)

This read-word function returns the present temperature range in effect.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	TR5	TR4	TR3	TR2A	TR2	TR1

LEGEND: All values read-only. RSVD = Reserved

**Figure B-13. TempRange**

- **TR1** – 1 = temperature range 1:  $Temperature < JT1$
- **TR2** – 1 = temperature range 2:  $JT1 < Temperature < JT2$
- **TR2A** – 1 = temperature range 3:  $JT2 < Temperature < JT2a$
- **TR3** – 1 = temperature range 4:  $JT2a < Temperature < JT3$
- **TR4** – 1 = temperature range 5:  $JT3 < Temperature < JT4$
- **TR5** – 1 = temperature range 6:  $JT4 < Temperature$

**B.31 LifetimeData1 (0x73)**

This read-block function returns the lifetime data, including lifetime temperature samples.



**Table B-20. LifetimeData1**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x73	R	LifetimeData1	String	32 + 1	–	–	–	–

**Table B-21. LifetimeData1 Block Format**

Byte	Data	Byte	Data
0	Lifetime Temp Max	16	Lifetime Max Chg Power
1		17	
2	Lifetime Min Temp	18	Lifetime Max Dsg Power
3		19	
4	Lifetime Max Cell Voltage	20	Lifetime Max Avg Dsg Current
5		21	
6	Lifetime Min Cell Voltage	22	Lifetime Max Avg Dsg Power
7		23	
8	Lifetime Max Pack Voltage	24	Lifetime Avg Temp
9		25	
10	Lifetime Min Pack Voltage	26	LT Temp Samples
11		27	
12	Lifetime Max Chg Current	28	
13		29	
14	Lifetime Max Dsg Current	30	-
15		31	

### B.32 LifetimeData2 (0x74)

This read-block function returns second part of the lifetime data including OT and OV event count and duration.

**Table B-22. LifetimeData2**

SBS Cmd.	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x74	R	LifetimeData2	String	8 + 1	–	–	–	–

**Table B-23. LifetimeData2 Block Format**

Byte	Data
0	OT Event Count
1	
2	OT Event Duration
3	
4	OV Event Count
5	
6	OV Event Duration
7	

### B.33 DataFlashSubClassID (0x77)

This write word function sets the bq20z60-R1/bq20z65-R1 data flash subclass, where data can be accessed by following the *DataFlashSubClass1..8* commands.

See *Accessing Data Flash*, [Section C.1](#), 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-24. DataFlashSubClassID**

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

**Related Variable:**

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

**B.34 DataFlashSubClassPage1..8 (0x78..0x7f)**

These commands are used to access the consecutive 32-byte pages of each subclass.

*DataFlashSubClassPage1* gets bytes 0 to 31 of the subclass, *DataFlashSubClassPage2* gets bytes 32 to 63, and so on.

---

**NOTE:** Any DF location deemed reserved responds with a *NACK* unless the bq20z60-R1/bq20z65-R1 is in the correct security state to allow access.

---

**Table B-25. DataFlashSubClass1..8**

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

**Related Variable:**

- SBS:DataFlashSubClassID(0x77)

**B.35 Extended SBS Command Values**
**Table B-26. 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	2	0x00	0xff	—	—
0x4f	R	StateOfHealth	Hex	2	0x0000	0xffff	—	—
0x50	R	SafetyAlert	Hex	2	0x0000	0xffff	—	—
0x51	R	SafetyStatus	Hex	2	0x0000	0xffff	—	—
0x52	R	PFAlert	Hex	2	0x0000	0xffff	—	—
0x53	R	PFStatus	Hex	2	0x0000	0xffff	—	—
0x54	R	OperationStatus	Hex	2	0x0000	0xffff	—	—
0x55	R	ChargingStatus	Hex	2	0x0000	0xffff	—	—
0x57	R	ResetData	Hex	2	0x0000	0xffff	—	—
0x58	R	WDRResetData	Unsigned integer	2	0	65535	—	—
0x5a	R	PackVoltage	Unsigned integer	2	0	65535	—	mV

**Table B-26. EXTENDED SBS COMMANDS (continued)**

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5d	R	AverageVoltage	Unsigned integer	2	0	65535	—	mV
0x5e	R	TS1Temperature	Integer	2	–400	1200	—	0.1°C
0x5f	R	TS2Temperature	Integer	2	–400	1200	—	0.1°C
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	—	—
0x68	R	SafetyAlert2	Hex	2	0x0000	0x000f	—	—
0x69	R	SafetyStatus2	Hex	2	0x0000	0x000f	—	—
0x6a	R	PFAAlert2	Hex	2	0x0000	0x000f	—	—
0x6b	R	PFStatus2	Hex	2	0x0000	0x000f	—	—
0x6c	R/W	ManufBlock1	String	20	—	—	—	—
0x6d	R/W	ManufBlock2	String	20	—	—	—	—
0x6e	R/W	ManufBlock3	String	20	—	—	—	—
0x6f	R/W	ManufBlock4	String	20	—	—	—	—
0x70	R/W	ManufacturerInfo	String	31+1	—	—	—	—
0x71	R/W	SenseResistor	Unsigned integer	2	0	65535	—	μΩ
0x72	R	TempRange	Hex	2	0x0000	0xffff	—	—
0x73	R	LifetimeData1	String	32+1	—	—	—	—
0x74	R	LifetimeData2	String	8+1	—	—	—	—
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 *2nd Level Protection Features*, [Section 2.3](#) of this technical reference.

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

### C.1 Accessing Data Flash

In different security modes, the data flash access conditions change. See *ManufacturerAccess*, [Section A.1](#), and *Security*, [Section 2.9](#), 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 bq20z60-R1/bq20z65-R1 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 NACKed if the bq20z60-R1/bq20z65-R1 is in sealed mode (*[SS]* flag is set).

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

Reading and writing subclass data are block operations which are each 32 bytes long. Data can be written in shorter block sizes, however. The final block in one subclass can be shorter than 32 bytes, so care must be taken not to write over the subclass boundary. None of the values written are bounded by the bq20z60-R1/bq20z65-R1, 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 not 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 bq20z60-R1/bq20z65-R1 using *DataFlashSubClassID* command.
2. Read a block of data using *DataFlashSubClassPage1..8* command. A subclass can hold up to 256 bytes of data, but subclass data can only be read in 32-byte-long data blocks. The *DataFlashSubClassPage1* command reads only the first 32 bytes in a subclass, the *DataFlashSubClassPage2* command reads the second 32 bytes in a subclass, and so on. For example if the subclass has 40 bytes, *DataFlashSubClassPage1* + *DataFlashSubClassPage2* is needed to read the whole subclass.

### C.1.3 Writing a SubClass

Information required:

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

Procedure:

1. Write the SubClassID to bq20z60-R1/bq20z65-R1 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 must be changed, use *DataFlashSubClassPage2* to write data from bytes 33–40 of the subclass.

### C.1.4 Example

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

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

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

Overwrite offset 45 of received data with 8.7 V:

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

Write the complete subclass back to the bq20z60-R1/bq20z65-R1:

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

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

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

- Write Subclass ID
  - SMB Slave Address (0x17)
  - SMB CMD 0x77 with 0x0050 as data (=80 decimal)
- Read Subclass (second block is needed, because its offset is 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 bq20z60-R1/bq20z65-R1:

- 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 LT COV Threshold (Offset 0)

When the bq20z60-R1/bq20z65-R1 is operating in the low temperature range (see Section 2.1 "JEITA Temperature Ranges"), it sets the *[COV]* flag in *SafetyAlert* if any *CellVoltage4..1* is equal to or higher than the **LT COV Threshold** for a period of time set by **COV Time**.

**Table C-1. LT COV Threshold**

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

#### Related Variables:

- DF:1st Level Safety:Voltage(0):LT COV Recovery(2)
- DF:1st Level Safety:Voltage(0):COV Time(12)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[COV]

#### C.2.1.2 LT COV Recovery (Offset 2)

When the q20z60/bq20z65 is operating in the low temperature range, it recovers from a cell overvoltage condition if all cell voltages are lower than the **LT COV Recovery** threshold level.

**Table C-2. LT COV Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	2	LT COV Recovery	Integer	2	0	4400	4100	mV

**Related Variables:**

- DF:1st Level Safety:Voltage(0):LT COV Threshold(0)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyStatus(0x51)[COV]
- SBS:TempRange(0x72)

**C.2.1.3 ST COV Threshold (Offset 4)**

When the bq20z60-R1/bq20z65-R1 is operating in the standard temperature range 1 or 2 (see [Chapter 2](#)), it sets the [COV] flag in *SafetyAlert* if any *CellVoltage4..1* is equal to or higher than the **ST COV Threshold** for a period of **COV Time**.

**Table C-3. ST COV Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	4	ST COV Threshold	Integer	2	3700	5000	4500	mV

**Related Variables:**

- DF:1st Level Safety:Voltage(0):ST COV Recovery(6)
- DF:1st Level Safety:Voltage(0):COV Time(12)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[COV]
- SBS:TempRange(0x72)

**C.2.1.4 ST COV Recovery (Offset 6)**

When the bq20z60-R1/bq20z65-R1 is operating in the standard temperature range 1 or 2 (see [Chapter 2](#)), it recovers from a cell overvoltage condition if all cell voltages are lower than the **ST COV Recovery** threshold level.

**Table C-4. ST COV Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	6	ST COV Recovery	Integer	2	0	4400	4300	mV

**Related Variables:**

- DF:1st Level Safety:Voltage(0):ST COV Threshold(4)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyStatus(0x51)[COV]

**C.2.1.5 HT COV Threshold (Offset 8)**

When the bq20z60-R1/bq20z65-R1 is operating in the high temperature range (see [Chapter 2](#)), it sets the [COV] flag in *SafetyAlert* if any *CellVoltage4..1* is equal to or higher than the **HT COV Threshold** for a period of **COV Time**.



**Table C-5. HT COV Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	8	HT COV Threshold	Integer	2	3700	5000	4200	mV

**Related Variables:**

- DF:1st Level Safety:Voltage(0):HT COV Recovery(10)
- DF:1st Level Safety:Voltage(0):COV Time(12)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[COV]

**C.2.1.6 HT COV Recovery (Offset 10)**

When the bq20z60-R1/bq20z65-R1 is operating in the high temperature range, it recovers from a cell overvoltage condition if all cell voltage are lower than the **HT COV Recovery** threshold level.

**Table C-6. HT COV Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	10	HT COV Recovery	Integer	2	0	4400	4000	mV

**Related Variables:**

- DF:1st Level Safety:Voltage(0):HT COV Threshold(8)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyStatus(0x51)[COV]
- SBS:TempRange(0x72)

**C.2.1.7 COV Time (Offset 12)**

If the [COV] *SafetyAlert* time period exceeds **COV Time** the bq20z60-R1/bq20z65-R1 goes into a cell overvoltage condition. This function is disabled if **COV Time** is set to 0.

**Table C-7. COV Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	12	COV Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Voltage(0):LT COV Threshold(0)
- DF:1st Level Safety:Voltage(0):ST COV Threshold(4)
- DF:1st Level Safety:Voltage(0):HT COV Threshold(8)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.2.1.8 CUV Threshold (Offset 13)

The bq20z60-R1/bq20z65-R1 sets *[CUV]* in *SafetyAlert* if any *CellVoltage4..1* is equal to or lower than the **CUV Threshold** for a period of **CUV Time**.

**Table C-8. CUV Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	13	CUV Threshold	Integer	2	0	3500	2200	mV

**Related Variables:**

- DF:1st Level Safety:Voltage(0):CUV Time(15)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.2.1.9 CUV Time (Offset 15)

If *[CUV]* in the *SafetyAlert* time period exceeds **CUV Time**, the bq20z60-R1/bq20z65-R1 goes into a cell undervoltage condition. This function is disabled if **CUV Time** is set to 0.

**Table C-9. CUV Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	15	CUV Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Voltage(0):CUV Threshold(13)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:SafetyAlert(0x50)[CUV]
- SBS:SafetyStatus(0x51)[CUV]

### C.2.1.10 CUV Recovery (Offset 16)

The bq20z60-R1/bq20z65-R1 recovers from a cell undervoltage condition if all *CellVoltage4..1* are higher than the **CUV Recovery** threshold (and a charge current is detected if the **CUV\_RECOV\_CHG** bit is set).

**Table C-10. CUV Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0	Voltage	16	CUV Recovery	Integer	2	0	3600	3000	mV

**Related Variables:**

- DF:1st Level Safety:Voltage(0):CUV Threshold(13)
- 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)[XD5G]

## C.2.2 Current (Subclass 1)

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

The bq20z60-R1/bq20z65-R1 sets *[OCC]* in *SafetyAlert* if charge *Current* is equal to or higher than the **OC (1st Tier) Chg** threshold for a period of **OC (1st Tier) Chg Time**.

**Table C-11. OC (1st Tier) Chg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	0	OC (1st Tier) Chg	Integer	2	0	20,000	6000	mA

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg Time(2)
- SBS:Current(0x00a)
- SBS:SafetyAlert(0x50)[OCC]

### C.2.2.2 OC (1st Tier) Chg Time (Offset 2)

If *[OCC]* in the *SafetyAlert* time period exceeds the **OC (1st Tier) Chg Time** time, the bq20z60-R1/bq20z65-R1 goes into an overcurrent charge condition. This function is disabled if **OC (1st Tier) Chg Time** is set to 0.

**Table C-12. OC (1st Tier) Chg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	2	OC (1st Tier) Chg Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg(0)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)
- SBS:SafetyAlert(0x50)[OCC]
- SBS:SafetyStatus(0x51)[OCC]

### C.2.2.3 OC Chg Recovery (Offset 3)

The bq20z60-R1/bq20z65-R1 recovers from an overcurrent charge condition in non-removable battery mode if *AverageCurrent* is equal to or lower than the **OC Chg Recovery** threshold for a duration of **Current Recovery Time**. The bq20z60-R1/bq20z65-R1 recovers in removable battery mode by removing and reinserting the battery pack. On recovery, *ChargingCurrent* and *ChargingVoltage* are set to appropriate values per the charging algorithm.

**Table C-13. OC Chg Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	3	OC Chg Recovery	Integer	2	-1000	1000	200	mA

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Chg(0)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x00b)

### C.2.2.4 OC (1st Tier) Dsg (Offset 5)

The bq20z60-R1/bq20z65-R1 sets [OCD] in *SafetyAlert* if the discharge *Current* is equal to or higher than the **OC (1st Tier) Dsg** threshold for a period of **OC (1st Tier) Dsg Time**.

**Table C-14. 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	Integer	2	0	20,000	6000	mA

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Dsg Time(7)
- SBS:Current(0x00a)
- SBS:SafetyAlert(0x50)[OCD]

### C.2.2.5 OC (1st Tier) Dsg Time (Offset 7)

If [OCD] in the *SafetyAlert* time period exceeds **OC (1st Tier) Dsg Time**, the bq20z60-R1/bq20z65-R1 goes into an overcurrent discharge condition. This function is disabled if **OC (1st Tier) Dsg Time** is set to 0.

**Table C-15. OC (1st Tier) Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	7	OC (1st Tier) Dsg Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Dsg(5)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:SafetyAlert(0x50)[OCD]
- SBS:SafetyStatus(0x51)[OCD]
- SBS:OperationStatus(0x54)[XDSDG]

### C.2.2.6 OC Dsg Recovery (Offset 8)

The bq20z60-R1/bq20z65-R1 recovers from an overcurrent discharge condition in non-removable battery mode if the *AverageCurrent* is equal to or lower than the **OC Dsg Recovery** current level for a duration of **Current Recovery Time**.

**Table C-16. OC Dsg Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	8	OC Dsg Recovery	Integer	2	0	1000	200	mA

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (1st Tier) Dsg(5)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]

### C.2.2.7 OC (2nd Tier) Chg (Offset 10)

The bq20z60-R1/bq20z65-R1 sets [OCC2] in *SafetyAlert* if charge *Current* is equal to or higher than the **OC (2nd Tier) Chg** threshold.

**Table C-17. OC (2nd Tier) Chg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	10	OC (2nd Tier) Chg	Integer	2	0	20,000	8000	mA

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Chg Time(12)
- SBS:Current(0x00a)
- SBS:SafetyAlert(0x50)[OCC2]

**C.2.2.8 OC (2nd Tier) Chg Time (Offset 12)**

If the [OCC2] *SafetyAlert* time period exceeds **OC (2nd Tier) Chg Time**, the bq20z60-R1/bq20z65-R1 goes into an overcurrent charge condition. This function is disabled if **OC (2nd Tier) Chg Time** is set to 0.

**Table C-18. OC (2nd Tier) Chg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	12	OC (2nd Tier) Chg Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Chg(10)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:SafetyAlert(0x50)[OCC2]
- SBS:SafetyStatus(0x51)[OCC2]

**C.2.2.9 OC (2nd Tier) Dsg (Offset 13)**

The bq20z60-R1/bq20z65-R1 sets [OCD2] in *SafetyAlert* if discharge *Current* is equal to or higher than the **OC (2nd Tier) Dsg** overcurrent threshold.

**Table C-19. OC (2nd Tier) Dsg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	13	OC (2nd Tier) Dsg	Integer	2	0	22,000	8000	mA

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Dsg Time(15)
- SBS:Current(0x00a)
- SBS:SafetyAlert(0x50)[OCD2]

**C.2.2.10 OC (2nd Tier) Dsg Time (Offset 15)**

If [OCD2] in the *SafetyAlert* time period exceeds **OC (2nd Tier) Dsg Time**, the bq20z60-R1/bq20z65-R1 goes into an overcurrent discharge condition. This function is disabled if **OC (2nd Tier) Dsg Time** is set to 0.

**Table C-20. OC (2nd Tier) Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	15	OC (2nd Tier) Dsg Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Current(1):OC (2nd Tier) Dsg(13)
- SBS:Charging Current(0x14)
- SBS:Charging Voltage(0x15)

**C.2.2.11 Current Recovery Time (Offset 16)**

**Current Recovery Time** sets the minimum time period where *AverageCurrent* must be below the overcurrent charge/discharge recovery threshold to recover from an overcurrent charge/discharge condition.

**Table C-21. Current Recovery Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	16	Current Recovery Time	Unsigned integer	1	0	240	8	s

**Related Variables:**

- DF:1st Level Safety:Current(1):OC Chg Recovery(3)
- DF:1st Level Safety:Current(1):OC Dsg Recovery(8)
- SBS:AverageCurrent(0x00b)

**C.2.2.12 AFE OC Dsg (Offset 17)**

The **AFE OC Dsg** threshold sets the OLV register of the AFE.

**Table C-22. AFE OC Dsg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	17	AFE OC Dsg	Hex	1	0x00	0xff	0x12	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	RSVD	RSVD	RSVD	OLV4	OLV3	OLV2	OLV1	OLV0

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

**Figure C-1. OLV Register**

**OLV4, OLV3, OLV2, OLV1, OLV0**— Sets the overload voltage threshold of the AFE

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

**Related Variable:**

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

**C.2.2.13 AFE OC Dsg Time (Offset 18)**

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

**Table C-23. AFE OC Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	18	AFE OC Dsg Time	Hex	1	0x00	0xff	0x0f	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	OLT3	OLT2	OLT1	OLT0

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

**Figure C-2. OLT Register**

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

0x00–0x00f sets the overvoltage trip delay between 1ms and 31ms in 2ms steps  
=

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[AOCD]

**C.2.2.14 AFE OC Dsg Recovery (Offset 19)**

The bq20z60-R1/bq20z65-R1 recovers from an overcurrent discharge condition in non-removable battery mode if *AverageCurrent* is equal to or lower than the **(–)AFE OC Dsg Recovery** current level for the duration of **Current Recovery Time**.

**Table C-24. AFE OC Dsg Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	19	AFE OC Dsg Recovery	Integer	2	5	1000	5	mA

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE OC Dsg(17)
- DF:1st Level Safety:Current Recovery Time(16)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x00b)

**C.2.2.15 AFE SC Chg Cfg (Offset 21)**

**AFE SC Chg Cfg** is programmed into the SCC register of the AFE. **AFE SC Chg Cfg** sets the short-circuit-in-charging voltage threshold and the short-circuit-in-charging delay of the AFE.

If the bq20z60-R1/bq20z65-R1 identifies a short-circuit-in-charging situation from the AFE, *ChargingCurrent* and *ChargingVoltage* are set to 0, [TCA] in *BatteryStatus* is set, and [SCC] in *SafetyStatus* is set.

**Table C-25. AFE SC Chg Cfg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	21	AFE SC Chg Cfg	Hex	1	0x00	0xff	0x77	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	SCCT3	SCCT2	SCCT1	SCCT0	SCCV3	SCCV2	SCCV1	SCCV0

**Figure C-3. SCC Register**



**SCCT3, SCCT2, SCCT1, SCCT0**— Sets the short-circuit delay in charging of the AFE

0x00–0xf = sets the short-circuit-in-charging delay between 0 $\mu$ s and 915 $\mu$ s in 61 $\mu$ s steps

**SCCV3, SCCV2, SCCV1, SCCV0**— Sets the short-circuit voltage threshold in charging of the AFE

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

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE SC Recovery(23)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:SafetyStatus(0x51)[SCC]

**C.2.2.16 AFE SC Dsg Cfg (Offset 22)**

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

If the bq20z60-R1/bq20z65-R1 identifies a short-circuit-in-discharging situation from the AFE, *ChargingCurrent* and *ChargingVoltage* are set to 0, [TDA] in *BatteryStatus* is set, [SCD] in *SafetyStatus* is set, and [XDSG] in *OperationStatus* is set.

**Table C-26. AFE SC Dsg Cfg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	22	AFE SC Dsg Cfg	Hex	1	0x00	0xff	0x77	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	SCDT3	SCDT2	SCDT1	SCDT0	SCDV3	SCDV2	SCDV1	SCDV0

**Figure C-4. SCD Register**

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

0x00–0xf = sets the short-circuit-in-discharging delay between 0  $\mu$ s and 915  $\mu$ s in 61- $\mu$ s steps

**SCDV3, SCDV2, SCDV1, SCDV0**— Sets the short-circuit voltage threshold in discharging of the AFE

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

**Related Variables:**

- DF:1st Level Safety:Current(1):AFE SC Recovery(23)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TDA]
- SBS:SafetyStatus(0x51)[SCD]
- SBS:OperationStatus(0x54)[XDSG]

### C.2.2.17 AFE SC Recovery (Offset 23)

The bq20z60-R1/bq20z65-R1 recovers from a short circuit in a charging or discharging condition in non-removable battery mode if the absolute value of *AverageCurrent* is equal to or lower than the **AFE SC Recovery** current level for the duration of **Current Recovery Time**. On recovery, *ChargingCurrent* and *ChargingVoltage* are set to their appropriate values per the charging algorithm.

**Table C-27. AFE SC Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
1	Current	23	AFE SC Recovery	Integer	2	0	200	1	mA

**Related Variables:**

- DF:1st Level Safety:Current Recovery Time(16)
- DF:1st Level Safety:Current(1):AFE SC Chg Cfg(21)
- DF:1st Level Safety:Current(1):AFE SC Dsg Cfg(22)
- DF:Configuration:Registers(64):Operation Cfg B(2)[NR]
- SBS:AverageCurrent(0x00b)

### C.2.3 Temperature (Subclass 2)

#### C.2.3.1 OT1 Chg Threshold (Offset 0)

The bq20z60-R1/bq20z65-R1 goes into an overtemperature charge condition and sets the *[OT1C]* flag in *SafetyAlert* if the pack *TS1 Temperature* is equal to or higher than the **OT1 Chg** threshold for a period of **OT1 Chg Time** during charging.

**Table C-28. OT1 Chg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	0	OT1 Chg Threshold	Integer	2	0	2550	550	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT1 Chg Time(2)
- SBS:TS1Temperature(0x5e)
- SBS:SafetyAlert(0x50)[OT1C]

#### C.2.3.2 OT1 Chg Time (Offset 2)

The bq20z60-R1/bq20z65-R1 goes into an overtemperature charge condition and sets the *[OT1C]* flag in *SafetyStatus* if the pack *TS1 Temperature* is equal to or higher than the **OT1 Chg Threshold** for a period of **OT1 Chg Time** during charging. This function is disabled if **OT1 Chg Time** is set to 0.

**Table C-29. OT1 Chg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	2	OT1 Chg Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT1 Chg Threshold(0)
- SBS:TS1 Temperature(0x5e)
- SBS:SafetyAlert(0x50)[OT1C]
- SBS:SafetyStatus(0x51)[OT1C]

### C.2.3.3 OT1 Chg Recovery (Offset 3)

The bq20z60-R1/bq20z65-R1 recovers from an overtemperature charge condition if *TS1Temperature* is equal to or lower than the **OT1 Chg Recovery** level.

**Table C-30. OT1 Chg Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	3	OT1 Chg Recovery	Integer	2	0	2550	500	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT1 Chg Threshold(0)
- SBS:TS1 Temperature(0x5e)
- SBS:SafetyStatus(0x51)[OT1C]

### C.2.3.4 OT2 Chg Threshold (Offset 5)

The bq20z0/bq20z65 goes into an overtemperature charge condition and sets the *[OT2C]* flag in *SafetyStatus2* if the pack *TS2Temperature* is equal to or higher than the **OT2 Chg Threshold** for a period of **OT2 Chg Time** during charging.

**Table C-31. OT2 Chg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	5	OT2 Chg Threshold	Integer	2	0	2550	550	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT2 Chg Time(7)
- SBS:TS2Temperature(0x5f)
- SBS:SafetyAlert2(0x68)[OT2C]

### C.2.3.5 OT2 Chg Time (Offset 7)

The bq20z60-R1/bq20z65-R1 goes into an overtemperature discharge condition and sets the *[OT2C]* flag in *SafetyAlert2* if the pack *TS2Temperature* is equal to or higher than the **OT2 Chg Threshold** for a period of **OT2 Chg Time** during charging. This function is disabled if **OT2 Chg Time** is set to 0.

**Table C-32. OT2 Chg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	7	OT2 Chg Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT2 Chg Threshold (5)
- SBS:TS2Temperature(0x5f)
- SBS:SafetyAlert2(0x68)[OT2C]
- SBS:SafetyStatus2(0x69)[OT2C]

### C.2.3.6 OT2 Chg Recovery (Offset 8)

The bq20z60-R1/bq20z65-R1 recovers from an overtemperature charge condition if *TS2Temperature* is equal to or lower than the **OT2 Chg Recovery** level.

**Table C-33. OT2 Chg Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	8	OT2 Chg Recovery	Integer	2	0	2550	500	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT2 Chg Threshold(5)
- SBS:TS2Temperature(0x5f)
- SBS:SafetyAlert2(0x68)[OT2C]
- SBS:SafetyStatus2(0x69)[OT2C]

**C.2.3.7 OT1 Dsg Threshold (Offset 10)**

The bq20z60-R1/bq20z65-R1 goes into an overtemperature discharge condition and sets the *[OT1D]* flag in *SafetyStatus* if the pack *TS1Temperature* is equal to or higher than the **OT1 Dsg Threshold** for a period of **OT1 Dsg Time** during discharging..

**Table C-34. OT1 Dsg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	10	OT1 Dsg Threshold	Integer	2	0	2550	600	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT1 Dsg Time(12)
- SBS:TS1Temperature(0x5e)
- SBS:SafetyAlert(0x50)[OT1D]

**C.2.3.8 OT1 Dsg Time (Offset 12)**

The bq20z60-R1/bq20z65-R1 goes into an overtemperature discharge condition and sets the *[OT1D]* flag in *SafetyStatus* if the pack *TS1Temperature* is equal to or higher than the **OT1 Dsg Threshold** for a period of **OT1 Dsg Time** during discharging.

**Table C-35. OT1 Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	12	OT1 Dsg Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT1 Dsg Threshold(10)
- DF:Configuration:Registers(64):Operation Cfg B(2)[OTFET]
- SBS:TS1Temperature(0x5e)
- SBS:SafetyAlert(0x50)[OT1D]
- SBS:SafetyStatus(0x51)[OT1D]

**C.2.3.9 OT1 Dsg Recovery (Offset 13)**

The bq20z60-R1/bq20z65-R1 recovers from an overtemperature discharge condition on TS1 if *TS1Temperature* is equal to or lower than the **T1 Dsg Recovery**.

**Table C-36. OT1 Dsg Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	13	OT1 Dsg Recovery	Integer	2	0	2550	550	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT1 Dsg Threshold(10)
- SBS:TS1Temperature(0x5e)
- SBS:SafetyStatus(0x51)[OT1D]

**C.2.3.10 OT2 Dsg Threshold (Offset 15)**

The bq20z60-R1/bq20z65-R1 goes into an overtemperature discharge condition and sets the *[OT2D]* flag in *SafetyStatus2* if the pack *TS2Temperature* is equal to or higher than the **OT2 Dsg Threshold** for a period of **OT2 Dsg Time** during discharging..

**Table C-37. OT2 Dsg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	15	OT2 Dsg Threshold	Integer	2	0	2550	600	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT2 Dsg Time(17)
- SBS:TS2Temperature(0x5f)
- SBS:SafetyAlert2(0x68)[OT2D]
- SBS:SafetyStatus2(0x69)[OT2D]

**C.2.3.11 OT2 Dsg Time (Offset 17)**

The bq20z60-R1/bq20z65-R1 goes into an overtemperature discharge condition and sets the *[OT2D]* flag in *SafetyStatus2* if the pack *TS2Temperature* is equal to or higher than the **OT2 Dsg Threshold** for a period of **OT2 Dsg Time** during discharging..

**Table C-38. OT2 Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	17	OT2 Dsg Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT2 Dsg Threshold(15)
- SBS:TS2Temperature(0x5f)
- SBS:SafetyAlert2(0x68)[OT2D]
- SBS:SafetyStatus2(0x69)[OT2D]

**C.2.3.12 OT2 Dsg Recovery (Offset 18)**

The bq20z60-R1/bq20z65-R1 recovers from an overtemperature discharge condition on *TS2* if *TS2Temperature* is equal to or lower than the **OT2 Dsg Recovery**.

**Table C-39. OT2 Dsg Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	18	OT2 Dsg Recovery	Integer	2	0	2550	550	0.1°C

**Related Variables:**

- DF:1st Level Safety:Temperature(2):OT2 Dsg Threshold(15)
- SBS:TS2Temperature(0x5f)
- SBS:SafetyStatus2(0x69)[OT2D]

**C.2.3.13 Hi Dsg Start Temp (Offset 20)**

If *Temperature* is above **Hi Dsg Start Temp** when starting discharge then discharge is inhibited. *[DSGIN]* flag in *OperationStatus* is set to indicate this condition.

**Table C-40. Hi Dsg Start Temp**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
2	Temperature	20	Hi Dsg Start Temp	Integer	2	0	1200	600	0.1°C

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:OperationStatus(0x54)[DSGIN]

**C.2.4 Host Comm (Subclass 4)****C.2.4.1 Host Watchdog Timeout (Offset 0)**

If the bq20z60-R1/bq20z65-R1 receives no valid SMBus communication for a time period greater than **Host Watchdog Timeout**, the FETs are turned off, *ChargingVoltage* and *ChargingCurrent* are set to 0, *[TCA]* and *[TDA]* in *BatteryStatus* are set, *[HWDG]* in *SafetyStatus* is set, and *[XDSEG]* in *OperationStatus* is set. The bq20z60-R1/bq20z65-R1 recovers if valid SMBus communication resumes.

**Table C-41. Host Watchdog Timeout**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
4	Host Comm	0	Host Watchdog Timeout	Unsigned integer	1	0	255	0	s

**Related Variables:**

- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[TCA],[TDA]
- SBS:SafetyStatus(0x51)[HWDG]
- SBS:OperationStatus(0x54)[XDSEG]

**C.3 2nd Level Safety****C.3.1 Voltage (Subclass 16)****C.3.1.1 LT SOV Threshold (Offset 0)**

When the bq20z60-R1/bq20z65-R1 is operating in the low temperature charging range (*[TR2]* = 1), it sets the *[SOV]* flag in *PFAIert* if any *CellVoltage4..1* is equal to or higher than the **LT SOV Threshold**. The *[SOV]* flag in *PFAIert* is cleared and the *[SOV]* flag in *PFStatus* is set if any *CellVoltage4..1* is equal to or higher than the **LT SOV Threshold** for period of **SOV Time**.

**Table C-42. LT SOV Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	0	LT SOV Threshold	Integer	2	0	20,000	4400	mV

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SOV Time(6)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAlert(0x52)[SOV]
- SBS:TempRange(0x72)[TR2]

**C.3.1.2 ST SOV Threshold (Offset 2)**

When the bq20z60-R1/bq20z65-R1 is operating in the standard temperature charging range 1 or 2 ( $[TR2A] = 1$ , or  $[TR3] = 1$ ), it sets the  $[SOV]$  flag in **PFAlert** if *CellVoltage4..1* is equal to or higher than the **ST SOV Threshold**. The  $[SOV]$  flag in **PFAlert** is cleared and the  $[SOV]$  flag in **PFStatus** is set if any *CellVoltage4..1* is equal to or higher than the **ST SOV Threshold** for period of **SOV Time**

**Table C-43. ST SOV Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	2	ST SOV Threshold	Integer	2	0	20,000	4600	mV

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SOV Time(6)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAlert(0x52)[SOV]
- SBS:TempRange(0x72)[TR2A][TR3]

**C.3.1.3 HT SOV Threshold (Offset 4)**

When the bq20z60-R1/bq20z65-R1 is operating in the high temperature charging range ( $[TR4] = 1$ ), it sets the  $[SOV]$  flag in **PFAlert** if *CellVoltage4..1* is equal to or higher than the **HT SOV Threshold**. The  $[SOV]$  flag in **PFAlert** is cleared and the  $[SOV]$  flag in **PFStatus** is set if any *CellVoltage4..1* is equal to or higher than the **HT SOV Threshold** for period of **SOV Time**

**Table C-44. HT SOV Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	4	HT SOV Threshold	Integer	2	0	20,000	4500	mV

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SOV Time(6)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)



- SBS:PFAlert(0x52)[SOV]
- SBS:TempRange(0x72)[TR4]

### C.3.1.4 SOV Time (Offset 6)

The bq20z60-R1/bq20z65-R1 sets the [SOV] flag in **PFStatus** and goes into a safety overvoltage condition if any *CellVoltage4..1* is equal to or higher than the appropriate SOV threshold (depending on temperature range) for a period of **SOV Time**. If the [XSOV] bit in **Permanent Fail Cfg 1** is set, the SAFE pin is driven high. This function is disabled if **SOV Time** is set to 0.

**Table C-45. SOV Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	6	SOV Time	Unsigned integer	1	0	240	0	s

#### Related Variables:

- DF:2nd Level Safety:Voltage(16):LT SOV Threshold(0)
- DF:2nd Level Safety:Voltage(16):ST SOV Threshold(2)
- DF:2nd Level Safety:Voltage(16):HT SOV Threshold(4)
- DF:Configuration:Registers(64):Permanent Fail Cfg 1(6)[XSOV]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAlert(0x52)[SOV]
- SBS:PFStatus(0x53)[SOV]

### C.3.1.5 PF SOV Fuse Blow Delay (Offset 7)

In case of a safety overvoltage permanent failure condition, the assertion of the SAFE output (to blow a fuse) can be delayed to allow the battery to discharge to a safe level before blowing the fuse. A PF timer is started once an SOV PF event occurs. The SAFE output will be driven high (thus blowing the fuse) once this timer reaches PF SOV Fuse Blow Delay, or as soon as all cell voltages go below the COV Recovery threshold for the current temperature range, whichever comes first.

**Table C-46. PF SOV Fuse Blow Delay**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	7	PF SOV Fuse Blow Delay	Unsigned integer	2	0	65,535	0	s

#### Related Variables:

- DF:1st Level Safety:Voltage(0):LT COV Recovery(2)
- DF:1st Level Safety:Voltage(0):ST COV Recovery(6)
- DF:1st Level Safety:Voltage(0):HT COV Recovery(10)
- DF:Configuration:Registers(64):Permanent Fail Cfg 1(6)[XSOV]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAlert(0x52)[SUV]



### C.3.1.6 SUV Threshold (Offset 9)

The bq20z60-R1/bq20z65-R1 sets the *[SUV]* flag in *PFAAlert* if *CellVoltage4..1* is less than the **SUV Threshold**. The *[SUV]* flag in *PFAAlert* is cleared and the *[SUV]* flag in *PFStatus* is set if any *CellVoltage4..1* is equal to or higher than the **SUV Threshold** for period of **SUV Time**

**Table C-47. SUV Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	9	SUV Threshold	Integer	2	0	20,000	2000	mV

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SUV Time(11)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAAlert(0x52)[SUV]

### C.3.1.7 SUV Time (Offset 11)

The bq20z60-R1/bq20z65-R1 sets the *[SUV]* flag in *PFStatus* if any *CellVoltage1..4* is less than the **SUV Threshold** for a period of **SUV Time**. If the *[XSUV]* bit in *Permanent Fail Cfg 1* is set, the SAFE pin is driven high. This function is disabled if **SUV Time** is set to 0.

**Table C-48. SUV Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	11	SUV Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):SUV Threshold(9)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSUV]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAAlert(0x52)[SUV]
- SBS:PFStatus(0x53)[SUV]

### C.3.1.8 Rest CIM Current (Offset 12)

The battery pack *Current* must be below the **Rest CIM Current** limit for period of **CIM Battery Rest Time** before the bq20z60-R1/bq20z65-R1 starts detecting cell imbalance at rest.

**Table C-49. Rest CIM Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	12	Rest CIM Current	Integer	1	0	200	5	mA

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):CIM Battery Rest Time(16)
- SBS:Current(0x00a)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)

- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.3.1.9 Rest CIM Fail Voltage (Offset 13)

When the conditions for detecting cell imbalance at rest are satisfied, the bq20z60-R1/bq20z65-R1 sets the *[CIM\_R]* flag in **PFAAlert** if the bq20z60-R1/bq20z65-R1 measures a difference between any *CellVoltage4..1* equal to or higher than the **Rest CIM Fail Voltage** threshold. The *[CIM\_R]* flag in **PFAAlert** is cleared and the *[CIM\_R]* flag in **PFStatus** is set if any *CellVoltage4..1* is equal to or higher than the **Rest CIM Fail Voltage threshold** for period of **Rest CIM Time**.

**Table C-50. Rest CIM Fail Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	13	Rest CIM Fail Voltage	Integer	2	0	5000	1000	mV

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Rest CIM Time(15)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAAlert(0x52)[CIM\_R]
- SBS:PFStatus(0x53)[CIM\_R]

### C.3.1.10 Rest CIM Time (Offset 15)

When the conditions for detecting cell imbalance at rest are satisfied, the bq20z60-R1/bq20z65-R1 sets the *[CIM\_R]* flag in **PFAAlert** if the bq20z60-R1/bq20z65-R1 measures a difference between any *CellVoltage4..1* equal to or higher than the **Rest CIM Fail Voltage** threshold. The *[CIM\_R]* flag in **PFAAlert** is cleared and the *[CIM\_R]* flag in **PFStatus** is set if any *CellVoltage4..1* is equal to or higher than the **Rest CIM Fail Voltage threshold** for period of **Rest CIM Time**. If the *[XIM\_R]* bit in **Permanent Fail Cfg** is set, the SAFE pin is also driven high. If **Rest CIM Time** is set to 0, then cell imbalance detection at rest is disabled.

**Table C-51. Rest CIM Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	15	Rest CIM Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Rest CIM Fail Voltage(13)
- DF:2nd Level Safety:Voltage(16):Rest CIM Current(12)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XCIM\_R]
- SBS:Current(0x00a)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAAlert(0x52)[CIM\_R]
- SBS:PFStatus(0x53)[CIM\_R]

### C.3.1.11 CIM Battery Rest Time (Offset 16)

The battery *Current* must be below the **Rest CIM Current** limit for at least the **CIM Battery Rest Time** period before the bq20z60-R1/bq20z65-R1 starts detecting a cell imbalance at rest. Cell imbalance detection at rest is disabled if **CIM Battery Rest Time** is set to 0.

**Table C-52. CIM Battery Rest Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	16	CIM Battery Rest Time	Unsigned integer	2	0	65,535	1800	s

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Cell Imbalance Current(10)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Fail Voltage(11)
- DF:2nd Level Safety:Voltage(16):Cell Imbalance Time(13)
- DF:2nd Level Safety:Voltage(16):Min CIM-check Voltage (16)
- SBS:Current(0x00a)

### C.3.1.12 Rest CIM Check Voltage (Offset 18)

For cell imbalance detection at rest, the bq20z60-R1/bq20z65-R1 starts detection only if any of the cell voltages (*CellVoltage4..1*) exceeds **Rest CIM Check Voltage**.

**Table C-53. Rest CIM Check Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	18	Rest CIM Check Voltage	Unsigned integer	2	0	65,535	3000	mV

**Related Variables:**

- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.3.1.13 Active CIM Fail Voltage (Offset 20)

When the conditions for detecting cell imbalance while active are satisfied, the bq20z60-R1/bq20z65-R1 sets the *[CIM\_A]* flag in **PFAAlert2** if the bq20z60-R1/bq20z65-R1 measures a difference between any *CellVoltage4..1* equal to or higher than the **Active CIM Fail Voltage** threshold. The *[CIM\_A]* flag in **PFAAlert2** is cleared and the *[CIM\_A]* flag in **PFStatus2** is set if any *CellVoltage4..1* is equal to or higher than the **Active CIM Fail Voltage** threshold for a period of Active CIM Time.

**Table C-54. Active CIM Fail Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	20	Active CIM Fail Voltage	Integer	2	0	5000	1000	mV

**Related Variables:**

- DF:2nd Level Safety:Voltage(16):Active CIM Time(22)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAAlert2(0x6a)[CIM\_A]

- SBS:PFStatus2(0x6b)[CIM\_A]

### C.3.1.14 Active CIM Time (Offset 22)

When the conditions for detecting cell imbalance while active are satisfied, the bq20z60-R1/bq20z65-R1 sets the [CIM\_A] flag in **PFAAlert2** if the bq20z60-R1/bq20z65-R1 measures a difference between any *CellVoltage4..1* equal to or higher than the **Active CIM Fail Voltage** threshold. The [CIM\_A] flag in **PFAAlert2** is cleared and the [CIM\_A] flag in **PFStatus2** is set if any *CellVoltage4..1* is equal to or higher than the **Active CIM Fail Voltage** threshold for a period of **Active CIM Time**. If the [XCIM\_A] flag in **Permanent Fail Cfg 2** is set, the SAFE pin is also driven high. If **Active CIM Time** is set to 0, then cell imbalance active detection is disabled.

**Table C-55. Active CIM Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	22	Active CIM Time	Unsigned integer	1	0	240	0	s

#### Related Variables:

- DF:2nd Level Safety:Voltage(16):Active CIM Fail Voltage(20)
- DF:Configuration:Registers(64):Permanent Fail Cfg 2(8)[XCIM\_A]
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)
- SBS:PFAAlert2(0x6a)[CIM\_A]
- SBS:PFStatus2(0x6b)[CIM\_A]

### C.3.1.15 Active CIM Check Voltage (Offset 23)

For active cell imbalance detection, the bq20z60-R1/bq20z65-R1 starts detection only if any of the cell voltages (*CellVoltage4..1*) exceeds **Active CIM Check Voltage**.

**Table C-56. Active CIM Check Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	23	Active CIM Check Voltage	Integer	2	0	32,768	3000	mV

#### Related Variables:

- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

### C.3.1.16 PFIN Detect Time (Offset 25)

If the PFIN pin is logic low, then [PFIN] in **PFAAlert** is set. If the [PFIN] PF alert time period exceeds **PFIN Detect Time**, the [PFIN] flag in **PFAAlert** is cleared, the [PFIN] bit in **PFStatus** is set, and, if [XPFIN] in **Permanent Fail Cfg** is set, the SAFE pin is also driven high. This function is disabled if **PFIN Detect Time** is set to 0.

**Table C-57. PFIN Detect Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	25	PFIN Detect Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XPFIN]
- SBS:PFAlert(0x52)[PFIN]
- SBS:PFStatus(0x53)[PFIN]

**C.3.1.17 PF Min Fuse Blow Voltage (Offset 26)**

In case of a safety permanent failure condition other than charge FET or discharge FET faults (*[CFETF]* or *[DFETF]*), the assertion of the SAFE output (to blow a fuse) is conditional on pack voltage being greater than **PF Min Fuse Blow Voltage**. The purpose of the feature is to ensure that there is sufficient battery power for a reliable fuse blow.

**Table C-58. PF Min Fuse Blow Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
16	Voltage	26	PF Min Fuse Blow Voltage	Integer	2	0	20,000	8000	mV

**Related Variables:**

- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

**C.3.2 Current (Subclass 17)****C.3.2.1 SOC Chg (Offset 0)**

The bq20z60-R1/bq20z65-R1 sets the *[SOCC]* in *PFAlert* if *Current* is equal to or higher than the **SOC Chg** threshold. If the time period exceeds **SOC Chg Time**, the *[SOCC]* flag in *PFAlert* is cleared, the *[SOCC]* flag in *PFStatus* is set, and if *[XSOCC]* in **Permanent Fail Cfg** is set, the SAFE pin is driven high.

**Table C-59. SOC Chg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
17	Current	0	SOC Chg	Integer	2	0	30,000	10,000	mA

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Chg Time(2)
- DF:Configuration:Registers(64):Permanent Fail Cfg(2)[XSOCC]
- SBS:Current(0x00a)
- SBS:PFAlert(0x52)[SOCC]
- SBS:PFStatus(0x53)[SOCC]

**C.3.2.2 SOC Chg Time (Offset 2)**

The bq20z60-R1/bq20z65-R1 sets the *[SOCC]* flag in *PFAlert* if *Current* is equal to or higher than the **SOC Chg** threshold. If the time period exceeds **SOC Chg Time**, the *[SOCC]* flag in *PFAlert* is cleared, the *[SOCC]* flag in *PFStatus* is set, and if *[XSOCC]* in **Permanent Fail Cfg** is set, the SAFE pin is driven high. This function is disabled if **SOC Chg Time** is set to 0.

**Table C-60. SOC Chg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
17	Current	2	SOC Chg Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Chg(0)
- DF:Configuration:Registers(64):Permanent Fail Cfg(2)[XSOCC]
- SBS:Current(0x00a)
- SBS:PFAlert(0x52)[SOCC]
- SBS:PFStatus(0x53)[SOCC]

**C.3.2.3 SOC Dsg (Offset 3)**

The bq20z60-R1/bq20z65-R1 sets the [SOCD] flag in *PFAlert* if discharge *Current* is equal to or higher than the (-)**SOC Dsg** threshold. If the [SOCD] condition time period equals or exceeds the **SOC Dsg Time** then the [SOCD] flag in *PFAlert* is cleared, the [SOCD] flag in *PFStatus* is set, and if the [XSOCD] bit in **Permanent Fail Cfg** is set, the SAFE pin is driven high.

**Table C-61. SOC Dsg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
17	Current	3	SOC Dsg	Integer	2	0	30,000	10,000	mA

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Dsg Time(5)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOCD]
- SBS:Current(0x00a)
- SBS:PFAlert(0x52)[SOCD]
- SBS:PFStatus(0x53)[SOCD]

**C.3.2.4 SOC Dsg Time (Offset 5)**

The bq20z60-R1/bq20z65-R1 sets the [SOCD] flag in *PFAlert* if discharge *Current* is equal to or higher than the (-)**SOC Dsg** threshold. If the time period exceeds **SOC Dsg Time**, the [SOCD] flag in *PFAlert* is cleared, the [SOCD] flag in *PFStatus* is set, and if [XSOCD] in **Permanent Fail Cfg** is set, the SAFE pin is driven high. This function is disabled if **SOC Dsg Time** is set to 0.

**Table C-62. SOC Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
17	Current	5	SOC Dsg Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Current(17):SOC Dsg(3)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOCD]
- SBS:Current(0x00a)
- SBS:PFAlert(0x52)[SOCD]
- SBS:PFStatus(0x53)[SOCD]

**C.3.3 Temperature (Subclass 18)****C.3.3.1 SOT1 Chg Threshold (Offset 0)**

The bq20z60-R1/bq20z65-R1 sets [SOT1C] flag in *PFAlert* if *TS1Temperature* is equal to or higher than the **SOT1 Chg Threshold** during charging ([DSG] = 0).

**Table C-63. SOT1 Chg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	0	SOT1 Chg Threshold	Integer	2	0	2550	650	0.1°C

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT1 Chg Time(2)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFAlert(0x52)[SOT1C]
- SBS:TS1Temperature(0x5e)

**C.3.3.2 SOT1 Chg Time (Offset 2)**

If the *[SOT1C]* flag in *PFAlert* time period exceeds **SOT1 Chg Time**, the *[SOT1C]* flag in *PFAlert* is cleared, the *[SOT1C]* flag in *PFStatus* is set, and if *[XSOT1C]* in **Permanent Fail Cfg** is set, the SAFE pin is driven high. This function is disabled if **SOT1 Chg Time** is set to 0.

**Table C-64. SOT1 Chg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	2	SOT1 Chg Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT1 Chg Threshold(0)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOT1C]
- SBS:TS1Temperature(0x5e)
- SBS:PFAlert(0x52)[SOT1C]
- SBS:PFStatus(0x53)[SOT1C]

**C.3.3.3 SOT2 Chg Threshold (Offset 3)**

The bq20z60-R1/bq20z65-R1 sets *[SOT2C]* flag in *PFAlert2* if *TS2Temperature* is equal to or higher than the **SOT2 Chg Threshold** during charging (*[DSG]* = 0).

**Table C-65. SOT2 Chg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	3	SOT2 Chg Threshold	Integer	2	0	2550	650	0.1°C

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT2 Chg Time(5)
- SBS:TS2Temperature(0x5f)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFAlert2(0x6a)[SOT2C]

**C.3.3.4 SOT2 Chg Time (Offset 5)**

The bq20z60-R1/bq20z65-R1 sets the *[SOT2C]* flag in *PFStatus2* if *TS2Temperature* is equal to or higher than the **SOT2 Chg Threshold** during charging (*[DSG]* = 0) for a period of **SOT2 Chg Time**. If *[XSOT2C]* in **Permanent Fail Cfg 2** is set, the SAFE pin is driven high. This function is disabled if **SOT2 Chg Time** is set to 0.



**Table C-66. SOT2 Chg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	5	SOT2 Chg Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT2 Chg Threshold(3)
- DF:Configuration:Registers(64):Permanent Fail Cfg 2(6)[XSOT2C]
- SBS:BatteryStatus(0x16)[DSG]
- SBS:TS2Temperature(0x5f)
- SBS:PFAlert2(0x6a)[SOT2C]
- SBS:PFStatus2(0x6b)[SOT2C]

**C.3.3.5 SOT1 Dsg Threshold (Offset 6)**

The bq20z60-R1/bq20z65-R1 sets the [SOT1D] flag in *PFAlert* if *TS1Temperature* is equal to or higher than the **SOT1 Dsg Threshold** during discharging ([DSG] = 1).

**Table C-67. SOT1 Dsg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	6	SOT1 Dsg Threshold	Integer	2	0	2550	750	0.1°C

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT1 Dsg Time(8)
- SBS:TS1Temperature(0x5e)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFAlert(0x52)[SOT1D]

**C.3.3.6 SOT1 Dsg Time (Offset 8)**

The bq20z60-R1/bq20z65-R1 clears the [SOT1D] flag in *PFAlert* and sets the [SOT1D] flag in *PFStatus* if *TS1Temperature* is equal to or higher than the **SOT1 Dsg Threshold** during discharging ([DSG] = 1) for a period of **SOT1 Dsg Time**. If [XSOT1D] in *Permanent Fail Cfg 1* is set, the SAFE pin is driven high. This function is disabled if **SOT1 Dsg Time** is set to 0.

**Table C-68. SOT1 Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	8	SOT1 Dsg Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT1 Dsg Threshold(6)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOT1D]
- SBS:TS1Temperature(0x5e)
- SBS:PFAlert(0x52)[SOT1D]
- SBS:PFStatus(0x53)[SOT1D]

**C.3.3.7 SOT2 Dsg Threshold (Offset 9)**

The bq20z60-R1/bq20z65-R1 sets the [SOT2D] flag in *PFAlert2* if *TS2Temperature* is equal to or higher than the **SOT2 Dsg Threshold** during discharging ([DSG] = 1).



**Table C-69. SOT2 Dsg Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	9	SOT2 Dsg Threshold	Integer	2	0	2550	750	0.1°C

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT2 Dsg Time(11)
- SBS:TS2Temperature(0x5f)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:PFAlert2(0x6a)[SOT2D]

**C.3.3.8 SOT2 Dsg Time (Offset 11)**

If *[SOT2D]* in the *PFAlert2* time period exceeds **SOT2 Dsg Time**, the *[SOT2D]* in *PFAlert2* is cleared, *[SOT2D]* in *PFStatus2* is set and, if *[XSOT2D]* in **Permanent Fail Cfg** is set, the SAFE pin is driven high. This function is disabled if **SOT2 Dsg Time** is set to 0.

**Table C-70. SOT2 Dsg Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	11	SOT2 Dsg Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):SOT2 Dsg Threshold(9)
- DF:Configuration:Registers(64):Permanent Fail Cfg 2(8)[XSOT2D]
- SBS:TS2Temperature(0x5f)
- SBS:PFAlert2(0x6a)[SOT2D]
- SBS:PFStatus2(0x6b)[SOT2D]

**C.3.3.9 Open Thermistor (Offset 12)**

The bq20z60-R1/bq20z65-R1 sets the *[SOPT1]* flag in *PFAlert* (or *[SOPT2]* flag in *PFAlert2*) if *TS1Temperature* (or *TS2Temperature*) is equal to or lower than the **Open Thermistor** threshold and **Open Time** > 0.

**Table C-71. Open Thermistor**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	12	Open Thermistor	Integer	2	-1000	1200	-333	0.1°C

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):Open Time(14)
- SBS:TS1Temperature(0x5e)
- SBS:TS2Temperature(0x5f)
- SBS:PFAlert(0x52)[SOPT1]
- SBS:PFAlert2(0x6a)[SOPT2]

**C.3.3.10 Open Time (Offset 14)**

If the *[SOPT1]* or *[SOPT2]* alert) *PFAlert* time period exceeds the **Open Time** period, the *[SOPT1]* flag in *PFAlert* (or *[SOPT2]* flag in *PFAlert2*) is cleared, *[SOPT1]* in *PFStatus* (or *[SOPT2]* flag in *PFStatus2*) is set, and if *[XSOPT1]* (or *[XSOPT2]*) in **Permanent Fail Cfg** (or **Permanent Fail Cfg 2**) is set, the SAFE pin is driven high. This function is disabled if **Open Time** is set to 0.

**Table C-72. Open Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
18	Temperature	14	Open Time	Integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Temperature(18):Open Thermistor(14)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XSOPT1]
- DF:Configuration:Registers(64):Permanent Fail Cfg 2(8)[XSOPT2]
- SBS:PFAlert(0x52)[SOPT1]
- SBS:PFStatus(0x53)[SOPT1]
- SBS:TS1Temperature(0x5e)
- SBS:TS2Temperature(0x5f)
- SBS:PFAlert2(0x6a)[SOPT2]
- SBS:PFStatus2(0x6b)[SOPT2]

**C.3.4 FET Verification (Subclass 19)****C.3.4.1 FET Fail Limit (Offset 0)**

The bq20z60-R1/bq20z65-R1 sets *[CFETF]* in *PFAlert* if the bq20z60-R1/bq20z65-R1 detects charge *Current* equal to or higher than the **FET Fail Limit** threshold when the CHG FET is supposed to be off.

The bq20z60-R1/bq20z65-R1 sets *[DFETF]* in *PFAlert* if the bq20z60-R1/bq20z65-R1 detects discharge *Current* equal to or lower than the **(-)FET Fail Limit** threshold when the DSG FET is supposed to be off.

**Table C-73. FET Fail Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
19	FET Verification	0	FET Fail Limit	Integer	2	0	500	20	mA

**Related Variables:**

- DF:2nd Level Safety:FET Verification(19):FET Fail Time(2)
- SBS:Current(0x00a)
- SBS:PFAlert(0x52)[CFETF],[DFETF]

**C.3.4.2 FET Fail Time (Offset 2)**

If the *[CFETF]* alert time period exceeds **FET Fail Time**, the *[CFETF]* flag in *PFAlert* is cleared, *[CFETF]* in *PFStatus* is set and, if *[XCFETF]* in **Permanent Fail Cfg** is set, the SAFE pin is driven high. This function is disabled if **FET Fail Time** is set to 0.

If the *[DFETF]* alert time period exceeds **FET Fail Time**, the *[DFETF]* flag in *PFAlert* is cleared, *[DFETF]* in *PFStatus* is set and, if *[XDFETF]* in **Permanent Fail Cfg** is set, the SAFE pin is driven high. This function is disabled if **FET Fail Time** is set to 0.

**Table C-74. FET Fail Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
19	AFE Verification	2	FET Fail Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:FET Verification(19):FET Fail Limit(0)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XCFETF],[XDFETF]
- SBS:Current(0x00a)
- SBS:PFAlert(0x52)[CFETF],[DFETF]
- SBS:PFStatus(0x53)[CFETF],[DFETF]

### C.3.5 AFE Verification (Subclass 20)

#### C.3.5.1 AFE Check Time (Offset 0)

The bq20z60-R1/bq20z65-R1 compares periodically, with a period of **AFE Check Time**, certain RAM content and expected control bit states of the AFE with the values stored in data flash. If an error is detected, the internal AFE fail counter is incremented. Set **AFE Check Time** to 0 to disable [AFE\_P] faults.

**Table C-75. AFE Check Time**

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

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Recovery Time(2)
- SBS:SafetyStatus(0x51)[WDF]
- SBS:PFStatus(0x53)[AFE\_P]

#### C.3.5.2 AFE Fail Limit (Offset 1)

If the internal AFE fail counter reaches **AFE Fail Limit**, the bq20z60-R1/bq20z65-R1 reports an [AFE\_C] permanent failure, and if [XAFE\_C] in **Permanent Fail Cfg** is set, the SAFE pin is driven high. This function is disabled if **AFE Fail Limit** is set to zero.

**Table C-76. AFE Fail Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
20	AFE Verification	1	AFE Fail Limit	Unsigned integer	1	0	255	0	

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Check Time(0)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Recovery Time(2)
- DF:Configuration:Registers(64):Permanent Fail Cfg(6)[XAFE\_C]
- SBS:AFEDData(0x45)
- SBS:PFStatus(0x53)[AFE\_C]

#### C.3.5.3 AFE Fail Recovery Time (Offset 2)

The bq20z60-R1/bq20z65-R1 decrements the internal AFE fail counter by one each AFE Fail Recovery Time period to a minimum of zero.

**Table C-77. AFE Fail Recovery Time**

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

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Check Time(0)
- DF:2nd Level Safety:AFE Verification(20):AFE Fail Limit(1)

**C.3.5.4 AFE Init Retry Limit (Offset 3)**

After a full reset, the AFE offset and gain values are read twice and then compared. **AFE Init Retry Limit** is the maximum number of times that the initial AFE offset and gain values are read, if they are not considered the same, until the [AFE\_C] permanent failure occurs.

**Table C-78. AFE Init Retry Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
20	AFE Verification	3	AFE Init Retry Limit	Unsigned integer	1	0	255	6	–

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Init Limit(4)
- SBS:PFStatus(0x53)[AFE\_C]

**C.3.5.5 AFE Init Limit (Offset 4)**

**AFE Init Limit** is the difference in A/D counts that two successive readings of AFE offset and gain can be, and still be considered the same value, after a full reset.

**Table C-79. AFE Init Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
20	AFE Verification	4	AFE Init Limit	Unsigned integer	1	0	255	20	

**Related Variables:**

- DF:2nd Level Safety:AFE Verification(20):AFE Init Retry Limit(3)
- SBS:PFStatus(0x53)[AFE\_C]

**C.3.6 Fuse Verification (Subclass 21)****C.3.6.1 Fuse Fail Limit (Offset 0)**

The bq20z60-R1/bq20z65-R1 sets the [FBF] flag in *PFAAlert* if the absolute value of charge or discharge *Current* is equal to or higher than the fuse fail limit threshold after a fuse blow attempt.

**Table C-80. Fuse Fail Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
21	Fuse Verification	0	Fuse Fail Limit	Integer	2	0	20	2	mA

**Related Variables:**

- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Time(2)
- SBS:Current(0x00a)
- SBS:PFAAlert(0x52)[FBF]

**C.3.6.2 Fuse Fail Time (Offset 2)**

If [FBF] in *PFAAlert* time period exceeds **Fuse Fail Time**, the bq20z60-R1/bq20z65-R1 reports a fuse blow failure permanent error, [FBF] in *PFAAlert* is reset, and [FBF] in *PFStatus* is set. This function is disabled if **Fuse Fail Time** is set to 0.

**Table C-81. Fuse Fail Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
21	Fuse Verification	2	Fuse Fail Time	Unsigned integer	1	0	240	0	s

**Related Variables:**

- DF:2nd Level Safety:Fuse Verification(21):Fuse Fail Limit(0)
- SBS:PFAlert(0x52)[FBF]
- SBS:PFStatus(0x53)[FBF]

## C.4 Charge Control

### C.4.1 Charge Temp Cfg (Subclass 32)

#### C.4.1.1 JT1 (Offset 0)

**JT1** is the lower bound of the low temperature charging range. If *Temperature* is below the **JT1** threshold, then the *[TR1]* flag in *TempRange* is set and charging is inhibited from starting. If the bq20z60-R1/bq20z65-R1 is in charge mode (*[DSG]* = 0), then charging is suspended, the *[CHGSUSP]* flag in *ChargingStatus* is set, and *ChargingCurrent* and *ChargingVoltage* are set to 0.

**Table C-82. JT1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Temp Cfg	0	JT1	Integer	2	-400	1200	0	0.1°C

#### Related Variables:

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[CHGSUSP]
- SBS:TempRange(0x72)[TR1]

#### C.4.1.2 JT2 (Offset 2)

**JT2** is the upper bound of the low temperature charging range and the lower bound of standard temperature charging range 1. If *Temperature* is between **JT1** and **JT2**, then the *[TR2]* flag in *TempRange* is set, *Charging Voltage* is set to **LT Chg Voltage** and *ChargingCurrent* is set to **LT Chg Current1**, **LT Chg Current2**, or **LT Chg Current3**, depending on cell voltage (see [Section 2.5.5](#)).

**Table C-83. JT2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Temp Cfg	2	JT2	Integer	2	-400	1200	120	0.1°C

#### Related Variables

- DF:Charge Control:Charge Temp Cfg(32):JT1(0)
- DF:Charge Control:Charge Cfg(34):LT Chg Voltage(0)
- DF:Charge Control:Charge Cfg(34):LT Chg Current1..3(2..6)
- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:TempRange(0x72)[TR2]

#### C.4.1.3 JT2a (Offset 4)

**JT2a** is the upper bound of the standard temperature charging range1 and the lower bound of standard charging temperature range 2. If *Temperature* is between **JT2** and **JT2a**, then the *[TR2A]* flag in *TempRange* is set, *Charging Voltage* is set to **ST1 Chg Voltage** and *ChargingCurrent* is set to **ST1 Chg Current1**, **ST1 Chg Current2**, or **ST1 Chg Current3**, depending on cell voltage (see [Section 2.5.5](#)).

**Table C-84. JT2a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Temp Cfg	4	JT2a	Integer	2	-400	1200	300	0.1°C

**Related Variables:**

- DF:Charge Control:Charge Temp Cfg(32):JT2(2)
- DF:Charge Control:Charge Cfg(34):ST1 Chg Voltage(8)
- DF:Charge Control:Charge Cfg(34):ST1 Chg Current1..3(10..14)
- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:TempRange(0x72)[TR2A]

**C.4.1.4 JT3 (Offset 6)**

**JT3** is the upper bound of the standard temperature charging range 2, and the lower bound of high temperature charging range. If *Temperature* is between **JT2a** and **JT3**, then *[TR3]* flag in *TempRange* is set, *Charging Voltage* is set to **ST2 Chg Voltage** and *ChargingCurrent* is set to **ST2 Chg Current1**, **ST2 Chg Current2**, or **ST2 Chg Current3**, depending on cell voltage (see [Section 2.5.5](#)).

If *Temperature* is greater than **JT3** and charging did not start (*[DSG]* = 1), then charging is inhibited from starting.

**Table C-85. JT3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Temp Cfg	6	JT3	Integer	2	-400	1200	450	0.1°C

**Related Variables:**

- DF:Charge Control:Charge Temp Cfg(32):JT2a(4)
- DF:Charge Control:Charge Cfg(34):ST2 Chg Voltage(16)
- DF:Charge Control:Charge Cfg(34):ST2 Chg Current1..3(18..22)
- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:TempRange(0x72)[TR3]

**C.4.1.5 JT4 (Offset 8)**

**JT4** is the upper bound of the high temperature charging range. If *Temperature* is between **JT3** and **JT4**, then the *[TR4]* flag in *TempRange* is set, *Charging Voltage* is set to **HT Chg Voltage** and *Charging Current* is set to **HT Chg Current1**, **HT Chg Current2**, or **HT Chg Current3**, depending on cell voltage (see [Section 2.5.5](#)).

If *Temperature* is greater than **JT4** then the *[TR5]* flag in *TempRange* is set. If bq20z60-R1/bq20z65-R1 is in charge mode (*[DSG]* = 0), charging is suspended, *[CHGSUSP]* flag in *ChargingStatus* is set, and *ChargingCurrent* and *ChargingVoltage* are set to 0.

**Table C-86. JT4**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Temp Cfg	8	JT4	Integer	2	-400	1200	550	0.1°C

**Related Variables:**

- DF:Charge Control:Charge Temp Cfg(32):JT3(6)
- DF:Charge Control:Charge Cfg(34):HT Chg Voltage(24)
- DF:Charge Control:Charge Cfg(34):HT Chg Current1..3(26..30)
- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingVoltage(0x15)
- SBS:BatteryStatus(0x16)[DSG]
- SBS:ChargingStatus(0x55)[CHGSUSP]
- SBS:TempRange(0x72)[TR4][TR5]

**C.4.1.6 Temp Hys (Offset 10)**

**Temp Hys** is used to make sure that transitions between temperature ranges are not affected by small transients on the temperature reading. For example, if the current temperature range is the standard temperature range 2 (*[TR3]* is set) and *Temperature* goes above **JT3** then the high temperature range is entered (*[TR3]* is cleared and *[TR4]* is set). Temperature has to fall below **JT3 - Temp Hys** for the bq20z60-R1/bq20z65-R1 to go back to the standard temperature range 2.

**Table C-87. Temp Hys**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
32	Charge Temp Cfg	8	Temp Hys	Integer	2	0	100	10	0.1°C

**Related Variables:**

- DF:Charge Control:Charge Temp Cfg(32):JT1(0)
- DF:Charge Control:Charge Temp Cfg(32):JT2(2)
- DF:Charge Control:Charge Temp Cfg(32):JT2a(4)
- DF:Charge Control:Charge Temp Cfg(32):JT3(6)
- DF:Charge Control:Charge Temp Cfg(32):JT3(8)
- SBS:Temperature(0x008)
- SBS:TempRange(0x72)

**C.4.2 Pre-Charge Cfg (Subclass 33)**
**C.4.2.1 Pre-Chg Voltage Threshold (Offset 0)**

The bq20z60-R1/bq20z65-R1 enters pre-charge mode and sets the *[PCHG]* flag in *ChargingStatus* if any *CellVoltage4..1* drops below the **Pre-chg Voltage Threshold**. In this mode, *Charging Voltage* is set to **LT Chg Voltage**, and *Charging Current* is set to **Pre-chg Current**.

**Table C-88. Pre-Chg Voltage Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
33	Pre-Charge Cfg	0	Pre-Chg Voltage Threshold	Integer	2	0	20,000	3000	mV

**Related Variables:**

- DF:Charge Control:Charge Cfg(34):LT Chg Voltage(0)
- DF:Charge Control:Pre-Charge Cfg(33):Pre-chg Current(4)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)



- SBS:ChargingStatus(0x55)[PCHG]

#### C.4.2.2 Pre-Chg Recovery Voltage (Offset 2)

The bq20z60-R1/bq20z65-R1 leaves pre-charge mode and clears the *[PCHG]* flag in *ChargingStatus* if all *CellVoltage4..1* are equal to or higher than the **Pre-Chg Recovery Voltage** threshold.

**Table C-89. Pre-Chg Recovery Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
33	Pre-Charge Cfg	2	Pre-Chg Recovery Voltage	Integer	2	0	20,000	3100	mV

**Related Variables:**

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

#### C.4.2.3 Pre-chg Current (Offset 4)

The bq20z60-R1/bq20z65-R1 sets the *ChargingCurrent* to the **Pre-chg Current** value when in pre-charge mode.

**Table C-90. Pre-chg Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
33	Pre-Charge Cfg	4	Pre-chg Current	Integer	2	0	2000	250	mA

**Related Variables:**

- SBS:ChargingCurrent(0x14)

### C.4.3 Charge Cfg (Subclass 34)

#### C.4.3.1 LT Chg Voltage (Offset 0)

The bq20z60-R1/bq20z65-R1 sets *ChargingVoltage* to the **LT Chg Voltage** value when *Temperature* is in the low temperature charging range (*[TR2] = 1*).

**Table C-91. LT Chg Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	0	LT Chg Voltage	Integer	2	0	20,000	12,000	mV

**Related Variables:**

- SBS: Temperature(0x008)
- SBS: ChargingVoltage(0x15)
- SBS:TempRange(0x72)[TR2]

### C.4.3.2 LT Chg Current1 (Offset 2)

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **LT Chg Current1** value when *Temperature* is in the low temperature charging range ( $[TR2] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR1 range.

**Table C-92. LT Chg Current1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	2	LT Chg Current1	Integer	2	0	20,000	250	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR2]

### C.4.3.3 LT Chg Current2 (Offset 4)

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **LT Chg Current2** value when *Temperature* is in the low temperature charging range ( $[TR2] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR2 range.

**Table C-93. LT Chg Current2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	4	LT Chg Current2	Integer	2	0	20,000	250	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR2]

### C.4.3.4 LT Chg Current3 (Offset 6)

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **LT Chg Current3** value when *Temperature* is in the low temperature charging range ( $[TR2] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR3 range.

**Table C-94. LT Chg Current3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	6	LT Chg Current3	Integer	2	0	20,000	250	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR2]

### C.4.3.5 ST1 Chg Voltage (Offset 8)

The bq20z60-R1/bq20z65-R1 sets *ChargingVoltage* to the **ST1 Chg Voltage** value when *Temperature* is in the standard temperature charging range 1 ( $[TR2A] = 1$ ).

**Table C-95. ST1 Chg Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	8	ST1 Chg Voltage	Integer	2	0	20,000	16,800	mV

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingVoltage(0x15)
- SBS:TempRange(0x72)[TR2A]

**C.4.3.6 ST1 Chg Current1 (Offset 10)**

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **ST1 Chg Current1** value when *Temperature* is in the standard temperature charging range ( $[TR2A] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR1 range.

**Table C-96. ST1 Chg Current1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	10	ST1 Chg Current1	Integer	2	0	20,000	4,000	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR2A]

**C.4.3.7 ST1 Chg Current2 (Offset 12)**

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **ST1 Chg Current2** value when *Temperature* is in the standard temperature charging range ( $[TR2A] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR2 range.

**Table C-97. ST1 Chg Current2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	12	ST1 Chg Current2	Integer	2	0	20,000	4000	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR2A]

**C.4.3.8 ST1 Chg Current3 (Offset 14)**

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **ST1 Chg Current3** value when *Temperature* is in the standard temperature charging range ( $[TR2A] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR3 range.

**Table C-98. ST1 Chg Current3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	14	ST1 Chg Current3	Integer	2	0	20,000	4000	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR2A]

### C.4.3.9 ST2 Chg Voltage (Offset 16)

The bq20z60-R1/bq20z65-R1 sets *ChargingVoltage* to the **ST2 Chg Voltage** value when *Temperature* is in the standard temperature charging range 2 ( $[TR3] = 1$ ).

**Table C-99. ST2 Chg Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	16	ST2 Chg Voltage	Integer	2	0	20,000	16,800	mV

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingVoltage(0x15)
- SBS:TempRange(0x72)[TR3]

### C.4.3.10 ST2 Chg Current1 (Offset 18)

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **ST2 Chg Current1** value when *Temperature* is in the standard temperature charging range 2 ( $[TR3] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR1 range.

**Table C-100. ST2 Chg Current1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	18	ST2 Chg Current1	Integer	2	0	20,000	4000	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR3]

### C.4.3.11 ST2 Chg Current2 (Offset 20)

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **ST2 Chg Current2** value when *Temperature* is in the standard temperature charging range 2 ( $[TR3] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR2 range.

**Table C-101. ST2 Chg Current2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	20	ST2 Chg Current2	Integer	2	0	20,000	4000	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR3]

### C.4.3.12 ST2 Chg Current3 (Offset 22)

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **ST2 Chg Current3** value when *Temperature* is in the standard temperature charging range 2 ( $[TR3] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR3 range.

**Table C-102. ST2 Chg Current3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	22	ST2 Chg Current3	Integer	2	0	20,000	4000	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR3]

**C.4.3.13 HT Chg Voltage (Offset 24)**

The bq20z60-R1/bq20z65-R1 sets *ChargingVoltage* to the **HT Chg Voltage** value when *Temperature* is in the high temperature charging range ( $[TR4] = 1$ ).

**Table C-103. HT Chg Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	24	HT Chg Voltage	Integer	2	0	20,000	16,760	mV

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingVoltage(0x15)
- SBS:TempRange(0x72)[TR4]

**C.4.3.14 HT Chg Current1 (Offset 26)**

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **HT Chg Current1** value when *Temperature* is in the high temperature charging range ( $[TR4] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR1 range.

**Table C-104. HT Chg Current1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	26	HT Chg Current1	Integer	2	0	20,000	3800	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR4]

**C.4.3.15 HT Chg Current2 (Offset 28)**

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **HT Chg Current2** value when *Temperature* is in the high temperature charging range ( $[TR4] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR2 range.

**Table C-105. HT Chg Current2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	28	HT Chg Current2	Integer	2	0	20,000	3800	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR4]

### C.4.3.16 HT Chg Current3 (Offset 30)

The bq20z60-R1/bq20z65-R1 sets *ChargingCurrent* to the **HT Chg Current3** value when *Temperature* is in the high temperature charging range ( $[TR4] = 1$ ) and  $\max(\text{CellVoltage4..1})$  is in the CVR3 range.

**Table C-106. HT Chg Current3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	30	HT Chg Current3	Integer	2	0	20,000	3800	mA

**Related Variables:**

- SBS:Temperature(0x008)
- SBS:ChargingCurrent(0x14)
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:TempRange(0x72)[TR4]

### C.4.3.17 Cell Voltage Threshold1 (Offset 32)

The bq20z60-R1/bq20z65-R1 is in cell voltage range 1 (CVR1) when  $\max(\text{CellVoltage4..1}) < \text{Cell Voltage Threshold1}$ .

**Table C-107. Cell Voltage Threshold1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	32	Cell Voltage Threshold1	Integer	2	0	5000	3900	mV

**Related Variables:**

- SBS:CellVoltage4..1(0x3c..0x3f)

### C.4.3.18 Cell Voltage Threshold2 (Offset 34)

The bq20z60-R1/bq20z65-R1 enters cell voltage range 2 (CVR2) when  $\text{Cell Voltage Threshold1} < \max(\text{CellVoltage4..1}) < \text{Cell Voltage Threshold2}$ . The bq20z60-R1/bq20z65-R1 enters cell voltage range 3 (CVR3) when  $\max(\text{CellVoltage4..1}) > \text{Cell Voltage Threshold2}$ .

**Table C-108. Cell Voltage Threshold2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	34	Cell Voltage Threshold2	Integer	2	0	5000	4000	mV

**Related Variables:**

- DF:Charge Control:Charge Cfg(34):Cell Voltage Threshold1(32)
- SBS:CellVoltage4..1(0x3c..0x3f)

### C.4.3.19 Cell Voltage Thresh Hys (Offset 36)

**Cell Voltage Thresh Hys** is used to make sure that transitions between cell voltage ranges are not affected by small transients. For example, if the current cell voltage range is CVR2 and cell voltage goes above **Cell Voltage Threshold2** then CVR3 is entered. Cell voltage has to fall below **Cell Voltage Threshold2 – Cell Voltage Thresh Hys** for the bq20z60-R1/bq20z65-R1 to go back to CVR2 range.

**Table C-109. Cell Voltage Thresh Hys**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
34	Charge Cfg	36	Cell Voltage Thresh Hys	Integer	2	0	1000	10	mV

**Related Variables:**

- SBS:CellVoltage4..1(0x3c..0x3f)
- DF:Charge Control:Charge Cfg(34):Cell Voltage Threshold1(32)
- DF:Charge Control:Charge Cfg(34):Cell Voltage Threshold2(34)

**C.4.4 Termination Cfg. (Subclass 36)****C.4.4.1 Maintenance Current (Offset 0)**

*ChargingCurrent* is set to **Maintenance Current** if a primary charge termination is detected or *RelativeStateOfCharge* > **TCA Set %**

**Table C-110. Maintenance Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
36	Termination Cfg.	0	Maintenance Current	Integer	2	0	1000	0	mA

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):TCA Set %(9)
- SBS:RelativeStateOfCharge(0x00d)
- SBS:ChargingCurrent(0x14)
- SBS:ChargingStatus(0x55)[MCHG]

**C.4.4.2 Taper Current (Offset 2)**

If battery *Current* falls below **Taper Current** for two consecutive **Current Taper Window** time periods during charging and *Voltage* is equal to or higher than **Charging Voltage – Taper Voltage**, the bq20z60-R1/bq20z65-R1 recognizes valid primary charge termination.

**Table C-111. 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	Integer	2	0	1000	250	mA

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):Taper Voltage(6)
- DF:Charge Control:Termination Cfg.(36):Current Taper Window(8)
- SBS:Voltage(0x009)
- SBS:Current(0x00a)

**C.4.4.3 Taper Voltage (Offset 6)**

For a valid primary charge termination, the taper voltage condition needs to be met. The taper voltage condition is either cell voltage based or pack voltage based, depending on [*CELL\_TAPER*] bit setting in **Operation Cfg C**.

- [*CELL\_TAPER*] = 1: Max (*CellVoltage4..1*) + **Taper Voltage**  $\hat{A}^3$  *ChargingVoltage* / number of cells
- [*CELL\_TAPER*] = 0: *Voltage* + **Taper Voltage**  $\hat{A}^3$  *ChargingVoltage*

**Table C-112. 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	Integer	2	0	1000	75	mV

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg C(4)[CELL\_TAPER]
- SBS:CellVoltage4..1(0x3c..0x3f)
- SBS:ChargingVoltage(0x15)

**C.4.4.4 Current Taper Window (Offset 8)**

If battery *Current* falls below **Taper Current** for two consecutive **Current Taper Window** time periods during charging and *Voltage* is equal to or higher than **Charging Voltage – Taper Voltage**, the bq20z60-R1/bq20z65-R1 recognizes valid primary charge termination.

**Table C-113. Current Taper Window**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
36	Termination Cfg.	8	Current Taper Window	Unsigned integer	1	0	240	40	s

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):Taper Current(2)
- DF:Charge Control:Termination Cfg.(36):Taper Voltage(6)
- SBS:Voltage(0x009)
- SBS:Current(0x00a)

**C.4.4.5 TCA Set % (Offset 9)**

When set between 0% and 100%, *[TCA]* in *BatteryStatus* is set if *RelativeStateOfCharge* is equal to or above **TCA Set %**. Set to –1 to disable this function. If set to –1, the *[MCHG]* flag in *ChargingStatus* and the *[TCA]* flag in *BatteryStatus* are set on primary charge termination and *ChargingCurrent* is set to **Maintenance Current**.

**Table C-114. TCA Set %**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
36	Termination Cfg.	9	TCA Set %	Integer	1	–1	100	–1	%

**Related Variables:**

- DF:Charge Control:Termination Cfg.(36):Maintenance Current(0)
- DF:Charge Control:Termination Cfg.(36):TCA Clear %(10)
- SBS:RelativeStateOfCharge(0x00d)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[MCHG]



#### C.4.4.6 TCA Clear % (Offset 10)

When set between 0% and 100%, *[TCA]* in *BatteryStatus* is cleared if *RelativeStateOfCharge* is below **TCA Clear %**. Set to -1 to disable this function.

**Table C-115. 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 %	Integer	1	-1	100	95	%

##### Related Variables:

- DF:Charge Control:Termination Cfg.(36):TCA Set %(9)
- SBS:RelativeStateOfCharge(0x00d)
- SBS:BatteryStatus(0x16)[TCA]

#### C.4.4.7 FC Set % (Offset 11)

When set between 0% and 100%, *[FC]* in *BatteryStatus* is set if *RelativeStateOfCharge* is equal to or above **FC Set %**. Set to -1 to disable this function.

**Table C-116. FC Set %**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
36	Termination Cfg.	11	FC Set %	Integer	1	-1	100	-1	%

##### Related Variables:

- DF:Charge Control:Termination Cfg.(36):FC Clear %(12)
- SBS:RelativeStateOfCharge(0x00d)
- SBS:BatteryStatus(0x16)[FC]

#### C.4.4.8 FC Clear % (Offset 12)

When set between 0% and 100%, *[FC]* in *BatteryStatus* is cleared if *RelativeStateOfCharge* reaches or falls below **FC Clear %**. Set to -1 to disable this function, however, it is not recommended to set **FC Clear %** to -1.

**Table C-117. 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 %	Integer	1	-1	100	98	%

##### Related Variables:

- DF:Charge Control:Termination Cfg.(36):FC Set %(11)
- SBS:RelativeStateOfCharge(0x00d)
- 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 units of balance time per mAh before the bq20z60-R1/bq20z65-R1 starts balancing cell capacity during charging. If **Min Cell Deviation** is set to 0, cell balancing is disabled.

**Table C-118. Min Cell Deviation**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
37	Cell Balancing Cfg	0	Min Cell Deviation	Unsigned integer	2	0	65,535	1350	s/mAh

## C.4.6 Charging Faults (Subclass 38)

### C.4.6.1 Over Charging Voltage (Offset 0)

If battery pack *Voltage* is equal to or greater than **ST2 Chg Voltage + Over Charging Voltage** for a time period greater than **Over Charging Volt Time**, the **[OCHGV]** flag is set, and the CHG FET and ZVCHG FET (if used) are turned off if **[OCHGV]** is also set in **Charge Fault Cfg**.

**Table C-119. Over Charging Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	0	Over Charging Voltage	Integer	2	0	3000	500	mV

#### Related Variables:

- DF:Charge Control:Charge Cfg(34):ST2 Chg Voltage(16)
- DF:Charge Control:Charging Faults(38):Over Charging Volt Time(2)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGV]
- SBS:Voltage(0x009)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGV]

### C.4.6.2 Over Charging Volt Time (Offset 2)

If battery pack *Voltage* is equal to or greater than **ST2 Chg Voltage + Over Charging Voltage** for a time period greater than **Over Charging Volt Time**, the **[OCHGV]** flag is set, and the CHG FET and ZVCHG FET (if used) are turned off if **[OCHGV]** is also set in **Charge Fault Cfg**. The bq20z60-R1/bq20z65-R1 recovers if the battery pack *Voltage* is equal to or below **ST2 Chg Voltage**.

**Table C-120. Over Charging Volt Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	2	Over Charging Volt Time	Unsigned integer	1	0	240	0	s

#### Related Variables:

- DF:Charge Control:Charge Cfg(34):ST2 Chg Voltage(16)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGV]
- SBS:Voltage(0x009)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGV]

### C.4.6.3 Over Charging Current (Offset 3)

If the current is equal to or greater than the sum of *ChargingCurrent* and **Over Charging Current** for a time period greater than **Over Charging Curr Time**, the **[OCHGI]** flag in *ChargingStatus* set and, if **[OCHGI]** in **Charge Fault Cfg** is set, the CHG FET turns off and the ZVCHG FET (if used) is turned on. If the ZVCHG FET is not used the CHG FET remains on, regardless of the bits set in **Charge Fault Cfg** because the CHG FET acts as the ZVCHG FET.

**Table C-121. Over Charging Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	3	Over Charging Current	Integer	2	0	2000	500	mA

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGI]
- SBS:Current(0x00a)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGI]

**C.4.6.4 Over Charging Curr Time (Offset 5)**

If *Current* is equal to or greater than the sum of *ChargingCurrent* and **Over Charging Current** for a time period greater than **Over Charging Curr Time**, the [OCHGI] flag in *ChargingStatus* is set and, if [OCHGI] in **Charge Fault Cfg** is set, the CHG FET turns off and the ZVCHG FET (if used) is turned on. If the ZVCHG FET is not used, the CHG FET remains on, regardless of the bits set in **Charge Fault Cfg** because the CHG FET acts as the ZVCHG FET. The bq20z60-R1/bq20z65-R1 recovers if *AverageCurrent* is equal to or lower than the **Over Charging Curr Recov** value.

**Table C-122. Over Charging Curr Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	5	Over Charging Curr Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Current(3)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Recov(6)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OCHGI]
- SBS:Current(0x00a)
- SBS:AverageCurrent(0x00b)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGI]

#### C.4.6.5 Over Charging Curr Recov (Offset 6)

The bq20z60-R1/bq20z65-R1 recovers from an overcharging current fault if *AverageCurrent* is equal to or lower than **Over Charging Curr Recov**. On recovery, the *[OCHGI]* flag in *ChargingStatus* is cleared, and the CHG and ZVCHG FETs return to their previous states.

**Table C-123. Over Charging Curr Recov**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	6	Over Charging Curr Recov	Integer	2	0	2000	100	mA

#### Related Variables:

- DF:Charge Control:Charging Faults(38):Over Charging Current(3)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- SBS:Current(0x00a)
- SBS:ChargingCurrent(0x14)
- SBS:BatteryStatus(0x16)[TCA]
- SBS:ChargingStatus(0x55)[OCHGI]

#### C.4.6.6 Depleted Voltage (Offset 8)

The bq20z60-R1/bq20z65-R1 enters a depleted voltage fault and sets *[XCHGLV]* if the charger is present (*PackVoltage* > **Charger Present**) and pack *Voltage* is equal to or lower than **Depleted Voltage** for a period equal to or greater than **Depleted Voltage Time**. The DSG FET is turned off and the CHG and ZVCHG FETs are set according to the *[ZVCHG1]* and *[ZVCHG0]* bits if *[CS\_XCHGLV]* is set in **Charge Fault Cfg**.

**Table C-124. Depleted Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	8	Depleted Voltage	Integer	2	0	16,000	8000	mV

#### Related Variables:

- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[CS\_XCHGLV]
- DF:Power:Power(68):Charger Present(8)
- SBS:Voltage(0x009)
- SBS:PackVoltage(0x5a)
- SBS:ChargingStatus(0x55)[XCHGLV]

#### C.4.6.7 Depleted Voltage Time (Offset 10)

The bq20z60-R1/bq20z65-R1 enters a depleted voltage fault and sets *[XCHGLV]* if the charger is present and pack *Voltage* is equal to or lower than **Depleted Voltage** for a period equal to or greater than **Depleted Voltage Time**. If *[CS\_XCHGLV]* is set in **Charge Fault Cfg**, the DSG FET is turned off and the CHG and ZVCHG FETs are set according to their pre-charge settings.

**Table C-125. Depleted Voltage Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	10	Depleted Voltage Time	Unsigned integer	1	0	240	2	s

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Depleted Voltage(8)
- DF:Charge Control:Charging Faults(38):Depleted Recovery(11)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[CS\_XCHGLV]
- SBS:Voltage(0x009)
- SBS:ChargingStatus(0x55)[XCHGLV]

**C.4.6.8 Depleted Recovery (Offset 11)**

The bq20z60-R1/bq20z65-R1 recovers from a depleted voltage fault if pack *Voltage* is equal to or higher than the **Depleted Recovery** threshold. On recovery, [OCHGLV] is reset and the DSG FET, CHG FET and ZVCHG FET return to their previous states.

**Table C-126. Depleted Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	11	Depleted Recovery	Integer	2	0	16,000	8500	mV

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- SBS:Voltage(0x009)
- SBS:ChargingStatus(0x55)[XCHGLV]

**C.4.6.9 Over Charge Capacity (Offset 13)**

The bq20z60-R1/bq20z65-R1 enters an overcharge fault and sets the [OC] flag in *ChargingStatus* if the internally counted remaining capacity exceeds *FullChargeCapacity* + **Over Charge Capacity**. The CHG FET and ZVCHG FET (if used) are also turned off if the [OC] bit is set in **Charge Fault Cfg**.

**Table C-127. 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	Integer	2	0	4000	300	mAh

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charge Recovery(15)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[OC]
- SBS:FullChargeCapacity(0x10)
- SBS:ChargingStatus(0x55)[OC]

**C.4.6.10 Over Charge Recovery (Offset 15)**

The bq20z60-R1/bq20z65-R1 recovers from an overcharge in non-removable battery mode ([NR] = 1) if it is continuously discharged by an amount of **Over Charge Recovery** charge.

**Table C-128. Over Charge Recovery**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	15	Over Charge Recovery	Integer	2	0	100	2	mAh

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charge Capacity(13)
- DF:Configuration:Registers(64):Operation B Cfg(2)[NR]
- SBS:RemainingCapacity(0x00f)

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

#### C.4.6.11 Charge Timeout (Offset 17)

If charge *Current* is equal to or greater than **Chg Current Threshold** for an **Charge Timeout** time period the bq20z60-R1/bq20z65-R1 generates a charge mode timeout fault and sets the [CMTO] flag. The CHG FET and ZVCHG FET (if used) are also turned off if [CMTO] is set in **Charge Fault Cfg**. Set to 0 to disable **Charge Timeout**.

**Table C-129. Charge Timeout**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	17	Charge Timeout	Unsigned integer	2	0	65,535	10,800	s

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[CMTO]
- SBS:Current(0x00a)
- SBS:ChargingStatus(0x55)[CMTO]

#### C.4.6.12 Precharge Timeout (Offset 19)

If charge *Current* is equal to or greater than **Chg Current Threshold** for a **Precharge Timeout** time period, the bq20z60-R1/bq20z65-R1 generates a precharge mode timeout error and sets the [PCMTO] flag. The CHG FET and ZVCHG FET (if used) are also turned off if [PCMTO] is set in **Charge Fault Cfg**. Set to 0 to disable **Precharge Timeout**.

**Table C-130. Precharge Timeout**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	19	Precharge Timeout	Unsigned integer	2	0	65,535	3600	s

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Chg Current Threshold(2)
- DF:Charge Control:Charging Faults(38):Charge Fault Cfg(21)[PCMTO]
- SBS:Current(0x00a)
- SBS:ChargingStatus(0x55)[PCMTO]

#### C.4.6.13 Charge Fault Cfg (Offset 21)

This register sets the behavior of the charge, discharge, and zero-volt-charge FETs in fault conditions.

**Table C-131. Charge Fault Cfg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	21	Charge Fault Cfg	Hex	1	0x00	0xffff	0x00	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	RSVD	RSVD	PCMTO	CMTO	OCHGV	OCHGI	OC	CS_XCHGL V

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

**Figure C-5. Charge Fault Cfg Register**

**PCMTO**— If this bit is set, the CHG FET and ZVCHG FET (if used) are turned off when a precharge timeout fault occurs.

**CMTO**— If this bit is set, the CHG FET and ZVCHG FET (if used) are turned off when a charge timeout fault occurs.

**OCHGV**— If this bit is set, the CHG FET and ZVCHG FET (if used) are turned off when a charge voltage fault occurs.

**OCHGI**— If this bit is set, the CHG FET is turned off and the ZVCHG FET (if used) is turned on when a charge current fault occurs. If the ZVCHG FET is not used, the CHG FET remains on, regardless of this bit, because it acts as ZVCHG FET.

**OC**— If this bit is set, the CHG FET and ZVCHG FET (if used) are turned off when an overcharge fault occurs.

**CS\_XCHGLV**— If this bit is set, the DSG FET is turned off when a battery-depleted fault occurs.

**Related Variables:**

- DF:Charge Control:Charging Faults(38):Over Charging Volt Time(2)
- DF:Charge Control:Charging Faults(38):Over Charging Curr Time(5)
- DF:Charge Control:Charging Faults(38):Depleted Voltage Time(10)
- DF:Charge Control:Charging Faults(38):Over Charge Capacity(13)
- DF:Charge Control:Charging Faults(38):Charge Timeout(17)
- DF:Charge Control:Charging Faults(38):Precharge Timeout(19)

## C.5 SBS Configuration

### C.5.1 Data (Subclass 48)

#### C.5.1.1 Rem Cap Alarm (Offset 0)

When *[CapM]* in *BatteryStatus* is set to 0, the default value of *RemainingCapacityAlarm* is stored in **Rem Cap Alarm** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-132. 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	Integer	2	0	700	300	mAh

**Related Variable:**

- SBS:RemainingCapacityAlarm(0x001)

#### C.5.1.2 Rem Energy Alarm (Offset 2)

When *[CapM]* in *BatteryStatus* is set to 1, the default value of *RemainingCapacityAlarm* is stored in **Rem Energy Alarm** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-133. Rem Energy Alarm**

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

**Related Variable:**

- SBS:RemainingCapacityAlarm(0x001)

#### C.5.1.3 Rem Time Alarm (Offset 4)

The default value of *RemainingTimeAlarm* is stored in **Rem Time Alarm** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-134. 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 Variable:**

- SBS:RemainingTimeAlarm(0x002)

#### C.5.1.4 Init Battery Mode (Offset 6)

The default value of *BatteryMode* is stored in **Init Battery Mode** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-135. 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	0x0000	0xffff	0x0081	



**Related Variable:**

- SBS:BatteryMode(0x003)

**C.5.1.5 Design Voltage (Offset 8)**

The default value of *DesignVoltage* is stored in **Design Voltage** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-136. Design Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	8	Design Voltage	Integer	2	7000	18,000	14,400	mV

**Related Variable:**

- SBS:DesignVoltage(0x19)

**C.5.1.6 Spec Info (Offset 10)**

The default value of *SpecificationInfo* is stored in **Spec Info** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-137. 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 Variable:**

- SBS:SpecificationInfo(0x1a)

**C.5.1.7 Manuf Date (Offset 12)**

The default value of *ManufacturerDate* is stored in **Manuf Date** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-138. 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	65,535	0	Day + Mo × 32 + (Yr – 1980) × 256

**Related Variable:**

- SBS:ManufactureDate(0x1b)

**C.5.1.8 Ser. Num. (Offset 14)**

The default value of *SerialNumber* is stored in **Ser. Num.** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization.

**Table C-139. 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 Variable:**

- SBS:SerialNumber(0x1c)

**C.5.1.9 Cycle Count (Offset 16)**

The default value of *CycleCount* is stored in **Cycle Count** and copied to the SBS value on bq20z60-R1/bq20z65-R1 initialization. When the SBS value changes, **Cycle Count** is also updated.

**Table C-140. Cycle Count**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	16	Cycle Count	Unsigned integer	2	0	65,535	0	

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[CCT]
- DF:SBS Configuration:Data(48):CC Threshold(18)
- DF:SBS Configuration:Data(48):CC %(20)
- SBS:CycleCount(0x17)

**C.5.1.10 CC Threshold (Offset 18)**

If the *[CCT]* bit is cleared, the cycle count function counts the accumulated discharge of the **CC Threshold** value as one cycle.

**Table C-141. CC Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	18	CC Threshold	Integer	2	100	32,767	4400	mAh

**Related Variables:**

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

**C.5.1.11 CC % (Offset 20)**

If the *[CCT]* bit is set, the cycle count function counts the accumulated discharge of (*FullChargeCapacity* × **CC %**) as one cycle. If (*FullChargeCapacity* × **CC %**) is smaller than **CC Threshold**, **CC Threshold** is used for counting.

**Table C-142. CC %**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	20	CC %	Unsigned integer	1	0	100	90	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg B(2)[CCT]
- DF:SBS Configuration:Data(48):CC Threshold(18)
- SBS:FullChargeCapacity(0x10)
- SBS:CycleCount(0x17)

**C.5.1.12 CF Max Error Limit (Offset 21)**

If the *MaxError* function value is greater than **CF Max Error Limit**, the *[CF]* flag in *BatteryMode* is set.

**Table C-143. 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(0x003)[CF]
- SBS:MaxError(0x00c)

**C.5.1.13 Design Capacity (Offset 22)**

If [CapM] in *BatteryMode* is set to 0, the *DesignCapacity* function reports **Design Capacity**.

**Table C-144. Design Capacity**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	22	Design Capacity	Integer	2	0	32,767	4400	mAh

**Related Variables:**

- DF:Gas Gauging:IT Config(80):Load Select(0)
- SBS:BatteryMode(0x003)[CapM]
- SBS:DesignCapacity(0x18)
- SBS:StateOfHealth(0x4f)

**C.5.1.14 Design Energy (Offset 24)**

If [CapM] in *BatteryMode* is set to 1, the *DesignCapacity* function reports **Design Energy**.

**Table C-145. Design Energy**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	24	Design Energy	Integer	2	0	32,767	6336	10mWh

**Related Variables:**

- DF:Gas Gauging:IT Config(80):Load Select(0)
- SBS:BatteryMode(0x003)[CapM]
- SBS:DesignCapacity(0x18)
- SBS:StateOfHealth(0x4f)

**C.5.1.15 Manuf Name (Offset 26)**

The *ManufacturerName* function returns a string stored in **Manuf Name**. The maximum text length is 20 characters.

**Table C-146. 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	20 + 1	–	–	Texas Instruments	

**Related Variable:**

- SBS:ManufacturerName(0x20)

**C.5.1.16 Device Name (Offset 47)**

The *DeviceName* function returns a string stored in **Device Name**. The maximum text length is 20 characters.

**Table C-147. Device Name**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	47	Device Name	String	20 + 1	–	–	bq20z60	

**Related Variable:**

- SBS:DeviceName(0x21)

**C.5.1.17 Device Chemistry (Offset 68)**

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

**Table C-148. Device Chemistry**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	68	Device Chemistry	String	4 + 1	–	–	LION	

**Related Variable:**

- SBS:DeviceChemistry(0x22)

**C.5.1.18 Deterioration Warn Limit (Offset 73)**

If the battery capacity as indicated by the *StateofHealth* percentage falls below **Deterioration Warn Limit**, the bq20z60-R1/bq20z65-R1 sets the *[DetW]* flag in *StateOfHealth*.

**Table C-149. Deterioration Warn Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	73	Deterioration Warn Limit	Unsigned integer	1	0	100	50	%

**Related Variable:**

- SBS:StateOfHealth(0x4f)

**C.5.1.19 Deterioration Fault Limit (Offset 74)**

If the battery capacity as indicated by the *StateofHealth* percentage falls below **Deterioration Fault Limit**, the bq20z60-R1/bq20z65-R1 sets the *[DetF]* flag in *StateOfHealth*.

**Table C-150. Deterioration Fault Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	74	Deterioration Fault Limit	Unsigned integer	1	0	100	30	%

**Related Variable:**

- SBS:StateOfHealth(0x4f)

**C.5.1.20 Cell Life Limit (Offset 75)**

If the battery capacity as indicated by the *StateofHealth* percentage falls below **Cell Life Limit**, the bq20z60-R1/bq20z65-R1 sets the *[CLL]* flag in *StateOfHealth*.

**Table C-151. Cell Life Limit**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
48	Data	75	Cell Life Limit	Unsigned integer	1	0	100	20	%

**Related Variable:**

- SBS:StateOfHealth(0x4f)

**C.5.2 Configuration (Subclass 49)****C.5.2.1 TDA Set % (Offset 0)**

If set between 0% and 100%, the bq20z60-R1/bq20z65-R1 sets the *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below **TDA Set %**. Set to -1 to disable this function.

**Table C-152. TDA Set %**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	0	TDA Set %	Integer	1	-1	100	6	%

**Related Variables:**

- SBS:RelativeStateOfCharge(0x00d)
- SBS:BatteryStatus(0x16)[TDA]

**C.5.2.2 TDA Clear % (Offset 1)**

If set between 0% and 100%, the bq20z60-R1/bq20z65-R1 clears the *[TDA]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above **TDA Clear %**. Set to -1 to disable this function.

**Table C-153. TDA Clear %**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	1	TDA Clear %	Integer	1	-1	100	8	%

**Related Variables:**

- SBS:RelativeStateOfCharge(0x00d)
- SBS:BatteryStatus(0x16)[TDA]

**C.5.2.3 FD Set % (Offset 2)**

If set between 0% and 100%, the bq20z60-R1/bq20z65-R1 sets the *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or falls below **FD Set %**. Set to -1 to disable this function.

**Table C-154. FD Set %**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	2	FD Set %	Integer	1	-1	100	2	%

**Related Variables:**

- SBS:RelativeStateOfCharge(0x00d)
- SBS:BatteryStatus(0x16)[FD]

**C.5.2.4 FD Clear % (Offset 3)**

If set between 0% and 100%, the bq20z60-R1/bq20z65-R1 clears the *[FD]* flag in *BatteryStatus* if the *RelativeStateOfCharge* reaches or rises above **FD Clear %**. Set to -1 to disable this function.

**Table C-155. FD Clear %**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	3	FC Clear %	Integer	1	-1	100	5	%

**Related Variables:**

- SBS:RelativeStateOfCharge(0x00d)
- SBS:BatteryStatus(0x16)[FD]

**C.5.2.5 TDA Set Volt Threshold (Offset 4)**

The bq20z60-R1/bq20z65-R1 sets the *[TDA]* flag in *BatteryStatus* if *Voltage* is equal to or lower than **TDA Set Volt Threshold** for a period equal to or greater than **TDA Set Volt Time**.

**Table C-156. 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	Integer	2	0	16,800	5000	mV

**Related Variables:**

- DF:SBS Configuration:Configuration(49):TDA Set Volt Time(6)
- SBS:Voltage(0x009)
- SBS:BatteryStatus(0x16)[TDA]

**C.5.2.6 TDA Set Volt Time (Offset 6)**

The bq20z60-R1/bq20z65-R1 sets the *[TDA]* flag in *BatteryStatus* if *Voltage* is equal to or lower than **TDA Set Volt Threshold** for a period equal to or greater than **TDA Set Volt Time**. Set to 0 to disable this feature.

**Table C-157. TDA Set Volt Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	6	TDA Set Volt Time	Unsigned integer	1	0	240	5	s

**Related Variables:**

- DF:SBS Configuration:Configuration(49):TDA Set Volt Threshold(4)
- SBS:Voltage(0x009)
- SBS:BatteryStatus(0x16)[TDA]

**C.5.2.7 TDA Clear Volt (Offset 7)**

The bq20z60-R1/bq20z65-R1 clears the *[TDA]* flag if *Voltage* is equal to or greater than **TDA Clear Volt**. **TDA Clear Volt** clears *[TDA]* only if *[TDA]* is set by **TDA Set Volt Threshold**. It does not clear *[TDA]* if *[TDA]* is set by **TDA Set %** or any other function.

**Table C-158. 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	Integer	2	0	16,800	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(0x009)
- SBS:BatteryStatus(0x16)[TDA]

**C.5.2.8 FD Set Volt Threshold (Offset 9)**

The bq20z60-R1/bq20z65-R1 sets the *[FD]* flag if *Voltage* is equal to or lower than **FD Set Volt Threshold** for a period equal to or greater than **FD Volt Time**.

**Table C-159. FD Set Volt Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	9	FD Set Volt Threshold	Integer	2	0	16,800	5000	mV

**Related Variables:**

- DF:SBS Configuration:Configuration(49):FD Volt Time(11)
- SBS:Voltage(0x009)
- SBS:BatteryStatus(0x16)[FD]

**C.5.2.9 FD Volt Time (Offset 11)**

The bq20z60-R1/bq20z65-R1 sets the *[FD]* flag if *Voltage* is equal to or lower than **FD Set Volt Threshold** for a period equal to or greater than **FD Volt Time**. Set to 0 to disable this feature.

**Table C-160. FD Volt Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	11	FD Volt Time	Unsigned integer	1	0	240	5	s

**Related Variables:**

- DF:SBS Configuration:Configuration(49):FD Set Volt Threshold(9)
- SBS:Voltage(0x009)
- SBS:BatteryStatus(0x16)[FD]

**C.5.2.10 FD Clear Volt (Offset 12)**

The bq20z60-R1/bq20z65-R1 clears the *[FD]* flag if *Voltage* is equal to or greater than **FD Clear Volt**.

**Table C-161. FD Clear Volt**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
49	Configuration	12	FD Clear Volt	Integer	2	0	16,800	5500	mV

**Related Variables:**

- DF:SBS Configuration:Configuration(49):FD Set Volt Threshold(9)
- SBS:Voltage(0x009)
- SBS:BatteryStatus(0x16)[FD]

**C.6 System Data****C.6.1 Manufacturer Data (Subclass 56)****C.6.1.1 Pack Lot Code (Offset 0)**

The *ManufacturerData* function reports **Pack Lot Code** as part of its return value.

**Table C-162. Pack Lot Code**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
56	Manufacturer Data	0	Pack Lot Code	Hex	2	0x0000	0xffff	0x0000	

**Related Variable:**

- SBS:ManufacturerData(0x23)

**C.6.1.2 PCB Lot Code (Offset 2)**

The *ManufacturerData* function reports **PCB Lot Code** as part of its return value.

**Table C-163. PCB Lot Code**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
56	Manufacturer Data	2	PCB Lot Code	Hex	2	0x0000	0xffff	0x0000	

**Related Variable:**

- SBS:ManufacturerData(0x23)

**C.6.1.3 Firmware Version (Offset 4)**

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

**Table C-164. Firmware Version**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
56	Manufacturer Data	4	Firmware Version	Hex	2	0x0000	0xffff	0x0000	

**Related Variable:**

- SBS:ManufacturerData(0x23)

**C.6.1.4 Hardware Revision (Offset 6)**

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

**Table C-165. Hardware Revision**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
56	Manufacturer Data	6	Hardware Revision	Hex	2	0x0000	0xffff	0x0000	



**Related Variable:**

- SBS:ManufacturerData(0x23)

**C.6.1.5 Cell Revision (Offset 8)**

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

**Table C-166. Cell Revision**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
56	Manufacturer Data	8	Cell Revision	Hex	2	0x0000	0xffff	0x0000	

**Related Variable:**

- SBS:ManufacturerData(0x23)

**C.6.2 Manufacturer Info (Subclass 58)****C.6.2.1 Manuf. Info 0 (Offset 0)**

The *ManufacturerInfo* function returns the string stored in **Manuf. Info**. The maximum text length is 31 characters.

**Table C-167. Manuf. Info 0**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
58	Manufacturer Info	0	Manuf. Info 0	String	31+1	–	–	012345678 9ABCDEF0 123456789 ABCDE	

**Related Variable:**

- SBS:ManufacturerInfo(0x70)

**C.6.2.2 Manuf. Block 1 (Offset 32)**

The 20-byte DF location is provided for manufacturer data that is accessible (read/write) in sealed and unsealed modes.

**Table C-168. Manuf. Block 1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
58	Manufacturer Info	32	Manuf. Block 1	String	20+1	–	–	0123456789A BCDEF012	

**Related Variable:**

- SBS:ManufBlock1(0x6c)

**C.6.3 Manuf. Block 2 (Offset 53)**

The 20-byte DF location is provided for manufacturer data that is accessible (read/write) in sealed and unsealed modes.

**Table C-169. Manuf. Block 2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
58	Manufacturer Info	53	Manuf. Block 2	String	20+1	–	–	0123456789A BCDEF012	

**Related Variable:**

- SBS:ManufBlock2(0x6d)

**C.6.4 Manuf. Block 3 (Offset 74)**

The 20-byte DF location is provided for manufacturer data that is accessible (read/write) in sealed and unsealed modes.

**Table C-170. Manuf. Block 3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
58	Manufacturer Info	74	Manuf. Block 3	String	20+1	–	–	0123456789A BCDEF012	

**Related Variable:**

- SBS:ManufBlock3(0x6e)

**C.6.5 Manuf. Block 4 (Offset 95)**

The 20-byte DF location is provided for manufacturer data that is accessible (read/write) in sealed and unsealed modes.

**Table C-171. Manuf. Block 4**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
58	Manufacturer Info	95	Manuf. Block 4	String	20+1	–	–	0123456789A BCDEF012	

**Related Variable:**

- SBS:ManufBlock4(0x6f)

**C.6.6 Lifetime Data (Subclass 59)****C.6.6.1 Lifetime Max Temp (Offset 0)**

If the [QEN] flag in *OperationStatus* is set, the **Lifetime Max Temp** value is updated with the temperature source value selected by the [Temp1] and [Temp0] bits in **Operation Cfg A** if one of the following conditions is met.

- Temperature source value > 70°C for a period > 60 seconds.
- Temperature source value > 70°C AND any other lifetime value is updated.

The event logging ends when the temperature source value < 69°C after the Lifetime Max Temp begins logging.

**Table C-172. Lifetime Max Temp**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	0	Lifetime Max Temp	Integer	2	0	1400	300	0.1°C

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- DF:Configuration:Operation Cfg A:Temp1(4) and Temp0(3)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.2 Lifetime Min Temp (Offset 2)

If the [QEN] flag is set in *OperationStatus*, **Lifetime Min Temp** is updated with the temperature source value selected by the [Temp1] and [Temp0] bits in **Operation Cfg A** if one of the following conditions is met.

- **Lifetime Min Temp** – temperature source value > 1°C.
- **Lifetime Min Temp** > temperature source value for a period > 60 seconds
- **Lifetime Min Temp** > temperature source value AND any other lifetime value is updated.

**Table C-173. Lifetime Min Temp**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	2	Lifetime Min Temp	Integer	2	-600	1400	200	0.1°C

#### Related Variables:

- DF:Gas Gauging:State(82):Update Status(12)
- DF:Configuration:Operation Cfg A:Temp1(4) and Temp0(3)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.3 Lifetime Max Cell Voltage (Offset 4)

If the [QEN] flag is set in *OperationStatus*, **Lifetime Max Cell Voltage** is updated if one of the following conditions is met:

- Any internally measured cell voltage > 4300mV for a period > 60 seconds.
- Any internally measured cell voltage > 4300mV AND any other lifetime value is updated.

The event logging ends when the cell voltage < 4290mV after the Lifetime Max Cell Voltage logging begins.

**Table C-174. Lifetime Max Cell Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	4	Lifetime Max Cell Voltage	Integer	2	0	32,767	3500	mV

#### Related Variables:

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.4 Lifetime Min Cell Voltage (Offset 6)

If the [QEN] flag is set in *OperationStatus*, **Lifetime Min Cell Voltage** is updated if one of the following conditions is met:

- **Lifetime Min Cell Voltage** – any internal measured cell voltage > 25 mV
- **Lifetime Min Cell Voltage** > any internal measured cell voltage for a period > 60 seconds
- **Lifetime Min Cell Voltage** > any internal measured cell voltage AND any other lifetime value is updated.

**Table C-175. Lifetime Min Cell Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	6	Lifetime Min Cell Voltage	Integer	2	0	32,767	3200	mV

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

**C.6.6.5 Lifetime Max Pack Voltage (Offset 8)**

If the [QEN] flag is set in *OperationStatus*, **Lifetime Max Pack Voltage** is updated if one of the following conditions is met:

- Internal measured cell stack voltage – **Lifetime Max Pack Voltage** > 100 mV
- Internal measured cell stack voltage > **Lifetime Max Pack Voltage** for a period > 60 seconds
- Internal measured cell stack voltage > **Lifetime Max Pack Voltage** AND any other lifetime value is updated.

**Table C-176. Lifetime Max Pack Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	8	Lifetime Max Pack Voltage	Integer	2	0	32,767	14,000	mV

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

**C.6.6.6 Lifetime Min Pack Voltage (Offset 10)**

If the [QEN] flag is set in *OperationStatus*, **Lifetime Min Pack Voltage** is updated if one of the following conditions is met:

- **Lifetime Min Pack Voltage** – internal measured cell stack voltage > 100 mV
- **Lifetime Min Pack Voltage** > internal measured cell stack voltage for a period > 60 seconds
- **Lifetime Min Pack Voltage** > internal measured cell stack voltage AND any other lifetime value is updated.

**Table C-177. Lifetime Min Pack Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	10	Lifetime Min Pack Voltage	Integer	2	0	32,767	12,800	mV

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

**C.6.6.7 Lifetime Max Chg Current (Offset 12)**

If the [QEN] flag is set in *OperationStatus*, **Lifetime Max Chg Current** is updated if one of the following conditions is met:

- Internal charge current – **Lifetime Max Chg Current** > 100 mA
- Internal charge current > **Lifetime Max Chg Current** for a period > 60 seconds
- Internal charge current > **Lifetime Max Chg Current** AND any other lifetime value is updated.

**Table C-178. Lifetime Max Chg Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	12	Lifetime Max Chg Current	Integer	2	-32,767	32,767	1500	mA

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

**C.6.6.8 Lifetime Max Dsg Current (Offset 14)**

If the [QEN] flag is set in *OperationStatus*, **Lifetime Max Dsg Current** is updated if one of the following conditions is met:

- **Lifetime Max Dsg Current** – internal discharge current < -100 mA
- **Lifetime Max Dsg Current** < internal discharge current for a period > 60 seconds
- **Lifetime Max Dsg Current** < internal discharge current AND any other lifetime value is updated.

**Table C-179. Lifetime Max Dsg Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	14	Lifetime Max Dsg Current	Integer	2	-32,767	32,767	-3000	mA

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

**C.6.6.9 Lifetime Max Chg Power (Offset 16)**

If the [QEN] flag is set in *OperationStatus*, **Lifetime Max Chg Power** is updated if one of the following conditions is met:

- (Internal measured voltage × internal measured current) – **Lifetime Max Chg Power** > 1000 mW
- (Internal measured voltage × internal measured current) > **Lifetime Max Chg Power** for a period > 60 seconds
- (Internal measured voltage × internal measured current) > **Lifetime Max Chg Power** AND any other lifetime value is updated.

**Table C-180. Lifetime Max Chg Power**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	16	Lifetime Max Chg Power	Integer	2	-32,767	32,767	1500	10 mW

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.10 Lifetime Max Dsg Power (Offset 18)

If the [QEN] flag is set in *OperationStatus*, **Lifetime Max Dsg Power** is updated if one of the following conditions is met:

- **Lifetime Max Dsg Power** – (internal measured voltage × internal measured current) > 1000 mW
- **Lifetime Max Dsg Power** > (internal measured voltage × internal measured current) for a period > 60 seconds
- **Lifetime Max Dsg Power** > (internal measured voltage × internal measured current) AND any other lifetime value is updated.

**Table C-181. Lifetime Max Dsg Power**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	18	Lifetime Max Dsg Power	Integer	2	-32,767	32,767	-1500	10 mW

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.11 Life Max AvgDsg Cur (Offset 22)

If the [QEN] flag is set in *OperationStatus*, **Life Max AvgDsg Cur** is updated if one of the following conditions us met:

- **Lifetime Max AvgDsg Cur** – internally measured average discharge current > 100 mA
- **Lifetime Max AvgDsg Cur** > internally measured average discharge current > 60 seconds
- **Lifetime Max AvgDsg Cur** > internally measured average discharge current AND any other lifetime value is updated.

**Table C-182. Life Max AvgDsg Cur**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	22	Life Max AvgDsg Cur	Integer	2	-32,767	32,767	-1000	mA

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.12 Life Max AvgDsg Pow (Offset 26)

If the [QEN] flag is set in *OperationStatus*, **Life Max AvgDsg Pow** is updated if one of the following conditions is met:

- **Life Max AvgDsg Pow** – averaged (internal measured voltage × internal measured current) > 1000 mW
- **Life Max AvgDsg Pow** > averaged (internal measured voltage × internal measured current) for a period > 60 seconds
- **Life Max AvgDsg Pow** > averaged (internal measured voltage × internal measured current) AND any other lifetime value is updated.

**Table C-183. Life Max AvgDsg Pow**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	26	Life Max AvgDsg Pow	Integer	2	-32,767	32,767	-1500	10 mW

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.13 Life Avg Temp (Offset 28)

If the [QEN] flag is set in *OperationStatus*, **Life Avg Temp** takes samples of the *Temperature* function every 225 s, but only updates if any other lifetime value is updated.

**Table C-184. Life Avg Temp**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	28	Life Avg Temp	Integer	2	0	1400	250	0.1°C

**Related Variables:**

- DF:Gas Gauging:State(82):Update Status(12)
- DF:System Data:Lifetime Temp Samples(60):LT Temp Samples(0)
- SBS:ManufacturerAccess(0x00):IT Enable(0x0021)
- SBS:Temperature(0x008)
- SBS:OperationStatus(0x54)[QEN]

### C.6.6.14 Life OT Count (Offset 30)

Whenever the Lifetime Max Temp is updated (see **Lifetime Max Temp** for conditions), the **Life OT Count** is incremented by 1.

**Table C-185. Life OT Count**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	30	Life OT Count	Unsigned Integer	2	0	65,535	0	

**Related Variables:**

- DF:System Data:Lifetime Data(59):Lifetime Max Temp(0)
- SBS:Temperature(0x008)

### C.6.6.15 Life OT Duration (Offset 32)

Whenever **Lifetime Max Temp** is updated (see **Lifetime Max Temp** for conditions), the duration of the event is timed and stored in **Life OT Duration**.

**Table C-186. Life OT Duration**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	32	Life OT Duration	Unsigned Integer	2	0	65,535	0	s

**Related Variables:**

- DF:System Data:Lifetime Data(59):Lifetime Max Temp(0)
- SBS:Temperature(0x008)

### C.6.6.16 Life OV Count (Offset 35)

Whenever the **Max Cell Voltage** is updated (see **Lifetime Max Cell Voltage** for conditions), the **Life OV Count** is incremented by 1.

**Table C-187. Life OV Count**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	35	Life OV Count	Unsigned Integer	2	0	65,535	0	



**Related Variables:**

- DF:System Data:Lifetime Data(59):Lifetime Max Cell Voltage(4)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

**C.6.6.17 Life OV Duration (Offset 37)**

Whenever the **Max Cell Voltage** is updated (see **Lifetime Max Cell Voltage** for conditions), the duration of the event is timed and stored in **Life OV Duration**.

**Table C-188. Life OV Duration**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
59	Lifetime Data	37	Life OV Duration	Unsigned Integer	2	0	65,535	0	s

**Related Variables:**

- DF:System Data:Lifetime Data(59):Lifetime Max Cell Voltage(4)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

**C.6.7 Lifetime Temp Samples (Subclass 60)****C.6.7.1 LT Temp Samples (Offset 0)**

This variable indicates the number of temperature samples used for the **Lifetime Avg Temp** calculation. Multiply this value by 225 seconds to get the total time that the Impedance Track algorithm is active.

**Table C-189. LT Temp Samples**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
60	Lifetime Temp Samples	0	LT Temp Samples	Integer	4	0	140,000,000	0	Count

**Related Variable:**

- DF:System Data:Lifetime Data(59):Lifetime Avg Temp(28)

**C.7 Configuration****C.7.1 Registers (Subclass 64)****C.7.1.1 Operation Cfg A (Offset 0)**

This register enables, disables or configures various features of the bq20z60-R1/bq20z65-R1.

**Table C-190. Operation Cfg A**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
64	Configuration	0	Operation Cfg A	Hex	2	0x0000	0xffff	0x0f29	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	LEDR	LEDRCA	CHGLED	DMODE	LED1	LED0	CC1	CC0
<b>Low Byte</b>	RSVD	RSVD	SLEEP	TEMP1	TEMP0	SLED	ZVCHG1	ZVCHG0

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

### Figure C-6. Operation Cfg A

**LEDR**— Enables activation of the LED display on device-reset exit.

- 0 = LED display is not activated on exit from device reset. (default)
- 1 = LED display is activated (simulates a  $\overline{DISP}$  transition) on exit from device reset.

**LEDRCA**— Enables flashing of the LED display when the *[RCA]* flag in *BatteryStatus* is set.

- 0 = The LED display is not activated when *[RCA]* is set. (default)
- 1 = If the LED display is activated when *[RCA]* is set, the display flashes with **LED Flash Period**.

**Related Variables:**

DF:LED Support:LED Cfg(67):LED Flash Period(0)  
SBS:BatteryStatus(0x16)[RCA]

**CHGLED**— Enables the LED display while charging.

- 0 = Display is not activated by charging; requires push-button event or SMBus command. (default)
- 1 = Display is active during charging.

**DMODE**— This bit sets the display to show the *RelativeStateOfCharge* or *AbsoluteStateOfCharge* LED representation.

- 0 = Display reflects *RelativeStateOfCharge* (default).
- 1 = Display reflects *AbsoluteStateOfCharge*.

**LED1, LED0**— These bits configure the number of LEDs and threshold levels used in the LED display.

- 0,0 = User defined threshold
- 0,1 = 3 LEDs used
- 1,0 = 4 LEDs used
- 1,1 = 5 LEDs used (default)

**CC1, CC0**— These bits configure the bq20z60-R1/bq20z65-R1 for the number of series cells in the battery stack.

- 0,0 = Reserved
- 0,1 = 2 cells
- 1,0 = 3 cells
- 1,1 = 4 cells (default)

**SLEEP**— Enables the bq20z60-R1/bq20z65-R1 to enter Sleep mode if the SMBus lines are low.

0 = The bq20z60-R1/bq20z65-R1 never enters Sleep mode.

1 = The bq20z60-R1/bq20z65-R1 enters Sleep mode under normal Sleep entry criteria (default).

**Related Variable:**

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

**TEMP1, TEMP0**— These bits configure the source of the *Temperature* function.

0,0 = Internal Temperature Sensor

0,1 = TS1 Input (default)

1,0 = TS2 Input

1,1 = Average of TS1 and TS2 Inputs

**Related Variable:**

SBS:Temperature(0x008)

**SLED**— Enables the bq20z60-R1/bq20z65-R1 display to be used in serial or parallel mode. The PF error code display doesn't work in serial LED mode

0 = Display is in parallel LED mode (default)

1 = Display is in serial LED mode

**ZVCHG1, ZVCHG0**— These bits enable or disable the use of the ZVCHG or CHG FET in Zero-Volt/Precharge modes.

0,0 = ZVCHG

0,1 = CHG (default)

1,0 = GPOD

1,1 = No Action

### C.7.1.2 Operation Cfg B (Offset 2)

This register enables, disables, or configures various features of the bq20z60-R1/bq20z65-R1.

**Table C-191. Operation Cfg B**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
64	Configuration	2	Operation Cfg B	Hex	2	0x0000	0xffff	0x6440	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	PDF1	PDF0	RESCAP	NCSMB	NRCHG	CSYNC	CHGTERM	CCT
<b>Low Byte</b>	CHGSUSP	OTFET	CHGFET	CHGIN	NR	CPE	HPE	BCAST

**Figure C-7. Operation Cfg B**

**PDF1, PDF0**— Configures the Permanent Failure LED display. This function is disabled if the **[SLED]** bit in **Operation Cfg A** is set.

- 0,0 = PF Error Code not available
- 0,1 = PF Error Code is activated after state of charge display if  $\overline{\text{DISP}}$  is held low for **LED Hold Time**. (default)
- 1,0 = PF Error Code not available
- 1,1 = PF Error Code is automatically activated after state-of charge-display

**Related Variables:**

DF:Configuration:Registers(64):Operation Cfg A(0)[SLED]  
 DF:LED Support:LED Cfg(67):LED Hold Time(6)

**RESCAP**— This bit configures the compensation model of the Impedance Track algorithm for reserve capacity calculation.

- 0 = Light Load Compensation
- 1 = Average Load Compensation defined by **Load Select** (default)

**Related Variables:**

DF:Gas Gauging:IT Cfg(80):Load Select(0)  
 DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(80)  
 DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(82)

**NCSMB**— Disables extended SMBUS  $t_{\text{TIMEOUT}}$  feature. Use this bit with caution.

- 0 = Normal SMBUS  $t_{\text{TIMEOUT}}$  (default)
- 1 = Extended SMBUS  $t_{\text{TIMEOUT}}$

**NRCHG**— Enables the CHG FET to remain on during sleep when the bq20z60-R1/bq20z65-R1 is in non-removable battery mode.

- 0 = The CHG FET turns off in Sleep Mode if the **[NR]** bit is set (default).
- 1 = The CHG FET remains on in Sleep Mode if the **[NR]** bit is set.

**Related Variable:**

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

**CSYNC**— Enables the bq20z60-R1/bq20z65-R1 to write *RemainingCapacity* equal to *FullChargeCapacity* when a valid charge termination is detected.

- 0 = *RemainingCapacity* is not modified on valid primary charge termination.
- 1 = *RemainingCapacity* is written to equal *FullChargeCapacity* on valid primary charge termination. (default)

**Related Variables:**

SBS:RemainingCapacity(0x00f)  
 SBS:FullChargeCapacity(0x10)

**CHGTERM**— This bit enables or disables the *[TCA]* and *[FC]* flags in *BatteryStatus* to be cleared after charge termination is confirmed.

- 0 = *[TCA]* and *[FC]* are not cleared by primary charge termination confirmation, but are cleared by other means. (default)
- 1 = *[TCA]* and *[FC]* flags are cleared on valid primary charge termination. Note: This does not disable clearing the flags by **TCA Clear %** and **FC Clear %**.

**Related Variables:**

DF:Charge Control:Termination Cfg(36):Taper Current(2)  
 DF:Charge Control:Termination Cfg(36):Current Taper Window(8)  
 DF:Charge Control:Termination Cfg(36):TCA Clear %(10)  
 DF:Charge Control:Termination Cfg(36):FC Clear %(12)  
 SBS:Current(0x00a)  
 SBS:BatteryStatus(0x16)[FC],[TCA]

**CCT**— This bit sets the formula for updating *Cycle Count*.

- 0 = The bq20z60-R1/bq20z65-R1 uses the **CC Threshold** value. (default)
- 1 = The bq20z60-R1/bq20z65-R1 uses **CC %** of *FullChargeCapacity*.

**Related Variables:**

DF:SBS Configuration:Data(48):Cycle Count(16)  
 DF:SBS Configuration:Data(48):CC Threshold(18)  
 DF:SBS Configuration Data(48):CC %(18\20)  
 SBS:FullChargeCapacity(0x10)

**CHGSUSP**— This bit enables the bq20z60-R1/bq20z65-R1 to turn off the CHG FET (and ZVCHG FET) when in charge suspend mode.

- 0 = No FETs change in Charge Suspend mode. (default)
- 1 = CHG FET and ZVCHG FET (if used) turn off in Charge Suspend mode.

**OTFET**— This bit enables or disables FET actions from reacting to an overtemperature fault.

- 0 = There is NO FET action when an overtemperature condition is detected.
- 1 = When the *[OTC]* flag is set, then the CHG FET is turned off, and when the *[OTD]* flag is set, then the DSG FET is turned off. (default)

**Related Variable:**

SBS:SafetyStatus(0x51)[OTC],[OTD]

**CHGFET**— This bit enables or disables the CHG FET from reacting to a valid charge termination.

- 0 = CHG FET stays on at charge termination (*[TCA]* is set). (default)
- 1 = CHG FET turns off at charge termination.

**Related Variable:**

SBS:BatteryStatus(0x16)[TCA]

**CHGIN**— This bit enables the CHG FET and ZVCHG FET (if used) to turn off when the bq20z60-R1/bq20z65-R1 is in charge-inhibit mode.

- 0 = No FET change in charge-inhibit mode. (default)
- 1 = CHG and ZVCHG FETs, if used, turn off in charge-inhibit mode.

**Related Variable:**

SBS:ChargingStatus(0x55)[XCHG]

**NR**— This bit configures the bq20z60-R1/bq20z65-R1 to be in removable or non-removable battery mode and determines the recovery method for current-based primary protection features.

- 0 = Removable battery mode (default)
- 1 = Non-removable battery mode.

**Related Variable:**

DF:Configuration:Registers(64): Non-Removable Cfg(8)

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

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

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

- 0 = No PEC byte on alarm warning to host and receiving communications from all sources in slave mode (default)
- 1 = PEC byte on alarm warning to host and receiving communications from all sources in slave mode. If host uses PEC, this bit should be set.

**BCAST**— This bit enables or disables SBS broadcasts to the smart-battery charger and host.

- 0 = Broadcasts to host and charger disabled (default)
- 1 = Broadcasts to host and charger enabled

### C.7.1.3 Operation Cfg C (Offset 4)

This register enables, disables, or configures various features of the bq20z60-R1/bq20z65-R1.

**Table C-192. 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	0xffff	0x0130	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	CHGOCV_ DIS	CELL_TAP ER
<b>Low Byte</b>	RSVD	CUV_RECO V_CHG	OCV_WGH T	LOCK_0	SUV_MOD E	SHUTV	PRE_ZT_P F_En	RSOCL

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

**Figure C-8. Operation Cfg C**

**CHGOCV\_DIS**— CHGOCV\_DIS prevents OCV reading from being taken when under the flat volt max and having come from charge. OCV readings are still taken if above flat volt max or if not coming from charge.

0 = OCV reading is not taken when under the flat volt max and having come from charge.

1 = OCV reading is taken when under the flat volt max and having come from charge.

**CELL\_TAPER**— Taper voltage (used for primary charge termination) is either cell voltage-based or pack voltage-based depending on this bit.

0 = Pack voltage-based taper voltage.

1 = Cell voltage-based taper voltage.

**CUV\_RECOV\_CHG**— Enable charge current detection as part of CUV recovery.

0 = No charge current detection required for CUV recovery

1 = Charge current detection required for CUV recovery

**OCV\_WGHT**— This bit enables evaluation of the accuracy of each state of charge reading from OCV during relaxation. Used to take into account both previous and new state of charge estimates weighed according to their respective accuracy. This results in improved accuracy and in reduction of RelativeStateofCharge jumps after relaxation.

0 = Evaluation of the accuracy of each state of charge reading from OCV during relaxation is disabled.

1 = Evaluation of the accuracy of each state of charge reading from OCV during relaxation is enabled.

**LOCK\_0**— This bit prevents RemainingCapacity and RelativeStateofCharge from increasing during relaxation after 0 value was reached during discharge and operates in mAh or mWh according to configuration of the BatteryMode to avoid possible oscillation when starting charge from fully discharged state

0 = *RemainingCapacity* and *RelativeStateofCharge* are not prevented from increasing during relaxation after 0 value was reached during discharge.

1 = *RemainingCapacity* and *RelativeStateofCharge* are prevented from increasing during relaxation after 0 value was reached during discharge.

**SUV\_MODE**— This bit controls the operation of safety undervoltage PF mechanism.

- 0 = If at any time any cell voltage goes below **SUV Threshold** then SUV PF mechanism starts.
- 1 = Cell voltage is checked only upon wakeup from Shutdown mode. Upon wakeup, the charge and precharge FETs are turned off and the cell voltage is checked. If any cell voltage is below **SUV Threshold** then SUV mechanism starts.

**SHUTV**— This bit configures the voltage threshold used when entering Shutdown mode.

- 0 = Shutdown occurs when  $Voltage \leq \text{Shutdown Voltage}$  AND  $Current \leq 0$  for a period greater than **Shutdown Time**.
- 1 = Shutdown occurs when  $\text{Min}(CellVoltage_{4..1}) \leq \text{Cell Shutdown Voltage}$  and  $Current \leq 0$  for a period greater than **Cell Shutdown Time**.

**PRE\_ZT\_PF\_En**— This bit enables or disables permanent failures from occurring before the Impedance Track™ algorithm is enabled.

- 0 = All PFs (except DFF) are prevented from occurring until the Impedance Track™ algorithm is enabled. Shutdown is also disabled. See the following note.
- 1 = All PFs are allowed regardless of whether the Impedance Track™ algorithm has been enabled or not.

**RSOCL**— This bit determines the method in which *RelativeStateOfCharge* and *RemainingCapacity* are updated to 100% when charging is complete.

- 0 = If the **[RSOCL]** bit in **Operation Cfg C** is cleared, then *RelativeStateOfCharge* and *RemainingCapacity* are **not** held at 99% until primary charge termination occurs. Fractions of % greater than 99% are rounded up to display 100%.
- 1 = If the **[RSOCL]** bit in **Operation Cfg C** is set, then *RelativeStateOfCharge* and *RemainingCapacity* are held at 99% until primary charge termination occurs and only display 100% on entering primary charge termination.

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**NOTE:** **PRE\_ZT\_PF\_En**—If this bit is set to 0, and a Permanent Failure does occur, *PFStatus* still reports that the failure has occurred. Also, if the FETs have been turned on, they turn off if a failure occurs. However, Data Flash write access is still granted and the Permanent Failure is NOT logged in the PF Status section of Data Flash. The *PFStatus* indicator clears and the FETs turn on once *ManufacturerAccess(0x00)* has received the *IT Enable (0x0021)* command or the *Reset (0x0041)* command, assuming the Permanent Failure condition no longer exists.

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#### C.7.1.4 Permanent Fail Cfg (Offset 6)

The **Permanent Fail Cfg** register enables or disables the use of the SAFE pin when the corresponding permanent fail error occurs. If the SAFE pin is driven high, **Fuse Flag** is set to 0x3672.

**Table C-193. 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	0xffff	0x0000	



	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	XVSHUT	XSUV	XSOPT1	XSOCD	XSOCC	XAFE_P	XAFE_C
<b>Low Byte</b>	XDFF	XDFETF	XCFETF	XCIM_R	XSOT1D	XSOT1C	XSOV	XPFIN

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

**Figure C-9. Permanent Fail Cfg**

**XVSHUT**— If this bit is set AND any permanent failure happens AND the bq20z60-R1/bq20z65-R1 goes into shutdown, the SAFE pin is driven high.

**XSUV**— If this bit is set AND a safety undervoltage permanent failure occurs, the SAFE pin is driven high.

**XSOPT1**— If this bit is set AND an open thermistor permanent failure on TS1 occurs, the SAFE pin is driven high.

**XSOCD**— If this bit is set AND a discharge safety overcurrent permanent failure occurs, the SAFE pin is driven high.

**XSOCC**— If this bit is set AND a charge safety overcurrent failure occurs the SAFE pin is driven high.

**XAFE\_P**— If this bit is set AND a periodic AFE-communications permanent failure occurs, the SAFE pin is driven high.

**XAFE\_C**— If this bit is set AND an AFE-communications permanent failure occurs, the SAFE pin is driven high.

**XDFF**— If this bit is set AND a Data Flash Fault permanent failure occurs, the SAFE pin is driven high.

**XDFETF**— If this bit is set AND a DSG FET permanent failure occurs, the SAFE pin is driven high.

**XCFETF**— If this bit is set AND a CHG FET permanent failure occurs, the SAFE pin is driven high.

**XCIM\_R**— If this bit is set AND a cell imbalance at rest permanent failure occurs, the SAFE pin is driven high.

**XSOT1D**— If this bit is set AND safety over temperature on TS1 during discharge failure occurs the SAFE pin is driven high..

**XSOT1C**— If this bit is set AND safety over temperature on TS1 during charge failure occurs the SAFE pin is driven high..

**XSOV**— If this bit is set AND a safety overvoltage permanent failure occurs, the SAFE pin is driven high.

**XPFIN**— If this bit is set AND an external input indication permanent failure occurs, the SAFE pin is driven high.

**Related Variables:**

- SBS:PFStatus (0x53)
- SBS:PFStatus2 (0x6b)

### C.7.1.5 Permanent Fail Cfg 2 (Offset 8)

The **Permanent Fail Cfg 2** register enables or disables the use of the SAFE pin when the corresponding permanent fail error occurs. If the SAFE pin is driven high, **Fuse Flag** is set to 0x3672

**Table C-194. Permanent Fail Cfg 2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
64	Configuration	8	Permanent Fail Cfg 2	Hex	2	0x0000	0xffff	0x0000	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	XSOPT2	XSOT2D	XSOT2C	XCIM_A

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

**Figure C-10. Permanent Fail Cfg 2**

**XSOPT2**— If this bit is set AND an open thermistor permanent failure on TS2 occurs, the SAFE pin is driven high.

**XSOT2D**— If this bit is set AND safety over temperature on TS2 during discharge failure occurs the SAFE pin is driven high.

**XSOT2C**— If this bit is set AND safety over temperature on TS2 during charge failure occurs the SAFE pin is driven high.

**XCIM\_A**— If this bit is set AND a cell imbalance while active permanent failure occurs, the SAFE pin is driven high.

### C.7.1.6 Non-Removable Cfg (Offset 10)

If the bq20z60-R1/bq20z65-R1 is in removable battery mode ( $[NR] = 0$ ), these bits set the recovery method from 1st-level safety errors. If the corresponding bit is set, this gives an additional recovery option for the particular fault. If  $[NR]$  is set to 1, this register has no effect.

**Table C-195. Non-Removable Cfg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
64	Configuration	10	Non-Removable Cfg	Hex	2	0x0000	0xffff	0x0000	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	OCD	OCC	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	AOCD	ASCC	ASCD

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

**Figure C-11. Non-Removable Cfg**

**OCD**— Overcurrent in Discharge

**OCC**— Overcurrent in Charge

**AOCD**— AFE Overcurrent in Discharge

**ASCC**— Short Circuit in Charge

**ASCD**— Short Circuit in Discharge

**Related Variable:**

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

### C.7.2 AFE (Subclass 65)

#### C.7.2.1 AFE.State\_CTL (Offset 1)

The **AFE.State\_CTL** register implements the STATE\_CONTROL register of the AFE.

**Table C-196. AFE.State\_CTL**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
65	AFE	1	AFE.State_CTL	Hex	1	0x00	0xff	0x00	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSNS	RSVD	RSVD	RSVD	RSVD

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

**RSNS**— If this bit is set to 1, then the AFE OC Dsg, AFE SC Chg Cfg, and AFE SC Dsg Cfg voltage thresholds are divided by 2, which is suitable for a low sense resistor value. Note: Do not alter bits 3:0.

## C.8 LED Support

### C.8.1 LED Cfg (Subclass 67)

#### C.8.1.1 LED Flash Period (Offset 0)

This value sets the LED flashing time period at a 50% duty cycle for alarm conditions.

**Table C-197. LED Flash Period**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	0	LED Flash Period	Unsigned integer	2	0	65,535	512	500µs

**Related Variables:**

- DF:LED Support:LED Cfg(67):LED Hold Time(6)

#### C.8.1.2 LED Blink Period (Offset 2)

This value sets the LED blinking time period to a 50% duty cycle for the LED indicating the highest actual charge of the battery.

**Table C-198. LED Blink Period**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	2	LED Blink Period	Unsigned integer	2	0	65,535	1024	500µs

**Related Variables:**

- DF:LED Support:LED Cfg(67):LED Hold Time(6)

#### C.8.1.3 LED Delay (Offset 4)

This value sets the activation delay time from one LED to the next LED after the display is activated.

**Table C-199. LED Delay**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	4	LED Delay	Unsigned integer	2	1	65,535	100	500µs

**Related Variables:**

- DF:LED Support:LED Cfg(67):LED Hold Time(6)

#### C.8.1.4 LED Hold Time (Offset 6)

This value sets the time the LED stays on after all LEDs required to indicate the state of charge are being activated.

**Table C-200. LED Hold Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	6	LED Hold Time	Unsigned integer	1	0	255	4	s

**Related Variables:**

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

**C.8.1.5 CHG Flash Alarm (Offset 7)**

If the bq20z60-R1/bq20z65-R1 is in charge mode ([DSG] = 0) and the battery charge is below this threshold the remaining enabled LEDs start flashing at LED Flash Period. Set to -1 to disable this feature.

**Table C-201. CHG Flash Alarm**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	7	CHG Flash Alarm	Integer	1	-1	101	10	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- DF:LED Support:LED Cfg(67):LED Flash Period(0)
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.6 CHG Thresh1 (Offset 8)**

If the bq20z60-R1/bq20z65-R1 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 1 is disabled.

**Table C-202. CHG Thresh 1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	8	CHG Thresh 1	Integer	1	-1	101	0	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.7 CHG Thresh 2 (Offset 9)**

If the bq20z60-R1/bq20z65-R1 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 2 is disabled.

**Table C-203. CHG Thresh 2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	9	CHG Thresh 2	Integer	1	-1	101	20	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.8 CHG Thresh 3 (Offset 10)

If the bq20z60-R1/bq20z65-R1 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 3 is disabled.

**Table C-204. CHG Thresh 3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	10	CHG Thresh 3	Integer	1	-1	101	40	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.9 CHG Thresh 4 (Offset 11)

If the bq20z60-R1/bq20z65-R1 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 4 is disabled.

**Table C-205. CHG Thresh 4**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	11	CHG Thresh 4	Integer	1	-1	101	60	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.10 CHG Thresh 5 (Offset 12)

If the bq20z60-R1/bq20z65-R1 is in charge mode ([DSG] = 0) and the battery charge is below this threshold, LED 5 is disabled.

**Table C-206. CHG Thresh 5**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	12	CHG Thresh 5	Integer	1	-1	101	80	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

### C.8.1.11 DSG Flash Alarm (Offset 13)

If the bq20z60-R1/bq20z65-R1 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, the remaining enabled LEDs start flashing with **LED Flash Period**. Set to -1 to disable this feature..

**Table C-207. DSG Flash Alarm**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	13	DSG Flash Alarm	Integer	1	-1	101	10	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.12 DSG Thresh 1 (Offset 14)**

If the bq20z60-R1/bq20z65-R1 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 1 is disabled.

**Table C-208. DSG Thresh 1**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	14	DSG Thresh 1	Integer	1	-1	101	0	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.13 DSG Thresh 2 (Offset 15)**

If the bq20z60-R1/bq20z65-R1 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 2 is disabled.

**Table C-209. DSG Thresh 2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	15	DSG Thresh 2	Integer	1	-1	101	20	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.14 DSG Thresh 3 (Offset 16)**

If the bq20z60-R1/bq20z65-R1 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 3 is disabled.

**Table C-210. DSG Thresh 3**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	16	DSG Thresh 3	Integer	1	-1	101	40	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.15 DSG Thresh 4 (Offset 17)**

If the bq20z60-R1/bq20z65-R1 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 4 is disabled.

**Table C-211. DSG Thresh 4**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	17	DSG Thresh 4	Integer	1	-1	101	60	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.16 DSG Thresh 5 (Offset 18)**

If the bq20z60-R1/bq20z65-R1 is in discharge mode ([DSG] = 1) and the battery charge is below this threshold, LED 5 is disabled.

**Table C-212. DSG Thresh 5**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	18	DSG Thresh 5	Integer	1	-1	101	80	%

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[DMODE],[LED1],[LED0]
- SBS:RelativeStateOfCharge(0x00d)
- SBS:AbsoluteStateOfCharge(0x00e)
- SBS:BatteryStatus(0x16)[DSG]

**C.8.1.17 Sink Current (Offset 19)**

The sink current setting of the LED inputs to the bq20z60-R1/bq20z65-R1 can be programmed with the following settings. All of the LEDs are programmed with the same current level.

**Table C-213. Sink Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	19	Sink Current	Unsigned integer	1	0	3	3	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	ILED1	ILED0

LEGEND: RSVD = Reserved and must be programmed to 0

**Table C-214. Sink Current Configuration**

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

## C.9 Power

### C.9.1 Power (Subclass 68)

#### C.9.1.1 Flash Update OK Voltage (Offset 0)

This value sets the minimum allowed battery pack voltage for a flash update. If the battery pack *Voltage* is below this threshold, no flash update is made. If a charger is detected by way of **Charger Present** voltage, it overrides **Flash Update OK Voltage** and the flash can be updated.

**Table C-215. 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	Integer	2	6000	20,000	7500	mV

#### Related Variables:

- DF:Power:Power(68):Charger Present(8)
- SBS:Voltage(0x009)

#### C.9.1.2 Shutdown Voltage (Offset 2)

The bq20z60-R1/bq20z65-R1 goes into shutdown mode if battery pack *Voltage* is equal to or less than **Shutdown Voltage** for **Shutdown Time** and has been out of shutdown mode for at least **Shutdown Time**.

**Table C-216. Shutdown Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	2	Shutdown Voltage	Integer	2	5000	20,000	7000	mV

#### Related Variables:

- DF:Power:Power(68):Shutdown Time(4)
- SBS:Voltage(0x009)

#### C.9.1.3 Shutdown Time (Offset 4)

The bq20z60-R1/bq20z65-R1 goes into shutdown mode if battery pack *Voltage* is equal to or less than **Shutdown Voltage** for **Shutdown Time** and has been out of shutdown mode for at least **Shutdown Time**.

**Table C-217. Shutdown Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	4	Shutdown Time	Unsigned integer	1	0	240	10	s



**Related Variables:**

- DF:Power:Power(68):Shutdown Voltage(2)
- SBS:Voltage(0x009)

**C.9.1.4 Cell Shutdown Voltage (Offset 5)**

The bq20z60-R1/bq20z65-R1 goes into shutdown mode if Min (*CellVoltage4..1*) is equal to or less than **Cell Shutdown Voltage** for 10s and has been out of shutdown mode for at least **Cell Shutdown Time**.

**Table C-218. Cell Shutdown Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	5	Cell Shutdown Voltage	Integer	2	0	5000	1750	mV

**Related Variables:**

- DF:Power:Power(68):Cell Shutdown Time(7)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

**C.9.1.5 Cell Shutdown Time (Offset 7)**

The bq20z60-R1/bq20z65-R1 goes into shutdown mode if Min (*CellVoltage4..1*) is equal to or less than **Cell Shutdown Voltage** for 10 s and has been out of shutdown mode for at least **Cell Shutdown Time**.

**Table C-219. Cell Shutdown Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	7	Cell Shutdown Time	Unsigned integer	1	0	240	10	s

**Related Variables:**

- DF:Power:Power(68):Cell Shutdown Voltage(5)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

**C.9.1.6 Charger Present (Offset 8)**

The bq20z60-R1/bq20z65-R1 detects a charger when the voltage at the PACK pin of the AFE is above the **Charger Present** threshold. If a charger is detected, it overrides **Flash Update OK Voltage** and the flash can be updated.

**Table C-220. Charger Present**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	8	Charger Present	Integer	2	0	23,000	3000	mV

**Related Variables:**

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

**C.9.1.7 Sleep Current (Offset 10)**

The bq20z60-R1/bq20z65-R1 is allowed to go into sleep mode if the charge or discharge current is below **Sleep Current**. Sleep mode can be enabled with the **[SLEEP]** bit. If the absolute value of *Current* is above **Sleep Current**, the bq20z60-R1/bq20z65-R1 returns to normal mode.

**Table C-221. Sleep Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	10	Sleep Current	Integer	2	0	100	10	mA

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Power:Power(68):Bus Low Time(12)
- SBS:ManufacturerAccess(0x00):Sleep(0x0011)
- SBS:Current(0x00a)

**C.9.1.8 Bus Low Time (Offset 12)**

The bq20z60-R1/bq20z65-R1 is allowed to go into sleep mode if it is enabled with the **[SLEEP]** bit and if the SMBus lines are low for a period greater than **Bus Low Time**.

**Table C-222. Bus Low Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	12	Bus Low Time	Unsigned integer	1	0	255	5	s

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- DF:Power:Power(68):Sleep Current(10)

**C.9.1.9 Cal Inhibit Temp Low (Offset 13)**

The bq20z60-R1/bq20z65-R1 does not perform auto-calibration on entry to sleep mode if *Temperature* is below **Cal Inhibit Temp Low** or above **Cal Inhibit Temp High**.

**Table C-223. Cal Inhibit Temp Low**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	13	Cal Inhibit Temp Low	Integer	2	-400	1200	50	0.1°C

**Related Variables:**

- DF:Power:Power(68):Cal Inhibit Temp High(15)
- SBS:Temperature(0x008)

**C.9.1.10 Cal Inhibit Temp High (Offset 15)**

The bq20z60-R1/bq20z65-R1 does not perform auto-calibration on entry to sleep mode if *Temperature* is below **Cal Inhibit Temp Low** or above **Cal Inhibit Temp High**.

**Table C-224. Cal Inhibit Temp High**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	15	Cal Inhibit Temp High	Integer	2	-400	1200	450	0.1°C

**Related Variables:**

- DF:Power:Power(68):Cal Inhibit Temp Low(13)
- SBS:Temperature(0x008)

**C.9.1.11 Sleep Voltage Time (Offset 17)**

During sleep mode, temperature and voltage measurements are taken in **Sleep Voltage Time** intervals.

**Table C-225. Sleep Voltage Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	17	Sleep Voltage Time	Unsigned integer	1	1	240	5	s

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:Temperature(0x008)
- SBS:Voltage(0x009)
- SBS:CellVoltage4(0x3c)
- SBS:CellVoltage3(0x3d)
- SBS:CellVoltage2(0x3e)
- SBS:CellVoltage1(0x3f)

**C.9.1.12 Sleep Current Time (Offset 18)**

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

**Table C-226. Sleep Current Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	18	Sleep Current Time	Unsigned integer	1	1	255	20	s

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[SLEEP]
- SBS:Current(0x00a)

**C.9.1.13 Wake Current Reg (Offset 19)**

**Wake Current Reg** configures the current threshold required to wake the bq20z60-R1/bq20z65-R1 from sleep mode by detecting voltage across SRP and SRN.

**Table C-227. Wake Current Reg**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	19	Wake Current Reg	Hex	1	0x00	0xff	0x00	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	IWAKE	RSNS1	RSNS0

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

**Figure C-12. Wake Current Reg**

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

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

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

**Table C-228. 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(0x00a)

### C.9.1.14 Sealed Ship Delay (Offset 20)

After the bq20z60-R1/bq20z65-R1 receives the 2 consecutive MAC (0x0010) commands in sealed mode, the CHG, DSG, and ZVCHG FETs are turned off after **Sealed Ship Delay** time period. After the passage of another **Sealed Ship Delay** period the bq20z60-R1/bq20z65-R1 enters ship mode (i. e . 2 times **Sealed Ship Delay** after the 2 commands.

**Table C-229. Sealed Ship Delay**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
68	Power	20	Sealed Ship Delay	Unsigned integer	1	0	255	5	s

**Related Variables:**

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

## C.10 Gas Gauging

### C.10.1 IT Cfg (Subclass 80)

#### C.10.1.1 Load Select (Offset 0)

This value defines the load compensation model used by the Impedance Track algorithm for the *RemainingCapacity* calculation.

**Constant Current (Load Mode = 0)**

0 = **Avg I Last Run**

1 = Present average discharge current

2 = *Current*

3 = *AverageCurrent* (default)

4 = **Design Capacity / 5**

5 = *AtRate* (mA)

6 = **User Rate-mA**

7 = **Max Avg I Last Run**

**Constant Power (Load Mode = 1)**

**Avg P Last Run**

Present average discharge power

*Current x Voltage*

*AverageCurrent x average Voltage*

**Design Energy / 5**

*AtRate* (10 mW)

**User Rate-10mW**

**Max Avg P Last Run**

**Table C-230. 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	7	

**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(76)
- DF:Gas Gauging:IT Cfg(80):User Rate-10mW(78)
- DF:Gas Gauging:State(82):Avg I Last Run(21)
- DF:Gas Gauging:State(82):Avg P Last Run(23)
- DF:Gas Gauging:State(82):Max Avg I Last Run(31)
- DF:Gas Gauging:State(82):Max Avg P Last Run(33)
- SBS.BatteryMode(0x003)[CapM]
- SBS:AtRate(0x004)
- SBS:Voltage(0x009)
- SBS:Current(0x00a)
- SBS:AverageCurrent(0x00b)
- SBS:RemainingCapacity(0x00f)

**C.10.1.2 Load Mode (Offset 1)**

This value defines the load mode used by the Impedance Track algorithm for the *RemainingCapacity* calculation.

- 0 = Constant Current (default)
- 1 = Constant Power

**Table C-231. Load Mode**

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

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- SBS:RemainingCapacity(0x00f)

**C.10.1.3 Term Voltage (Offset 60)**

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

**Table C-232. Term Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	60	Term Voltage	Integer	2	-32,768	32,767	12,000	mV

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mAh(80)
- DF:Gas Gauging:IT Cfg(80):Reserve Cap-mWh(82)
- SBS:Voltage(0x009)
- SBS:RemainingCapacity(0x00f)

**C.10.1.4 User Rate-mA (Offset 77)**

This value specifies the discharge rate used by the Impedance Track algorithm for the *RemainingCapacity* calculation, if selected by **Load Select**.

**Table C-233. User Rate-mA**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	77	User Rate-mA	Integer	2	-9000	0	0	mA

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x00f)

**C.10.1.5 User Rate-10mW (Offset 79)**

This value specifies the discharge rate in 10 mW used by the Impedance Track algorithm for the *RemainingCapacity* calculation, if selected by **Load Select**.

**Table C-234. User Rate-mW**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	79	User Rate-10mW	Integer	2	-32,768	0	0	10 mW

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x00f)

**C.10.1.6 Reserve Cap-mAh (Offset 81)**

This value reserves an amount of charge, in mAh if  $[CapM] = 0$ , for the system to react if the *RemainingCapacity* reports zero energy remaining in the battery. The **Reserve Cap-mAh** reserves an amount of charge between when the final **Term Voltage** is reached and the *RemainingCapacity* reports zero energy. The *FullChargeCapacity* function reports the internal full charge capacity – **Reserve Cap-mAh**.

**Table C-235. Reserve Cap-mAh**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	81	Reserve Cap-mAh	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(59)
- DF:Configuration:Registers(64):Operation Cfg B(2)[RESCAP]
- SBS:BatteryMode(0x003):[CapM]
- SBS:RemainingCapacity(0x00f)
- SBS:FullChargeCapacity(0x10)

### C.10.1.7 Reserve Cap-mWh (Offset 83)

This value reserves an amount of charge in, 10 mWh if  $[CapM] = 1$ , for the system to react if the *RemainingCapacity* reports zero energy remaining in the battery. The **Reserve Cap-mWh** reserves an amount of charge between when the final **Term Voltage** is reached and the *RemainingCapacity* reports zero energy. The *FullChargeCapacity* function reports the internal full charge capacity – **Reserve Cap-mWh**.

**Table C-236. Reserve Cap-mAh**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	83	Reserve Cap-mWh	Integer	2	0	14,000	0	10 mWh

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- DF:Gas Gauging:IT Cfg(80):Term Voltage(59)
- DF:Configuration:Registers(64):Operation Cfg B(2)[RESCAP]
- SBS:BatteryMode(0x003):[CapM]
- SBS:RemainingCapacity(0x00f)
- SBS:FullChargeCapacity(0x10)

### C.10.1.8 Ra Max Delta (Offset 88)

In order to prevent abnormally fast resistance change, resistance change is limited to old value  $\pm Ra$  Max Delta (m $\Omega$ ). Recommended setting is 15% of 4 Ra grid point value, after optimized values of Ra are obtained from optimization cycle.

**Table C-237. Ra Max Delta**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
80	IT Cfg	88	Ra Max Delta	Integer	2	0	32,000	44	10 mWh

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x00f)
- SBS:FullChargeCapacity(0x10)

## C.10.2 Current Thresholds (Subclass 81)

### C.10.2.1 Dsg Current Threshold (Offset 0)

The bq20z60-R1/bq20z65-R1 enters discharge mode from relaxation mode or charge mode if *Current* < (**-Dsg Current Threshold**).

**Table C-238. Dsg Current Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	Current Thresholds	0	Dsg Current Threshold	Integer	2	0	2000	100	mA

**Related Variables:**

- SBS:Current(0x00a)
- SBS:BatteryStatus(0x16)[DSG]

### C.10.2.2 Chg Current Threshold (Offset 2)

The bq20z60-R1/bq20z65-R1 enters charge mode from relaxation mode or discharge mode if *Current* > **Chg Current Threshold**.

**Table C-239. Chg Current Threshold**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	Current Thresholds	2	Chg Current Threshold	Integer	2	0	2000	50	mA

**Related Variables:**

- SBS:Current(0x00a)
- SBS:BatteryStatus(0x16)[DSG]

**C.10.2.3 Quit Current (Offset 4)**

The bq20z60-R1/bq20z65-R1 enters relaxation mode from charge mode if *Current* goes below **Quit Current** for a period of **Chg Relax Time**. The bq20z60-R1/bq20z65-R1 enters relaxation mode from discharge mode if *Current* goes above **(–)Quit Current** for a period of **Dsg Relax Time**.

**Table C-240. Quit Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	Current Thresholds	4	Quit Current	Integer	2	0	1000	10	mA

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Dsg Relax Time(6)
- DF:Gas Gauging:Current Thresholds(81):Chg Relax Time(7)
- SBS:Current(0x00a)
- SBS:BatteryStatus(0x16)[DSG]

**C.10.2.4 Dsg Relax Time (Offset 6)**

The bq20z60-R1/bq20z65-R1 enters relaxation mode from discharge mode if *Current* goes above **(–)Quit Current** for at least **Dsg Relax Time**.

**Table C-241. Dsg Relax Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	Current Thresholds	6	Dsg Relax Time	Unsigned integer	1	0	240	1	s

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Quit Current(4)
- SBS:Current(0x00a)
- SBS:BatteryStatus(0x16)[DSG]

**C.10.2.5 Chg Relax Time (Offset 7)**

The bq20z60-R1/bq20z65-R1 enters relaxation mode from charge mode if *Current* goes below **Quit Current** for at least **Chg Relax Time**.

**Table C-242. Chg Relax Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
81	Current Thresholds	7	Chg Relax Time	Unsigned integer	1	0	240	60	s

**Related Variables:**

- DF:Gas Gauging:Current Thresholds(81):Quit Current(4)
- SBS:Current(0x00a)
- SBS:BatteryStatus(0x16)[DSG]



### C.10.3 State (Subclass 82)

#### C.10.3.1 Qmax Cell 0..3 (Offset 0..6)

These values define the maximum chemical capacity for each cell used for the capacity calculation. The value should be taken directly from the battery cell datasheet.

**Table C-243. 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	Integer	2	0	32,767	4400	mAh
		2	Qmax Cell 1		2	0	32,767	4400	mAh
		4	Qmax Cell 2		2	0	32,767	4400	mAh
		6	Qmax Cell 3		2	0	32,767	4400	mAh

**Related Variables:**

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

#### C.10.3.2 Qmax Pack (Offset 8)

This value defines the maximum chemical capacity of the battery pack. It usually is set to the smallest value of **Qmax Cell 0..3**.

**Table C-244. Qmax Pack**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	8	Qmax Pack	Integer	2	0	32,767	4400	mAh

**Related Variables:**

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

#### C.10.3.3 Update Status (Offset 12)

It is recommended to use *ManufacturerAccess* to enable or disable the Impedance Track algorithm and lifetime data updating.

- 0x00 = Impedance Track algorithm and lifetime data updating is disabled (default).
- 0x02 = QMAX and Ra table have been updated.
- 0x04 = Impedance Track algorithm and lifetime data updating is enabled.
- 0x05 = Ra table updated and Impedance Track algorithm and lifetime data updating are enabled.
- 0x06 = QMAX and Ra table have been updated and Impedance Track algorithm and lifetime data updating is enabled.
- 0x0e = QMAX has been updated with FC set and qualified OCV in discharge and charge.

**Table C-245. Update Status**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	12	Update Status	Hex	1	0x00	0x0e	0x00	

**Related Variable:**

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

**C.10.3.4 Cell 0..3 Chg DOD at EOC (Offset 13..19)**

This value is the calculated depth of discharge (DOD) for cell 0..3 at the end of charging. It is used for QMax calculations..

**Table C-246. Cell 0..3 Chg dod at EOC**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	13	Cell 0 Chg dod at EOC	Integer	2	0	16,384	0	100% / 16,384
		15	Cell 1 Chg dod at EOC						
		17	Cell 2 Chg dod at EOC						
		19	Cell 3 Chg dod at EOC						

**Related Variables:**

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

**C.10.3.5 Avg I Last Run (Offset 21)**

The bq20z60-R1/bq20z65-R1 calculates and stores the average discharge current from the last discharge cycle in this value. This value is used by the Impedance Track algorithm for the *RemainingCapacity* calculation. It is not recommended to change this value.

**Table C-247. Avg I Last Run**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	21	Avg I Last Run	Integer	2	-32,768	32,767	-2000	mA

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x00f)

**C.10.3.6 Avg P Last Run (Offset 23)**

The bq20z60-R1/bq20z65-R1 calculates and stores the average discharge power from the last discharge cycle in this value. This value is used by the Impedance Track algorithm for the *RemainingCapacity* calculation. It is not recommended to change this value.

**Table C-248. Avg P Last Run**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	23	Avg P Last Run	Integer	2	-32,768	32,767	-3022	10 mW

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x00f)

### C.10.3.7 Delta Voltage (Offset 25)

The bq20z60-R1/bq20z65-R1 stores the maximum difference of *Voltage* during short load spikes and normal loads so the Impedance Track algorithm can calculate the *RemainingCapacity* for pulsed loads. It is not recommended to change this value.

**Table C-249. Delta Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	25	Delta Voltage	Integer	2	-32,768	32,767	0	mV

**Related Variables:**

- SBS:Voltage(0x009)
- SBS:RemainingCapacity(0x00f)

### C.10.3.8 Max Avg I Last Run (Offset 31)

This value is the maximum of the *AverageCurrent* values from the last discharge cycle. It is used by the Impedance Track algorithm as an initial value for rate compensation if **Load Select 7** is selected, and **Load Mode 0** (current) is selected.

**Table C-250. Max Avg I Last Run**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	31	Max Avg I Last Run	Integer	2	-32,767	32,767	-2000	mA

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x00f)

### C.10.3.9 Max Avg P Last Run (Offset 33)

This value is the maximum average power from the last discharge cycle. It is used by the Impedance Track algorithm as an initial value for rate compensation if **Load Select 7** is selected, and **Load Mode 1** (power) is selected.

**Table C-251. Max Avg P Last Run**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
82	State	33	Max Avg P Last Run	Integer	2	-32,767	32,767	-3022	10 mW

**Related Variables:**

- DF:Gas Gauging:IT Cfg(80):Load Select(0)
- DF:Gas Gauging:IT Cfg(80):Load Mode(1)
- SBS:RemainingCapacity(0x00f)

## C.11 Ra Table

### C.11.1 R\_a0 (Subclass 88)

#### C.11.1.1 Cell0 R\_a flag (Offset 0)

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

<b>High Byte</b>		<b>Low Byte</b>	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in progress	0x55	Table being used
0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cell impedance update
0xff	Cell impedance never updated		

**Table C-252. 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 Variable:**

- DF:Ra Table:R\_a0(88):Cell0 R\_a 0..14(2..30)

**C.11.1.2 Cell0 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 0 in this table.

**Table C-253. 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	Integer	2	38	38	38	2 <sup>-10</sup> Ω
		4	Cell0 R_a 1			41	41	41	
		6	Cell0 R_a 2			43	43	43	
		8	Cell0 R_a 3			44	44	44	
		10	Cell0 R_a 4			42	42	42	
		12	Cell0 R_a 5			42	42	42	
		14	Cell0 R_a 6			45	45	45	
		16	Cell0 R_a 7			48	48	48	
		18	Cell0 R_a 8			49	49	49	
		20	Cell0 R_a 9			52	52	52	
		22	Cell0 R_a 10			56	56	56	
		24	Cell0 R_a 11			64	64	64	
		26	Cell0 R_a 12			74	74	74	
		28	Cell0 R_a 13			128	128	128	
30	Cell0 R_a 14	378	378	378					

**Related Variable:**

- DF:Ra Table:R\_a0(88):Cell0 R\_a flag(0)

**C.11.2 R\_a1 (Subclass 89)**
**C.11.2.1 Cell1 R\_a flag (Offset 0)**

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

<b>High Byte</b>		<b>Low Byte</b>	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in progress	0x55	Table being used

0x55	Discharge mode and cell impedance updated	0xff	Table never used, no QMAX or cell impedance update
0xff	Cell impedance never updated		

**Table C-254. 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 Variable:**

- DF:Ra Table:R\_a1(89):Cell1 R\_a 0..14(2..30)

**C.11.2.2 Cell1 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 1 in this table.

**Table C-255. Cell1 R\_a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
89	R_a1	2	Cell1 R_a 0	Signed integer	2	38	38	38	$2^{-10} \Omega$
		4	Cell1 R_a 1			41	41	41	
		6	Cell1 R_a 2			43	43	43	
		8	Cell1 R_a 3			44	44	44	
		10	Cell1 R_a 4			42	42	42	
		12	Cell1 R_a 5			42	42	42	
		14	Cell1 R_a 6			45	45	45	
		16	Cell1 R_a 7			48	48	48	
		18	Cell1 R_a 8			49	49	49	
		20	Cell1 R_a 9			52	52	52	
		22	Cell1 R_a 10			56	56	56	
		24	Cell1 R_a 11			64	64	64	
		26	Cell1 R_a 12			74	74	74	
		28	Cell1 R_a 13			128	128	128	
30	Cell1 R_a 14	378	378	378					

**Related Variable:**

- DF:Ra Table:R\_a1(89):Cell1 R\_a flag(0)

**C.11.3 R\_a2 (Subclass 90)****C.11.3.1 Cell2 R\_a flag (Offset 0)**

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

**High Byte**

0x00	Tell impedance and QMAX updated
0x05	Relaxation mode and QMAX update in progress
0x55	Discharge mode and cell impedance updated
0xff	Cell impedance never updated

**Low Byte**

0x00	Table not used and QMAX updated
0x55	Table being used
0xff	Table never used, no QMAX or cell impedance update

**Table C-256. 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 Variable:**

- DF:Ra Table:R\_a2(90):Cell2 R\_a 0..14(2..30)

**C.11.3.2 Cell2 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 2 in this table.

**Table C-257. Cell2 R\_a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
90	R_a2	2	Cell2 R_a 0	Signed integer	2	38	38	38	$2^{-10} \Omega$
		4	Cell2 R_a 1			41	41	41	
		6	Cell2 R_a 2			43	43	43	
		8	Cell2 R_a 3			44	44	44	
		10	Cell2 R_a 4			42	42	42	
		12	Cell2 R_a 5			42	42	42	
		14	Cell2 R_a 6			45	45	45	
		16	Cell2 R_a 7			48	48	48	
		18	Cell2 R_a 8			49	49	49	
		20	Cell2 R_a 9			52	52	52	
		22	Cell2 R_a 10			56	56	56	
		24	Cell2 R_a 11			64	64	64	
		26	Cell2 R_a 12			74	74	74	
		28	Cell2 R_a 13			128	128	128	
		30	Cell2 R_a 14			378	378	378	

**Related Variable:**

- DF:Ra Table:R\_a2(90):Cell2 R\_a flag(0)

**C.11.4 R\_a3 (Subclass 91)****C.11.4.1 Cell3 R\_a flag (Offset 0)**

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

**High Byte**

0x00	Cell impedance and QMAX updated
0x05	Relaxation mode and QMAX update in progress
0x55	Discharge mode and cell impedance updated
0xff	Cell impedance never updated

**Low Byte**

0x00	Table not used and QMAX updated
0x55	Table being used
0xff	Table never used, no QMAX or cell impedance update

**Table C-258. 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 Variable:**

- DF:Ra Table:R\_a3(91):Cell3 R\_a 0..14(2..30)

**C.11.4.2 Cell3 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 3 in this table.

**Table C-259. Cell3 R\_a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
91	R_a3	2	Cell3 R_a 0	Signed integer	2	38	38	38	$2^{-10} \Omega$
		4	Cell3 R_a 1			41	41	41	
		6	Cell3 R_a 2			43	43	43	
		8	Cell3 R_a 3			44	44	44	
		10	Cell3 R_a 4			42	42	42	
		12	Cell3 R_a 5			42	42	42	
		14	Cell3 R_a 6			45	45	45	
		16	Cell3 R_a 7			48	48	48	
		18	Cell3 R_a 8			49	49	49	
		20	Cell3 R_a 9			52	52	52	
		22	Cell3 R_a 10			56	56	56	
		24	Cell3 R_a 11			64	64	64	
		26	Cell3 R_a 12			74	74	74	
		28	Cell3 R_a 13			128	128	128	
30	Cell3 R_a 14	378	378	378					

**Related Variable:**

- DF:Ra Table:R\_a3(91):Cell3 R\_a flag(0)

**C.11.5 R\_a0x (Subclass 92)****C.11.5.1 xCell0 R\_a flag (Offset 0)**

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

**High Byte**

0x00	Cell impedance and QMAX updated
0x05	Relaxation mode and QMAX update in progress
0x55	Discharge mode and cell impedance updated
0xff	Cell impedance never updated

**Low Byte**

0x00	Table not used and QMAX updated
0x55	Table being used
0xff	Table never used, no QMAX or cell impedance update

**Table C-260. xCell0 R\_a flag**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
92	R_a0x	0	xCell0 R_a flag	Hex	2	0xffff	0xffff	0xffff	

**Related Variable:**

- DF:Ra Table:R\_a0x(92):xCell0 R\_a 0..14(2..30)

**C.11.5.2 xCell0 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 0 in this table.

**Table C-261. xCell0 R\_a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
92	R_a0x	2	xCell0 R_a 0	Signed integer	2	38	38	38	2 <sup>-10</sup> Ω
		4	xCell0 R_a 1			41	41	41	
		6	xCell0 R_a 2			43	43	43	
		8	xCell0 R_a 3			44	44	44	
		10	xCell0 R_a 4			42	42	42	
		12	xCell0 R_a 5			42	42	42	
		14	xCell0 R_a 6			45	45	45	
		16	xCell0 R_a 7			48	48	48	
		18	xCell0 R_a 8			49	49	49	
		20	xCell0 R_a 9			52	52	52	
		22	xCell0 R_a 10			56	56	56	
		24	xCell0 R_a 11			64	64	64	
		26	xCell0 R_a 12			74	74	74	
		28	xCell0 R_a 13			128	128	128	
30	xCell0 R_a 14	378	378	378					

**Related Variable:**

- DF:Ra Table:R\_a0x(92):xCell0 R\_a flag(0)

**C.11.6 R\_a1x (Subclass 93)****C.11.6.1 xCell1 R\_a flag (Offset 0)**

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

**High Byte**

0x00	Cell impedance and QMAX updated
0x05	Relaxation mode and QMAX update in progress
0x55	Discharge mode and cell impedance updated
0xff	Cell impedance never updated

**Low Byte**

0x00	Table not used and QMAX updated
0x55	Table being used
0xff	Table never used, no QMAX or cell impedance update

**Table C-262. xCell1 R\_a flag**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
93	R_a1x	0	xCell1 R_a flag	Hex	2	0xffff	0xffff	0xffff	

**Related Variable:**

- DF:Ra Table:R\_a1x(93):xCell1 R\_a 0..14(2..30)

**C.11.6.2 xCell1 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 1 in this table.



**Table C-263. xCell1 R\_a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
93	R_a1x	2	xCell1 R_a 0	Signed integer	2	38	38	38	2 <sup>-10</sup> Ω
		4	xCell1 R_a 1			41	41	41	
		6	xCell1 R_a 2			43	43	43	
		8	xCell1 R_a 3			44	44	44	
		10	xCell1 R_a 4			42	42	42	
		12	xCell1 R_a 5			42	42	42	
		14	xCell1 R_a 6			45	45	45	
		16	xCell1 R_a 7			48	48	48	
		18	xCell1 R_a 8			49	49	49	
		20	xCell1 R_a 9			52	52	52	
		22	xCell1 R_a 10			56	56	56	
		24	xCell1 R_a 11			64	64	64	
		26	xCell1 R_a 12			74	74	74	
		28	xCell1 R_a 13			128	128	128	
30	xCell1 R_a 14	378	378	378					

**Related Variable:**

- DF:Ra Table:R\_a1x(93):xCell1 R\_a flag(0)

**C.11.7 R\_a2x (Subclass 94)****C.11.7.1 xCell2 R\_a flag (Offset 0)**

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

**High Byte**

0x00	Cell impedance and QMAX updated
0x05	Relaxation mode and QMAX update in progress
0x55	Discharge mode and cell impedance updated
0xff	Cell impedance never updated

**Low Byte**

0x00	Table not used and QMAX updated
0x55	Table being used
0xff	Table never used, no QMAX or cell impedance update

**Table C-264. xCell2 R\_a flag**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
94	R_a2x	0	xCell2 R_a flag	Hex	2	0xffff	0xffff	0xffff	

**Related Variable:**

- DF:Ra Table:R\_a2x(94):xCell2 R\_a 0..14(2..30)

**C.11.7.2 xCell2 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 2 in this table.

**Table C-265. xCell2 R\_a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
94	R_a2x	2	xCell2 R_a 0	Signed integer	2	38	38	38	2 <sup>-10</sup> Ω
		4	xCell2 R_a 1			41	41	41	
		6	xCell2 R_a 2			43	43	43	
		8	xCell2 R_a 3			44	44	44	
		10	xCell2 R_a 4			42	42	42	
		12	xCell2 R_a 5			42	42	42	
		14	xCell2 R_a 6			45	45	45	
		16	xCell2 R_a 7			48	48	48	
		18	xCell2 R_a 8			49	49	49	
		20	xCell2 R_a 9			52	52	52	
		22	xCell2 R_a 10			56	56	56	
		24	xCell2 R_a 11			64	64	64	
		26	xCell2 R_a 12			74	74	74	
		28	xCell2 R_a 13			128	128	128	
30	xCell2 R_a 14	378	378	378					

**Related Variable:**

- DF:Ra Table:R\_a2x(94):xCell2 R\_a flag(0)

**C.11.8 R\_a3x (Subclass 95)****C.11.8.1 xCell3 R\_a flag (Offset 0)**

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

**High Byte**

0x00	Cell impedance and QMAX updated
0x05	Relaxation mode and QMAX update in progress
0x55	Discharge mode and cell impedance updated
0xff	Cell impedance never updated

**Low Byte**

0x00	Table not used and QMAX updated
0x55	Table being used
0xff	Table never used, no QMAX or cell impedance update

**Table C-266. xCell3 R\_a flag**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
95	R_a3x	0	xCell3 R_a flag	Hex	2	0xffff	0xffff	0xffff	

**Related Variable:**

- DF:Ra Table:R\_a3x(95):xCell3 R\_a 0..14(2..30)

**C.11.8.2 xCell3 R\_a 0..14 (Offset 2..30)**

The bq20z60-R1/bq20z65-R1 stores and updates the impedance profile for cell 3 in this table.

**Table C-267. xCell3 R\_a**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
95	R_a3x	2	xCell3 R_a 0	Signed integer	2	38	38	38	2 <sup>-10</sup> Ω
		4	xCell3 R_a 1			41	41	41	
		6	xCell3 R_a 2			43	43	43	
		8	xCell3 R_a 3			44	44	44	
		10	xCell3 R_a 4			42	42	42	
		12	xCell3 R_a 5			42	42	42	
		14	xCell3 R_a 6			45	45	45	
		16	xCell3 R_a 7			48	48	48	
		18	xCell3 R_a 8			49	49	49	
		20	xCell3 R_a 9			52	52	52	
		22	xCell3 R_a 10			56	56	56	
		24	xCell3 R_a 11			64	64	64	
		26	xCell3 R_a 12			74	74	74	
		28	xCell3 R_a 13			128	128	128	
30	xCell3 R_a 14	378	378	378					

**Related Variable:**

- DF:Ra Table:R\_a3x(95):xCell3 R\_a flag(0)

**C.12 PF Status****C.12.1 Device Status Data (Subclass 96)****C.12.1.1 Saved PF Flags 1..2 (Offset 0..2)**

The flags in the **Saved PF Flags 1..2** register indicate the reason that the bq20z60-R1/bq20z65-R1 has entered permanent failure. If the failure flag in **Saved PF Flags 1..2** matches the bit in **Permanent Fail Cfg** or **Permanent Fail Cfg 2**, the SAFE pin is driven high and the **Fuse Flag** is set to 0x3672. The SAFE pin can be used to blow an optional fuse in a severe failure condition to prevent more damage to the system.

All permanent failure flags in the failure sequence are stored in **Saved PF Flags 1..2**. Only the first permanent failure flag in a failure sequence is stored in **Saved 1st PF Flag 1..2** to indicate the cause of the permanent failure.

**Table C-268. Saved PF Flags 1..2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	0	Saved PF Flags 1	Hex	2	0x0000	0xffff	0x0000	
96	Device Status Data	2	Saved PF Flags 2	Hex	2	0x0000	0xffff	0x0000	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	FBF	PFVSHUT	SUV	SOPT1	S OCD	S OCC	AFE_P	ACE_C
<b>Low Byte</b>	DFF	DFETF	CFETF	CIM_R	SOT1D	SOT1C	SOV	PFIN

LEGEND: All values read-only

**Figure C-13. Saved PF Flags 1**

**FBF**— 1 = Fuse Blow Failure. The fuse has not cut off current even though the SAFE pin output has been driven high.

**PFVSHUT**— 1 = Another permanent failure has occurred AND the device went into shutdown after that event

**SUV**— 1 = Safety Undervoltage permanent failure

- SOPT1**— 1 = Open Thermistor permanent failure  
**SOCD**— 1 = Safety Overcurrent in Discharge permanent failure  
**SOCC**— 1 = Safety Overcurrent in Charge permanent failure  
**AFE\_P**— 1 = Periodic AFE-Communications permanent failure  
**AFE\_C**— 1 = AFE-Communications permanent failure  
**DFF**— 1 = Data Flash Fault permanent failure  
**DFETF**— 1 = Discharge FET permanent failure  
**CFETF**— 1 = Charge FET permanent failure  
**CIM\_R**— 1 = Cell-Imbalance at rest permanent failure  
**SOT1D**— 1 = Discharge Safety Overtemperature on TS1 permanent failure  
**SOT1C**— 1 = Charge Safety Overtemperature on TS1 permanent failure  
**SOV**— 1 = Safety Overvoltage permanent failure  
**PFIN**— 1 = External PFIN Input Indication of a permanent failure

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>High Byte</b>	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
<b>Low Byte</b>	RSVD	RSVD	RSVD	RSVD	SOPT2	SOT2D	SOT2C	CIM_A

LEGEND: All values read-only

**Figure C-14. Saved PF Flags 2**

- SOPT2**— 1 = Open Thermistor on TS2 permanent failure  
**SOT2D**— 1 = Safety over temperature on TS2 during discharge failure  
**SOT2C**— 1 = Safety over temperature on TS2 during charge failure  
**CIM\_A**— 1 = Cell imbalance while active permanent failure

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg 1..2(6..8)
- DF:PF Status:Device Status Data(96):Fuse Flag(2)
- DF:PF Status:Device Status Data(96):Saved 1st PF Flag 1..2(32..34)
- SBS:PFStatus(0x53)
- SBS:PFStatus2(0x6b)

**C.12.1.2 Fuse Flag (Offset 4)**

The **Fuse Flag** is set to 0x3672 when a 2nd level protection failure occurs and the matching bit is set in the **Permanent Fail Cfg** register. The SAFE pin is driven high.

0x0000 = No failure (default)

0x3672 = The **Permanent Fail Cfg** flag matches the **Saved PF Flags 1** flag, and the SAFE pin is driven low.

**Table C-269. Fuse Flag**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	4	Fuse Flag	Hex	2	0x0000	0xffff	0x0000	

**Related Variables:**

- DF:Configuration:Registers(64):Permanent Fail Cfg(6)
- DF:PF Status:Device Status Data(96):Saved PF Flags 1(0)

**C.12.1.3 PF Voltage (Offset 6)**

When a permanent failure is detected, *Voltage* is captured and stored in **PF Voltage**.

**Table C-270. PF Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	6	PF Voltage	Integer	2	0	32,767	0	mV

**Related Variable:**

- SBS:Voltage(0x009)

**C.12.1.4 PF C4 Voltage (Offset 8)**

When a permanent failure is detected, *CellVoltage4* is captured and stored in **PF C4 Voltage**.

**Table C-271. PF C4 Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	8	PF C4 Voltage	Integer	2	0	9999	0	mV

**Related Variable:**

- SBS:CellVoltage4(0x3c)

**C.12.1.5 PF C3 Voltage (Offset 10)**

When a permanent failure is detected, *CellVoltage3* is captured and stored in **PF C3 Voltage**.

**Table C-272. PF C3 Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	10	PF C3 Voltage	Integer	2	0	9999	0	mV

**Related Variable:**

- SBS:CellVoltage3(0x3d)

**C.12.1.6 PF C2 Voltage (Offset 12)**

When a permanent failure is detected, *CellVoltage2* is captured and stored in **PF C2 Voltage**.

**Table C-273. PF C2 Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	12	PF C2 Voltage	Integer	2	0	9999	0	mV

**Related Variable:**

- SBS:CellVoltage2(0x3e)

**C.12.1.7 PF C1 Voltage (Offset 14)**

When a permanent failure is detected, *CellVoltage1* is captured and stored in **PF C1 Voltage**.

**Table C-274. PF C1 Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	14	PF C1 Voltage	Integer	2	0	9999	0	mV

**Related Variable:**

- SBS:CellVoltage1(0x3f)

**C.12.1.8 PF Current (Offset 16)**

When a permanent failure is detected, the pack *Current* is captured and stored in **PF Current**.

**Table C-275. PF Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	16	PF Current	Integer	2	-32,768	32,767	0	mA

**Related Variable:**

- SBS:Current(0x00a)

**C.12.1.9 PF Temperature (Offset 18)**

When a permanent failure is detected, the pack *Temperature* is captured and stored in **PF Temperature**.

**Table C-276. PF Temperature**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	18	PF Temperature	Integer	2	-9999	9999	0	0.1 K

**Related Variable:**

- SBS:Temperature(0x008)

**C.12.1.10 PF Batt Stat (Offset 20)**

When a permanent failure is detected, the *BatteryStatus* flags are captured and stored in **PF Batt Stat**.

**Table C-277. PF Batt Stat**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	20	PF Batt Stat	Hex	2	0x0000	0xffff	0x0000	

**Related Variable:**

- SBS:BatteryStatus(0x16)

**C.12.1.11 PF RC-mAh (Offset 22)**

When a permanent failure is detected, *RemainingCapacity*, in mAh, is captured and stored in **PF RC-mAh**.

**Table C-278. PF RC-mAh**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	22	PF RC-mAh	Integer	2	0	32,767	0	mAh

**Related Variables:**

- SBS:BatteryMode(0x003)[CapM]
- SBS:RemainingCapacity(0x00f)

**C.12.1.12 PF RC-10mWh (Offset 24)**

When a permanent failure is detected, *RemainingCapacity*, in 10 mWh, is captured and stored in **PF-RC 10mWh**.

**Table C-279. PF RC-10mWh**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	24	PF RC-10mWh	Integer	2	0	32,767	0	10 mWh

**Related Variables:**

- SBS:BatteryMode(0x003)[CapM]
- SBS:RemainingCapacity(0x00f)

**C.12.1.13 PF Chg Status (Offset 26)**

When a permanent failure is detected, the *ChargingStatus* flags are captured and stored in **PF Chg Status**.

**Table C-280. PF Chg Status**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	26	PF Chg Status	Hex	2	0x0000	0xffff	0x0000	

**Related Variable:**

- SBS:ChargingStatus(0x55)

**C.12.1.14 PF Safety Status 1..2 (Offset 28..30)**

When a permanent failure is detected, the *SafetyStatus* and *SafetyStatus2* flags are captured and stored in **PF Safety Status 1** and **PF Safety Status 2**.

**Table C-281. PF Safety Status 1..2**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	28	PF Safety Status 1	Hex	2	0x0000	0xffff	0x0000	
96	Device Status Data	30	PF Safety Status 2	Hex	2	0x0000	0xffff	0x0000	

**Related Variable:**

- SBS:SafetyStatus(0x51)
- SBS:SafetyStatus2(0x69)

**C.12.1.15 Saved 1st PF Flag 1..2 (Offset 32..34)**

On the first occurrence of a permanent failure, when *PFStatus* or *PFStatus2* changes from 0x0000, the *PFStatus* and *PFStatus2* flags are captured and stored in this value. Only the first permanent failure flag in a failure sequence is stored in **Saved 1st PF Flag 1..2**, to indicate the cause of the permanent failure. All permanent failure flags in the failure sequence are stored in **Saved PF Flags 1..2**.

**Table C-282. Saved 1st PF Flag**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	32	Saved 1st PF Flag 1	Hex	2	0x0000	0xffff	0x0000	
96	Device Status Data	34	Saved 1st PF Flag 2	Hex	2	0x0000	0xffff	0x0000	

**Related Variables:**

- DF:PF Status:Device Status Data(96):Saved PF Flags 1..2(0..2)
- SBS:PFStatus(0x53)
- SBS:PFStatus2(0x6b)

**C.12.2 AFE Regs (Subclass 97)**

When the bq20z60-R1/bq20z65-R1 detects a permanent failure, a complete copy of the AFE register values is stored in **AFE Regs**.

**Table C-283. AFE Regs**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
97	AFE Regs	0	AFE Status	Hex	1	0x00	0xff	0x00	
		1	AFE Output						
		2	AFE State						
		3	AFE Function						
		4	AFE Cell Select						
		5	AFE OLV						
		6	AFE OLT						
		7	AFE SCC						
		8	AFE SCD						

**C.13 Calibration**
**C.13.1 Data (Subclass 104)**
**C.13.1.1 CC Gain (Offset 0)**

**CC Gain** sets the mA current scale factor for the coulomb counter. Use calibration routines to set this value.

**Table C-284. CC Gain**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	0	CC Gain	Floating point	4	0.1	4	0.9419	

**Related Variable:**

- SBS:Current(0x00a)

**C.13.1.2 CC Delta (Offset 4)**

**CC Delta** sets the mAh capacity scale factor for the coulomb counter. Use calibration routines to set this value.



**Table C-285. 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	29,826	1,193,046	280,932.6	

**Related Variables:**

- SBS:RemainingCapacity(0x00f)
- SBS:FullChargeCapacity(0x10)

**C.13.1.3 Ref Voltage (Offset 8)**

This register value stores the AFE reference voltage in units of 50  $\mu$ V.

**Table C-286. Ref Voltage**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	8	Ref Voltage	Integer	2	0	32,767	24,500	

**C.13.1.4 AFE Pack Gain (Offset 12)**

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

**Table C-287. 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	Integer	2	0	32,767	22,050	

**C.13.1.5 CC Offset (Offset 14)**

This register value stores the coulomb counter offset compensation. It is set by automatic calibration of the bq20z60-R1/bq20z65-R1. It is not recommended to change this value.

**Table C-288. CC Offset**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	14	CC Offset	Integer	2	-32,768	32,767	-1667	

**C.13.1.6 Board Offset (Offset 16)**

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

**Table C-289. Board Offset**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
104	Data	16	Board Offset	Integer	2	-32,767	32,767	0	

**Related Variable:**

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

**C.13.1.7 Int Temp Offset (Offset 18)**

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

**Table C-290. 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	Integer	1	-128	127	0	

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x008)

**C.13.1.8 Ext1 Temp Offset (Offset 19)**

This register value stores the temperature sensor offset compensation for external temperature sensor 1, connected at the TS1 pin of the bq20z60-R1/bq20z65-R1. Use calibration routines to set this value.

**Table C-291. 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(0x008)

**C.13.1.9 Ext2 Temp Offset (Offset 20)**

This register value stores the temperature sensor offset compensation for external temperature sensor 2, connected at the TS2 pin of the bq20z60-R1/bq20z65-R1. Use calibration routines to set this value.

**Table C-292. 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	Integer	1	-128	127	0	-

**Related Variables:**

- DF:Configuration:Registers(64):Operation Cfg A(0)[TEMP1], [TEMP0]
- SBS:Temperature(0x008)

**C.13.2 Config (Subclass 105)**
**C.13.2.1 CC Current (Offset 0)**

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

**Table C-293. CC Current**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	0	CC Current	Integer	2	0	32,767	3000	mA

**Related Variable:**

- SBS:Current(0x00a)

**C.13.2.2 Voltage Signal (Offset 2)**

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

**Table C-294. Voltage Signal**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	2	Voltage Signal	Integer	2	0	32,767	16,800	

**Related Variable:**

- SBS:Voltage(0x009)

**C.13.2.3 Temp Signal (Offset 4)**

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

**Table C-295. Temp Signal**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	4	Temp Signal	Integer	2	0	32,767	2980	

**Related Variable:**

- SBS:Temperature(0x008)

**C.13.2.4 CC Offset Time (Offset 6)**

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

**Table C-296. CC Offset Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	6	CC Offset Time	Unsigned integer	2	0	65,535	250	

**Related Variable:**

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

**C.13.2.5 ADC Offset Time (Offset 8)**

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

**Table C-297. ADC Offset Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	8	ADC Offset Time	Unsigned integer	2	0	65,535	32	

**C.13.2.6 CC Gain Time (Offset 10)**

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

**Table C-298. CC Gain Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	10	CC Gain Time	Unsigned integer	2	0	65,535	250	

**Related Variable:**

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

**C.13.2.7 Voltage Time (Offset 12)**

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

**Table C-299. Voltage Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	12	Voltage Time	Unsigned integer	2	0	65,535	1984	

**Related Variable:**

- SBS:Voltage(0x009)

**C.13.2.8 Temperature Time (Offset 14)**

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

**Table C-300. Temperature Time**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	14	Temperature Time	Unsigned integer	2	0	65,535	32	

**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(0x008)

**C.13.2.9 Cal Mode Timeout (Offset 17)**

The bq20z60-R1/bq20z65-R1 exits calibration mode automatically after a **Cal Mode Timeout** period.

**Table C-301. Cal Mode Timeout**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
105	Config	17	Cal Mode Timeout	Unsigned integer	2	0	65,535	38,400	-

**Related Variable:**

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

**C.13.3 Temp Model (Subclass 106)**
**C.13.3.1 Ext Coef 1..4, Ext Min AD, Ext Max Temp (Offset 0..10)**

These values characterize the external thermistor connected to the TS1 pin or the TS2 pin of the bq20z60-R1/bq20z65-R1. The default values characterize the Semitec 103AT NTC thermistor. Do not modify these values without consulting TI.

**Table C-302. 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	Integer	2	-32,768	32,767	-28,285	
		2	Ext Coef 2					20,848	
		4	Ext Coef 3					-7537	
		6	Ext Coef 4					4012	
		8	Ext Min AD					0	
		10	Ext Max Temp					4012	

### C.13.3.2 Int Coef 1..4, Int Min AD, Int Max Temp (Offset 12..22)

These values characterize the internal thermistor of the bq20z60-R1/bq20z65-R1. Do not modify these values without consulting TI.

**Table C-303. 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	Integer	2	-32,768	32,767	0	
		14	Int Coef 2					0	
		16	Int Coef 3					-11,136	
		18	Int Coef 4					5754	
		20	Int Min AD					0	
		22	Int Max Temp					5754	

### C.13.4 Current (Subclass 107)

#### C.13.4.1 Filter (Offset 0)

**Filter** defines the filter constant used in the *AverageCurrent* calculation:

$$AverageCurrent_{new} = a \times AverageCurrent_{old} + (1 - a) \times Current$$

with:

$$a = \langle Filter \rangle / 256; \text{ the time constant} = 1 \text{ s} / \ln(1/a) \text{ (default 14.5 s)}$$

**Table C-304. 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(0x00a)
- SBS:AverageCurrent(0x00b)

#### C.13.4.2 Deadband (Offset 1)

Any current within  $\pm$  **Deadband** is reported as 0 mA by the *Current* function.

**Table C-305. 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 Variable:**

- SBS:Current(0x00a)

**C.13.4.3 CC Deadband (Offset 2)**

This constant defines the deadband voltage for the measured voltage between the SR1 and SR2 pins used for capacity accumulation in units of 294 nV. Any voltages within  $\pm$ **CC Deadband** do not contribute to capacity accumulation.

**Table C-306. CC Deadband**

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
107	Current	2	CC Deadband	Unsigned integer	1	0	255	34	294 nV

**Related Variable:**

- SBS:RemainingCapacity(0x00f)

**C.14 Data Flash Values**
**Table C-307. DATA FLASH VALUES**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSU Units)*
1st Level Safety	0	Voltage	0	LT COV Threshold	I2	3700	5000	4300	mV
1st Level Safety	0	Voltage	2	LT COV Recovery	I2	0	4400	4100	mV
1st Level Safety	0	Voltage	4	ST COV Threshold	I2	3700	5000	4500	mV
1st Level Safety	0	Voltage	6	ST COV Recovery	I2	0	4400	4300	mV
1st Level Safety	0	Voltage	8	HT COV Threshold	I2	3700	5000	4200	mV
1st Level Safety	0	Voltage	10	HT COV Recovery	I2	0	4400	4000	mV
1st Level Safety	0	Voltage	12	COV Time	U1	0	240	2	s
1st Level Safety	0	Voltage	13	CUV Threshold	I2	0	3500	2200	mV
1st Level Safety	0	Voltage	15	CUV Time	U1	0	240	2	s
1st Level Safety	0	Voltage	16	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	2	OC (1st Tier) Chg Time	U1	0	240	2	mA (s)
1st Level Safety	1	Current	3	OC Chg Recovery	I2	-1000	1000	200	mA
1st Level Safety	1	Current	5	OC (1st Tier) Dsg	I2	0	20000	6000	mA
1st Level Safety	1	Current	7	OC (1st Tier) Dsg Time	U1	0	240	2	mA (s)
1st Level Safety	1	Current	8	OC Dsg Recovery	I2	0	1000	200	mA
1st Level Safety	1	Current	10	OC (2nd Tier) Chg	I2	0	20000	8000	mA
1st Level Safety	1	Current	12	OC (2nd Tier) Chg Time	U1	0	240	2	s
1st Level Safety	1	Current	13	OC (2nd Tier) Dsg	I2	0	22000	8000	mA

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSU Units)*
1st Level Safety	1	Current	15	OC (2nd Tier) Dsg Time	U1	0	240	2	s
1st Level Safety	1	Current	16	Current Recovery Time	U1	0	240	8	s
1st Level Safety	1	Current	17	AFE OC Dsg	H1	0x0	0xff	0x12	-
1st Level Safety	1	Current	18	AFE OC Dsg Time	H1	0x0	0xff	0xf	-
1st Level Safety	1	Current	19	AFE OC Dsg Recovery	I2	5	1000	5	mA
1st Level Safety	1	Current	21	AFE SC Chg Cfg	H1	0x0	0xff	0x77	-
1st Level Safety	1	Current	22	AFE SC Dsg Cfg	H1	0x0	0xff	0x77	-
1st Level Safety	1	Current	23	AFE SC Recovery	I2	0	200	1	mA
1st Level Safety	2	Temperature	0	OT1 Chg Threshold	I2	0	2550	550	0.1°C (°C)
1st Level Safety	2	Temperature	2	OT1 Chg Time	U1	0	240	2	s
1st Level Safety	2	Temperature	3	OT1 Chg Recovery	I2	0	2550	500	0.1°C (°C)
1st Level Safety	2	Temperature	5	OT2 Chg Threshold	I2	0	2550	550	0.1°C (°C)
1st Level Safety	2	Temperature	7	OT2 Chg Time	U1	0	240	2	s
1st Level Safety	2	Temperature	8	OT2 Chg Recovery	I2	0	2550	500	0.1°C (°C)
1st Level Safety	2	Temperature	10	OT1 Dsg Threshold	I2	0	2550	600	0.1°C (°C)
1st Level Safety	2	Temperature	12	OT1 Dsg Time	U1	0	240	2	s
1st Level Safety	2	Temperature	13	OT1 Dsg Recovery	I2	0	2550	550	0.1°C (°C)
1st Level Safety	2	Temperature	15	OT2 Dsg Threshold	I2	0	2550	600	0.1°C (°C)
1st Level Safety	2	Temperature	17	OT2 Dsg Time	U1	0	240	2	s
1st Level Safety	2	Temperature	18	OT2 Dsg Recovery	I2	0	2550	550	0.1°C (°C)
1st Level Safety	2	Temperature	20	Hi Dsg Start Temp	I2	0	1200	600	0.1°C (°C)
1st Level Safety	4	Host Comm	0	Host Watchdog Timeout	U1	0	255	0	s
2nd Level Safety	16	Voltage	0	LT SOV Threshold	I2	0	20000	4400	mV
2nd Level Safety	16	Voltage	2	ST SOV Threshold	I2	0	20000	4600	mV
2nd Level Safety	16	Voltage	4	HT SOV Threshold	I2	0	20000	4500	mV
2nd Level Safety	16	Voltage	6	SOV Time	U1	0	240	0	s
2nd Level Safety	16	Voltage	7	PF SOV Fuse Blow Delay	U2	0	65535	0	s
2nd Level Safety	16	Voltage	9	SUV Threshold	I2	0	20000	2000	mV
2nd Level Safety	16	Voltage	11	SUV Time	U1	0	240	0	s
2nd Level Safety	16	Voltage	12	Rest CIM Current	U1	0	200	5	mA

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSU Units)*
2nd Level Safety	16	Voltage	13	Rest CIM Fail Voltage	I2	0	5000	1000	mV
2nd Level Safety	16	Voltage	15	Rest CIM Time	U1	0	240	0	s
2nd Level Safety	16	Voltage	16	CIM Battery Rest Time	U2	0	65535	1800	s
2nd Level Safety	16	Voltage	18	Rest CIM Check Voltage	U2	0	65535	3000	mV
2nd Level Safety	16	Voltage	20	Active CIM Fail Voltage	I2	0	5000	1000	mV
2nd Level Safety	16	Voltage	22	Active CIM Time	U1	0	240	0	s
2nd Level Safety	16	Voltage	23	Active CIM Check Voltage	I2	0	32768	3000	mV
2nd Level Safety	16	Voltage	25	PFIN Detect Time	U1	0	240	0	s
2nd Level Safety	16	Voltage	26	PF Min Fuse Blow Voltage	I2	0	20000	8000	mV
2nd Level Safety	17	Current	0	SOC Chg	I2	0	30000	10000	mA
2nd Level Safety	17	Current	2	SOC Chg Time	U1	0	240	0	s
2nd Level Safety	17	Current	3	SOC Dsg	I2	0	30000	10000	mA
2nd Level Safety	17	Current	5	SOC Dsg Time	U1	0	240	0	s
2nd Level Safety	18	Temperature	0	SOT1 Chg Threshold	I2	0	2550	650	0.1°C (°C)
2nd Level Safety	18	Temperature	2	SOT1 Chg Time	U1	0	240	0	s
2nd Level Safety	18	Temperature	3	SOT2 Chg Threshold	I2	0	2550	650	0.1°C (°C)
2nd Level Safety	18	Temperature	5	SOT2 Chg Time	U1	0	240	0	s
2nd Level Safety	18	Temperature	6	SOT1 Dsg Threshold	I2	0	2550	750	0.1°C (°C)
2nd Level Safety	18	Temperature	8	SOT1 Dsg Time	U1	0	240	0	s
2nd Level Safety	18	Temperature	9	SOT2 Dsg Threshold	I2	0	2550	750	0.1°C (°C)
2nd Level Safety	18	Temperature	11	SOT2 Dsg Time	U1	0	240	0	s
2nd Level Safety	18	Temperature	12	Open Thermistor	I2	-1000	1200	-333	0.1°C (°C)
2nd Level Safety	18	Temperature	14	Open Time	I1	0	240	0	s
2nd Level Safety	19	FET Verification	0	FET Fail Limit	I2	0	500	20	mA
2nd Level Safety	19	FET Verification	2	FET Fail Time	U1	0	240	0	s
2nd Level Safety	20	AFE Verification	0	AFE Check Time	U1	0	255	0	s
2nd Level Safety	20	AFE Verification	1	AFE Fail Limit	U1	0	255	0	-
2nd Level Safety	20	AFE Verification	2	AFE Fail Recovery Time	U1	0	255	20	s
2nd Level Safety	20	AFE Verification	3	AFE Init Retry Limit	U1	0	255	6	-
2nd Level Safety	20	AFE Verification	4	AFE Init Limit	U1	0	255	20	-



**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSU Units)*
2nd Level Safety	21	Fuse Verification	0	Fuse Fail Limit	I2	0	20	2	mA
2nd Level Safety	21	Fuse Verification	2	Fuse Fail Time	U1	0	240	0	s
Charge Control	32	Charge Temp Cfg	0	JT1	I2	-400	1200	0	0.1°C (°C)
Charge Control	32	Charge Temp Cfg	2	JT2	I2	-400	1200	120	0.1°C (°C)
Charge Control	32	Charge Temp Cfg	4	JT2a	I2	-400	1200	300	0.1°C (°C)
Charge Control	32	Charge Temp Cfg	6	JT3	I2	-400	1200	450	0.1°C (°C)
Charge Control	32	Charge Temp Cfg	8	JT4	I2	-400	1200	550	0.1°C (°C)
Charge Control	32	Charge Temp Cfg	10	Temp Hys	I2	0	100	10	0.1°C (°C)
Charge Control	33	Pre-Charge Cfg	0	Pre-chg Voltage Threshold	I2	0	20000	3000	mV
Charge Control	33	Pre-Charge Cfg	2	Pre-chg Recovery Voltage	I2	0	20000	3100	mV
Charge Control	33	Pre-Charge Cfg	4	Pre-chg Current	I2	0	2000	250	mA
Charge Control	34	Charge Cfg	0	LT Chg Voltage	I2	0	20000	12000	mV
Charge Control	34	Charge Cfg	2	LT Chg Current1	I2	0	20000	250	mA
Charge Control	34	Charge Cfg	4	LT Chg Current2	I2	0	20000	250	mA
Charge Control	34	Charge Cfg	6	LT Chg Current3	I2	0	20000	250	mA
Charge Control	34	Charge Cfg	8	ST1 Chg Voltage	I2	0	20000	16800	mV
Charge Control	34	Charge Cfg	10	ST1 Chg Current1	I2	0	20000	4000	mA
Charge Control	34	Charge Cfg	12	ST1 Chg Current2	I2	0	20000	4000	mA
Charge Control	34	Charge Cfg	14	ST1 Chg Current3	I2	0	20000	4000	mA
Charge Control	34	Charge Cfg	16	ST2 Chg Voltage	I2	0	20000	16800	mV
Charge Control	34	Charge Cfg	18	ST2 Chg Current1	I2	0	20000	4000	mA
Charge Control	34	Charge Cfg	20	ST2 Chg Current2	I2	0	20000	4000	mA
Charge Control	34	Charge Cfg	22	ST2 Chg Current3	I2	0	20000	4000	mA
Charge Control	34	Charge Cfg	24	HT Chg Voltage	I2	0	20000	16760	mV
Charge Control	34	Charge Cfg	26	HT Chg Current1	I2	0	20000	3800	mA
Charge Control	34	Charge Cfg	28	HT Chg Current2	I2	0	20000	3800	mA
Charge Control	34	Charge Cfg	30	HT Chg Current3	I2	0	20000	3800	mA
Charge Control	34	Charge Cfg	32	Cell Voltage Threshold1	I2	0	5000	3900	mV
Charge Control	34	Charge Cfg	34	Cell Voltage Threshold2	I2	0	5000	4000	mV
Charge Control	34	Charge Cfg	36	Cell Voltage Thresh Hys	I2	0	1000	10	mV

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
Charge Control	36	Termination Cfg.	0	Maintenance Current	I2	0	1000	0	mA
Charge Control	36	Termination Cfg.	2	Taper Current	I2	0	1000	250	mA
Charge Control	36	Termination Cfg.	6	Taper Voltage	I2	0	1000	75	mV
Charge Control	36	Termination Cfg.	8	Current Taper Window	U1	0	240	40	s
Charge Control	36	Termination Cfg.	9	TCA Set %	I1	-1	100	-1	%
Charge Control	36	Termination Cfg.	10	TCA Clear %	I1	-1	100	95	%
Charge Control	36	Termination Cfg.	11	FC Set %	I1	-1	100	-1	%
Charge Control	36	Termination Cfg.	12	FC Clear %	I1	-1	100	98	%
Charge Control	37	Cell Balancing Cfg	0	Min Cell Deviation	U2	0	65535	1350	s/mAh
Charge Control	38	Charging Faults	0	Over Charging Voltage	I2	0	3000	500	mV
Charge Control	38	Charging Faults	2	Over Charging Volt Time	U1	0	240	2	s
Charge Control	38	Charging Faults	3	Over Charging Current	I2	0	2000	500	mA
Charge Control	38	Charging Faults	5	Over Charging Curr Time	U1	0	240	2	s
Charge Control	38	Charging Faults	6	Over Charging Curr Recov	I2	0	2000	100	mA
Charge Control	38	Charging Faults	8	Depleted Voltage	I2	0	16000	8000	mV
Charge Control	38	Charging Faults	10	Depleted Voltage Time	U1	0	240	2	s
Charge Control	38	Charging Faults	11	Depleted Recovery	I2	0	16000	8500	mV
Charge Control	38	Charging Faults	13	Over Charge Capacity	I2	0	4000	300	mAh
Charge Control	38	Charging Faults	15	Over Charge Recovery	I2	0	100	2	mAh
Charge Control	38	Charging Faults	17	CMTO	U2	0	65535	10800	s
Charge Control	38	Charging Faults	19	PCMTO	U2	0	65535	3600	s
Charge Control	38	Charging Faults	21	Charge Fault Cfg	H1	0x0	0xffff	0x0	-
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	mWh
SBS Configuration	48	Data	4	Rem Time Alarm	U2	0	30	10	min
SBS Configuration	48	Data	6	Init Battery Mode	H2	0x0	0xffff	0x81	-
SBS Configuration	48	Data	8	Design Voltage	I2	7000	18000	14400	mV
SBS Configuration	48	Data	10	Spec Info	H2	0x0	0xffff	0x31	-
SBS Configuration	48	Data	12	Manuf Date	U2	0	65535	0	Day + Mo*32 + (Yr -1980)*256 (date)

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
SBS Configuration	48	Data	14	Ser. Num.	H2	0x0000	0xffff	0x1	-
SBS Configuration	48	Data	16	Cycle Count	U2	0	65535	0	-
SBS Configuration	48	Data	18	CC Threshold	I2	100	32767	4400	mAh
SBS Configuration	48	Data	20	CC %	U1	0	100	90	%
SBS Configuration	48	Data	21	CF MaxError Limit	U1	0	100	100	%
SBS Configuration	48	Data	22	Design Capacity	I2	0	32767	4400	mAh
SBS Configuration	48	Data	24	Design Energy	I2	0	32767	6336	10mWh (mWh)
SBS Configuration	48	Data	26	Manuf Name	S21	x	x	Texas Instruments	-
SBS Configuration	48	Data	47	Device Name	S21	x	x	bq20z60	-
SBS Configuration	48	Data	68	Device Chemistry	S5	x	x	LION	-
SBS Configuration	48	Data	73	Deterioration Warn Limit	U1	0	100	50	%
SBS Configuration	48	Data	74	Deterioration Fault Limit	U1	0	100	30	%
SBS Configuration	48	Data	75	Cell Life Limit	U1	0	100	20	%
SBS Configuration	49	Configuration	0	TDA Set %	I1	-1	100	6	%
SBS Configuration	49	Configuration	1	TDA Clear %	I1	-1	100	8	%
SBS Configuration	49	Configuration	2	FD Set %	I1	-1	100	2	%
SBS Configuration	49	Configuration	3	FD Clear %	I1	-1	100	5	%
SBS Configuration	49	Configuration	4	TDA Set Volt Threshold	I2	0	16800	5000	mV
SBS Configuration	49	Configuration	6	TDA Set Volt Time	U1	0	240	5	s
SBS Configuration	49	Configuration	7	TDA Clear Volt	I2	0	16800	5500	mV
SBS Configuration	49	Configuration	9	FD Set Volt Threshold	I2	0	16800	5000	mV
SBS Configuration	49	Configuration	11	FD Volt Time	U1	0	240	5	s
SBS Configuration	49	Configuration	12	FD Clear Volt	I2	0	16800	5500	mV
System Data	56	Manufacturer Data	0	Pack Lot Code	H2	0x0	0xffff	0x0	-
System Data	56	Manufacturer Data	2	PCB Lot Code	H2	0x0	0xffff	0x0	-
System Data	56	Manufacturer Data	4	Firmware Version	H2	0x0	0xffff	0x0	-
System Data	56	Manufacturer Data	6	Hardware Revision	H2	0x0	0xffff	0x0	-
System Data	56	Manufacturer Data	8	Cell Revision	H2	0x0	0xffff	0x0	-
System Data	58	Manufacturer Info	0	Manuf. Info 0	S32	x	x	0123456789A BCDEF01234 56789ABCDE	-
System Data	58	Manufacturer Info	32	Manuf. Block 1	S21	x	x	0123456789A BCDEF0123	-
System Data	58	Manufacturer Info	53	Manuf. Block 2	S21	x	x	0123456789A BCDEF0123	-
System Data	58	Manufacturer Info	74	Manuf. Block 3	S21	x	x	0123456789A BCDEF0123	-

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
System Data	58	Manufacturer Info	95	Manuf. Block 4	S21	x	x	0123456789A BCDEF0123	-
System Data	59	Lifetime Data	0	Lifetime Max Temp	I2	0	1400	300	0.1°C (°C)
System Data	59	Lifetime Data	2	Lifetime Min Temp	I2	-600	1400	200	0.1°C (°C)
System Data	59	Lifetime Data	4	Lifetime Max Cell Voltage	I2	0	32767	3500	mV
System Data	59	Lifetime Data	6	Lifetime Min Cell Voltage	I2	0	32767	3200	mV
System Data	59	Lifetime Data	8	Lifetime Max Pack Voltage	I2	0	32767	14000	mV
System Data	59	Lifetime Data	10	Lifetime Min Pack Voltage	I2	0	32767	12800	mV
System Data	59	Lifetime Data	12	Lifetime Max Chg Current	I2	-32767	32767	1500	mA
System Data	59	Lifetime Data	14	Lifetime Max Dsg Current	I2	-32767	32767	-3000	mA
System Data	59	Lifetime Data	16	Lifetime Max Chg Power	I2	-32767	32767	1500	10mW (mW)
System Data	59	Lifetime Data	18	Lifetime Max Dsg Power	I2	-32767	32767	-1500	10mW (mW)
System Data	59	Lifetime Data	22	Life Max AvgDsg Cur	I2	-32767	32767	-1000	mA
System Data	59	Lifetime Data	26	Life Max AvgDsg Pow	I2	-32767	32767	-1500	10mW
System Data	59	Lifetime Data	28	Life Avg Temp	I2	0	1400	250	0.1°C (°C)
System Data	59	Lifetime Data	30	Life OT Count	U2	0	65535	0	-
System Data	59	Lifetime Data	32	Life OT Duration	U2	0	65535	0	s
System Data	59	Lifetime Data	35	Life OV Count	U2	0	65535	0	-
System Data	59	Lifetime Data	37	Life OV Duration	U2	0	65535	0	s
System Data	60	Lifetime Temp Samples	0	LT Temp Samples	I4	0	1400000 00	0	-
Configuration	64	Registers	0	Operation Cfg A	H2	0x0	0xffff	0xf29	-
Configuration	64	Registers	2	Operation Cfg B	H2	0x0	0xffff	0x6440	-
Configuration	64	Registers	4	Operation Cfg C	H2	0x0	0xffff	0x130	-
Configuration	64	Registers	6	Permanent Fail Cfg	H2	0x0	0xffff	0x0	-
Configuration	64	Registers	8	Permanent Fail Cfg 2	H2	0x0	0xffff	0x0	-
Configuration	64	Registers	10	Non-Removable Cfg	H2	0x0	0xffff	0x0	-
Configuration	65	AFE	1	AFE.State_CTL	H1	0x0	0xff	0x0	-
LED Support	67	LED Cfg	0	LED Flash Period	U2	0	65535	512	500us
LED Support	67	LED Cfg	2	LED Blink Period	U2	0	65535	1024	500us
LED Support	67	LED Cfg	4	LED Delay	U2	1	65535	100	500us
LED Support	67	LED Cfg	6	LED Hold Time	U1	0	255	4	sec (s)
LED Support	67	LED Cfg	7	CHG Flash Alarm	I1	-1	101	10	%
LED Support	67	LED Cfg	8	CHG Thresh 1	I1	-1	101	0	%
LED Support	67	LED Cfg	9	CHG Thresh 2	I1	-1	101	20	%
LED Support	67	LED Cfg	10	CHG Thresh 3	I1	-1	101	40	%
LED Support	67	LED Cfg	11	CHG Thresh 4	I1	-1	101	60	%
LED Support	67	LED Cfg	12	CHG Thresh 5	I1	-1	101	80	%
LED Support	67	LED Cfg	13	DSG Flash Alarm	I1	-1	101	10	%
LED Support	67	LED Cfg	14	DSG Thresh 1	I1	-1	101	0	%
LED Support	67	LED Cfg	15	DSG Thresh 2	I1	-1	101	20	%
LED Support	67	LED Cfg	16	DSG Thresh 3	I1	-1	101	40	%
LED Support	67	LED Cfg	17	DSG Thresh 4	I1	-1	101	60	%
LED Support	67	LED Cfg	18	DSG Thresh 5	I1	-1	101	80	%
LED Support	67	LED Cfg	19	Sink Current	U1	0	3	3	
Power	68	Power	0	Flash Update OK Voltage	I2	6000	20000	7500	mV
Power	68	Power	2	Shutdown Voltage	I2	5000	20000	7000	mV
Power	68	Power	4	Shutdown Time	U1	0	240	10	s
Power	68	Power	5	Cell Shutdown Voltage	I2	0	5000	1750	mV
Power	68	Power	7	Cell Shutdown Time	U1	0	240	10	s
Power	68	Power	8	Charger Present	I2	0	23000	3000	mV

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
Power	68	Power	10	Sleep Current	I2	0	100	10	mA
Power	68	Power	12	Bus Low Time	U1	0	255	5	s
Power	68	Power	13	Cal Inhibit Temp Low	I2	-400	1200	50	0.1°C (°C)
Power	68	Power	15	Cal Inhibit Temp High	I2	-400	1200	450	0.1°C (°C)
Power	68	Power	17	Sleep Voltage Time	U1	1	240	5	s
Power	68	Power	18	Sleep Current Time	U1	1	255	20	s
Power	68	Power	19	Wake Current Reg	H1	0x0	0xff	0x0	-
Power	68	Power	20	Sealed Ship Delay	U1	0	255	5	s
Gas Gauging	80	IT Cfg	0	Load Select	U1	0	255	7	-
Gas Gauging	80	IT Cfg	1	Load Mode	U1	0	255	0	-
Gas Gauging	80	IT Cfg	60	Term Voltage	I2	-32768	32767	12000	mV
Gas Gauging	80	IT Cfg	77	User Rate-mA	I2	-9000	0	0	mA
Gas Gauging	80	IT Cfg	79	User Rate-mW	I2	-32768	0	0	10mW (mW)
Gas Gauging	80	IT Cfg	81	Reserve Cap-mAh	I2	0	9000	0	mAh
Gas Gauging	80	IT Cfg	83	Reserve Cap-mWh	I2	0	14000	0	10mWh (mWh)
Gas Gauging	80	IT Cfg	88	Ra Max Delta	I2	0	32000	44	mOhms
Gas Gauging	81	Current Thresholds	0	Dsg Current Threshold	I2	0	2000	100	mA
Gas Gauging	81	Current Thresholds	2	Chg Current Threshold	I2	0	2000	50	mA
Gas Gauging	81	Current Thresholds	4	Quit Current	I2	0	1000	10	mA
Gas Gauging	81	Current Thresholds	6	Dsg Relax Time	U1	0	240	1	s
Gas Gauging	81	Current Thresholds	7	Chg Relax Time	U1	0	240	60	s
Gas Gauging	82	State	0	Qmax Cell 0	I2	0	32767	4400	mAh
Gas Gauging	82	State	2	Qmax Cell 1	I2	0	32767	4400	mAh
Gas Gauging	82	State	4	Qmax Cell 2	I2	0	32767	4400	mAh
Gas Gauging	82	State	6	Qmax Cell 3	I2	0	32767	4400	mAh
Gas Gauging	82	State	8	Qmax Pack	I2	0	32767	4400	mAh
Gas Gauging	82	State	12	Update Status	H1	0x0	0x6	0x0	-
Gas Gauging	82	State	13	Cell 0 Chg dod at EoC	I2	0	16384	0	-
Gas Gauging	82	State	15	Cell 1 Chg dod at EoC	I2	0	16384	0	-
Gas Gauging	82	State	17	Cell 2 Chg dod at EoC	I2	0	16384	0	-
Gas Gauging	82	State	19	Cell 3 Chg dod at EoC	I2	0	16384	0	-
Gas Gauging	82	State	21	Avg I Last Run	I2	-32768	32767	-2000	mA
Gas Gauging	82	State	23	Avg P Last Run	I2	-32768	32767	-3022	10mW
Gas Gauging	82	State	25	Delta Voltage	I2	-32768	32767	0	mV
Gas Gauging	82	State	31	Max Avg I Last Run	I2	-32767	32767	-2000	mA
Gas Gauging	82	State	33	Max Avg P Last Run	I2	-32767	32767	-3022	10mW
Ra Table	88	R_a0	0	Cell0 R_a flag	H2	0x0	0x0	0xff55	-
Ra Table	88	R_a0	2	Cell0 R_a 0	I2	38	38	38	2~10Ω
Ra Table	88	R_a0	4	Cell0 R_a 1	I2	41	41	41	2~10Ω
Ra Table	88	R_a0	6	Cell0 R_a 2	I2	43	43	43	2~10Ω
Ra Table	88	R_a0	8	Cell0 R_a 3	I2	44	44	44	2~10Ω
Ra Table	88	R_a0	10	Cell0 R_a 4	I2	42	42	42	2~10Ω
Ra Table	88	R_a0	12	Cell0 R_a 5	I2	42	42	42	2~10Ω
Ra Table	88	R_a0	14	Cell0 R_a 6	I2	45	45	45	2~10Ω
Ra Table	88	R_a0	16	Cell0 R_a 7	I2	48	48	48	2~10Ω
Ra Table	88	R_a0	18	Cell0 R_a 8	I2	49	49	49	2~10Ω
Ra Table	88	R_a0	20	Cell0 R_a 9	I2	52	52	52	2~10Ω
Ra Table	88	R_a0	22	Cell0 R_a 10	I2	56	56	56	2~10Ω
Ra Table	88	R_a0	24	Cell0 R_a 11	I2	64	64	64	2~10Ω

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
Ra Table	88	R_a0	26	Cell0 R_a 12	I2	74	74	74	2 <sup>~</sup> 10Ω
Ra Table	88	R_a0	28	Cell0 R_a 13	I2	128	128	128	2 <sup>~</sup> 10Ω
Ra Table	88	R_a0	30	Cell0 R_a 14	I2	378	378	378	2 <sup>~</sup> 10Ω
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	38	38	38	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	4	Cell1 R_a 1	I2	41	41	41	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	6	Cell1 R_a 2	I2	43	43	43	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	8	Cell1 R_a 3	I2	44	44	44	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	10	Cell1 R_a 4	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	12	Cell1 R_a 5	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	14	Cell1 R_a 6	I2	45	45	45	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	16	Cell1 R_a 7	I2	48	48	48	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	18	Cell1 R_a 8	I2	49	49	49	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	20	Cell1 R_a 9	I2	52	52	52	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	22	Cell1 R_a 10	I2	56	56	56	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	24	Cell1 R_a 11	I2	64	64	64	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	26	Cell1 R_a 12	I2	74	74	74	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	28	Cell1 R_a 13	I2	128	128	128	2 <sup>~</sup> 10Ω
Ra Table	89	R_a1	30	Cell1 R_a 14	I2	378	378	378	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	0	Cell2 R_a flag	H2	0x0	0x0	0xff55	-
Ra Table	90	R_a2	2	Cell2 R_a 0	I2	38	38	38	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	4	Cell2 R_a 1	I2	41	41	41	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	6	Cell2 R_a 2	I2	43	43	43	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	8	Cell2 R_a 3	I2	44	44	44	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	10	Cell2 R_a 4	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	12	Cell2 R_a 5	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	14	Cell2 R_a 6	I2	45	45	45	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	16	Cell2 R_a 7	I2	48	48	48	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	18	Cell2 R_a 8	I2	49	49	49	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	20	Cell2 R_a 9	I2	52	52	52	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	22	Cell2 R_a 10	I2	56	56	56	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	24	Cell2 R_a 11	I2	64	64	64	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	26	Cell2 R_a 12	I2	74	74	74	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	28	Cell2 R_a 13	I2	128	128	128	2 <sup>~</sup> 10Ω
Ra Table	90	R_a2	30	Cell2 R_a 14	I2	378	378	378	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	0	Cell3 R_a flag	H2	0x0	0x0	0xff55	-
Ra Table	91	R_a3	2	Cell3 R_a 0	I2	38	38	38	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	4	Cell3 R_a 1	I2	41	41	41	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	6	Cell3 R_a 2	I2	43	43	43	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	8	Cell3 R_a 3	I2	44	44	44	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	10	Cell3 R_a 4	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	12	Cell3 R_a 5	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	14	Cell3 R_a 6	I2	45	45	45	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	16	Cell3 R_a 7	I2	48	48	48	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	18	Cell3 R_a 8	I2	49	49	49	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	20	Cell3 R_a 9	I2	52	52	52	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	22	Cell3 R_a 10	I2	56	56	56	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	24	Cell3 R_a 11	I2	64	64	64	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	26	Cell3 R_a 12	I2	74	74	74	2 <sup>~</sup> 10Ω
Ra Table	91	R_a3	28	Cell3 R_a 13	I2	128	128	128	2 <sup>~</sup> 10Ω

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
Ra Table	91	R_a3	30	Cell3 R_a 14	I2	378	378	378	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	0	xCell0 R_a flag	H2	0xffff	0xffff	0xffff	-
Ra Table	92	R_a0x	2	xCell0 R_a 0	I2	38	38	38	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	4	xCell0 R_a 1	I2	41	41	41	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	6	xCell0 R_a 2	I2	43	43	43	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	8	xCell0 R_a 3	I2	44	44	44	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	10	xCell0 R_a 4	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	12	xCell0 R_a 5	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	14	xCell0 R_a 6	I2	45	45	45	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	16	xCell0 R_a 7	I2	48	48	48	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	18	xCell0 R_a 8	I2	49	49	49	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	20	xCell0 R_a 9	I2	52	52	52	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	22	xCell0 R_a 10	I2	56	56	56	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	24	xCell0 R_a 11	I2	64	64	64	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	26	xCell0 R_a 12	I2	74	74	74	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	28	xCell0 R_a 13	I2	128	128	128	2 <sup>~</sup> 10Ω
Ra Table	92	R_a0x	30	xCell0 R_a 14	I2	378	378	378	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	0	xCell1 R_a flag	H2	0xffff	0xffff	0xffff	-
Ra Table	93	R_a1x	2	xCell1 R_a 0	I2	38	38	38	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	4	xCell1 R_a 1	I2	41	41	41	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	6	xCell1 R_a 2	I2	43	43	43	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	8	xCell1 R_a 3	I2	44	44	44	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	10	xCell1 R_a 4	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	12	xCell1 R_a 5	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	14	xCell1 R_a 6	I2	45	45	45	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	16	xCell1 R_a 7	I2	48	48	48	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	18	xCell1 R_a 8	I2	49	49	49	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	20	xCell1 R_a 9	I2	52	52	52	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	22	xCell1 R_a 10	I2	56	56	56	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	24	xCell1 R_a 11	I2	64	64	64	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	26	xCell1 R_a 12	I2	74	74	74	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	28	xCell1 R_a 13	I2	128	128	128	2 <sup>~</sup> 10Ω
Ra Table	93	R_a1x	30	xCell1 R_a 14	I2	378	378	378	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	0	xCell2 R_a flag	H2	0xffff	0xffff	0xffff	-
Ra Table	94	R_a2x	2	xCell2 R_a 0	I2	38	38	38	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	4	xCell2 R_a 1	I2	41	41	41	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	6	xCell2 R_a 2	I2	43	43	43	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	8	xCell2 R_a 3	I2	44	44	44	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	10	xCell2 R_a 4	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	12	xCell2 R_a 5	I2	42	42	42	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	14	xCell2 R_a 6	I2	45	45	45	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	16	xCell2 R_a 7	I2	48	48	48	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	18	xCell2 R_a 8	I2	49	49	49	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	20	xCell2 R_a 9	I2	52	52	52	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	22	xCell2 R_a 10	I2	56	56	56	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	24	xCell2 R_a 11	I2	64	64	64	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	26	xCell2 R_a 12	I2	74	74	74	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	28	xCell2 R_a 13	I2	128	128	128	2 <sup>~</sup> 10Ω
Ra Table	94	R_a2x	30	xCell2 R_a 14	I2	378	378	378	2 <sup>~</sup> 10Ω
Ra Table	95	R_a3x	0	xCell3 R_a flag	H2	0xffff	0xffff	0xffff	-

**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
Ra Table	95	R_a3x	2	xCell3 R_a 0	I2	38	38	38	2~10Ω
Ra Table	95	R_a3x	4	xCell3 R_a 1	I2	41	41	41	2~10Ω
Ra Table	95	R_a3x	6	xCell3 R_a 2	I2	43	43	43	2~10Ω
Ra Table	95	R_a3x	8	xCell3 R_a 3	I2	44	44	44	2~10Ω
Ra Table	95	R_a3x	10	xCell3 R_a 4	I2	42	42	42	2~10Ω
Ra Table	95	R_a3x	12	xCell3 R_a 5	I2	42	42	42	2~10Ω
Ra Table	95	R_a3x	14	xCell3 R_a 6	I2	45	45	45	2~10Ω
Ra Table	95	R_a3x	16	xCell3 R_a 7	I2	48	48	48	2~10Ω
Ra Table	95	R_a3x	18	xCell3 R_a 8	I2	49	49	49	2~10Ω
Ra Table	95	R_a3x	20	xCell3 R_a 9	I2	52	52	52	2~10Ω
Ra Table	95	R_a3x	22	xCell3 R_a 10	I2	56	56	56	2~10Ω
Ra Table	95	R_a3x	24	xCell3 R_a 11	I2	64	64	64	2~10Ω
Ra Table	95	R_a3x	26	xCell3 R_a 12	I2	74	74	74	2~10Ω
Ra Table	95	R_a3x	28	xCell3 R_a 13	I2	128	128	128	2~10Ω
Ra Table	95	R_a3x	30	xCell3 R_a 14	I2	378	378	378	2~10Ω
PF Status	96	Device Status Data	0	Saved PF Flags 1	H2	0x0	0xffff	0x0	-
PF Status	96	Device Status Data	2	Saved PF Flags 2	H2	0x0	0xffff	0x0	-
PF Status	96	Device Status Data	4	Fuse Flag	H2	0x0	0xffff	0x0	-(flg)
PF Status	96	Device Status Data	6	PF Voltage	I2	0	32767	0	mV
PF Status	96	Device Status Data	8	PF C4 Voltage	I2	0	9999	0	mV
PF Status	96	Device Status Data	10	PF C3 Voltage	I2	0	9999	0	mV
PF Status	96	Device Status Data	12	PF C2 Voltage	I2	0	9999	0	mV
PF Status	96	Device Status Data	14	PF C1 Voltage	I2	0	9999	0	mV
PF Status	96	Device Status Data	16	PF Current	I2	-32768	32767	0	mA
PF Status	96	Device Status Data	18	PF Temperature	I2	-9999	9999	0	0.1 K (°K)
PF Status	96	Device Status Data	20	PF Batt Stat	H2	0x0	0xffff	0x0	-
PF Status	96	Device Status Data	22	PF RC-mAh	I2	0	32767	0	mAh
PF Status	96	Device Status Data	24	PF RC-10mWh	I2	0	32767	0	10mWh (mWh)
PF Status	96	Device Status Data	26	PF Chg Status	H2	0x0	0xffff	0x0	-
PF Status	96	Device Status Data	28	PF Safety Status 1	H2	0x0	0xffff	0x0	-
PF Status	96	Device Status Data	30	PF Safety Status2	H2	0x0	0xffff	0x0	-
PF Status	96	Device Status Data	32	Saved 1st PF Flags 1	H2	0x0	0xffff	0x0	-
PF Status	96	Device Status Data	34	Saved 1st PF Flags 2	H2	0x0	0xffff	0x0	-
PF Status	97	AFE Regs	0	AFE Status	H1	0x0	0xff	0x0	-
PF Status	97	AFE Regs	1	AFE Output	H1	0x0	0xff	0x0	-
PF Status	97	AFE Regs	2	AFE State	H1	0x0	0xff	0x0	-
PF Status	97	AFE Regs	3	AFE Function	H1	0x0	0xff	0x0	-
PF Status	97	AFE Regs	4	AFE Cell Select	H1	0x0	0xff	0x0	-
PF Status	97	AFE Regs	5	AFE OLV	H1	0x0	0x1f	0x0	-
PF Status	97	AFE Regs	6	AFE OLT	H1	0x0	0xff	0x0	-
PF Status	97	AFE Regs	7	AFE SCC	H1	0x0	0xff	0x0	-
PF Status	97	AFE Regs	8	AFE SCD	H1	0x0	0xff	0x0	-
Calibration	104	Data	0	CC Gain	F4	1.00E-01	4.00E+00	0.9419	-
Calibration	104	Data	4	CC Delta	F4	2.9826E+04	1.193046E+06	280932.625	-
Calibration	104	Data	8	Ref Voltage	I2	0	32767	24500	-
Calibration	104	Data	12	AFE Pack Gain	I2	0	32767	22050	-
Calibration	104	Data	14	CC Offset	I2	-32768	32767	-1667	-
Calibration	104	Data	16	Board Offset	I2	-32767	32767	0	-



**Table C-307. DATA FLASH VALUES (continued)**

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
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	-
Calibration	105	Config	2	Voltage Signal	I2	0	32767	16800	-
Calibration	105	Config	4	Temp Signal	I2	0	32767	2980	-
Calibration	105	Config	6	CC Offset Time	U2	0	65535	250	-
Calibration	105	Config	8	ADC Offset Time	U2	0	65535	32	-
Calibration	105	Config	10	CC Gain Time	U2	0	65535	250	-
Calibration	105	Config	12	Voltage Time	U2	0	65535	1984	-
Calibration	105	Config	14	Temperature Time	U2	0	65535	32	-
Calibration	105	Config	17	Cal Mode Timeout	U2	0	65535	38400	-
Calibration	106	Temp Model	0	Ext Coef 1	I2	-32768	32767	-28285	-
Calibration	106	Temp Model	2	Ext Coef 2	I2	-32768	32767	20848	-
Calibration	106	Temp Model	4	Ext Coef 3	I2	-32768	32767	-7537	-
Calibration	106	Temp Model	6	Ext Coef 4	I2	-32768	32767	4012	-
Calibration	106	Temp Model	8	Ext Min AD	I2	-32768	32767	0	-
Calibration	106	Temp Model	10	Ext Max Temp	I2	-32768	32767	4012	-
Calibration	106	Temp Model	12	Int Coef 1	I2	-32768	32767	0	-
Calibration	106	Temp Model	14	Int Coef 2	I2	-32768	32767	0	-
Calibration	106	Temp Model	16	Int Coef 3	I2	-32768	32767	-11136	-
Calibration	106	Temp Model	18	Int Coef 4	I2	-32768	32767	5754	-
Calibration	106	Temp Model	20	Int Min AD	I2	-32768	32767	0	-
Calibration	106	Temp Model	22	Int Max Temp	I2	-32768	32767	5754	-
Calibration	107	Current	0	Filter	U1	0	255	239	-
Calibration	107	Current	1	Deadband	U1	0	255	3	-
Calibration	107	Current	2	CC Deadband	U1	0	255	34	-



## **Glossary**

ADC	Analog to Digital Converter
AFE	Analog Front End
alert	A warning set by the bq20z60-R1/bq20z65-R1
bit	A single bit in a SBS command or data flash value which can be changed by the user
CC	Coulomb Counter
CHG FET	charge FET, connected to the CHG pin of the bq20z60-R1/bq20z65-R1; used to enable or disable charging
COV	Cell overvoltage
CPU	Central Processing Unit
CUV	Cell undervoltage
DF	Data flash
DOD	Depth of Discharge
DSG	Flag set by the bq20z60-R1/bq20z65-R1 to indicate charge (DSG= 0) or discharge (DSG=1)
DSG FET	Discharge FET, connected to the DSG pin of the bq20z60-R1/bq20z65-R1; used to enable or disable discharging
FAS	Full Access Security
FBF	Fuse Blow Failure
FC	Fully Charged
CMTO	Charge Mode Timeout
FD	Fully Discharged
flag	A single bit in an SBS command or data flash value which is set by the bq20z60-R1/bq20z65-R1 and indicates a status change
IC	Integrated Circuit
LED	Light Emitting Diode
Li-Ion	Lithium-Ion
NR	Non-removable
OC	Overcurrent
OCA	Overcharge alarm
OCV	Open-circuit voltage
OTC	Overtemperature charging
OTD	Overtemperature discharging
PCHG	Pre-Charge
PCMTO	Pre-Charge Timeout
PEC	Packet Error Checking
PF	Permanent Fail
POV	Pack overvoltage
PRES	System Present Flag

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PUV	Pack undervoltage
Qmax	Maximum Chemical Capacity
RCA	Remaining Capacity Alarm
RSOC	Relative State of Charge
SBS	Smart Battery System
SCC	Short Circuit Charge
SCD	Short Circuit Discharge
SMBus	System Management Bus
SOC	Safety overcurrent
SOT	Safety overtemperature
SS	Sealed mode flag
TCA	Terminate Charge Alarm
TDA	Terminate Discharge Alarm
ZVCHG FET	Pre-charge FET, connected to the ZVCHG pin; depending on the configuration it is used for pre-charging and/or zero-volt charging
XDSG	Discharge Fault flag

1st Level Protection  
 2nd Level (Permanent) Failure Actions  
 2nd Level Protection  
 2nd Level Protection IC Input

## A

AbsoluteStateOfCharge  
 Active CIM Check Voltage  
 Active CIM Fail Voltage  
 Active CIM Time  
 ADC Offset Time  
 AFE\_C , ,  
 AFE\_P , ,  
 AFE Cell Select  
 AFE Check Time  
 AFE Communication Fault  
 AFEData  
 AFE Fail Limit  
 AFE Fail Recovery Time  
 AFE Function  
 AFE Init Limit  
 AFE Init Retry Limit  
 AFE Init Verification  
 AFE OC Dsg  
 AFE OC Dsg Recovery  
 AFE OC Dsg Time  
 AFE OLT  
 AFE OLV  
 AFE Output  
 AFE Pack Gain  
 AFE Regs  
 AFE SCC  
 AFE SC Chg Cfg  
 AFE SCD  
 AFE SC Dsg Cfg  
 AFE SC Recovery  
 AFE State  
 AFE.State\_CTL  
 AFE Status  
 AFE Watchdog  
 AM  
 AOCD , ,  
 ASCC  
 ASCD  
 AtRate  
 AtRateOK  
 AtRateTimeToEmpty  
 AtRateTimeToFull  
 AuthenKey0

AuthenKey1  
 AuthenKey2  
 AuthenKey3  
 Authenticate  
 AverageCurrent  
 AverageTimeToEmpty  
 AverageTimeToFull  
 AverageVoltage  
 Avg I Last Run  
 Avg P Last Run

## B

Battery Depleted  
 BatteryMode  
 Battery Pack Removed  
 BatteryStatus  
 BCAST  
 Board Offset  
 BootROM  
 Bus Low Time

## C

Calibration Mode  
 Cal Inhibit Temp High  
 Cal Inhibit Temp Low  
 Cal Mode Timeout  
 CapM  
 CB  
 CC ,  
 CC0  
 CC1  
 CC Current  
 CC Deadband  
 CC Delta  
 CC Gain  
 CC Gain Time  
 CC Offset  
 CC Offset Time  
 CCT  
 CC Threshold  
 Cell 0 Chg dod at EOC  
 Cell0 R\_a 0  
 Cell0 R\_a 1  
 Cell0 R\_a 2  
 Cell0 R\_a 3  
 Cell0 R\_a 4  
 Cell0 R\_a 5  
 Cell0 R\_a 6  
 Cell0 R\_a 7

Cell0 R_a 8	Cell3 R_a 13
Cell0 R_a 9	Cell3 R_a 14
Cell0 R_a 10	Cell3 R_a flag
Cell0 R_a 11	CELL_TAPER
Cell0 R_a 12	Cell Balancing
Cell0 R_a 13	Cell Imbalance Fault
Cell0 R_a 14	Cell Life Limit
Cell0 R_a flag	Cell Overvoltage
Cell 1 Chg dod at EOC	Cell Revision
Cell1 R_a 0	Cell Shutdown Time
Cell1 R_a 1	Cell Shutdown Voltage
Cell1 R_a 2	Cell Undervoltage
Cell1 R_a 3	CellVoltage1
Cell1 R_a 4	CellVoltage2
Cell1 R_a 5	CellVoltage3
Cell1 R_a 6	CellVoltage4
Cell1 R_a 7	Cell Voltage Thresh Hys
Cell1 R_a 8	Cell Voltage Threshold1
Cell1 R_a 9	Cell Voltage Threshold2
Cell1 R_a 10	CF
Cell1 R_a 11	CFETF , ,
Cell1 R_a 12	CF Max Error Limit
Cell1 R_a 13	Charge Alarm
Cell1 R_a 14	Charge Control
Cell1 R_a flag	Charge Control SMBus Broadcasts
Cell 2 Chg dod at EOC	Charge Fault Cfg
Cell2 R_a 0	Charge Inhibit
Cell2 R_a 1	Charge Mode Timeout
Cell2 R_a 2	Charge Overcurrent
Cell2 R_a 3	Charger-Dependent Fully-Charged State
Cell2 R_a 4	Charger Present
Cell2 R_a 5	Charge Suspend
Cell2 R_a 6	Charge Timeout ,
Cell2 R_a 7	ChargingCurrent
Cell2 R_a 8	Charging Faults
Cell2 R_a 9	ChargingStatus
Cell2 R_a 10	ChargingVoltage
Cell2 R_a 11	Chemistry ID
Cell2 R_a 12	CHG
Cell2 R_a 13	Chg Current Threshold
Cell2 R_a 14	CHGFET
Cell2 R_a flag	Chg FET Fault
Cell 3 Chg dod at EOC	CHG Flash Alarm
Cell3 R_a 0	CHGIN
Cell3 R_a 1	CHGLED ,
Cell3 R_a 2	ChgM
Cell3 R_a 3	Chg Mode
Cell3 R_a 4	CHGOCV_DIS
Cell3 R_a 5	Chg Relax Time
Cell3 R_a 6	CHGSUSP ,
Cell3 R_a 7	CHGTERM
Cell3 R_a 8	CHG Thresh 1
Cell3 R_a 9	CHG Thresh 2
Cell3 R_a 10	CHG Thresh 3
Cell3 R_a 11	CHG Thresh 4
Cell3 R_a 12	CHG Thresh 5

CIM\_A , ,  
 CIM\_R , ,  
 CIM Active Detection  
 CIM At Rest Detection  
 CIM Battery Rest Time  
 Clearing Permanent Failure  
 CLL  
 CMTO ,  
 COV ,  
 COV Time  
 CPE  
 CS\_XCHGLV  
 CSV  
 CSYNC  
 Current  
 Current Recovery Time  
 Current Taper Window  
 CUV ,  
 CUV\_RECOV\_CHG  
 CUV Recovery  
 CUV Threshold  
 CUV Time  
 CycleCount ,

## D

DataFlashSubClassID  
 DataFlashSubClassPage1  
 DataFlashSubClassPage2  
 DataFlashSubClassPage3  
 DataFlashSubClassPage4  
 DataFlashSubClassPage5  
 DataFlashSubClassPage6  
 DataFlashSubClassPage8  
 DataFlashSubClassPageDataFlashSubClassPage7  
 Data Flash Value Summary Table , , , , , , , , , ,  
 Deadband  
 Delta Voltage  
 Depleted Recovery  
 Depleted Voltage  
 Depleted Voltage Time  
 DesignCapacity ,  
 Design Energy  
 DesignVoltage ,  
 Deterioration Fault Limit  
 Deterioration Warn Limit  
 DetF  
 DetW  
 DeviceChemistry ,  
 DeviceName ,  
 Device Type  
 DF Checksum  
 DFETF , ,  
 DFF , ,  
 DF Failure  
 Discharge Alarm  
 Discharge Overcurrent

Display Activation  
 Display Configuration  
 Display Format  
 Display ON ,  
 DMODE ,  
 DSG ,  
 Dsg Current Threshold  
 Dsg FET Fault  
 DSG Flash Alarm  
 DSGIN  
 Dsg Mode  
 Dsg Relax Time  
 DSG Thresh 1  
 DSG Thresh 2  
 DSG Thresh 3  
 DSG Thresh 4  
 DSG Thresh 5

## E

EC0  
 EC1  
 EC2  
 EC3  
 Ext1 Temp Offset  
 Ext2 Temp Offset  
 Ext Coef 1  
 Ext Coef 2  
 Ext Coef 3  
 Ext Coef 4  
 Extended SBS Commands ,  
 Ext Max Temp  
 Ext Min AD

## F

FAS  
 FBF , ,  
 FC  
 FC Clear %  
 FC Set %  
 FD  
 FD Clear%  
 FD Clear Volt  
 FD Set %  
 FD Set Volt Threshold  
 FD Volt Time  
 FET0  
 FET1  
 FETControl  
 FET Fail Limit  
 FET Fail Time  
 Filter  
 Firmware Version ,  
 Flash Update OK Voltage  
 Full Access Device  
 FullAccessKey  
 FullChargeCapacity

Fuse Fail Limit  
 Fuse Fail Time  
 Fuse Flag  
 Fuse State Detection

## G

Gas Gauging

## H

Hardware Revision  
 Hardware Version  
 Hi Dsg Start Temp  
 Host Watchdog  
 Host Watchdog Timeout  
 HPE  
 HTCHG  
 HT Chg Current1  
 HT Chg Current2  
 HT Chg Current3  
 HT Chg Voltage  
 HT COV Recovery  
 HT COV Threshold  
 HT SOV Threshold  
 HWDG ,

## I

ICC  
 Impedance Track  
 INIT  
 Init Battery Mode  
 Int Coef 1  
 Int Coef 2  
 Int Coef 3  
 Int Coef 4  
 Int Max Temp  
 Int Min AD  
 Int Temp Offset  
 IT Enable  
 IWAKE ,

## J

JEITA Temperature Ranges  
 JT1  
 JT2  
 JT2a  
 JT3  
 JT4

## L

LDMD  
 LED0 ,  
 LED1 ,  
 LED Blink Period ,  
 LED Current Configuration  
 LED Delay ,  
 LED Flash Period ,  
 LED Hold Time ,

LEDR ,  
 LEDRCA ,  
 LEDs OFF ,  
 LEDs ON ,  
 Life Avg Temp  
 Life Max AvgDsg Cur  
 Life Max AvgDsg Pow  
 Life OT Count  
 Life OT Duration  
 Life OV Count  
 Life OV Duration  
 LifetimeData1  
 LifetimeData2  
 Lifetime Max Cell Voltage  
 Lifetime Max Chg Current  
 Lifetime Max Chg Power  
 Lifetime Max Dsg Current  
 Lifetime Max Dsg Power  
 Lifetime Max Pack Voltage  
 Lifetime Max Temp  
 Lifetime Min Cell Voltage  
 Lifetime Min Pack Voltage  
 Lifetime Min Temp  
 Load Mode ,  
 Load Select ,  
 LOCK\_0  
 LTCHG  
 LT Chg Current1  
 LT Chg Current2  
 LT Chg Current3  
 LT Chg Voltage  
 LT COV Recovery  
 LT COV Threshold  
 LT SOV Threshold  
 LT Temp Samples

## M

Maintenance Current  
 ManufactureDate  
 ManufacturerAccess  
 ManufacturerData  
 ManufacturerInfo  
 ManufacturerName  
 Manufacturer Status  
 Manuf. Block 1  
 Manuf. Block 2  
 Manuf. Block 3  
 Manuf. Block 4  
 ManufBlock1..4  
 Manuf Date  
 Manuf. Info 0  
 Manuf Name  
 Max Avg I Last Run  
 Max Avg P Last Run  
 MaxError  
 MCHG



Min Cell Deviation

## N

NCSMB

Non-Removable Battery Mode Recovery ,

Non-Removable Cfg

Normal Mode

NR

NRCHG

## O

OC , ,

OC (1st Tier) Chg

OC (1st Tier) Chg Time

OC (1st Tier) Dsg

OC (1st Tier) Dsg Time

OC (2nd Tier) Chg

OC (2nd Tier) Chg Time

OC (2nd Tier) Dsg

OC (2nd Tier) Dsg Time

OCA

OCC , ,

OCC2 ,

OC Chg Recovery

OCD , ,

OCD2 ,

OC Dsg Recovery

OCHGI , ,

OCHGV , ,

OCV\_WGHT

OD

Open Thermistor ,

Open Time

Operation Cfg A

Operation Cfg B

Operation Cfg C

OperationStatus

OT1C ,

OT1 Chg Recovery

OT1 Chg Threshold

OT1 Chg Time

OT1D ,

OT1 Dsg Recovery

OT1 Dsg Threshold

OT1 Dsg Time

OT2C ,

OT2 Chg Recovery

OT2 Chg Threshold

OT2 Chg Time

OT2D ,

OT2 Dsg Recovery

OT2 Dsg Threshold

OT2 Dsg Time

OTA

OTFET

Overcharge

Over Charge Capacity

Over Charge Recovery

Overcharging Current ,

Over Charging Curr Recov

Over Charging Curr Time

Overcharging Voltage ,

Over Charging Volt Time

Overcurrent Conditions

Overtemperature Protection

## P

Pack Lot Code

PackVoltage

PB

PBS

PCB Lot Code

PCHG

PCMTO ,

PDF0

PDF1

Periodic AFE Verification

Permanent Fail Cfg

Permanent Fail Cfg 2

Permanent Fail Clear

PF ,

PF0

PF1

PFAAlert

PFAAlert2

PF Batt Stat

PF C1 Voltage

PF C2 Voltage

PF C3 Voltage

PF C4 Voltage

PF Chg Status

PF Current

PFD0

PFD1

PFIN ,

PFIN Detect Time

PFKey

PF Min Fuse Blow Voltage

PF RC-10mWh

PF RC-mAh

PF Safety Status1

PF Safety Status 2

PF SOV Fuse Blow Delay

PFStatus

PFStatus2

PF Temperature

PF Voltage

PFVSHUT

PRE\_ZT\_PF\_En

Precharge Mode Timeout

Precharge Timeout

Precharge Timeout - PCMTO

Pre-chg Current	Safety Undervoltage Protection
Pre-Chg Recovery Voltage	Saved 1st PF Flag 1
Pre-Chg Voltage Theshold	Saved 1st PF Flag 2
PRES	Saved PF Flags 1..2
Primary Charge Termination	SBS Command Table ,
Pulsed Load Compensation	SCC ,
	SCD ,
	Seal Device
	Sealed Ship Delay
	Security
	SenseResistor
	SerialNumber
	Ser. Num.
	Ship Mode
	Short-Circuit Protection
	Shutdown
	Shutdown Mode
	Shutdown Time
	Shutdown Voltage
	SHUTV
	Sink Current
	SLED ,
	Sleep ,
	Sleep Current
	Sleep Current Time
	Sleep Mode
	Sleep Voltage Time
	SOCC , ,
	SOC Chg
	SOC Chg Time
	SOCD , ,
	SOC Dsg
	SOC Dsg Time
	SOPT1 , ,
	SOPT2 , ,
	SOT1C , ,
	SOT1 Chg Threshold
	SOT1 Chg Time
	SOT1D , ,
	SOT1 Dsg Threshold
	SOT1 Dsg Time
	SOT2C , ,
	SOT2 Chg Threshold
	SOT2 Chg Time
	SOT2D , ,
	SOT2 Dsg Threshold
	SOT2 Dsg Time
	SOV ,
	SOV Time
	SpecificationInfo
	Spec Info
	SS
	ST1CHG
	ST1 Chg Current1
	ST1 Chg Current2
	ST1 Chg Current3

**Q**

QEN  
Qmax  
Qmax Cell 0  
Qmax Cell 1  
Qmax Cell 2  
Qmax Cell 3  
Qmax initial values  
Qmax Pack  
Qmax Update Condition  
Quit Current

**R**

R\_DIS  
Ra Max Delta  
RCA  
Ref Voltage  
RelativeStateOfCharge  
Relaxation Mode  
RemainingCapacity  
RemainingCapacityAlarm  
RemainingTimeAlarm  
Rem Cap Alarm  
Rem Energy Alarm  
Rem Time Alarm  
RESCAP  
Reserve Battery Capacity  
Reserve Cap-mAh  
Reserve Cap-mWh  
Reset  
ResetData  
Rest CIM Check Voltage  
Rest CIM Current  
Rest CIM Fail Voltage  
Rest CIMTime  
RSNS  
RSOCL  
RTA  
RunTimeToEmpty

**S**

SAFE Activation  
SAFE Clear  
SafetyAlert  
SafetyAlert2  
Safety Overcurrent Protection  
Safety Overtemperature Protection  
Safety Overvoltage Protection  
SafetyStatus  
SafetyStatus2

ST1 Chg Voltage	User Rate-10mW
ST2CHG	User Rate-mA
ST2 Chg Current1	
ST2 Chg Current2	<b>V</b>
ST2 Chg Current3	VOK
ST2 Chg Voltage	Voltage
Standard Recovery ,	Voltage Signal
STATE0	Voltage Time
STATE1	
STATE2	<b>W</b>
STATE3	WAKE
StateOfHealth	Wake Current Reg
ST COV Recovery	Wake Function
ST COV Threshold	WDF ,
ST SOV Threshold	WDRResetData
SUV , ,	
SUV_MODE	<b>X</b>
SUV Threshold	XAFE_C
SUV Time	XAFE_P
System Present	xCell0 R_a 0
	xCell0 R_a 1
<b>T</b>	xCell0 R_a 2
Taper Current	xCell0 R_a 3
Taper Voltage	xCell0 R_a 4
TCA	xCell0 R_a 5
TCA Clear %	xCell0 R_a 6
TCA Set %	xCell0 R_a 7
TDA	xCell0 R_a 8
TDA Clear %	xCell0 R_a 9
TDA Clear Volt	xCell0 R_a 10
TDA Set %	xCell0 R_a 11
TDA Set Volt Threshold	xCell0 R_a 12
TDA Set Volt Time	xCell0 R_a 13
TEMP0	xCell0 R_a 14
TEMP1	xCell0 R_a flag
Temperature	xCell1 R_a 0
Temperature Time	xCell1 R_a 1
Temp Hys	xCell1 R_a 2
TempRange	xCell1 R_a 3
Temp Signal	xCell1 R_a 4
Termination Voltage	xCell1 R_a 5
Term Voltage	xCell1 R_a 6
Time-Limit-Based Protection	xCell1 R_a 7
TR1	xCell1 R_a 8
TR2	xCell1 R_a 9
TR2A	xCell1 R_a 10
TR3	xCell1 R_a 11
TR4	xCell1 R_a 12
TR5	xCell1 R_a 13
TS1Temperature	xCell1 R_a 14
TS2Temperature	xCell1 R_a flag
	xCell2 R_a 0
<b>U</b>	xCell2 R_a 1
Unseal Device	xCell2 R_a 2
UnSealKey	xCell2 R_a 3
Update Status	xCell2 R_a 4
	xCell2 R_a 5

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xCell2 R_a 6	XCFETF
xCell2 R_a 7	XCHG
xCell2 R_a 8	XCHGLV ,
xCell2 R_a 9	XCIM_A
xCell2 R_a 10	XCIM_R
xCell2 R_a 11	XDFETF
xCell2 R_a 12	XDFF
xCell2 R_a 13	XDSG
xCell2 R_a 14	XDSGI
xCell2 R_a flag	XPFIN
xCell3 R_a 0	XSOCC
xCell3 R_a 1	XSOCD
xCell3 R_a 2	XSOPT1
xCell3 R_a 3	XSOPT2
xCell3 R_a 4	XSOT1C
xCell3 R_a 5	XSOT1D
xCell3 R_a 6	XSOT2C
xCell3 R_a 7	XSOT2D
xCell3 R_a 8	XSOV
xCell3 R_a 9	XSUV
xCell3 R_a 10	XVSHUT
xCell3 R_a 11	
xCell3 R_a 12	<b>Z</b>
xCell3 R_a 13	ZVCHG
xCell3 R_a 14	ZVCHG0
xCell3 R_a flag	ZVCHG1

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