bq34z653

Technical Reference

Literature Number: SLUU986A
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Contents

Preface

Read This First

This manual discusses modules and peripherals of the bq34z653, and how each is used to build a complete battery pack gas gauge and protection solution. See the *bq34z653 SBS 1.1-Compliant Gas Gauge and Protection Enabled with Impedance Track™ with External Battery Heater Control and LCD Display Data Sheet* (SLUSB53) for bq34z653 electrical specifications.

NOTE: Many parameters in this TRM have *LED* in their names, because of their inherited properties from another device; however, in the bq34z653 device, the LED parameters are used to configure the liquid crystal display (LCD). This device does not support an LED display.

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

All SBS commands, data flash values and flags mentioned in a 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:ManufacterAccess(0x00):Manufacturer Access Command(MA No.), for example:

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

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

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

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

Trademarks

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Glossary

TI Glossary —This glossary lists and explains terms, acronyms, and definitions.

Detailed Description

1.1 JEITA Temperature Ranges

The bq34z653 follows the JEITA guidelines, which specify that charging voltage and charging current depend on the temperature. Temperature ranges are used for specifying what should be the charging voltage and charging current.

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

- T1 – T2: Low charging temperature range (T1 ≤ Temperature < T2)
- T2 – T3: Standard charging temperature range (T2 ≤ Temperature < T3)
- T3 – T4: High charging temperature range (T3 ≤ Temperature < T4)

For added flexibility the standard temperature range is divided into two 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 bq34z653 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 1-1. Temperature Ranges in bq34z653

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*.

1.2 1st Level Protection Features

The bq34z653 supports a wide range of battery and system protection features that are easily configured or enabled via the integrated data flash.

1.2.1 Cell Overvoltage (COV) and Cell Undervoltage (CUV)

The bq34z653 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 bq34z653 goes into overvoltage/undervoltage condition and switches off the CHG/DSG FET. The bq34z653 recovers from a cell overvoltage condition if all the cell voltages drop below the cell overvoltage recovery threshold. The bq34z653 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.

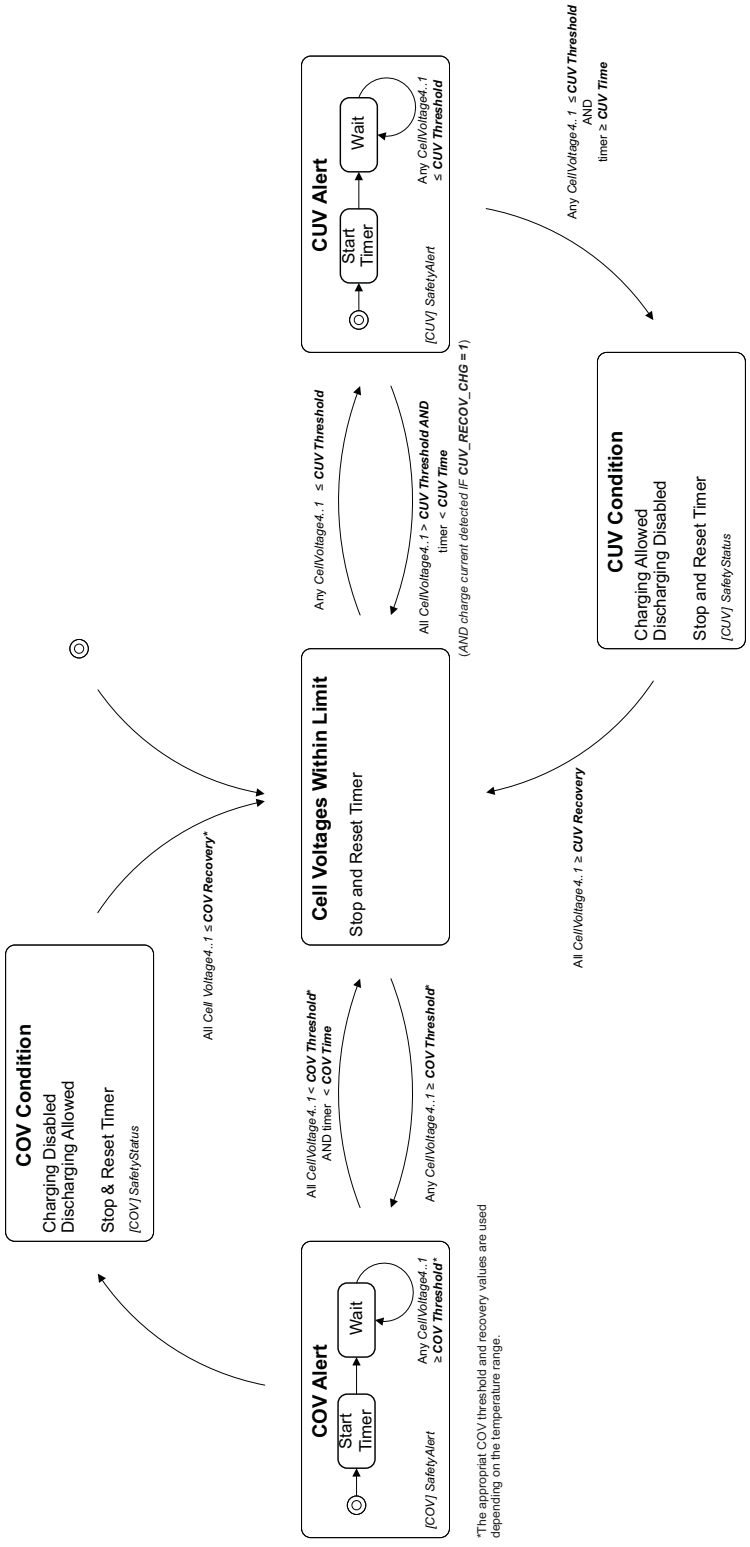


Figure 1-1. COV and CUV

Table 1-2. COV and CUV

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

The bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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.

1.2.2 Charge and Discharge Overcurrent

The bq34z653 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 1-3. Charge and Discharge Overcurrent

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

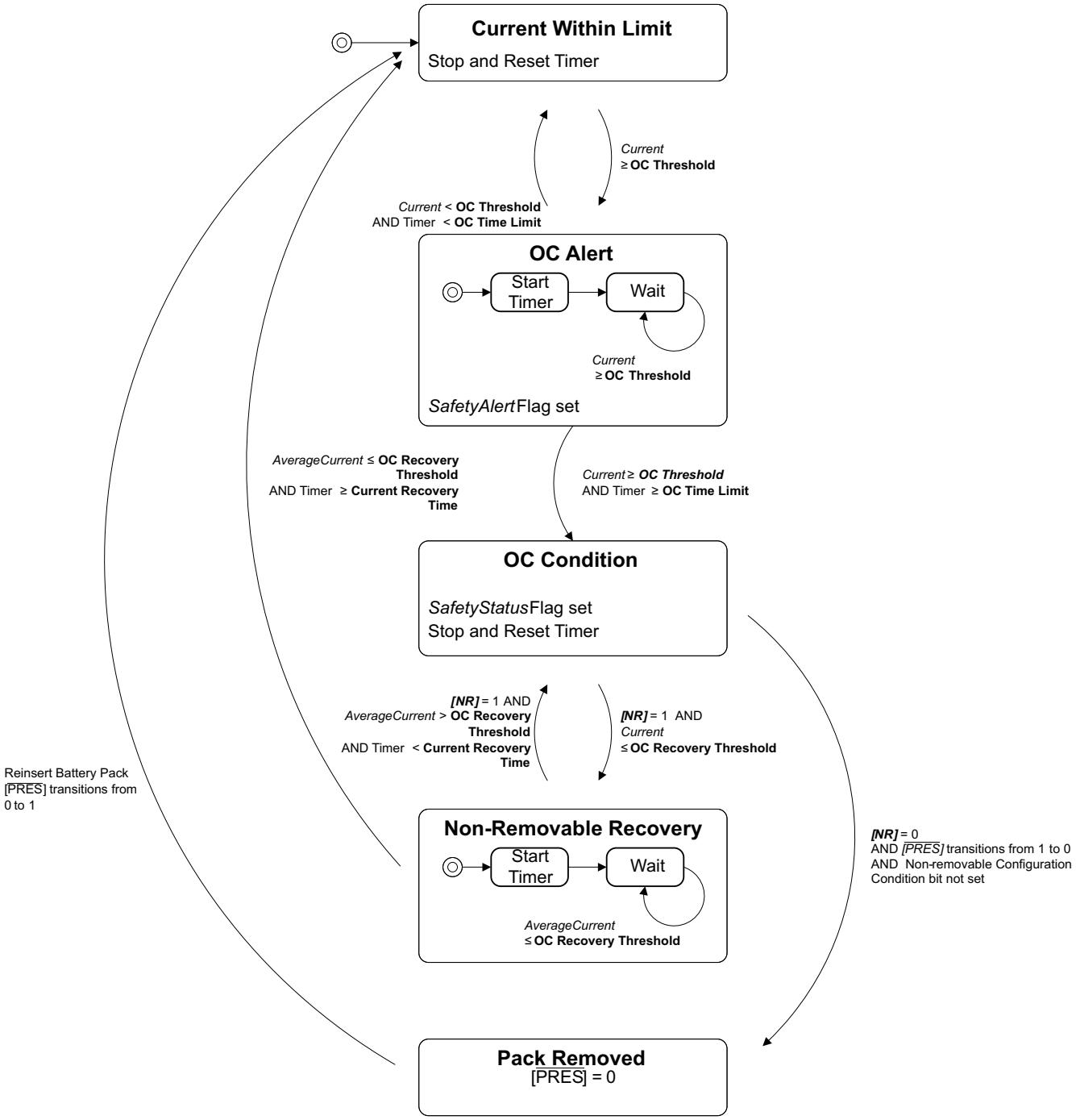


Figure 1-2. OC Protection

For the first two tiers of overcurrent protection, the specific flag in *SafetyAlert* is set if *Current* exceeds the OC Threshold. The bq34z653 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 bq34z653 has either of *[OCC]* or *[OCC2]* flags in *SafetyStatus* set, the CHG FET are turned on again during discharge (*Current* ≤ ***(–)Dsg Current Threshold***). This prevents overheating of the CHG FET body diode during discharge. No other flags change state until full recovery is reached. This action is not affected by the setting of the ***[NR]*** 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***, *[XDSGI]* 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 bq34z653 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 bq34z653 has any *[OCD]*, *[OCD2]*, *[AOCD]* set, the DSG FET is turned on again during charging (*Current* ≥ ***Chg Current Threshold***). This prevents overheating of the discharge-FET body diode during charge. No other flags change state until full recovery is reached. This action is not affected by the state of ***[NR]*** bit.

Table 1-4. Overcurrent Conditions

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

The bq34z653 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 $\overline{\text{PRES}}$ input. When the overcurrent tier is selected in ***Non-Removable Cfg***, that particular feature uses the Non-Removable Battery Mode recovery.

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

When a charging-fault recovery condition is detected, then the CHG FET is allowed to be turned on, if other safety and configuration states permit, *[TCA]* 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.

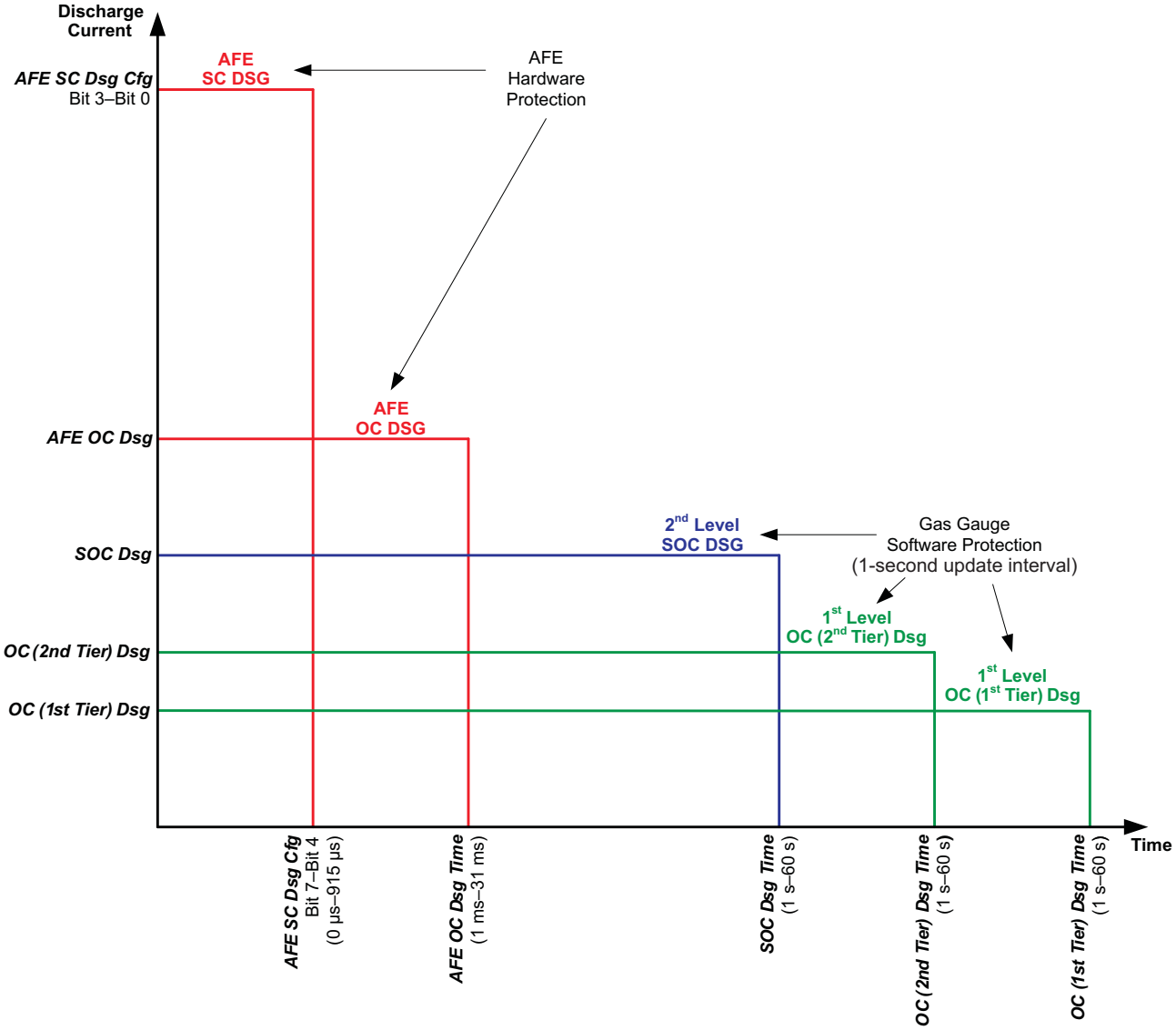


Figure 1-3. Overcurrent Protection Levels

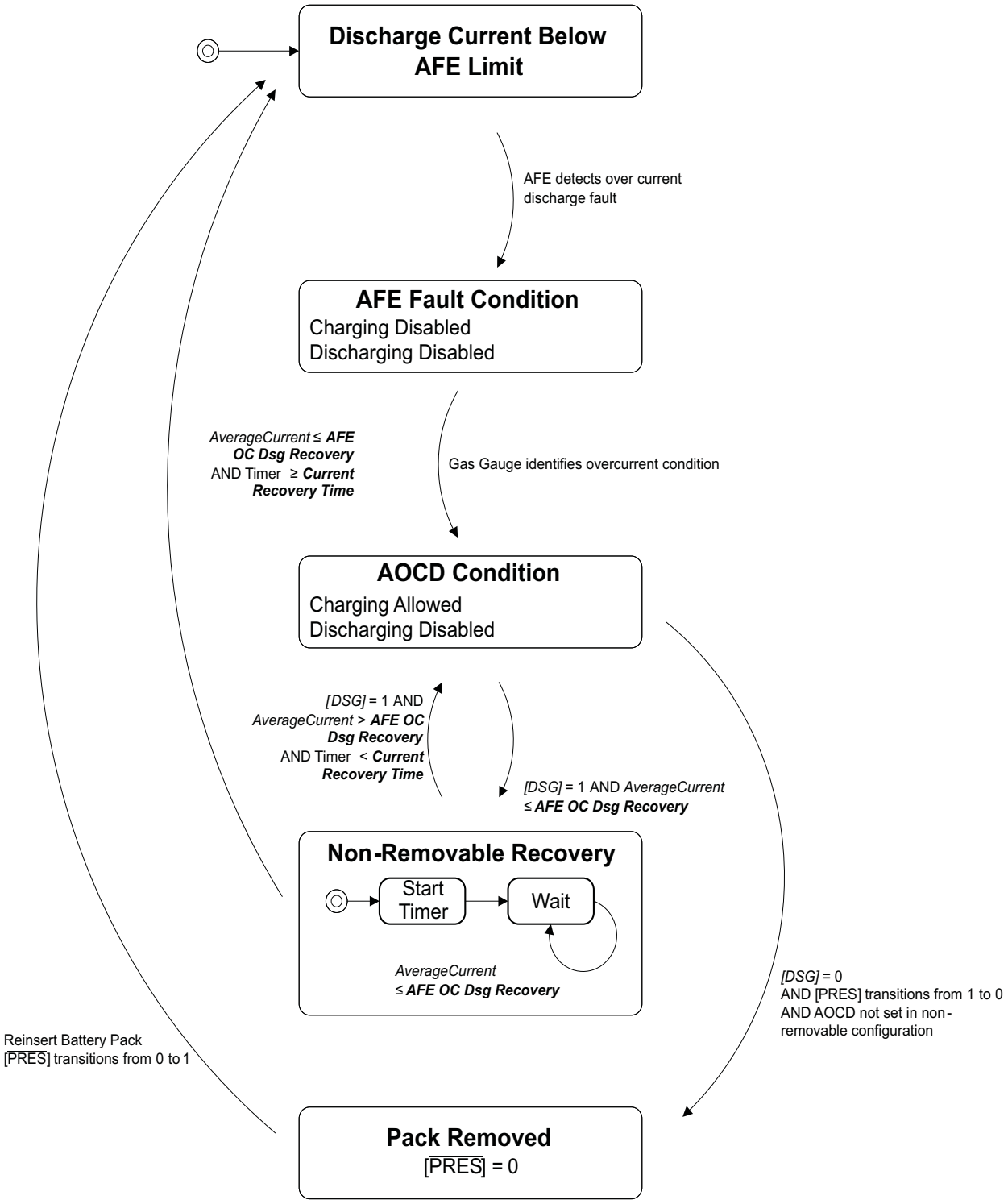


Figure 1-4. AFE Discharge Overcurrent Protection

1.2.3 Short-Circuit Protection

The bq34z653 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 bq34z653 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 *[XDSG]* flag is also set.

Each bq34z653 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 ≤ the ***AFE SC Recovery*** threshold and for the internal *Current_Fault* timer to be ≥ ***Current Recovery Time***.

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

Table 1-5. Short-Circuit Protection

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

1.2.4 Overtemperature Protection

The bq34z653 has overtemperature protection for both charge and discharge conditions with separate thresholds and alarms for the 2 temperature sensors TS1 and TS2.

The bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 recovers from an *[OT1C]* condition if *TS1Temperature* is equal to or below the ***OT1 Chg Recovery*** limit. The bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 sets the overtemperature discharging *[OT2D]* flag in *SafetyAlert2* if the measured temperature on TS2 reaches or surpasses the ***OT2 Dsg Threshold*** during discharging. The bq34z653 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 bq34z653 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 bq34z653 recovers from an *[OT1D]* condition if *TS1Temperature* is equal to or below the ***OT1 Dsg Recovery*** limit. The bq34z653 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 1-6. Overtemperature Protection

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

1.2.5 Host Watchdog

The bq34z653 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 bq34z653 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.

1.2.6 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 bq34z653 is able to interrogate the AFE.

When the XALERT signal is triggered, the bq34z653 reads the STATUS register of the AFE. If *[WDF]* is set, the bq34z653 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.

1.3 2nd-Level Protection Features

The bq34z653 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 *PFAlert* flag is set. If the PF Threshold condition is cleared within the PF time limit, the appropriate PFAlert flag is cleared. But if the PF Threshold condition continues over the PF Time Limit, then the bq34z653 goes into a permanent failure condition and the *PFStatus* flag is set, ad the *PFlert* 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***.

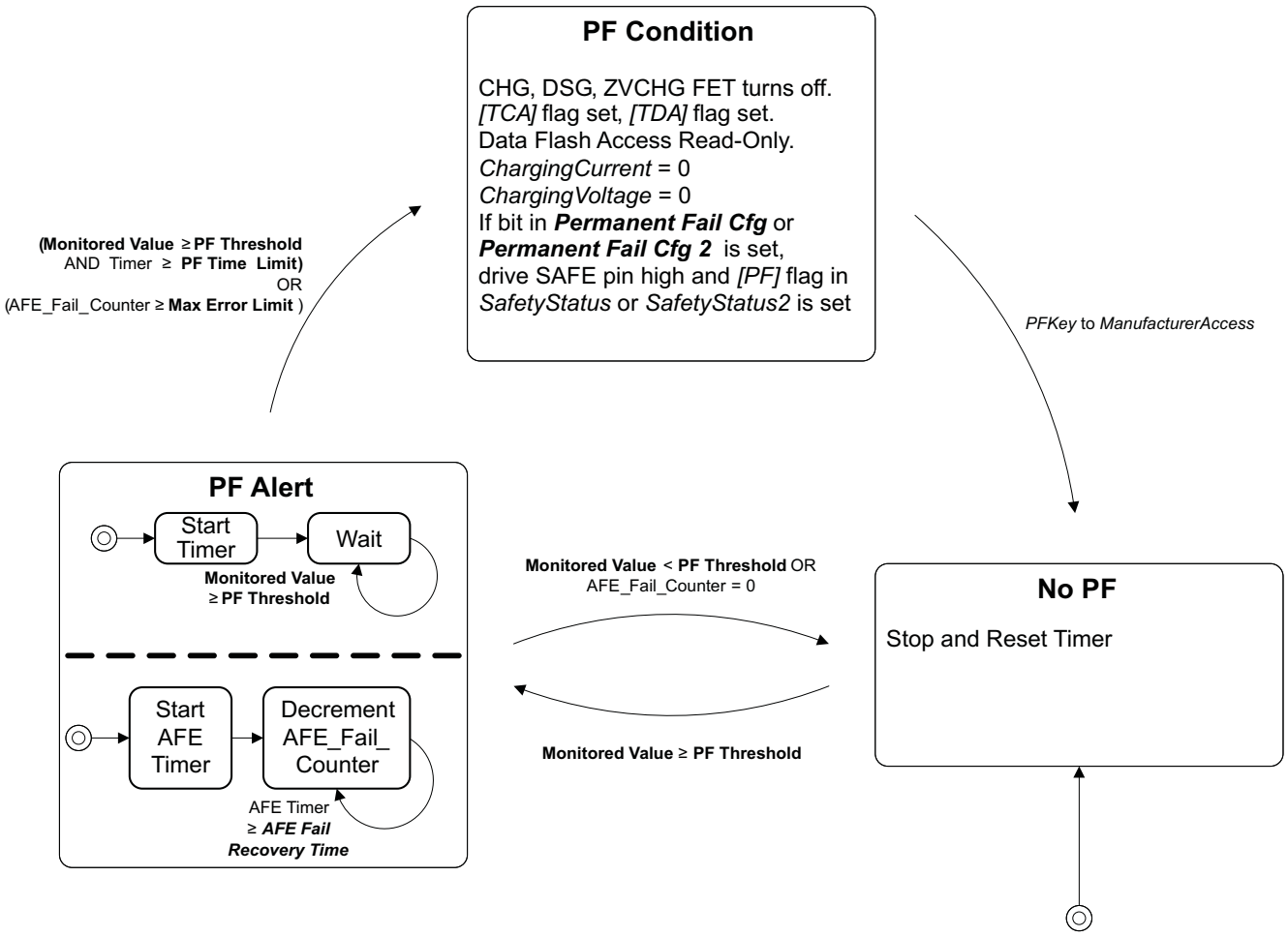


Figure 1-5. 2nd-Level Protection

1.3.1 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.

1.3.2 Time-Limit Based Protection

The bq34z653 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 bq34z653 reports a 2nd-level permanent failure, clears the appropriate *PFAlert* flag, and sets the appropriate *PFStatus* flag. See Table 1-7 for all Protection Thresholds and Max Alert durations.

Safety Overvoltage Protection — The bq34z653 monitors the individual cell voltages for extreme values.

Safety Undervoltage Protection — The bq34z653 monitors the individual cell voltages for extreme undervoltage values. Additionally, the bq34z653 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*| ≤ ***Rest CIM Current*** for ***CIM Battery Rest Time***

  The bq34z653 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* ≥ Charge Threshold Current

  The bq34z653 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 bq34z653 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 $\overline{\text{PFIN}}$ input of the bq34z653 can be used to determine the state of an external protection device such as the bq294xx. The bq34z653 watches for the $\overline{\text{PFIN}}$ pin being driven low by an external device.

Safety Overcurrent Protection — The bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 can detect if an attempt has been made to blow the fuse, but the attempt has failed. The bq34z653 monitors if the ***Fuse Flag*** is set to 0x3672 and current is still flowing.

Table 1-7. Time-Limit Based 2nd Level Protection

Protection	Conditions	Monitored Value	PF Threshold	PF Time Limit	*PFAlert* **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)	• Any (*CellVoltage4..1*) > ***Rest CIM Check Voltage*** • |*Current*| ≤ ***Rest CIM Current*** for ***CIM Battery Rest Time***	Max difference Any *CellVoltage4..1*	***Rest CIM Fail Voltage***	***Rest CIM Time***	*[CIM_R]*	*[XCIM_R]*
Cell imbalance fault (active)	• Any (*CellVoltage4..1*) > ***Active CIM Check Voltage*** • |*Current*| ≥ ***Charge Detection Current***	Max difference Any *CellVoltage4..1*	***Active CIM Fail Voltage***	***Active CIM Time***	*[CIM_A]*	*[XCIM_A]*
2nd-level protection IC input	—	PFIN pin	PFIN pin low	***PFIN Detect Time***	*[PFIN]*	*[XPFIN]*
Safety overcurrent charge	*Current* > 0	*Current*	***SOC Chg***	***SOC Chg Time***	*[SOCC]*	*[XSOCC]*
Safety overcurrent discharge	*Current* < 0	*Current*	***SOC Dsg***	***SOC Dsg Time***	*[SOCD]*	*[XSOCD]*
Safety overtemperature chg	*Current* > 0	*TS1Temperature*	***SOT1 Chg Threshold***	***SOT1 Chg Time***	*[SOT1C]*	*[XSOT1C]*
		TS2Temperature	***SOT2 Chg Threshold***	***SOT2 Chg Time***	*[SOT2C]*	*[XSOT2C]*
Safety overtemperature dsg	*Current* < 0	*TS1Temperature*	***SOT1 Dsg Threshold***	***SOT1 Dsg Time***	*[SOT1D]*	*[XSOT1D]*
		TS2Temperature	***SOT2 Dsg Threshold***	***SOT2 Dsg Time***	*[SOT2D]*	*[XSOT2D]*
Open thermistor 1	—	*TS1Temperature*	***Open Thermistor***	***Open Time***	*[SOPT1]*	*[XSOPT1]*
Open thermistor 2	—	*TS2Temperature*	***Open Thermistor***	***Open Time***	*[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*	***FET Fail Limit***	***FET Fail Time***	*[CFETF]*	*[XCFETF]*
Discharge FET fault	(DSG FET turn off attempt or DSG Flag in AFE OUTPUT register set) and *Current* < 0	(–)*Current*	***FET Fail Limit***	***FET Fail Time***	*[DFETF]*	*[XDFETF]*
Fuse state	***Fuse Flag*** = 0x3672	|*Current*|	***Fuse Fail Limit***	***Fuse Fail Time***	*[FBF]*	*[XFBF]*

1.3.3 Limit-Based Protection

The bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 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 bq34z653 reports a permanent failure.

AFE Init Verification — After a full reset, the bq34z653 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 bq34z653 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 bq34z653 reports a permanent failure error.

Data Flash Failure — The bq34z653 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 1-8. Error-Based 2nd-Level Protection

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

1.3.4 Clearing Permanent Failure

A bq34z653 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.

1.4 Gas Gauging

The bq34z653 features Impedance Track™ gauging algorithm and is capable of supporting a maximum battery pack capacity of 32 Ah. The gas gauge measures individual cell voltages, pack voltage, temperature, and current using features of the AFE. The bq34z653 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 bq34z653 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.

1.4.1 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 × R drop near the end of discharge, the bq34z653 must be configured for whatever current (or power) will flow in the future. While it cannot be exactly known, the bq34z653 can use load history such as the average current of the present discharge to make a sufficiently accurate prediction. The bq34z653 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 (***Load Mode*** = 0)	**Constant Power** (***Load Mode*** = 1)
0 =	***Avg I Last Run***	***Avg P Last Run***
1 =	Present average discharge current	Present average discharge power
2 =	*Current*	*Current* × *Voltage*
3 =	*AverageCurrent* (default)	*AverageCurrent* × average *Voltage*
4 =	***Design Capacity*** / 5	***Design Energy*** / 5
5 =	*AtRate* (mA)	*AtRate* (10 mW)
6 =	***User Rate-mA***	***User Rate-mW***
7 =	***Max Avg I Last Run***	***Max Avg P Last Run***

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 bq34z653 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 bq34z653 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***.

1.4.2 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 (mΩ). Recommended setting is 15% of 4 Ra grid point value, after optimized values of Ra are obtained from optimization cycle.

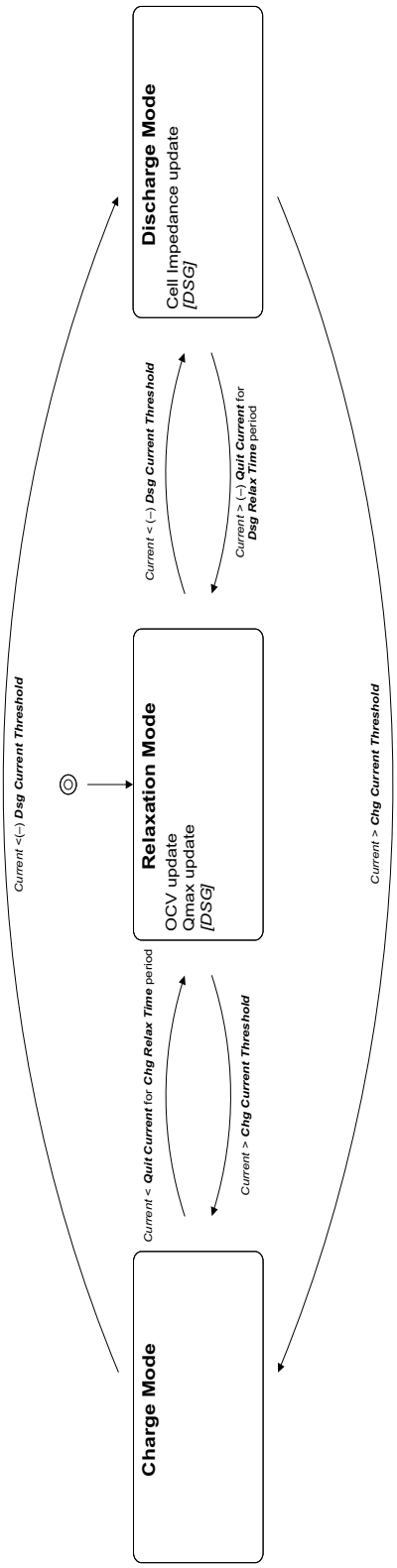


Figure 1-6. Gas Gauge Operating Modes

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***.

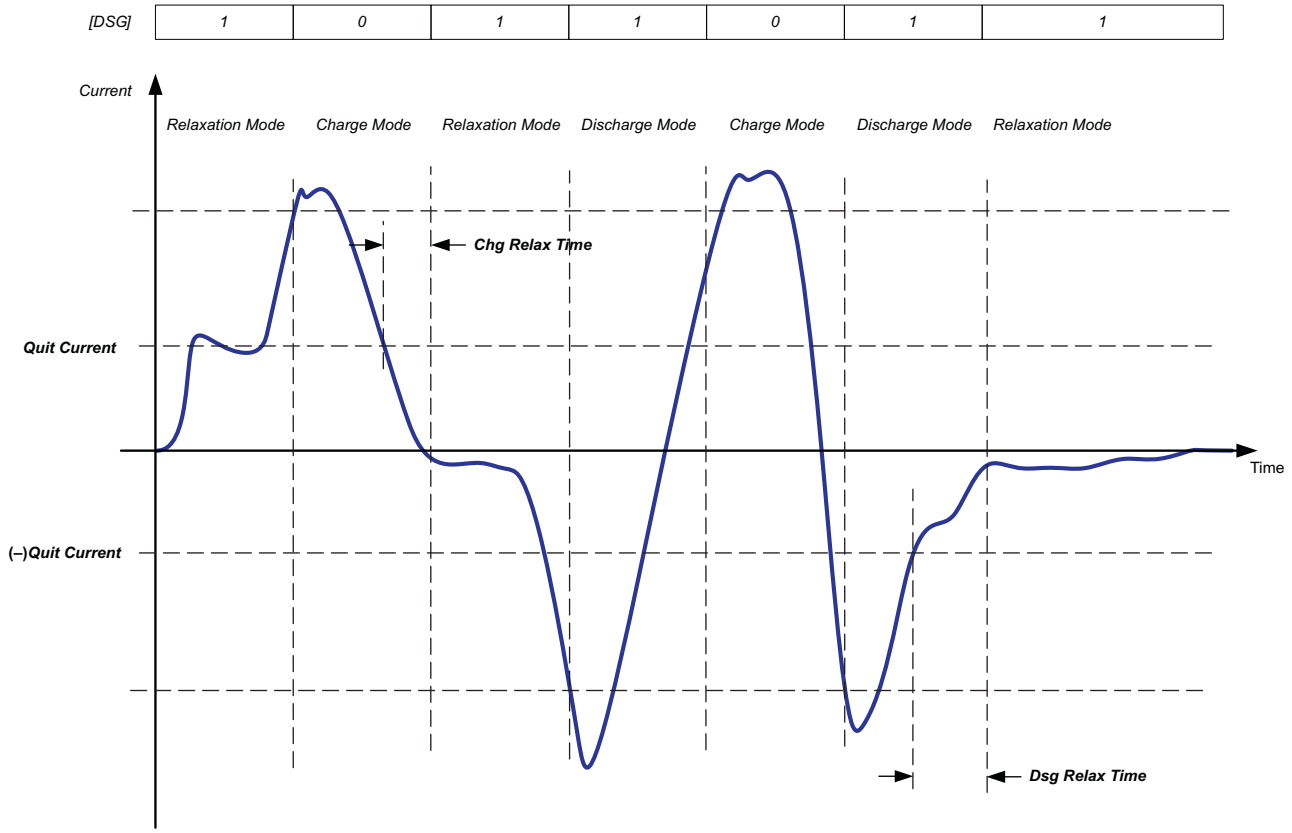


Figure 1-7. Gas Gauge Operating Mode Example

1.4.3 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 bq34z653 acquires and updates the battery-impedance profile during normal battery usage. It uses this profile, along with state-of-charge and the *QMAX* values, to determine *FullChargeCapacity* and *RelativeStateOfCharge* specifically for the present load and temperature. *FullChargeCapacity* reports a capacity or energy available from a fully charged battery reduced by ***Reserve Cap-mAh*** or ***Reserve Cap-mWh*** under the present load and present temperature until *Voltage* reaches the ***Term Voltage***.

1.4.3.1 QMAX Initial Values

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

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

1.4.3.2 QMAX Update Conditions

The bq34z653 updates the no-load full capacity (QMAX) 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 QMAX update is disqualified under the following conditions:

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

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

Voltage — If *CellVoltage4..1* is 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.

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.

1.5 Charge Control

The bq34z653 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 bq34z653 is indicated with flags and can be read out with the *ChargingStatus* function.

1.5.1 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.

1.5.2 Cell Balancing

The bq34z653 can determine the chemical state of charge of each cell using the Impedance Track algorithm. The cell balancing algorithm used in the bq34z653 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:

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

Where:

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

V_avg = 3.6 V

duty_cycle = 0.4 typ.

1.5.3 CHARGE-INHIBIT Mode

If the bq34z653 is in DISCHARGE mode or relaxation mode (*[DSG]* = 1), the bq34z653 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 bq34z653 is in CHARGE INHIBIT mode.

The bq34z653 allows charging to resume when:

- *Temperature* ≥ ***JT1*** + ***Temp Hys*** AND
- *Temperature* ≤ ***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).

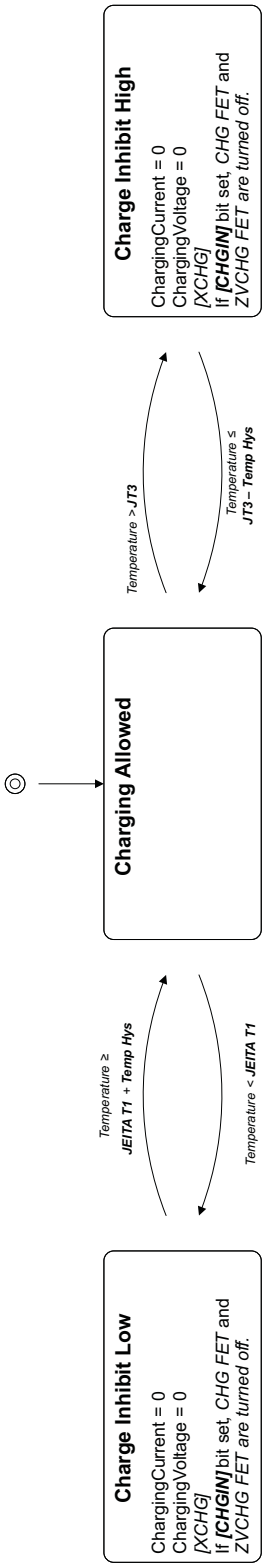


Figure 1-8. Charge Inhibit

1.5.4 Charge-Suspend Mode

The bq34z653 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 bq34z653 resumes charging if:

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

On resuming, the bq34z653 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 bq34z653 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).

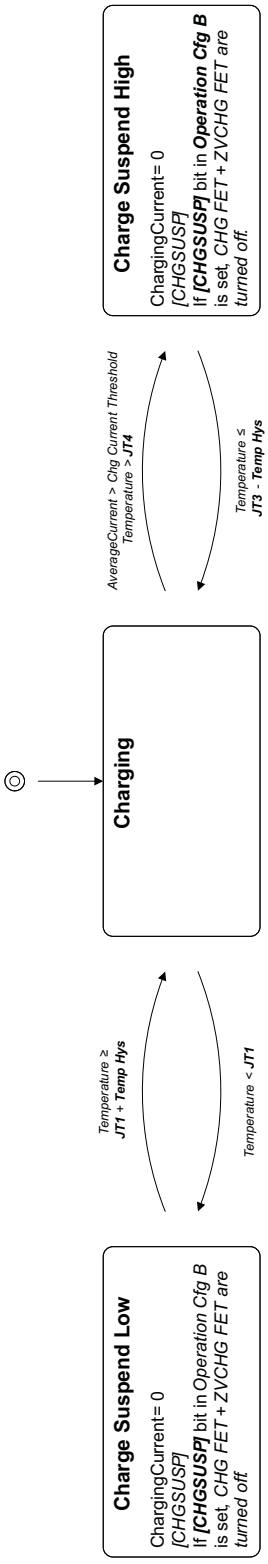


Figure 1-9. Charge Suspend

1.5.5 Charging and Temperature Ranges

The bq34z653 requests different charging current and charging voltage for each of the temperature ranges defined in Section 1.1, 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 1-9). 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 1-9. Cell Voltage Ranges

Condition	Cell Voltage Range
max(*CellVoltage4..1*) < ***Cell Voltage Threshold 1***	CVR1
Cell Voltage Threshold 1 < max(*CellVoltage4..1*) < ***Cell Voltage Threshold 2***	CVR2
Cell Voltage Threshold 2 < max(*CellVoltage4..1*)	CVR3

The dependency of the *Charging Voltage* and *Charging Current* on temperature range and cell voltage range is summarized in Table 1-10 and illustrated in Figure 1-10 and Figure 1-11.

Table 1-10. 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	***LT Chg Voltage***	***LT Chg Current1***
	CVR2		***LT Chg Current2***
	CVR3		***LT Chg Current3***
TR2A	CVR1	***ST1 Chg Voltage***	***ST1 Chg Current1***
	CVR2		***ST1 Chg Current2***
	CVR3		***ST1 Chg Current3***
TR3	CVR1	***ST2 Chg Voltage***	***ST2 Chg Current1***
	CVR2		***ST2 Chg Current2***
	CVR3		***ST2 Chg Current3***
TR4	CVR1	***HT Chg Voltage***	***HT Chg Current1***
	CVR2		***HT Chg Current2***
	CVR3		***HT Chg Current3***
TR5	—	0	0

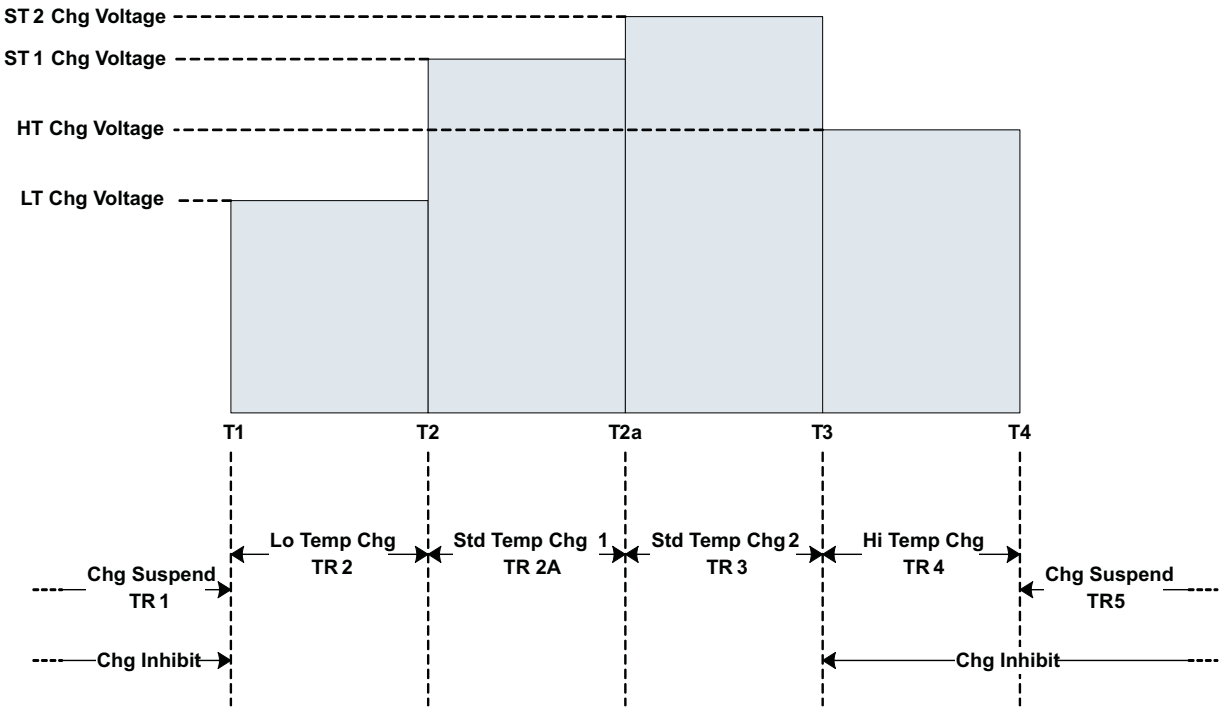


Figure 1-10. Temp Ranges and Charge Voltage for JEITA With Enhancements for More Complex Charging Profiles

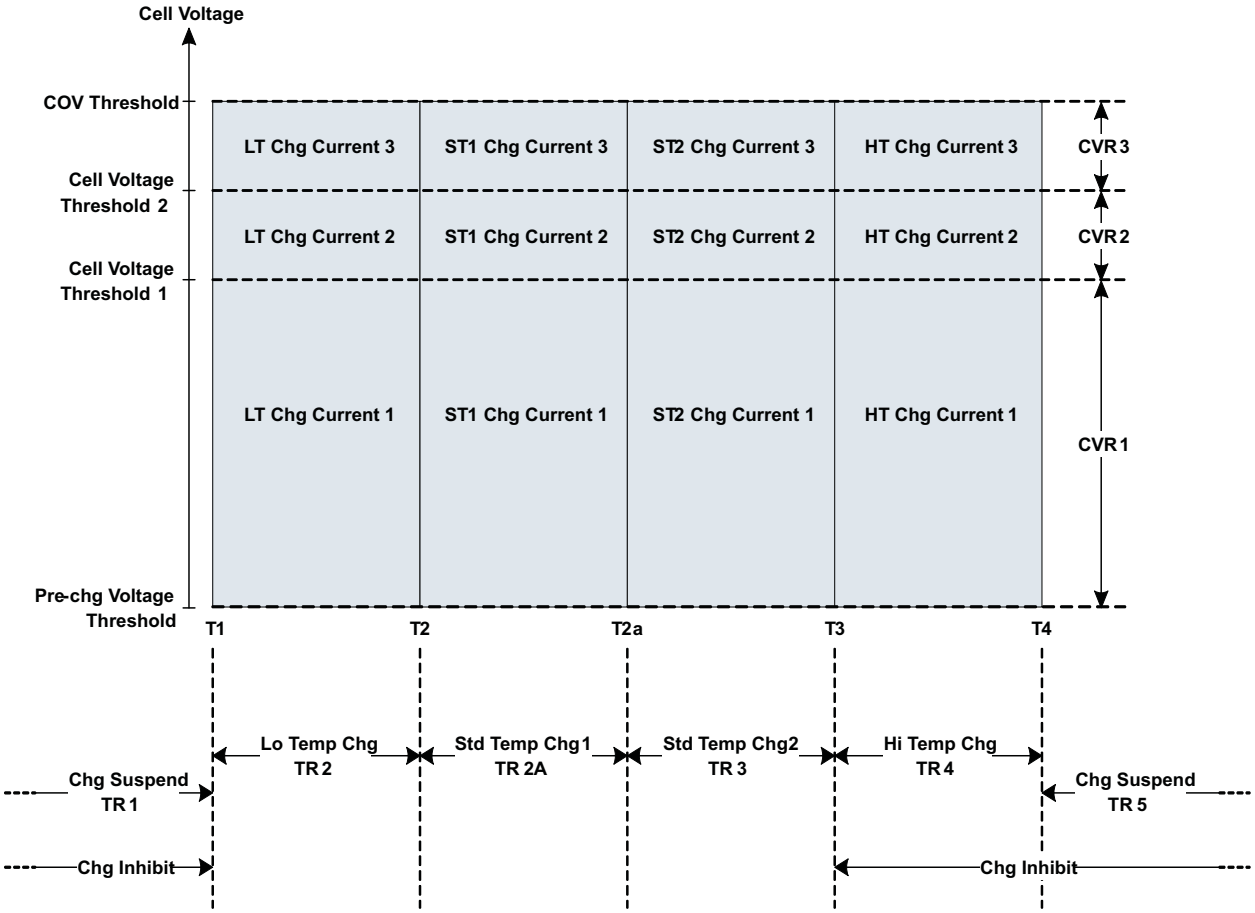


Figure 1-11. Temp Ranges and Charge Current for JEITA With Enhancements for More Complex Charging Profiles

1.5.5.1 Low Temperature Charging

The bq34z653 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 bq34z653 leaves this mode and clears the *[LTCHG]* flag if the *Temperature* goes below ***JT1*** or above ***JT2*** + *Temp Hys*.

1.5.5.2 Standard Temperature Charging 1

The bq34z653 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 bq34z653 leaves this mode and clears the *[ST1CHG]* flag if the *Temperature* goes below ***JT2*** or above ***JT2a***.

1.5.5.3 Standard Temperature Charging 2

The bq34z653 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 bq34z653 leaves this mode and clears the *[ST2CHG]* flag if the *Temperature* goes below ***JT2a – Temp Hys*** or above ***JT3*** .

1.5.5.4 High Temperature Charging

The bq34z653 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 bq34z653 leaves this mode and clears the *[HTCHG]* flag if the *Temperature* goes below ***JT3 – Temp Hys*** or above ***JT4***.

1.5.6 Precharge

The bq34z653 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 PRECHARGE mode.

Table 1-11. Precharge FET

ZVCHG1	ZVCHG0	FET USED
0	0	ZVCHG FET
0	1	CHG FET
1	0	GPOD Pin (on the AFE when used with bq34z653)
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 bq34z653 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.

1.5.7 Primary Charge Termination

The bq34z653 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 bq34z653 on charge termination:

Table 1-12. Primary Charge Termination

Parameter	Behavior on Primary Charge Termination
[TCA Set %] = –1	*[TCA]* flag set, *[MCHG]* flag set, *ChargingCurrent* = ***Maintenance Current***
[FC Set %] = –1	*[FC]* flag set
[CHGFET] set	CHG FET turned off
[CSYNC] set	*RemainingCapacity* = *FullChargeCapacity* regardless of ***TCA Set %*** value
[RSOCL] set	If the *[RSOCL]* bit in ***Operation Cfg C*** is set then *RelativeStateofCharge* and *RemainingCapacity* are held at 99% until primary charge termination occurs. Only on entering primary charge termination is 100% displayed.

Table 1-12. Primary Charge Termination (continued)

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

1.5.8 Charging Faults

The bq34z653 can report charging faults in the *ChargingStatus* register. When the *[OCHGI]* bit in ***Charge Fault Cfg*** is set, the CHG FET is turned OFF and the ZVCHG FET is turned ON if the *[ZVCHG1]*, *[ZVCHG0]* bits in ***Operation Cfg A*** are set appropriately. If the ZVCHG FET is not used the CHG FET remains ON, regardless of the bits set in ***Charge Fault Cfg***, because it acts as the ZVCHG FET.

On occurrence of a charging fault, the bq34z653:

- 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 bq34z653:

- 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 bq34z653 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 bq34z653 goes into PRECHARGE mode charging timeout *[PCMTO]* if:

- Precharge timer ≥ ***Precharge Timeout***

The bq34z653 recovers if:

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

Charge Mode Timeout

When *Current* is ≥ ***Chg Current Threshold***, the bq34z653 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 ***Overcharge Recovery*** is detected or if the pack is removed and reinserted when ***[NR]*** = 0. Set ***Charge Timeout*** to 0 to disable this feature.

The bq34z653 goes into CHARGE mode charging timeout if:

- Charge timer ≥ ***Charge Timeout***

The bq34z653 recovers if:

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

Overcharging Voltage

The bq34z653 goes into overcharging voltage mode if:

- *Voltage* ≥ ***ST2 Chg Voltage*** + ***Over Charging Voltage*** for minimum ***Over Charging Volt Time*** period.

The bq34z653 recovers, if:

- *Voltage* ≤ ***ST2 Chg Voltage***

Overcharging Current

The bq34z653 goes into overcharging current mode if:

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

The bq34z653 recovers, if:

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

Overcharge

The bq34z653 goes into overCHARGE mode if the battery pack is charged in excess of *FullChargeCapacity* by ***Overcharge Capacity***:

The bq34z653 recovers if any of the following conditions are met:

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

Battery Depleted

The bq34z653 goes into battery depleted mode if:

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

The bq34z653 recovers, if:

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

Table 1-13. Charging Faults

Charge Fault	Fault Condition	Recovery Condition	*ChargingStatus* **Flag,** *Charge Fault Configuration* **Flag**
Precharge Timeout	Precharge Timer ≥ ***Precharge Timeout***	*Current* ≤ ***(–)Dsg Current Threshold***, OR pack removed and reinserted if ***[NR]*** = 0	*[PCMTO]*
Charge Timeout	Charge Timer ≥ ***Charge Timeout***		*[CMTO]*
Overcharging Voltage	*Voltage* ≥ ST2 Chg Voltage + ***Over Charging Voltage*** for minimum ***Over Charging Volt Time***	*Voltage* ≤ ST2 Chg Voltage	*[OCHGV]*
Overcharging Current	*Current* ≥ *ChargingCurrent* + ***Over Charging Current*** for minimum ***Over Charging Curr Time***	*AverageCurrent* ≤ ***Over Charging Curr Recov***	*[OCHGI]*
Overcharge	*RemainingCapacity* – *FullChargeCapacity* ≥ ***Overcharge Capacity***	Pack removed and reinserted if ***[NR]*** = 0, OR continuous amount of discharge of ***Overcharge Recovery*** if ***[NR]*** = 1, OR *RemainingCapacity* ≤ ***FC Clear %***	*[OC]*
Battery Depleted	*Voltage* ≤ ***Depleted Voltage*** for minimum ***Depleted Voltage Time***	*Voltage* > ***Depleted Voltage Recovery***	*[XCHGLV]*

1.5.9 Discharge and Charge Alarms

The bq34z653 enables *[TDA], [FD], [TCA] and [FC]* flags in *BatteryStatus* to be set or cleared on the following thresholds based on *RelativeStateOfCharge*. All thresholds can be disabled by setting them to –1. ***FC Clear %*** should not be disabled by setting to –1.

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

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

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

1.5.10 Charge Enable (CE) Pin

Pin 19 is used as Charge Enable (CE) control pin. It is an input. A logical high on this pin only affects the NORMAL operation on the charge FET when the battery is in charge/relax mode(SMBus [DSG] flag = 0).

If the battery is in CHARGE mode and the charge current is less than the Chg Inhibit Threshold, the charge FET still works as NORMAL. When the charge current exceeds the Chg Inhibit Threshold for Chg Inhibit Hold Time, the charge FET will be turned off if the CE pin is logical high. The charge FET does not turn back again unless the CE pin changes to logical low or battery changes to DISCHARGE mode or the CE function is disabled.

The CE function is disabled once the Chg Inhibit Threshold is set to 0.

The related data flash:

Charge Control --> External Charge Control

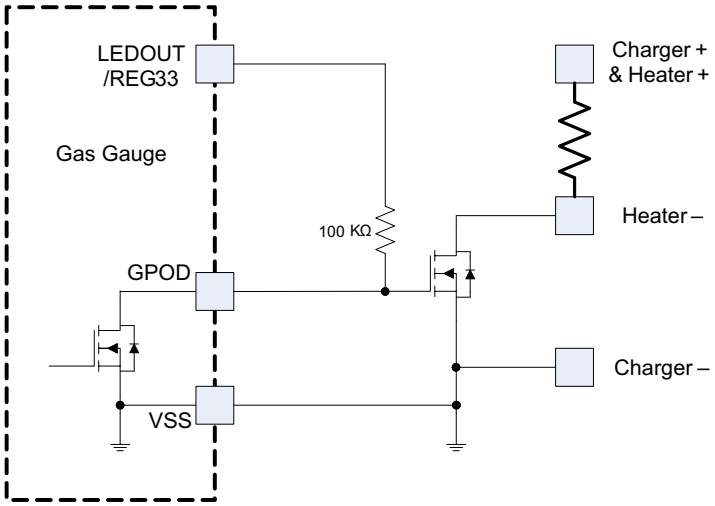
- Chg Inhibit Threshold: default is 0 mA, from 0 ~ 20000 mA.
- Chg Inhibit Hold Time: default is 0 s, from 0 ~ 240 s

1.6 Heater Control

1.6.1 Hardware Connection

The bq34z653 uses the GPOD pin (Pin 5) to control the external heater. The polarity of the GPOD pin is set by ***DF:OperationCfgA[HPOL]***.

OperationCfgC[HPOL]	GPOD
0	Active Low
1	Active High



1.7 Heater Activation

The bq34z653 can control the GPOD output based on the detection of the charger, *Temperature()*, and ***DF:OperationCfg[HEATALL]***.

The GPOD pin will activate under the following conditions:

When the charge cycle begins (*Charger Detection* changes to *Charger Detected*) AND *Temperature()* ≤ ***DF:Heater Temp***.

OR

When the charge cycle has already started (*Charger Detection* occurred prior to the last *Heater ON* check) AND If *Temperature()* ≤ ***DF:Heater Temp*** – ***DF: Heater Hys***.

The GPOD pin will deactivate under the following conditions:

If Temperature > ***DF:Heater Temp***.

If ***OperationCfg[HEATALL]*** = 0, then GPOD can only activate when a charger is detected.

1.8 Charger Detection

The bq34z653 detects that a charger is present when the voltage on PACK > ***DF:Charger Present***.

1.9 SMBus Broadcasts and FET Control

When the heater is enabled [GPOD = Active], the CHG FET is turned OFF and the following data is available via the SMBus. For smart charger broadcasts to occur, Operation Cfg B ***[BCAST]*** must be set.

SMBus Broadcast	Data Flash Value
ChargingCurrent()	Heater Current
ChargingVoltage()	Heater Voltage

When the heater is disabled [GPOD = Inactive], then the FET operation and SMBus data follow the standard bq34z653 charge control operation.

1.10 Data Flash Configuration

Table 1-14. Operation Cfg A (Offset 0) Additions

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	LEDR	LEDRCA	CHGLED	DMODE	LED1	LED0	CC1	CC0
Low Byte	HEATALL	HPOL	SLEEP	TEMP1	TEMP0	SLED	ZVCHG1	ZVCHG0

HEATALL (Bit 7): HEATALL enables activation of the GPOD output under ALL conditions.

0 = GPOD is only activated when the charger is detected and the temperature conditions permit it (default).

1 = GPOD is only activated when the temperature conditions permit it.

HPOL (Bit 6): HPOL determines the active polarity of the GPOD pin.

0 = GPOD is active Low (default).

1 = GPOD is active high.

For testing, *FETControl() [OD]* can still be used to test the heater enable function.

The following data flash configurations are in the ***Charge Control Class***.

Table 1-15. Heater Temp

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
39	Heater Control	0	Heater Temp	Signed Integer	2	–126	127	0	1°C

Table 1-16. Heater ON Temp

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
39	Heater Control	2	Heater Hys	Integer	1	0	255	20	0.1°C

Table 1-17. Heater Voltage

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
39	Heater Control	4	Heater Voltage	Integer	2	0	65535	0	mV

Table 1-18. Heater Current

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
39	Heater Control	6	Heater Current	Integer	2	0	65535	0	mA

Table 1-19. Heater Voltage Plus/Minus

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
39	Heater Control	8	Heater Voltage Plus/Minus	Integer	2	0	5000	0	mV

1.11 Heater Disable

The bq34z653 disables the use of the GPOD pin for heater control if both ***Heater Temp*** and ***Heater Hys*** are set to 0.

1.12 Discharge-Inhibit Mode

The bq34z653 prevents discharging if *Temperature* > ***Hi Dsg Start Temp***. When this happens, the bq34z653 goes into discharge inhibit mode. In discharge inhibit mode, discharging is disabled, and *[XDSG]*, [*DSGIN]* in *OperationStatus* and *[TDA]* in *BatteryStatus* are set. The bq34z653 returns to NORMAL mode and allows discharging if *Temperature* becomes less than or equal ***Hi Dsg Start Temp***.

1.13 Liquid Crystal Display

NOTE: Many parameters in this TRM have *LED* in their names, because of their inherited properties from another device; however, in this device, the LED parameters are used to configure the liquid crystal display (LCD). This device does not support an LED display.

1.13.1 LCD Activation

The LCD is activated at all times during operation, except when the device is in shutdown.

1.13.2 Display Configuration

The bq34z653 device can only be configured to support the LCD display mode.

1.13.2.1 LCD Display Configuration

The following parameters configure the LCD 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 LCD segments and the charge threshold levels used in the LCD display. The bq34z653 can use predefined charge levels for 3, 4, or 5 LCD segments or user defined levels.

SLED — This parameter is not used in this device.

LED Blink Period — During charging, the top LCD segment flashes with the ***LED Blink Period***; e.g. if battery charge is 36% and the display uses 5 LCD segments, LCD segment 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 LCD segments flash with ***LED Flash Period***; e.g. if battery charge is 36% and the display uses 5 LCD segments, LCD segments 1 and 2 will blink.

LED Delay — This parameter is not used in this device.

LED Hold Time — This parameter is not used in this device.

1.13.2.2 LCD Configuration

The LCD refresh frequency is configurable through data flash. LCD Freq: default is 35 Hz, from 20 to 100 Hz.

The related data flash:

- DF:LED Support:LED Cfg(67):LED Flash Period(20)

1.13.3 $\overline{DISP}$ Pin

The $\overline{DISP}$ pin is not used by this device.

1.13.4 Display Format

The bq34z653 can show state of charge using the LCD display. Predefined levels for 3, 4, or 5 LCD segments 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 LCD segment flashes at the rate of ***LED Blink Period*** (eg: if *RelativeStateOfCharge* = 36% and 5 LCD segments are being used then LCD segment 2 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 LCD segments will flash at the ***LED Flash Period***. The flash alarm can be disabled by setting it to –1.

Table 1-20. Display Charge Level Threshold

LED1, LED0 Setting:	3 LCD Segments	4 LCD Segments	5 LCD Segments	USER	
Threshold Level:	**!~C!~charge + !~d!~Discharge !~l!~Level**			**!~c!~Charging !~l!~Level**	**!~d!~Discharging !~l!~Level**
Flash Alarm active	0% – 10%	0% – 10%	0% – 10%	0% !~!~– ***CHG Flash Alarm***	0% !~!~– ***DSG Flash Alarm***
LCD Segment 1 active	0% – 100%	0% – 100%	0% – 100%	***CHG Thresh 1*** – 100%	***DSG Thresh 1*** – 100%
LCD Segment 2 active	34% – 100%	25% – 100%	20% – 100%	***CHG Thresh 2*** – 100%	***DSG Thresh 2*** – 100%
LCD Segment 3 active	67% – 100%	50% – 100%	40% – 100%	***CHG Thresh 3*** – 100%	***DSG Thresh 3*** – 100%
LCD Segment 4 active	—	75% – 100%	60% – 100%	***CHG Thresh 4*** – 100%	***DSG Thresh 4*** – 100%
LCD Segment 5 active	—	—	80% – 100%	***CHG Thresh 5*** – 100%	***DSG Thresh 5*** – 100%

1.13.5 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 LED Flash Period and LED Blink Period are fixed for these errors and not affected by the LED data flash settings.

PFStatus	LCD Segment 3	LCD Segment 2	LCD Segment 1
[SOPT2]	Flashing with LED Flash Period	Off	Flashing with LED Blink Period
[SOT2D]	On	Off	Flashing with LED Blink Period
[SOT2C]	Off	Off	Flashing with LED Blink Period
[CIM_A]	Flashing with LED Flash Period	Flashing with LED Blink Period	Flashing with LED Flash Period
[FBF]	On	Flashing with LED Blink Period	Flashing with LED Flash Period
[VSHUT]	Off	Flashing with LED Blink Period	Flashing with LED Flash Period
[SUV]	Flashing with LED Flash Period	Flashing with LED Blink Period	On
[SOPT1]	On	Flashing with LED Blink Period	On
[SOCD]	Off	Flashing with LED Blink Period	On
[SOCC]	Flashing with LED Flash Period	Flashing with LED Blink Period	Off
[AFE_P]	On	Flashing with LED Blink Period	Off

PFStatus	LCD Segment 3	LCD Segment 2	LCD Segment 1
[AFE_C]	Off	Flashing with LED Blink Period	Off
[DFF]	Flashing with LED Blink Period	Flashing with LED Flash Period	Flashing with LED Flash Period
[DFETF]	Flashing with LED Blink Period	On	Flashing with LED Flash Period
[CFETF]	Flashing with LED Blink Period	Off	Flashing with LED Flash Period
[CIM_R]	Flashing with LED Blink Period	Flashing with LED Flash Period	On
[SOT1D]	Flashing with LED Blink Period	On	On
[SOT1C]	Flashing with LED Blink Period	Off	On
[SOV]	Flashing with LED Blink Period	Flashing with LED Flash Period	Off
[PFIN]	Flashing with LED Blink Period	On	Off
None	Flashing with LED Blink Period	Off	Off

1.14 Supported Display Types

The bq34z653 device supports a static liquid crystal display (LCD).

1.15 Display Requirements

1.15.1 Liquid Crystal Display

The LCD controller supports 3- to 5-segment static bar graph liquid crystal displays (LCDs). The LCD is operational at all times except when the bq34z653 is in SHUTDOWN mode. See Table 1-21.

A static LCD generally has one large electrode on one side of the liquid crystal material called a "common," and a lot of smaller electrodes on the other side called "segments". Segments are made visible (black) by applying a differential voltage between the back plane signal of the LCD and the corresponding segment pin. Segments are turned off when there is no voltage difference between the back plane signal and a segment signal. The display signals must be periodically reversed to ensure zero average DC voltage and to refresh the display. See Figure 1-12 for details of control waveform and corresponding view of the display.

Table 1-21. LCD Enabled vs Device Mode

Mode	LCD
NORMAL	Enabled
REMOVED	Enabled
SLEEP	Enabled
WAKE	Enabled
SHUTDOWN	Disabled

Liquid crystal displays having an operating voltage range of 2.5 V to 6 V and refresh frequency between 30 and 200 Hz (TBD) are supported. The display refresh must be implemented such that the device current consumption requirements during sleep and active modes are not violated. The display refresh frequency must always be set as low as the LCD specification allows in order to minimize current consumption.

Static LCD drive procedure is described below.

- Step 1. Drive back plane to ground, drive "on" segments high, "off" segments to ground.
- Step 2. Wait for time 1/refresh frequency.
- Step 3. Drive back plane high, drive "on" segments to ground, "off" segments high.
- Step 4. Wait for time 1/refresh frequency.
- Step 5. Go to Step 1.

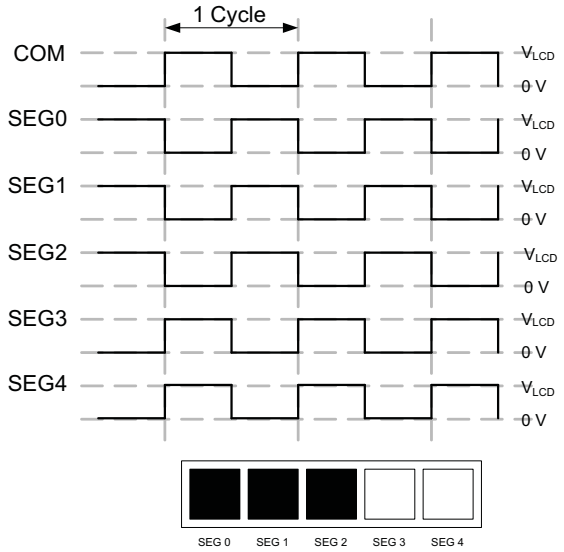


Figure 1-12. Static LCD Control Waveform

1.16 Device Operating Mode

The bq34z653 has several device power modes. During these modes, the bq34z653 modifies its operation to minimize power consumption from the battery.

1.16.1 NORMAL Mode

During NORMAL operation, the bq34z653 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 bq34z653 is in a reduced-power state.

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

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

1.16.2 Battery Pack Removed Mode/System Present Detection

1.16.2.1 Battery Pack Removed

The bq34z653 detects the Battery Pack Removed mode if the ***[NR]*** bit is set to 0 AND the $\overline{\text{PRES}}$ input is high (*[PRES]* = 0).

On entry to the Battery Pack Removed mode, the *[TCA]* and *[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 bq34z653 exits the Battery Pack Removed state if the ***[NR]*** flag is set to 0 AND the $\overline{\text{PRES}}$ input is low (*[PRES]* = 1). When this occurs, the *[TCA]* and *[TDA]* flags in *BatteryStatus* are reset.

1.16.2.2 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.

1.16.3 SLEEP Mode

In SLEEP mode, the bq34z653 measures *Voltage* and *Temperature* in ***Sleep Voltage Time*** intervals and *Current* at ***Sleep Current Time*** intervals. At each interval the bq34z653 performs calculations, updates SBS data, and makes protection and status decisions. Between these periods of activity, the bq34z653 is in a reduced-power state.

The bq34z653 enters SLEEP mode when the following conditions exist:

- If the ***[NR]*** bit is set to 0, *[PRES]* must also be set to 0 for the bq34z653 to enter sleep.

  AND one of the following conditions:
- (|*Current*| ≤ ***Sleep Current***) AND (SMBus is low for ***Bus Low Time***) AND (the ***[SLEEP]*** bit is set)

  OR
- (|*Current*| ≤ ***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* ≤ ***Cal Inhibit Temp Low*** or *Temperature* ≥ ***Cal Inhibit Temp High***, autocalibration is not started on entry to SLEEP mode. The activation of autocalibration is not affected by the state of ***[SLEEP]***, ***Sleep Voltage Time***, ***Sleep Current Time***, or *Current*.

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

The bq34z653 exits SLEEP mode when one or more of the following conditions exist:

- If the ***[NR]*** bit is set to 0 and *[PRES]* is set to 1.
- |*Current*| > ***Sleep Current***
- SMBC or SMBD 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 bq34z653 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 bq34z653 exits SLEEP mode when *[PRES]* = 1.

1.16.4 Wake Function

The bq34z653 can exit SLEEP mode, if enabled, by the presence of a voltage across SRP and SRN. The level of the current signal needed is programmed in ***Wake Current Reg***.

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

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

Figure 1-13. 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 1-22. Wake Current Reg

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

1.16.5 SHUTDOWN Mode

The bq34z653 enters SHUTDOWN mode if the following conditions are met:

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

  OR

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

  OR

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

When the bq34z653 meets these conditions, the CHG, DSG, and ZVCHG FETs are turned off, and the AFE is commanded to shut down. In SHUTDOWN mode, the bq34z653 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 bq34z653, 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.

1.16.6 SHIP Mode

While in SEALED mode, the bq34z653 enters SHIP mode if *ManufacturerAccess* (MAC) shutdown command (0x0010) is received two consecutive times AND *PackVoltage* < ***Charger Present*** threshold AND no safety conditions. The two MAC writes cannot have any other MAC commands following or between them. After the bq34z653 receives the two 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 two MAC (0x0010) commands the FETs will turn off, and 10 seconds after receiving the two commands, the bq34z653 will enter SHIP mode.

1.17 Security (Enables and Disables Features)

There are three levels of secured operation within the bq34z653. 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 bq34z653 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 bq34z653 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 bq34z653 to allow full access to all SBS commands and data flash. The bq34z653 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 *FullAccessKey* can be read and changed via the extended SBS block command *FullAccessKey* when in FULL ACCESS mode. In FULL ACCESS mode, the command to go to boot ROM can be sent.

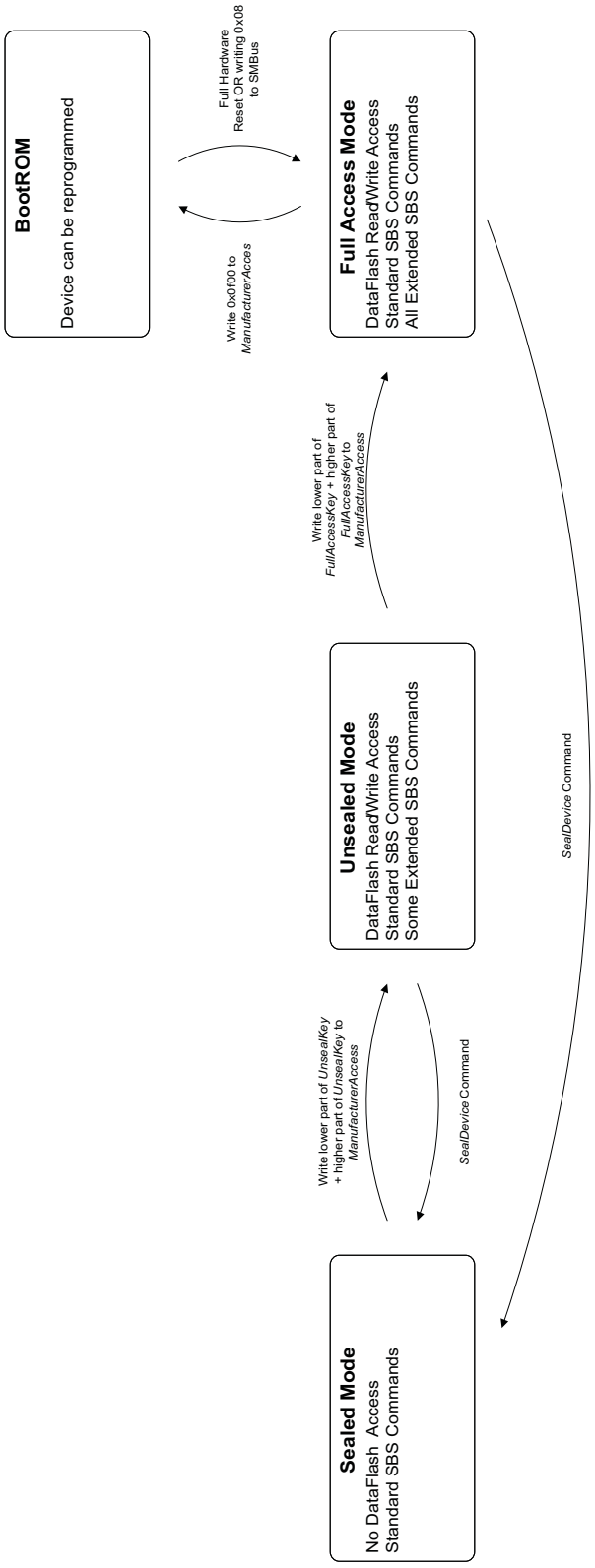


Figure 1-14. Security

1.18 Calibration

1.18.1 Coulomb-Counter Deadband

The bq34z653 does not accumulate charge or discharge for gas gauging when the current input is below the dead-band current threshold. The threshold is programmed in ***CC Deadband*** (coulomb-counter deadband) and should be set sufficiently high to prevent false signal detection with no charge or discharge flowing through the sense resistor.

1.18.2 Autocalibration

The bq34z653 provides an autocalibration feature to cancel the voltage offset error across SRP and SRN for maximum charge measurement accuracy. The bq34z653 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***.

1.19 Communications

The bq34z653 uses SMBus v1.1 with master mode and packet error checking (PEC) options per the SBS specification.

1.19.1 SMBus On and Off States

The bq34z653 detects an SMBus off state when SMBC and SMBD are logic-low for ≥ 2 seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

1.19.2 Packet Error Checking

The bq34z653 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 bq34z653 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 bq34z653 compares the value to its calculation. If the PEC is correct, the bq34z653 responds with an ACKNOWLEDGE. If it is not correct, the bq34z653 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 bq34z653. The bq34z653 then sends the PEC, and the host, acting as a master receiver, generates a NOT ACKNOWLEDGE and a stop condition.

1.19.3 bq34z653 Slave Address

The bq34z653 uses address 0x16 on the SMB for communication.

1.19.4 Broadcasts to Smart Charger and Smart Battery Host

The bq34z653 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.

Standard SBS Commands

The bq34z653 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 bq34z653 is in UNSEALED mode or FULL ACCESS mode, indicated by the *[SS]* and *[FAS]* flags. A write to this command forces the bq34z653 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 bq34z653 is in NORMAL operation. This 16-bit word reports the battery status.

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

LEGEND: All bits are read-only.

Figure A-1. Manufacturer Status

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

0,0 = Both charge and discharge FETs are on.
0,1 = CHG FET is off, DSG FET is on.
1,0 = Both charge and discharge FETs are off.
1,1 = CHG FET is on, DSG FET is off.

PF1, PF0 — Indicates permanent failure cause when permanent failure 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 bq34z653 to take actions when written. No data is returned.

A.1.2.1 Shutdown (0x0010)

Instructs the bq34z653 to verify and enter SHUTDOWN mode (when the bq34z653 is in UNSEALED or FULL ACCESS mode). This command is only available when the bq34z653 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 two consecutive times, the bq34z653 enters SHIP mode. The 2 MAC writes cannot have any other MAC commands following or between them. For bq34z653 to enter SHIP mode, Pack Voltage must be less than ***Charger Present*** threshold AND there are no safety conditions.

A.1.2.2 Sleep (0x0011)

Instructs the bq34z653 to verify and enter SLEEP mode if no other command is sent after the *Sleep* command. Any SMB transition wakes up the bq34z653. It takes about 1 minute before the device goes to sleep. This command is only available when the bq34z653 is in UNSEALED or FULL ACCESS mode.

A.1.2.3 Seal Device (0x0020)

Instructs the bq34z653 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 bq34z653 is in UNSEALED or FULL ACCESS mode.

See *Security,* Section 1.17, for detailed information.

A.1.2.4 IT Enable (0x0021)

This command forces the bq34z653 to begin the Impedance Track algorithm, changes ***Update Status***, and sets the *[QEN]* flag.

This command is only available when the bq34z653 is in UNSEALED or FULL ACCESS mode.

A.1.2.5 SAFE Activation (0x0030)

This command drives the SAFE pin high.

This command is only available when the bq34z653 is in UNSEALED or FULL ACCESS mode.

A.1.2.6 SAFE Clear (0x0031)

This command sets the SAFE pin back to low.

This command is only available when the bq34z653 is in UNSEALED or FULL ACCESS mode.

A.1.2.7 LEDs ON (0x0032)

This command is not available in this device.

A.1.2.8 LEDs OFF (0x0033)

This command is not available in this device.

A.1.2.9 Display ON (0x0034)

This command is not available in this device.

A.1.2.10 CALIBRATION Mode (0x0040)

Places the bq34z653 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 bq34z653 is in UNSEALED or FULL ACCESS mode.

A.1.2.11 Reset (0x0041)

The bq34z653 undergoes a full reset. The bq34z653 holds the clock line down for a few milliseconds to complete the reset

This command is only available when the bq34z653 is in UNSEALED or FULL ACCESS mode.

A.1.2.12 BootROM (0x0f00)

The bq34z653 goes into BootROM mode.

This command is only available when the bq34z653 is in FULL ACCESS mode.

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 bq34z653 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 bq34z653 is in UNSEALED or FULL ACCESS mode.

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 bq34z653 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 s must pass before the command can be reissued.

This command is only available when the bq34z653 is in SEALED mode.

See *Security,* Section 1.17, for detailed information.

A.1.2.15 FULL ACCESS Device (*FullAccessKey*)

Instructs the bq34z653 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 bq34z653 is in UNSEALED mode.

See *Security,* Section 1.17, for detailed information.

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:WDResetData(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 bq34z653 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

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 bq34z653 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

A.4 BatteryMode (0x03)

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

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

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

Figure A-2. BatteryMode

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

0 = Reports in mA or mAh (default)
1 = Reports in 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 bq34z653 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)

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 bq34z653 sends the *AlarmWarning* messages to the SMBus Host and the Smart Battery Charger any time an alarm condition is detected.

1 = Disable *AlarmWarning* broadcast to host and Smart BatteryCharger. The bq34z653 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 bq34z653 60 seconds after being set to 1, independent of the ***[BCAST]*** bit.

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 bq34z653 and should be set to 0.

CC — Enable or disable internal charge controller. This flag is not used by bq34z653 and should be set to 0.

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

0 = Battery OK

1 = Condition cycle requested

PBS — Primary battery support is not supported by bq34z653 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

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 bq34z653 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

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 bq34z653 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

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 bq34z653 updates this value within 1 second after the SMBus host sets the *AtRate* function value. The bq34z653 updates *AtRateOK* at 1-second intervals.

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

0 = FALSE bq34z653 **cannot** deliver energy for 10 seconds, based on discharge rate indicated in *AtRate*

1..65,535 = TRUE bq34z653 cn 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

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 bq34z653. It has a range of 0 to 6553.5 K.

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

Table A-13. Temperature

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

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

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

A.13 MaxError (0x0c)

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

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

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	—	%

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+	—	%

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

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

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

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

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

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 = Charger should operate as current source outside its maximum regulated voltage range.

Table A-26. ChargingVoltage

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

A.23 BatteryStatus (0x16)

This read-word function returns the status of the bq34z653-based battery.

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

LEGEND: All values read-only; RSVD = Reserved

Figure A-3. BatteryStatus

OCA — 1 = Overcharged 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 = bq34z653 is in charging mode
1 = bq34z653 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	bq34z653 processed the function code with no errors detected.
0,0,0,1 = BUSY	bq34z653 is unable to process the function code at this time.
0,0,1,0 = Reserved	bq34z653 detected an attempt to read or write to a function code reserved by this version of the specification, or bq34z653 detected an attempt to access an unsupported optional manufacturer function code.
0,0,1,1 = Unsupported	bq34z653 does not support this function code as defined in this version of the specification.

0,1,0,0 =	AccessDenied	bq34z653 detected an attempt to write to a read-only function code.
0,1,0,1 =	Over/Underflow	bq34z653 detected a data overflow or underflow.
0,1,1,0 =	BadSize	bq34z653 detected an attempt to write to a function code with an incorrect data block.
0,1,1,1 =	UnknownError	bq34z653 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 bq34z653 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	—

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 bq34z653 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

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 bq34z653 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

A.27 SpecificationInfo (0x1a)

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

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

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

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

When the bq34z653 is in UNSEALED or FULL ACCESS mode, this block is R/W.

Table A-30. SpecificationInfo

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

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

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

Figure A-4. SpecificationInfo

A.28 ManufactureDate (0x1b)

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

(Year – 1980) × 512 + month × 32 + day

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

When the bq34z653 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

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 bq34z653 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	—

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 bq34z653 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	—

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 bq34z653 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	—	—	bq34z653	—

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 bq34z653 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	—

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 bq34z653 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	
	9		
bq34z653 Counter	10	Partial Reset Counter	
	11	Full Reset Counter	
	12	Watchdog Reset Counter	
	13	Checksum	
	14	String Length Byte	

A.34 Authenticate (0x2f)

This read- or write-block function allows the host to authenticate a bq34z653-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

Table A-39. SBS COMMANDS (continued)

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
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+	—	%
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	—	—	bq34z653	—
0x22	R/W	DeviceChemistry	String	4 + 1	—	—	LION	—
0x23	R/W	ManufacturerData	String	14 + 1	—	—	—	—
0x2f	R/W	Authenticate	String	20 + 1	—	—	—	—

Table A-39. SBS COMMANDS (continued)

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	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 bq34z653 device is in UNSEALED or FULL ACCESS mode, unless otherwise noted.

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 bq34z653 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	
bq34z653	9	Internal AFE_Fail_Counter high byte	
	10	Internal AFE_Fail_Counter low byte	
	11	String Length Byte	

B.2 FETControl (0x46)

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

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
FETControl	RSVD	RSVD	RSVD	OD	ZVCHG	CHG	DSG	RSVD

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

Figure B-1. FETControl

OD — 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
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	CLL	DetF	DetW
Low Byte	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

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 1.2, for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	OT1D	OT1C	OCD	OCC	OCD2	OCC2	RSVD	RSVD
Low Byte	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 1.2, for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	OT1D	OT1C	OCD	OCC	OCD2	OCC2	RSVD	RSVD
Low Byte	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 PFAlert (0x52)

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

See *2nd-Level Protection Features*, Section 1.3, for further details.

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

LEGEND: All values read-only; RSVD = Reserved

Figure B-5. PFAlert

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

B.7 PFStatus (0x53)

The permanent failure status register indicates the source of the bq34z653 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 1.3, for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	FBF	RSVD	SUV	SOPT1	SOCD	SOCC	AFE_P	AFE_C
Low Byte	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

B.8 OperationStatus (0x54)

This read-word function returns the current operation status of the bq34z653.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	PRES	FAS	SS	CSV	RSVD	LDMD	RSVD	RSVD
Low Byte	WAKE	DSG	XDSG	XDSGI	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 = bq34z653 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
High Byte	XCHG	CHSUSP	PCHG	MCHG	LTCHG	ST1CHG	ST2CHG	HTCHG
Low Byte	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 WDResetData (0x58)

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

Table B-3. WDResetData

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

B.12 PackVoltage (0x5a)

This read-word function returns an unsigned integer 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

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 bq34z653 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	—	—

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 bq34z653 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	—	—

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 bq34z653 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	—	—

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 bq34z653 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	—

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 bq34z653 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	—

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 bq34z653 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	—

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 bq34z653 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	—

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 Section 1.2 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
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	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

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 Section 1.2 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
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	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

B.25 PFAlert2 (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 Section 1.3 for further details.

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

LEGEND: All values read-only. RSVD = Reserved

Figure B-11. PFAlert2

CIM_A — 1 = Cell-Imbalance (Active method) permanent failure 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

B.26 PFStatus2 (0x6b)

The permanent failure status register indicates the source of the bq34z653 permanent failure condition.

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

See Section 1.3 for further details.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	RSVD	RSVD	RSVD	RSVD	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

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.

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	—	—	—	—

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.

Table B-18. ManfacturerInfo

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

B.29 SenseResistor (0x71)

This read or write word command allows the user to change the sense resistor value used in μΩ. The bq34z653 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	μΩ

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
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	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 bq34z653 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	—	—

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 bq34z653 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	—	—

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	WDResetData	Unsigned integer	2	0	65535	—	—

Table B-26. EXTENDED SBS COMMANDS (continued)

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x5a	R	PackVoltage	Unsigned integer	2	0	65535	—	mV
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	PFAlert2	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 1.3 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 1.17, 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 bq34z653 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 bq34z653 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 bq34z653, 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.

C.1.2 Reading a SubClass

Information required:

- SubClassID
- Number of bytes in the subclass

- Variable Offset

Procedure:

1. Write the SubClassID to bq34z653 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 bq34z653 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)
  - SMBSlave Address (0x16)
  - SMB CMD 0x78 receiving 32 bytes of data
  - SMB CMD 0x79 receiving 32 bytes of data

Overwrite offset 45 of received data with 8.7 V:

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

Write the complete subclass back to the bq34z653:

- 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 bq34z653:

- 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 bq34z653 is operating in the low temperature range (see Section 1.1), it sets the *[COV]* flag in *SafefyAlert* 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

C.2.1.2 LT COV Recovery (Offset 2)

When the bq34z653 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

C.2.1.3 ST COV Threshold (Offset 4)

When the bq34z653 is operating in the standard temperature range 1 or 2 (see Chapter 1), it sets the *[COV]* flag in *SafefyAlert* 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

C.2.1.4 ST COV Recovery (Offset 6)

When the bq34z653 is operating in the standard temperature range 1 or 2 (see Chapter 1), 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

C.2.1.5 HT COV Threshold (Offset 8)

When the bq34z653 is operating in the high temperature range (see Chapter 1), it sets the *[COV]* flag in *SafefyAlert* 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

C.2.1.6 HT COV Recovery (Offset 10)

When the bq34z653 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

C.2.1.7 COV Time (Offset 12)

If the *[COV] SafetyAlert* time period exceeds ***COV Time*** the bq34z653 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

C.2.1.8 CUV Threshold (Offset 13)

The bq34z653 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

C.2.1.9 CUV Time (Offset 15)

If *[CUV]* in the *SafetyAlert* time period exceeds ***CUV Time***, the bq34z653 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

C.2.1.10 CUV Recovery (Offset 16)

The bq34z653 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

C.2.2 Current (Subclass 1)

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

The bq34z653 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

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 bq34z653 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

C.2.2.3 OC Chg Recovery (Offset 3)

The bq34z653 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 bq34z653 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

C.2.2.4 OC (1st Tier) Dsg (Offset 5)

The bq34z653 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

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 bq34z653 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

C.2.2.6 OC Dsg Recovery (Offset 8)

The bq34z653 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

C.2.2.7 OC (2nd Tier) Chg (Offset 10)

The bq34z653 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

C.2.2.8 OC (2nd Tier) Chg Time (Offset 12)

If the *[OCC2] SafetyAlert* time period exceeds ***OC (2nd Tier) Chg Time***, the bq34z653 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

C.2.2.9 OC (2nd Tier) Dsg (Offset 13)

The bq34z653 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

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 bq34z653 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

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

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
Low Byte	RSVD	RSVD	RSVD	OLV4	OLV3	OLV2	OLV1	OLV0

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

Figure C-1. OLV Register

OLV4, OLV3, OLV2, OLV1, OLV0— Sets the overload voltage threshold of the AFE

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

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
Low Byte	RSVD	RSVD	RSVD	RSVD	OLT3	OLT2	OLT1	OLT0

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

Figure C-2. OLT Register

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

0x00–0x00f = Sets the overvoltage trip delay between 1 ms and 31 ms in 2-ms steps

C.2.2.14 AFE OC Dsg Recovery (Offset 19)

The bq34z653 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

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 bq34z653 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
Low Byte	SCCT3	SCCT2	SCCT1	SCCT0	SCCV3	SCCV2	SCCV1	SCCV0

Figure C-3. SCC Register

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

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

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

0x00–0xf = Sets the short-circuit voltage threshold between 0.1 V and 0.475 V in 25-mV steps

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 bq34z653 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
Low Byte	SCDT3	SCDT2	SCDT1	SCDT0	SCDV3	SCDV2	SCDV1	SCDV0

Figure C-4. SCD Register

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

0x00–0xf = Sets the short-circuit-in-discharging delay between 0 μs and 915 μs in 61-μs 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

C.2.2.17 AFE SC Recovery (Offset 23)

The bq34z653 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

C.2.3 Temperature (Subclass 2)

C.2.3.1 OT1 Chg Threshold (Offset 0)

The bq34z653 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

C.2.3.2 OT1 Chg Time (Offset 2)

The bq34z653 goes into an overtemperature charge condition and sets the *[OT1C]* flag in *SafetyStatus* if the pack *TS1Temperature* 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

C.2.3.3 OT1 Chg Recovery (Offset 3)

The bq34z653 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

C.2.3.4 OT2 Chg Threshold (Offset 5)

The bq34z653 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

C.2.3.5 OT2 Chg Time (Offset 7)

The bq34z653 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

C.2.3.6 OT2 Chg Recovery (Offset 8)

The bq34z653 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

C.2.3.7 OT1 Dsg Threshold (Offset 10)

The bq34z653 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

C.2.3.8 OT1 Dsg Time (Offset 12)

The bq34z653 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

C.2.3.9 OT1 Dsg Recovery (Offset 13)

The bq34z653 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

C.2.3.10 OT2 Dsg Threshold (Offset 15)

The bq34z653 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

C.2.3.11 OT2 Dsg Time (Offset 17)

The bq34z653 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

C.2.3.12 OT2 Dsg Recovery (Offset 18)

The bq34z653 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

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

C.2.4 Host Comm (Subclass 4)

C.2.4.1 Host Watchdog Timeout (Offset 0)

If the bq34z653 receives no valid SMBus communication for a time period greater than ***Host Watchdog Timeout***, the FETs are turned off, *ChargingVoltage* and *ChargingCurrent* are set to 0, *[TCA]* and *[TDA]* in *BatteryStatus* are set, *[HWDG]* in *SafetyStatus* is set, and *[XDSG]* in *OperationStatus* is set. The bq34z653 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

C.3 2nd-Level Safety

C.3.1 Voltage (Subclass 16)

C.3.1.1 LT SOV Threshold (Offset 0)

When the bq34z653 is operating in the low temperature charging range (*[TR2]* = 1), it sets the *[SOV]* flag in *PFAlert* if any *CellVoltage4..1* is equal to or higher than the ***LT 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 ***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

C.3.1.2 ST SOV Threshold (Offset 2)

When the bq34z653 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

C.3.1.3 HT SOV Threshold (Offset 4)

When the bq34z653 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

C.3.1.4 SOV Time (Offset 6)

The bq34z653 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

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

C.3.1.6 SUV Threshold (Offset 9)

The bq34z653 sets the *[SUV]* flag in *PFAlert* if *CellVoltage4..1* is less than the ***SUV Threshold***. The *[SUV]* flag in ***PFAlert*** 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

C.3.1.7 SUV Time (Offset 11)

The bq34z653 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

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 bq34z653 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

C.3.1.9 Rest CIM Fail Voltage (Offset 13)

When the conditions for detecting cell imbalance at rest are satisfied, the bq34z653 sets the *[CIM_R]* flag in ***PFAlert*** if the bq34z653 measures a difference between any *CellVoltage4..1* equal to or higher than the ***Rest CIM Fail Voltage*** threshold. The *[CIM_R]* flag in ***PFAlert*** 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

C.3.1.10 Rest CIM Time (Offset 15)

When the conditions for detecting cell imbalance at rest are satisfied, the bq34z653 sets the *[CIM_R]* flag in ***PFAlert*** if the bq34z653 measures a difference between any *CellVoltage4..1* equal to or higher than the ***Rest CIM Fail Voltage*** threshold. The *[CIM_R]* flag in ***PFAlert*** 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

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 bq34z653 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

C.3.1.12 Rest CIM Check Voltage (Offset 18)

For cell imbalance detection at rest, the bq34z653 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

C.3.1.13 Active CIM Fail Voltage (Offset 20)

When the conditions for detecting cell imbalance while active are satisfied, the bq34z653 sets the *[CIM_A]* flag in ***PFAlert2*** if the bq34z653 measures a difference between any *CellVoltage4..1* equal to or higher than the ***Active CIM Fail Voltage*** threshold. The *[CIM_A]* flag in ***PFAlert2*** 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

C.3.1.14 Active CIM Time (Offset 22)

When the conditions for detecting cell imbalance while active are satisfied, the bq34z653 sets the *[CIM_A]* flag in ***PFAlert2*** if the bq34z653 measures a difference between any *CellVoltage4..1* equal to or higher than the ***Active CIM Fail Voltage*** threshold. The *[CIM_A]* flag in ***PFAlert2*** 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

C.3.1.15 Active CIM Check Voltage (Offset 23)

For active cell imbalance detection, the bq34z653 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

C.3.1.16 PFIN Detect Time (Offset 25)

If the $\overline{\text{PFIN}}$ pin is logic low, then *[PFIN]* in *PFAlert* is set. If the *[PFIN]* PF alert time period exceeds ***PFIN Detect Time***, the *[PFIN]* flag in *PFAlert* 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

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

C.3.2 Current (Subclass 17)

C.3.2.1 SOC Chg (Offset 0)

The bq34z653 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

C.3.2.2 SOC Chg Time (Offset 2)

The bq34z653 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

C.3.2.3 SOC Dsg (Offset 3)

The bq34z653 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

C.3.2.4 SOC Dsg Time (Offset 5)

The bq34z653 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

C.3.3 Temperature (Subclass 18)

C.3.3.1 SOT1 Chg Threshold (Offset 0)

The bq34z653 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

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

C.3.3.3 SOT2 Chg Threshold (Offset 3)

The bq34z653 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

C.3.3.4 SOT2 Chg Time (Offset 5)

The bq34z653 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

C.3.3.5 SOT1 Dsg Threshold (Offset 6)

The bq34z653 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

C.3.3.6 SOT1 Dsg Time (Offset 8)

The bq34z653 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

C.3.3.7 SOT2 Dsg Threshold (Offset 9)

The bq34z653 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

C.3.3.8 SOT2 Dsg Time (Offset 11)

If *[SOT2D]* in the *PFAlert*2 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

C.3.3.9 Open Thermistor (Offset 12)

The bq34z653 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

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

C.3.4 FET Verification (Subclass 19)

C.3.4.1 FET Fail Limit (Offset 0)

The bq34z653 sets *[CFETF]* in *PFAlert* if the bq34z653 detects charge *Current* equal to or higher than the ***FET Fail Limit*** threshold when the CHG FET is supposed to be off.

The bq34z653 sets *[DFETF]* in *PFAlert* if the bq34z653 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

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

C.3.5 AFE Verification (Subclass 20)

C.3.5.1 AFE Check Time (Offset 0)

The bq34z653 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

C.3.5.2 AFE Fail Limit (Offset 1)

If the internal AFE fail counter reaches ***AFE Fail Limit***, the bq34z653 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	

C.3.5.3 AFE Fail Recovery Time (Offset 2)

The bq34z653 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

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	—

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	

C.3.6 Fuse Verification (Subclass 21)

C.3.6.1 Fuse Fail Limit (Offset 0)

The bq34z653 sets the *[FBF]* flag in *PFAlert* if the absolute value of charge or discharge *Current* is equal to or higher than the fuse fail limit threshold after a fuse blow attempt.

Table C-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

C.3.6.2 Fuse Fail Time (Offset 2)

If [FBF] in *PFAlert* time period exceeds ***Fuse Fail Time***, the bq34z653 reports a fuse blow failure permanent error, *[FBF]* in *PFAlert* is reset, and *[FBF]* in *PFStatus* is set. This function is disabled if ***Fuse Fail Time*** is set to 0.

Table C-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

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 bq34z653 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

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 1.5.5).

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

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 1.5.5).

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

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 1.5.5).

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

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 1.5.5).

If *Temperature* is greater than ***JT4*** then the *[TR5]* flag in *TempRange* is set. If bq34z653 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

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 bq34z653 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

C.4.2 Pre-Charge Cfg (Subclass 33)

C.4.2.1 Pre-Chg Voltage Threshold (Offset 0)

The bq34z653 enters PRECHARGE 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

C.4.2.2 Pre-Chg Recovery Voltage (Offset 2)

The bq34z653 leaves PRECHARGE 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

C.4.2.3 Pre-chg Current (Offset 4)

The bq34z653 sets the *ChargingCurrent* to the ***Pre-chg Current*** value when in PRECHARGE 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

C.4.3 Charge Cfg (Subclass 34)

C.4.3.1 LT Chg Voltage (Offset 0)

The bq34z653 sets *ChargingVoltage* to the ***LT Chg Voltage*** value when *Temperature* in is 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

C.4.3.2 LT Chg Current1 (Offset 2)

The bq34z653 sets *ChargingCurrent* to the ***LT Chg Current1*** value when *Temperature* is in the low temperature charging range (*[TR2]* = 1) and max(*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

C.4.3.3 LT Chg Current2 (Offset 4)

The bq34z653 sets *ChargingCurrent* to the ***LT Chg Current2*** value when *Temperature* in the low temperature charging range (*[TR2]* = 1) and max(*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

C.4.3.4 LT Chg Current3 (Offset 6)

The bq34z653 sets *ChargingCurrent* to the ***LT Chg Current3*** value when *Temperature* in the low temperature charging range (*[TR2]* = 1) and max(*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

C.4.3.5 ST1 Chg Voltage (Offset 8)

The bq34z653 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

C.4.3.6 ST1 Chg Current1 (Offset 10)

The bq34z653 sets *ChargingCurrent* to the ***ST1 Chg Current1*** value when *Temperature* is in the standard temperature charging range (*[TR2A]* = 1) and max(*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

C.4.3.7 ST1 Chg Current2 (Offset 12)

The bq34z653 sets *ChargingCurrent* to the ***ST1 Chg Current2*** value when *Temperature* is in the standard temperature charging range (*[TR2A]* = 1) and max(*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

C.4.3.8 ST1 Chg Current3 (Offset 14)

The bq34z653 sets *ChargingCurrent* to the ***ST1 Chg Current3*** value when *Temperature* is in the standard temperature charging range (*[TR2A]* = 1) and max(*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

C.4.3.9 ST2 Chg Voltage (Offset 16)

The bq34z653 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

C.4.3.10 ST2 Chg Current1 (Offset 18)

The bq34z653 sets *ChargingCurrent* to the ***ST2 Chg Current1*** value when *Temperature* is in the standard temperature charging range 2 (*[TR3]* = 1) and max(*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

C.4.3.11 ST2 Chg Current2 (Offset 20)

The bq34z653 sets *ChargingCurrent* to the ***ST2 Chg Current2*** value when *Temperature* is in the standard temperature charging range 2 (*[TR3]* = 1) and max(*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

C.4.3.12 ST2 Chg Current3 (Offset 22)

The bq34z653 sets *ChargingCurrent* to the ***ST2 Chg Current3*** value when *Temperature* is in the standard temperature charging range 2 (*[TR3]* = 1) and max(*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

C.4.3.13 HT Chg Voltage (Offset 24)

The bq34z653 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

C.4.3.14 HT Chg Current1 (Offset 26)

The bq34z653 sets *ChargingCurrent* to the ***HT Chg Current1*** value when *Temperature* is in the high temperature charging range (*[TR4]* = 1) and max(*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

C.4.3.15 HT Chg Current2 (Offset 28)

The bq34z653 sets *ChargingCurrent* to the ***HT Chg Current2*** value when *Temperature* is in the high temperature charging range (*[TR4]* = 1) and max(*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

C.4.3.16 HT Chg Current3 (Offset 30)

The bq34z653 sets *ChargingCurrent* to the ***HT Chg Current3*** value when *Temperature* is in the high temperature charging range (*[TR4]* = 1) and max(*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

C.4.3.17 Cell Voltage Threshold1 (Offset 32)

The bq34z653 is in cell voltage range 1 (CVR1) when max(*CellVoltage4..1*) < ***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

C.4.3.18 Cell Voltage Threshold2 (Offset 34)

The bq34z653 enters cell voltage range 2 (CVR2) when ***Cell Voltage Threshold1*** < max(*CellVoltage4..1*) < ***Cell Voltage Threshold2***. The bq34z653 enters cell voltage range 3 (CVR3) when max(*CellVoltage4..1*) > ***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

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 bq34z653 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

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

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 bq34z653 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

C.4.4.3 Taper Voltage (Offset 6)

For a valid primary charge termination, the taper voltage condition must 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*** *ChargingVoltage* / number of cells
- *[CELL_TAPER]* = 0: *Voltage* + ***Taper Voltage*** *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

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 bq34z653 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

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	%

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	%

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	%

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	%

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 bq34z653 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

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 bq34z653 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

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

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 bq34z653 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

C.4.6.5 Over Charging Curr Recov (Offset 6)

The bq34z653 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

C.4.6.6 Depleted Voltage (Offset 8)

The bq34z653 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

C.4.6.7 Depleted Voltage Time (Offset 10)

The bq34z653 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

C.4.6.8 Depleted Recovery (Offset 11)

The bq34z653 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

C.4.6.9 Overcharge Capacity (Offset 13)

The bq34z653 enters an overcharge fault and sets the *[OC]* flag in *ChargingStatus* if the internally counted remaining capacity exceeds *FullChargeCapacity* + ***Overcharge 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. Overcharge Capacity

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	13	Overcharge Capacity	Integer	2	0	4000	300	mAh

C.4.6.10 Overcharge Recovery (Offset 15)

The bq34z653 recovers from an overcharge in non-removable battery mode (***[NR]*** = 1) if it is continuously discharged by an amount of ***Overcharge Recovery*** charge.

Table C-128. Overcharge Recovery

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
38	Charging Faults	15	Overcharge Recovery	Integer	2	0	100	2	mAh

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 bq34z653 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

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 bq34z653 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

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
Low Byte	RSVD	RSVD	PCMTO	CMTO	OCHGV	OCHGI	OC	CS_XCHGLV

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.

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 bq34z653 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

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 bq34z653 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

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 bq34z653 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

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 bq34z653 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	

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 bq34z653 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

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 bq34z653 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	

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 bq34z653 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

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 bq34z653 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	

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 bq34z653 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	

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

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	%

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	%

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

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	10 mWh

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	

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	—	—	bq34z653	

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	

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 bq34z653 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	%

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 bq34z653 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	%

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 bq34z653 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	%

C.5.2 Configuration (Subclass 49)

C.5.2.1 TDA Set % (Offset 0)

If set between 0% and 100%, the bq34z653 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	%

C.5.2.2 TDA Clear % (Offset 1)

If set between 0% and 100%, the bq34z653 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	%

C.5.2.3 FD Set % (Offset 2)

If set between 0% and 100%, the bq34z653 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	%

C.5.2.4 FD Clear % (Offset 3)

If set between 0% and 100%, the bq34z653 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	%

C.5.2.5 TDA Set Volt Threshold (Offset 4)

The bq34z653 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

C.5.2.6 TDA Set Volt Time (Offset 6)

The bq34z653 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

C.5.2.7 TDA Clear Volt (Offset 7)

The bq34z653 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

C.5.2.8 FD Set Volt Threshold (Offset 9)

The bq34z653 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

C.5.2.9 FD Volt Time (Offset 11)

The bq34z653 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

C.5.2.10 FD Clear Volt (Offset 12)

The bq34z653 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

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	

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	

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	

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	

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	

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	—	—	0123456789ABCDEF0123456789ABCDE	

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	—	—	0123456789ABCDEF012	

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	

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	

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	

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

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

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 > 4300 mV for a period > 60 seconds.
- Any internally measured cell voltage > 4300 mV AND any other lifetime value is updated.

The event logging ends when the cell voltage < 4290 mV 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

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

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

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

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

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

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

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

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

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

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

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-185. 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

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 bq34z653.

Table C-186. Operation Cfg A

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
64	Configuration	0	Operation Cfg A	Hex	2	0x0000	0xffff	0x0f29	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	LEDR	LEDRCA	CHGLED	DMODE	LED1	LED0	CC1	CC0
Low Byte	RSVD	RSVD	SLEEP	TEMP1	TEMP0	SLED[(1)]	ZVCHG1	ZVCHG0

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

Figure C-6. Operation Cfg A

(1) For LCD, this is not used: It has the same setting as SLED = 0.

LEDR — This bit is not used in this device. For LCD, the display is activated on device-reset exit.

LEDRCA — Enables flashing of the LED display when the *[RCA]* flag in *BatteryStatus* is set.

0 = The LCD display is not flashing when *[RCA]* is set. (default)
1 = When *[RCA]* is set, the LCD display flashes with ***LED Flash Period***.

CHGLED — This bit is not used in this device. For LCD, the display is always enabled while charging.

DMODE — This bit sets the display to show the *RelativeStateOfCharge* or *AbsoluteStateOfCharge* LCD representation.

0 = Display reflects RelativeStateOfCharge (default).
1 = Display reflects AbsoluteStateOfCharge.

LED1, LED0 — These bits configure the number of threshold levels used in the LED display.

0,0 = User defined threshold
0,1 = 3 LCD threshold levels used
1,0 = 4 LCD threshold levels used
1,1 = 5 LCD threshold levels used (default)

CC1, CC0 — These bits configure the bq34z653 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 bq34z653 to enter SLEEP mode if the SMBus lines are low.

0 = The bq34z653 never enters SLEEP mode.
1 = The bq34z653 enters SLEEP mode under normal Sleep entry criteria (default).

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

SLED — This bit is not used in this device.

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 bq34z653.

Table C-187. Operation Cfg B

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
64	Configuration	2	Operation Cfg B	Hex	2	0x0000	0xffff	0x6440	

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High Byte	PDF1	PDF0	RESCAP	NCSMB	NRCHG	CSYNC	CHGTERM	CCT
Low Byte	CHGSUSP	OTFET	CHGFET	CHGIN	NR	CPE	HPE	BCAST

Figure C-7. Operation Cfg B

PDF1, PDF0 — Configures the Permanent Failure LCD display.

0,0 = PF Error Code is not available.
0,1 = PF Error Code is automatically activated after state-of charge-display. (default)
1,0 = PF Error Code is not available.
1,1 = PF Error Code is automatically activated after state-of charge-display.

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)

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

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

NRCHG — Enables the CHG FET to remain on during sleep when the bq34z653 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.

CSYNC — Enables the bq34z653 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)

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 %***.

CCT — This bit sets the formula for updating *Cycle Count*.

0 = The bq34z653 uses the ***CC Threshold*** value. (default)
1 = The bq34z653 uses ***CC %*** of *FullChargeCapacity*.

CHGSUSP — This bit enables the bq34z653 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)

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.

CHGIN — This bit enables the CHG FET and ZVCHG FET (if used) to turn off when the bq34z653 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.

NR — This bit configures the bq34z653 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.

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 bq34z653.

Table C-188. 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
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD!~	TemperatureSim!~	CHGOCV_DIS	CELL_TAPER
Low Byte	RSVD	CUV_RECOV_CHG	OCV_!~WGHT	LOCK_0	SUV_MODE	SHUTV	PRE_ZT_PF_En	RSOCL

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

Figure C-8. Operation Cfg C

TemperatureSim — Controls whether the gauge runs a simulation when!~ the temperature changes by !~*Sim Temperature Delta*!~ ~~changes the temperature!~ changes by Sim Temperature Delta.~~!~.

0 = ~~!~0 = G~~!~The gauge does not necessarily run a simulation when!~ the temperature changes by!~ *Sim Temperature Delta*!~ ~~changes the temperature!~ changes by *Sim Temperature Delta*~~!~.
1 = ~~!~1 = G~~!~The gauge runs a simulation when!~ the temperature changes by !~*Sim Temperature Delta*!~ ~~changes the temperature changes!~ by *Sim Temperature Delta*~~!~.

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 = !~An OCV reading is not taken when under the flat volt max and having come from charge.
1 = !~An 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 tapper voltage
1 = Cell voltage-based tapper 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 !~an 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 = !~E!~An evaluation of the accuracy of each state of charge reading from OCV during relaxation is disabled.

1 = !~An e!~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* ≤ ***Shutdown Voltage*** AND *Current* ≤ 0 for a period greater than ***Shutdown Time***.

1 = Shutdown occurs when Min (*CellVoltage4..1*) ≤ ***Cell Shutdown Voltage*** and *Current* ≤ 0 for a period greater than ***Cell Shutdown Time***.

PRE_ZT_PF_En — This bit enables or disables permanent failures from occurring before 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.

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.

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-189. 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
High Byte	RSVD	XVSHUT	XSUV	XSOPT1	XSOCD	XSOCC	XAFE_P	XAFE_C
Low Byte	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 bq34z653 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.

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-190. 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
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	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 bq34z653 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-191. 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
High Byte	RSVD	RSVD	OCD	OCC	RSVD	RSVD	RSVD	RSVD
Low Byte	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

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-192. 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
Low Byte	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 LCD flashing time period at a 50% duty cycle for alarm conditions.

Table C-193. 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	500 µs

C.8.1.2 LED Blink Period (Offset 2)

This value sets the LCD blinking time period to a 50% duty cycle for the LCD indicating the highest actual charge of the battery.

Table C-194. 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	500 µs

C.8.1.3 LED Delay (Offset 4)

This setting is not used in this device.

NOTE: ***LED Delay*** does not apply to the LCD.

Table C-195. LED Delay

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
67	LED Cfg	4	LED Delay	Unsigned integer	2	1	65,535	100	500 µs

C.8.1.4 LED Hold Time (Offset 6)

This setting is not used in this device.

Table C-196. 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

C.8.1.5 CHG Flash Alarm (Offset 7)

If the bq34z653 is in CHARGE mode ([DSG] = 0) and the battery charge is below this threshold the remaining enabled LCD segments start flashing at LED Flash Period. Set to –1 to disable this feature.

Table C-197. 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	%

C.8.1.6 CHG Thresh1 (Offset 8)

If the bq34z653 is in CHARGE mode ([DSG] = 0) and the battery charge is below this threshold, LCD segment 1 is disabled.

Table C-198. 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	%

C.8.1.7 CHG Thresh 2 (Offset 9)

If the bq34z653 is in CHARGE mode ([DSG] = 0) and the battery charge is below this threshold, LCD segment 2 is disabled.

Table C-199. 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	%

C.8.1.8 CHG Thresh 3 (Offset 10)

If the bq34z653 is in CHARGE mode ([DSG] = 0) and the battery charge is below this threshold, LCD segment 3 is disabled.

Table C-200. 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	%

C.8.1.9 CHG Thresh 4 (Offset 11)

If the bq34z653 is in CHARGE mode ([DSG] = 0) and the battery charge is below this threshold, LCD segment 4 is disabled.

Table C-201. 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	%

C.8.1.10 CHG Thresh 5 (Offset 12)

If the bq34z653 is in CHARGE mode ([DSG] = 0) and the battery charge is below this threshold, LCD segment 5 is disabled.

Table C-202. 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	%

C.8.1.11 DSG Flash Alarm (Offset 13)

If the bq34z653 is in DISCHARGE mode ([DSG] = 1) and the battery charge is below this threshold, the remaining enabled LCD segments start flashing with ***LED Flash Period***. Set to –1 to disable this feature..

Table C-203. 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	%

C.8.1.12 DSG Thresh 1 (Offset 14)

If the bq34z653 is in DISCHARGE mode ([DSG] = 1) and the battery charge is below this threshold, LCD segment 1 is disabled.

Table C-204. 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	%

C.8.1.13 DSG Thresh 2 (Offset 15)

If the bq34z653 is in DISCHARGE mode ([DSG] = 1) and the battery charge is below this threshold, LCD segment 2 is disabled.

Table C-205. 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	%

C.8.1.14 DSG Thresh 3 (Offset 16)

If the bq34z653 is in DISCHARGE mode ([DSG] = 1) and the battery charge is below this threshold, LCD segment 3 is disabled.

Table C-206. 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	%

C.8.1.15 DSG Thresh 4 (Offset 17)

If the bq34z653 is in DISCHARGE mode ([DSG] = 1) and the battery charge is below this threshold, LCD segment 4 is disabled.

Table C-207. 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	%

C.8.1.16 DSG Thresh 5 (Offset 18)

If the bq34z653 is in DISCHARGE mode ([DSG] = 1) and the battery charge is below this threshold, LCD segment 5 is disabled.

Table C-208. 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	%

C.8.1.17 Sink Current (Offset 19)

This setting is not used in this device.

NOTE: Sink Current does not apply to the LCD.

Table C-209. 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
Low Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	ILED1	ILED0

LEGEND: RSVD = Reserved and must be programmed to 0

Table C-210. 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.8.1.18 LCD RFSH (Offset 20)

The LCD RFSH parameter is the LCD refresh frequency register.

Table C-211. LCD RFSH

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Units
67	LED Cfg	20	LCD Refresh	Unsigned Integer	1	0	255	60	Hz

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-212. 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

C.9.1.2 Shutdown Voltage (Offset 2)

The bq34z653 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-213. 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

C.9.1.3 Shutdown Time (Offset 4)

The bq34z653 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-214. 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

C.9.1.4 Cell Shutdown Voltage (Offset 5)

The bq34z653 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-215. 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

C.9.1.5 Cell Shutdown Time (Offset 7)

The bq34z653 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-216. 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

C.9.1.6 Charger Present (Offset 8)

The bq34z653 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-217. 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

C.9.1.7 Sleep Current (Offset 10)

The bq34z653 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 bq34z653 returns to NORMAL mode.

Table C-218. 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

C.9.1.8 Bus Low Time (Offset 12)

The bq34z653 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-219. 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

C.9.1.9 Cal Inhibit Temp Low (Offset 13)

The bq34z653 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-220. 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

C.9.1.10 Cal Inhibit Temp High (Offset 15)

The bq34z653 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-221. 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

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-222. 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

C.9.1.12 Sleep Current Time (Offset 18)

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

Table C-223. 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

C.9.1.13 Wake Current Reg (Offset 19)

Wake Current Reg configures the current threshold required to wake the bq34z653 from SLEEP mode by detecting voltage across SRP and SRN.

Table C-224. 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
Low Byte	RSVD	RSVD	RSVD	RSVD	RSVD	IWAKE	RSNS1	RSNS0

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

Figure C-12. Wake Current Reg

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

0 = 0.5 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-225. Wake Current Reg

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

Table C-225. Wake Current Reg (continued)

RSNS1	RSNS0	Resistance
1	0	5 mΩ
1	1	10 mΩ

C.9.1.14 Sealed Ship Delay (Offset 20)

After the bq34z653 receives the two 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 bq34z653 enters SHIP mode (i.e., two times ***Sealed Ship Delay*** after the two commands.

Table C-226. 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

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

Table C-227. 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	

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-228. 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	

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-229. 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

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-230. 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

C.10.1.5 User Rate–10 mW (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-231. 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-10 mW	Integer	2	–32,768	0	0	10 mW

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-232. 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

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-233. 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

C.10.1.8 Ra Max Delta (Offset 88)

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

Table C-234. 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

C.10.2 Current Thresholds (Subclass 81)

C.10.2.1 Dsg Current Threshold (Offset 0)

The bq34z653 enters DISCHARGE mode from relaxation mode or CHARGE mode if *Current* < ***(–)Dsg Current Threshold***.

Table C-235. 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

C.10.2.2 Chg Current Threshold (Offset 2)

The bq34z653 enters CHARGE mode from relaxation mode or DISCHARGE mode if *Current* > ***Chg Current Threshold***.

Table C-236. 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

C.10.2.3 Quit Current (Offset 4)

The bq34z653 enters relaxation mode from CHARGE mode if *Current* goes below ***Quit Current*** for a period of ***Chg Relax Time***. The bq34z653 enters relaxation mode from DISCHARGE mode if *Current* goes above ***(–)Quit Current*** for a period of ***Dsg Relax Time***.

Table C-237. 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

C.10.2.4 Dsg Relax Time (Offset 6)

The bq34z653 enters relaxation mode from DISCHARGE mode if *Current* goes above ***(–)Quit Current*** for at least ***Dsg Relax Time***.

Table C-238. 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

C.10.2.5 Chg Relax Time (Offset 7)

The bq34z653 enters relaxation mode from CHARGE mode if *Current* goes below ***Quit Current*** for at least ***Chg Relax Time.***

Table C-239. 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

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-240. 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

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-241. 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

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 are disabled (default).
0x02 = QMAX and Ra table have been updated.
0x04 = Impedance Track algorithm and lifetime data updating are 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 are enabled.
0x0e = QMAX has been updated with FC set and qualified OCV in discharge and charge.

Table C-242. 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	

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-243. 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						

C.10.3.5 Avg I Last Run (Offset 21)

The bq34z653 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-244. 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

C.10.3.6 Avg P Last Run (Offset 23)

The bq34z653 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-245. 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

C.10.3.7 Delta Voltage (Offset 25)

The bq34z653 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-246. 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

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-247. 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

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-248. 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

C.11 Ra Table

C.11.1 R_a0 (Subclass 88)

C.11.1.1 Cell0 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in 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-249. 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	

C.11.1.2 Cell0 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 0 in this table.

Table C-250. 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^{-10} 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	

C.11.2 R_a1 (Subclass 89)

C.11.2.1 Cell1 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in 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-251. 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	

C.11.2.2 Cell1 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 1 in this table.

Table C-252. 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} Ω
		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	

C.11.3 R_a2 (Subclass 90)

C.11.3.1 Cell2 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Tell 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-253. 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	

C.11.3.2 Cell2 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 2 in this table.

Table C-254. 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} Ω
		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	

C.11.4 R_a3 (Subclass 91)

C.11.4.1 Cell3 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in 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-255. 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	

C.11.4.2 Cell3 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 3 in this table.

Table C-256. 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} Ω
		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	

C.11.5 R_a0x (Subclass 92)

C.11.5.1 xCell0 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in 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-257. 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	

C.11.5.2 xCell0 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 0 in this table.

Table C-258. 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^{-10} 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	

C.11.6 R_a1x (Subclass 93)

C.11.6.1 xCell1 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in 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-259. 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	

C.11.6.2 xCell1 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 1 in this table.

Table C-260. 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^{-10} 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	

C.11.7 R_a2x (Subclass 94)

C.11.7.1 xCell2 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in 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-261. 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	

C.11.7.2 xCell2 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 2 in this table.

Table C-262. 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^{-10} 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	

C.11.8 R_a3x (Subclass 95)

C.11.8.1 xCell3 R_a flag (Offset 0)

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

High Byte		Low Byte	
0x00	Cell impedance and QMAX updated	0x00	Table not used and QMAX updated
0x05	Relaxation mode and QMAX update in 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-263. 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	

C.11.8.2 xCell3 R_a 0..14 (Offset 2..30)

The bq34z653 stores and updates the impedance profile for cell 3 in this table.

Table C-264. 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^{-10} 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	

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 bq34z653 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-265. 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
High Byte	FBF	PFVSHUT	SUV	SOPT1	SOCD	SOCC	AFE_P	ACE_C
Low Byte	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
High Byte	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Low Byte	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

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-266. 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	

C.12.1.3 PF Voltage (Offset 6)

When a permanent failure is detected, *Voltage* is captured and stored in ***PF Voltage***.

Table C-267. 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

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-268. 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

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-269. 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

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-270. 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

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-271. 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

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-272. 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

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-273. 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

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-274. 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	

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-275. 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

C.12.1.12 PF RC-10 mWh (Offset 24)

When a permanent failure is detected, *RemainingCapacity*, in 10 mWh, is captured and stored in ***PF-RC 10 mWh***.

Table C-276. PF RC-10 mWh

Subclass ID	Subclass Name	Offset	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
96	Device Status Data	24	PF RC–10 mWh	Integer	2	0	32,767	0	10 mWh

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-277. 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	

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-278. 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	

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-279. 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	

C.12.2 AFE Regs (Subclass 97)

When the bq34z653 detects a permanent failure, a complete copy of the AFE register values is stored in ***AFE Regs***.

Table C-280. 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-281. 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	

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-282. 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	

C.13.1.3 Ref Voltage (Offset 8)

This register value stores the AFE reference voltage in units of 50 μV.

Table C-283. 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-284. 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 bq34z653. It is not recommended to change this value.

Table C-285. 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-286. 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	

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-287. 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	

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 bq34z653. Use calibration routines to set this value.

Table C-288. 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	

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 bq34z653. Use calibration routines to set this value.

Table C-289. 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	—

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-290. 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

C.13.2.2 Voltage Signal (Offset 2)

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

Table C-291. 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	

C.13.2.3 Temp Signal (Offset 4)

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

Table C-292. 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	

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-293. 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	

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-294. 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-295. 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	

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-296. 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	

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-297. 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	

C.13.2.9 Cal Mode Timeout (Offset 17)

The bq34z653 exits CALIBRATION mode automatically after a ***Cal Mode Timeout*** period.

Table C-298. 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	—

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 bq34z653. The default values characterize the Semitec 103AT NTC thermistor.

NOTE: Do not modify these values without consulting TI.

Table C-299. 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 bq34z653. Do not modify these values without consulting TI.

Table C-300. 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 × *AverageCurrent* old + (1 – a) × *Current*

with:

a = <*Filter*> / 256; the time constant = 1 s/ln(1/a) (default 14.5 s)

Table C-301. 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

C.13.4.2 Deadband (Offset 1)

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

Table C-302. 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

C.13.4.3 CC Deadband (Offset 2)

This constant defines the deadband voltage for the measured voltage between the SR1 and SR2 pins used for capacity accumulation in units of 294 nV. Any voltages within ±***CC Deadband*** do not contribute to capacity accumulation.

Table C-303. 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

C.14 Data Flash Values

Table C-304. DATA FLASH VALUES

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW 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)

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
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
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

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
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
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

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
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	-
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

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
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
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	Overcharge Capacity	I2	0	4000	300	mAh
Charge Control	38	Charging Faults	15	Overcharge 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

Table C-304. 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	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)
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	10 mWh (mWh)
SBS Configuration	48	Data	26	Manuf Name	S21	x	x	Texas Instruments	-
SBS Configuration	48	Data	47	Device Name	S21	x	x	bq34z653	-
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	-

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
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	0123456789ABCDEF0123456789ABCDE	-
System Data	58	Manufacturer Info	32	Manuf. Block 1	S21	x	x	0123456789ABCDEF0123	-
System Data	58	Manufacturer Info	53	Manuf. Block 2	S21	x	x	0123456789ABCDEF0123	-
System Data	58	Manufacturer Info	74	Manuf. Block 3	S21	x	x	0123456789ABCDEF0123	-
System Data	58	Manufacturer Info	95	Manuf. Block 4	S21	x	x	0123456789ABCDEF0123	-
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	10 mW (mW)
System Data	59	Lifetime Data	18	Lifetime Max Dsg Power	I2	–32767	32767	–1500	10 mW (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	10 mW
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	60	Lifetime Temp Samples	0	LT Temp Samples	I4	0	140000000	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	500 µs
LED Support	67	LED Cfg	2	LED Blink Period	U2	0	65535	1024	500 µs
LED Support	67	LED Cfg	4	LED Delay	U2	1	65535	100	500 µs
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	%

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
LED Support	67	LED Cfg	16	DSG Thresh 3	I1	–1	101	40	%
LED Support	67	LED Cfg	17	DSG Thresh 4	I1	–1	101	60	%
LED Support	67	LED Cfg	18	DSG Thresh 5	I1	–1	101	80	%
LED Support	67	LED Cfg	19	Sink Current	U1	0	3	3	
Power	68	Power	0	Flash Update OK Voltage	I2	6000	20000	7500	mV
Power	68	Power	2	Shutdown Voltage	I2	5000	20000	7000	mV
Power	68	Power	4	Shutdown Time	U1	0	240	10	s
Power	68	Power	5	Cell Shutdown Voltage	I2	0	5000	1750	mV
Power	68	Power	7	Cell Shutdown Time	U1	0	240	10	s
Power	68	Power	8	Charger Present	I2	0	23000	3000	mV
Power	68	Power	10	Sleep Current	I2	0	100	10	mA
Power	68	Power	12	Bus Low Time	U1	0	255	5	s
Power	68	Power	13	Cal Inhibit Temp Low	I2	–400	1200	50	0.1°C (°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	10 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	10 mWh
Gas Gauging	80	IT Cfg	88	Ra Max Delta	I2	0	32000	44	mΩ
Gas Gauging	80	IT Cfg	91	!~Sim Temperature Delta	I2	0	100	5	°C
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	10 mW
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	10 mW
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^{-10} Ω
Ra Table	88	R_a0	4	Cell0 R_a 1	I2	41	41	41	2^{-10} Ω

Table C-304. 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	6	Cell0 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	88	R_a0	8	Cell0 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	88	R_a0	10	Cell0 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	88	R_a0	12	Cell0 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	88	R_a0	14	Cell0 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	88	R_a0	16	Cell0 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	88	R_a0	18	Cell0 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	88	R_a0	20	Cell0 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	88	R_a0	22	Cell0 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	88	R_a0	24	Cell0 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	88	R_a0	26	Cell0 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	88	R_a0	28	Cell0 R_a 13	I2	128	128	128	2^{-10} Ω
Ra Table	88	R_a0	30	Cell0 R_a 14	I2	378	378	378	2^{-10} Ω
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^{-10} Ω
Ra Table	89	R_a1	4	Cell1 R_a 1	I2	41	41	41	2^{-10} Ω
Ra Table	89	R_a1	6	Cell1 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	89	R_a1	8	Cell1 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	89	R_a1	10	Cell1 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	89	R_a1	12	Cell1 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	89	R_a1	14	Cell1 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	89	R_a1	16	Cell1 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	89	R_a1	18	Cell1 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	89	R_a1	20	Cell1 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	89	R_a1	22	Cell1 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	89	R_a1	24	Cell1 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	89	R_a1	26	Cell1 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	89	R_a1	28	Cell1 R_a 13	I2	128	128	128	2^{-10} Ω
Ra Table	89	R_a1	30	Cell1 R_a 14	I2	378	378	378	2^{-10} Ω
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^{-10} Ω
Ra Table	90	R_a2	4	Cell2 R_a 1	I2	41	41	41	2^{-10} Ω
Ra Table	90	R_a2	6	Cell2 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	90	R_a2	8	Cell2 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	90	R_a2	10	Cell2 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	90	R_a2	12	Cell2 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	90	R_a2	14	Cell2 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	90	R_a2	16	Cell2 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	90	R_a2	18	Cell2 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	90	R_a2	20	Cell2 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	90	R_a2	22	Cell2 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	90	R_a2	24	Cell2 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	90	R_a2	26	Cell2 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	90	R_a2	28	Cell2 R_a 13	I2	128	128	128	2^{-10} Ω
Ra Table	90	R_a2	30	Cell2 R_a 14	I2	378	378	378	2^{-10} Ω
Ra Table	91	R_a3	0	Cell3 R_a flag	H2	0x0	0x0	0xff55	-

Table C-304. 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	2	Cell3 R_a 0	I2	38	38	38	2^{-10} Ω
Ra Table	91	R_a3	4	Cell3 R_a 1	I2	41	41	41	2^{-10} Ω
Ra Table	91	R_a3	6	Cell3 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	91	R_a3	8	Cell3 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	91	R_a3	10	Cell3 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	91	R_a3	12	Cell3 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	91	R_a3	14	Cell3 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	91	R_a3	16	Cell3 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	91	R_a3	18	Cell3 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	91	R_a3	20	Cell3 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	91	R_a3	22	Cell3 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	91	R_a3	24	Cell3 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	91	R_a3	26	Cell3 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	91	R_a3	28	Cell3 R_a 13	I2	128	128	128	2^{-10} Ω
Ra Table	91	R_a3	30	Cell3 R_a 14	I2	378	378	378	2^{-10} Ω
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^{-10} Ω
Ra Table	92	R_a0x	4	xCell0 R_a 1	I2	41	41	41	2^{-10} Ω
Ra Table	92	R_a0x	6	xCell0 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	92	R_a0x	8	xCell0 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	92	R_a0x	10	xCell0 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	92	R_a0x	12	xCell0 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	92	R_a0x	14	xCell0 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	92	R_a0x	16	xCell0 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	92	R_a0x	18	xCell0 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	92	R_a0x	20	xCell0 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	92	R_a0x	22	xCell0 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	92	R_a0x	24	xCell0 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	92	R_a0x	26	xCell0 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	92	R_a0x	28	xCell0 R_a 13	I2	128	128	128	2^{-10} Ω
Ra Table	92	R_a0x	30	xCell0 R_a 14	I2	378	378	378	2^{-10} Ω
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^{-10} Ω
Ra Table	93	R_a1x	4	xCell1 R_a 1	I2	41	41	41	2^{-10} Ω
Ra Table	93	R_a1x	6	xCell1 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	93	R_a1x	8	xCell1 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	93	R_a1x	10	xCell1 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	93	R_a1x	12	xCell1 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	93	R_a1x	14	xCell1 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	93	R_a1x	16	xCell1 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	93	R_a1x	18	xCell1 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	93	R_a1x	20	xCell1 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	93	R_a1x	22	xCell1 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	93	R_a1x	24	xCell1 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	93	R_a1x	26	xCell1 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	93	R_a1x	28	xCell1 R_a 13	I2	128	128	128	2^{-10} Ω

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
Ra Table	93	R_a1x	30	xCell1 R_a 14	I2	378	378	378	2^{-10} Ω
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^{-10} Ω
Ra Table	94	R_a2x	4	xCell2 R_a 1	I2	41	41	41	2^{-10} Ω
Ra Table	94	R_a2x	6	xCell2 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	94	R_a2x	8	xCell2 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	94	R_a2x	10	xCell2 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	94	R_a2x	12	xCell2 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	94	R_a2x	14	xCell2 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	94	R_a2x	16	xCell2 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	94	R_a2x	18	xCell2 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	94	R_a2x	20	xCell2 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	94	R_a2x	22	xCell2 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	94	R_a2x	24	xCell2 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	94	R_a2x	26	xCell2 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	94	R_a2x	28	xCell2 R_a 13	I2	128	128	128	2^{-10} Ω
Ra Table	94	R_a2x	30	xCell2 R_a 14	I2	378	378	378	2^{-10} Ω
Ra Table	95	R_a3x	0	xCell3 R_a flag	H2	0xffff	0xffff	0xffff	-
Ra Table	95	R_a3x	2	xCell3 R_a 0	I2	38	38	38	2^{-10} Ω
Ra Table	95	R_a3x	4	xCell3 R_a 1	I2	41	41	41	2^{-10} Ω
Ra Table	95	R_a3x	6	xCell3 R_a 2	I2	43	43	43	2^{-10} Ω
Ra Table	95	R_a3x	8	xCell3 R_a 3	I2	44	44	44	2^{-10} Ω
Ra Table	95	R_a3x	10	xCell3 R_a 4	I2	42	42	42	2^{-10} Ω
Ra Table	95	R_a3x	12	xCell3 R_a 5	I2	42	42	42	2^{-10} Ω
Ra Table	95	R_a3x	14	xCell3 R_a 6	I2	45	45	45	2^{-10} Ω
Ra Table	95	R_a3x	16	xCell3 R_a 7	I2	48	48	48	2^{-10} Ω
Ra Table	95	R_a3x	18	xCell3 R_a 8	I2	49	49	49	2^{-10} Ω
Ra Table	95	R_a3x	20	xCell3 R_a 9	I2	52	52	52	2^{-10} Ω
Ra Table	95	R_a3x	22	xCell3 R_a 10	I2	56	56	56	2^{-10} Ω
Ra Table	95	R_a3x	24	xCell3 R_a 11	I2	64	64	64	2^{-10} Ω
Ra Table	95	R_a3x	26	xCell3 R_a 12	I2	74	74	74	2^{-10} Ω
Ra Table	95	R_a3x	28	xCell3 R_a 13	I2	128	128	128	2^{-10} Ω
Ra Table	95	R_a3x	30	xCell3 R_a 14	I2	378	378	378	2^{-10} Ω
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–10 mWh	I2	0	32767	0	10 mWh (mWh)
PF Status	96	Device Status Data	26	PF Chg Status	H2	0x0	0xffff	0x0	-

Table C-304. DATA FLASH VALUES (continued)

Class	Subclass ID	Subclass	Offset	Name	Data Type	Min Value	Max Value	Default Value	Units (EVSW Units)*
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	-
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 bq34z653
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 bq34z653; 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 bq34z653 to indicate charge (DSG= 0) or discharge (DSG=1)
DSG FET	Discharge FET, connected to the DSG pin of the bq34z653; 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 bq34z653 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
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	Precharge 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

Revision History

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

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

- Added the note in *Read This First* 7
- Deleted the *LED Current Configuration* section 41
- Changed *Liquid Crystal Display* 41
- Deleted the *LED Display Activation* section 41
- Deleted LED references in *Display Configuration* 41
- Changed parameter explanations 41
- Deleted the pin function description 42
- Changed display description 42
- Changed *Display Format* 42
- Deleted *LED Current Configuration* 43
- Changed the description of display, removed the table of Applicable Data Flash Parameters vs Display Type 43
- Deleted the *LED Display* section 43
- Deleted unused commands in *LEDs ON (0x0032)*, *LEDs OFF (0x0033)*, and *Display ON (0x0034)* 53
- Changed bit descriptions in Figure C-6 127
- Changed bit description 128
- Changed bit descriptions in Figure C-7 129
- Changed bit name 131
- Changed bit name 131
- Changed bit names and descriptions in *Operation Cfg C (Offset 4)* 131
- Changed parameter descriptions to reflect LCD rather than LED display 135
- Deleted the note related to LED operation 138

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