bq35100

Technical Reference Manual

Literature Number: SLUUBH1C
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Contents

Read This First

About This Manual

This technical reference manual (TRM) discusses the modules and peripherals of the bq35100 device, and how each is used to build a complete battery fuel gauge and end-of-service monitor. Content in this TRM complements, not supersedes, information in the *bq35100 Lithium Primary Battery Fuel Gauge and End-Of-Service Monitor Data Sheet* (SLUSCM6).

Notational Conventions

This document uses the following conventions:

- Hexadecimal numbers may be shown with the suffix h or the prefix 0x. For example, the following number is 40 hexadecimal (decimal 64): 40h or 0x40.
- Registers in this document are shown in figures and described in tables.
  - Each register figure shows a rectangle divided into fields that represent the fields of the register. Each field is labeled with its bit name, its beginning and ending bit numbers above, and its read/write properties with default reset value below. A legend explains the notation used for the properties.
  - Reserved bits in a register figure can have one of multiple meanings:
    - Not implemented on the device,
    - Reserved for future device expansion,
    - Reserved for TI testing,
    - Reserved configurations of the device that are not supported.
  - Writing non-default values to the Reserved bits could cause unexpected behavior and should be avoided.

Formatting in This Document

The following formatting convention is used in this document:

- SBS Commands: *italic* with parenthesis and no breaking spaces; for example, *RemainingCapacity()*
- Data Flash: *italic*, **bold**, and breaking spaces; for example, ***Design Capacity***
- Data Flash Bits: *italic* and **bold**; for example, ***[LED1]***
- Register Bits and Flags: *italic* and brackets; for example, *[TDA]*
- Modes and States: ALL CAPITALS; for example, UNSEALED

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Related Documentation From Texas Instruments

See the *bq35100 Lithium Primary Battery Fuel Gauge and End-Of-Service Monitor Data Sheet* (SLUSCM6).

For product information, visit the Texas Instruments website at http://www.ti.com/product/bq35100.

Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community— *TI's Engineer-to-Engineer (E2E) Community.* Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support— *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

Definitions

A *Battery Glossary* is available at the Battery University on ti.com.

Glossary

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

Introduction

The bq35100 Battery Fuel Gauge and End-Of-Service Monitor provides highly configurable fuel gauging for non-rechargeable lithium primary batteries—without requiring forced discharge of the battery. Built so that optimization is not necessary, the patented TI gauging algorithms support replaceable batteries and enable accurate results with ultra-low average power consumption through host control via the GAUGE ENABLE (GE) pin.

The fuel gauging functions use voltage, current, and temperature information to provide State-Of-Health (SOH) and End-Of-Service (EOS) data. The bq35100 device is only required to be powered long enough to gather data and to make calculations to support the selected algorithm and the frequency of updates required by the system.

The host can read the gathered data through a 400-kHz I^2C bus. An $\overline{\text{ALERT}}$ output is also available to interrupt the host, based on a variety of configurable options.

The device has extended capabilities, including:

- Fuel Gauge for Single- and Multi-Cell Primary (Non-Rechargeable) Batteries
- Supports Lithium Thionyl Chloride ($LiSOCl_2$) and Lithium Manganese Dioxide ($LiMnO_2$)
- Provides Four Configurable Algorithm Options:
  - Coulomb Accumulation (ACC)
  - State-Of-Health (SOH)
  - End-Of-Service (EOS)
- Ultra-Low Average Power Consumption Supported Through Gauge-Enable Control
- Accurate Coulomb Counter, Voltage, and Temperature Measurement Options
- I^2C Host Communication, Providing Battery Parameter and Status Access
- Configurable Host Interrupt
- Data Logging Options
- SHA-1 Authentication

Basic Measurement Systems

2.1 Voltage

The bq35100 device measures the BAT input using the integrated delta-sigma ADC, which is scaled by the internal translation network, through the ADC. The measured voltage is available through *Voltage()*, and is updated for the host to read once per second. The translation gain function is determined by a calibration process. See *Factory Calibration* for further details.

In systems where the battery voltage is greater than $V_{IN(BAT)}$ MAX (for example, 2-series cell or more), an external voltage scaling circuit is required. If ***[EXTVCELL]*** is set, then the voltage is measured via the VIN pin. The input to VIN must be scaled to a maximum of 1 V.

The VEN pin can be used to enable and disable the external divider to conserve power. The firmware will then scale this < 1-V value to reflect an average cell value, and then again by the number of series cells to reflect the full battery voltage value.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Gas gauging	Design	Series cell count	Integer	1	1	8	1	Count

The configured battery voltage measurement is made available through the *Voltage()* command.

2.2 Temperature

The device can measure temperature through an integrated temperature sensor or an external NTC thermistor using the integrated delta-sigma ADC. Only one source can be used for gauging and the selection is made by setting ***Operation A [TEMPS]*** appropriately. The resulting measured temperature is available through the *Temperature()* command, and is updated for the host to read once per second. The internal temperature sensor is always measured in support of voltage measurement accuracy, and the result is also available through the *InternalTemperature()* command.

When an external thermistor is used, REG25 (pin 7) is used to bias the thermistor, and TS (pin 11) is used to measure the thermistor voltage (a pull-down circuit is implemented inside the device). The device then correlates the voltage to temperature, assuming the thermistor is a Semitec 103AT or similar device.

There is a configurable option for the host to write the temperature to the *Temperature()* command when ***[WRTEMP]*** = 1. This option is disabled by default.

2.3 Coulombs

The integrating delta-sigma ADC (coulomb counter) in the device measures the discharge flow of the battery by measuring the voltage drop across a small-value sense resistor between the SRP and SRN pins in a range from –0.125 V to 0.125 V. The device continuously monitors the measured current and integrates this value over time using an internal counter. This measurement is updated for the host to read once per second.

2.4 Current

For the primary battery current, the integrating delta-sigma ADC in the device measures the discharge current of the battery by measuring the voltage drop across a small-value sense resistor between the SRP and SRN pins, and is available through the *Current()* command, and is updated for the host to read once per second.

The measured current also includes the current consumed by the device. To subtract this value from the reported current, a value programmed in ***EOS Gauge Load Current*** is subtracted for improved accuracy.

Current() = Actual Measured (SRP–SRN) Current – ***EOS Gauge Load Current***

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
EOS data	Values	EOS gauge load current	Integer	1	1	255	35	0.01 mA

Factory Calibration

The bq35100 fuel gauge requires factory calibration. The gauge performs only a limited number of calibration functions. The rest must be performed by a host system using commands provided by the gauge for this purpose. The following sections give a detailed description of the various calibration sequences with the help of flowcharts.

3.1 General I²C Command Information

In the following flowcharts, all I²C functions take three arguments.

Write command arguments:

- Address
- Data
- Wait time in ms

Read command arguments:

- Address
- Number of bytes read
- Wait time in ms

3.2 Calibration Overview

3.2.1 Method

The calibration method is broken up into the following sections. The first four sequences are subroutines to be used in the main calibration sequences. Once in CALIBRATION mode, it is important to perform voltage calibration first.

- Section 3.3, *Enter CALIBRATION Mode*
- Section 3.4, *Voltage Calibration*
- Section 3.5, *CC Offset*
- Section 3.6, *Board Offset*
- Section 3.7, *Obtain Raw Calibration Data*
- Section 3.8, *Current Calibration*
- Section 3.9, *Temperature Calibration*
- Section 3.10, *Floating Point Conversion*
- Section 3.11, *Exit CALIBRATION Mode*

3.2.2 Sequence

Perform the following calibration sequence during battery pack manufacturing process:

1. Perform Voltage Calibration.
2. Perform CC Offset.
3. Perform Board Offset.
4. Perform Current Calibration.
5. Perform Temperature Calibration.

6. Write calibration results to data flash.

3.3 Enter CALIBRATION Mode

The bq35100 device must be enabled (GE High) and in ACC mode (***Operation Config A [GMSEL1:0]*** = 00) AND the *GAUGE_START()* command should have been sent. When using bqStudio, these steps are automatic.

This sequence puts the gauge into CALIBRATION mode. These steps must be performed when the gauge is in UNSEALED mode.

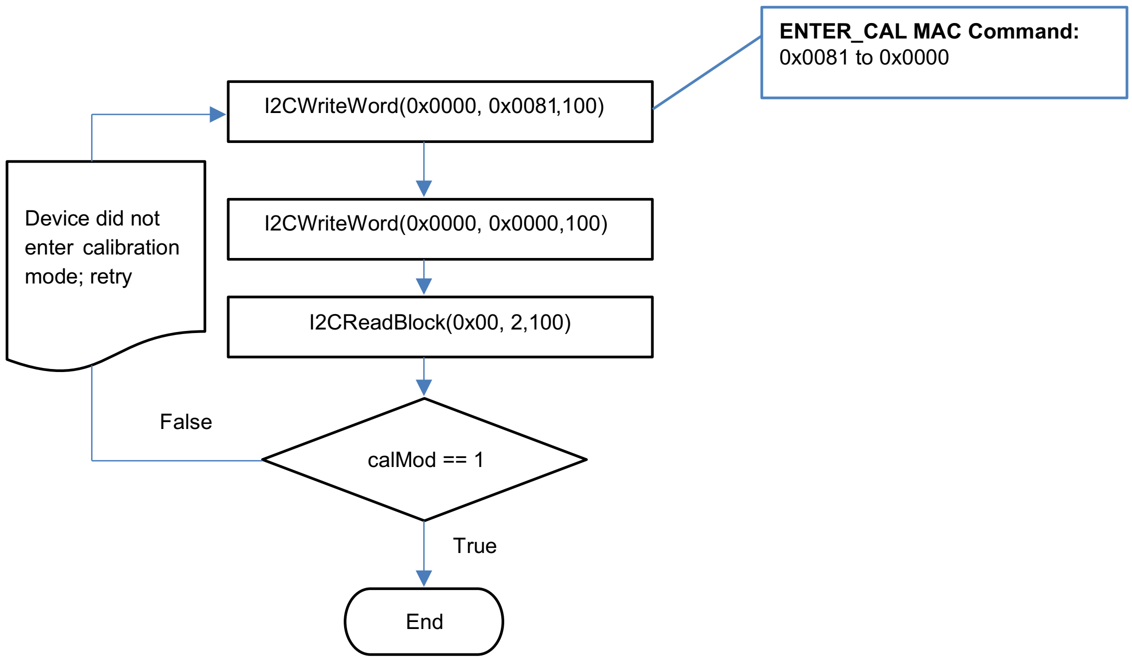


Figure 3-1. Enter CALIBRATION Mode Flow

3.4 Voltage Calibration

A known voltage must be applied to the device for voltage calibration, but the voltage can be measured in two different ways. See *Voltage* for more details.

The bq35100 device is default-configured to use the BAT input for voltage measurement, and the data used for calibration is made available through the calibration commands in units of millivolts (mV). In this setup, the calculated voltage offset must be written to the corresponding location in DF. The voltage offset is represented by an integer that is a single byte in size and can be written to the appropriate location in DF without any intermediate steps. The host system must ensure that the fuel gauge is UNSEALED.

The device has the option to use an external voltage divider circuit where the voltage is measured through the VIN pin, and the data used for calibration is made available through the calibration commands. In this setup, there is no user offset required and the reported RawVoltage is actually ***RawADCounts***. The gain of the voltage translation circuit needs to be calculated and stored, where: $V_{cellGain} = (V_{cal}/\textbf{\textit{RawADCounts}}) \times 65536$. This resulting integer is written to $\textbf{\textit{VIN}}_{Gain}$.

NOTE: The step labeled **Obtain avgRawVoltage** refers to Section 3.7, *Obtain Raw Calibration Data*.

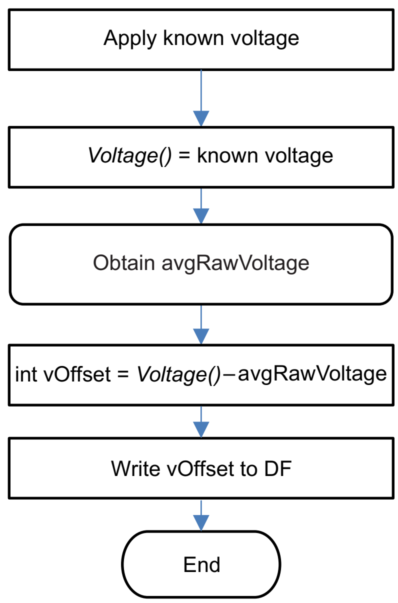


Figure 3-2. Voltage Calibration Flow

3.5 CC Offset

Use MAC commands for ***CC Offset*** calibration. The host system does not need to write information to the data flash (DF). See *CONTROL_STATUS: 0x0000* for the description of the *CONTROL_STATUS[CCA]* bit. The host system must ensure that the fuel gauge is UNSEALED.

NOTE: While the device is calibrating the ***CC Offset***, the host system must not read the *CONTROL_STATUS* register at a rate greater than once every 0.5 seconds and no current should be flowing.

The step labeled **Enter CALIBRATION Mode** refers to Section 3.3, *Enter CALIBRATION Mode*.

The step labeled **Exit CALIBRATION Mode** refers to Section 3.11, *Exit CALIBRATION Mode*.

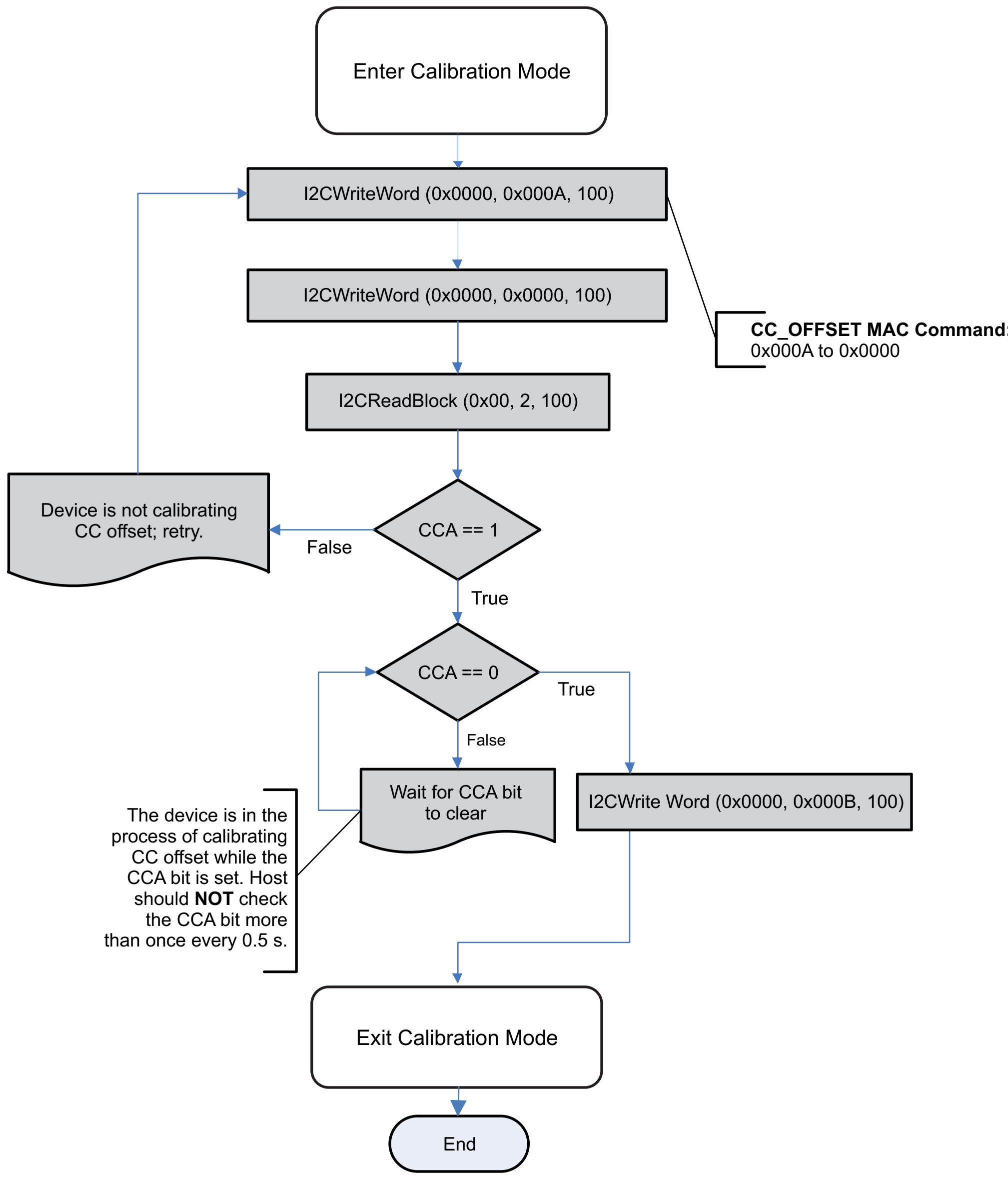


Figure 3-3. CC Offset Flow

3.6 Board Offset

Use MAC commands for ***Board Offset*** calibration. The host system does not need to write information to the DF. The host system must ensure that the fuel gauge is UNSEALED. See *CONTROL_STATUS: 0x0000* for the description of the *CONTROL_STATUS[CCA]* and *[BCA]* bits.

NOTE: While the device is calibrating the ***Board Offset***, the host system should not read the *CONTROL_STATUS()* register at a rate greater than once every 0.5 seconds and no current should be flowing.

The step labeled **Enter CALIBRATION Mode** refers to Section 3.3, *Enter CALIBRATION Mode*.

The step labeled **Exit CALIBRATION Mode** refers to Section 3.11, *Exit CALIBRATION Mode*.

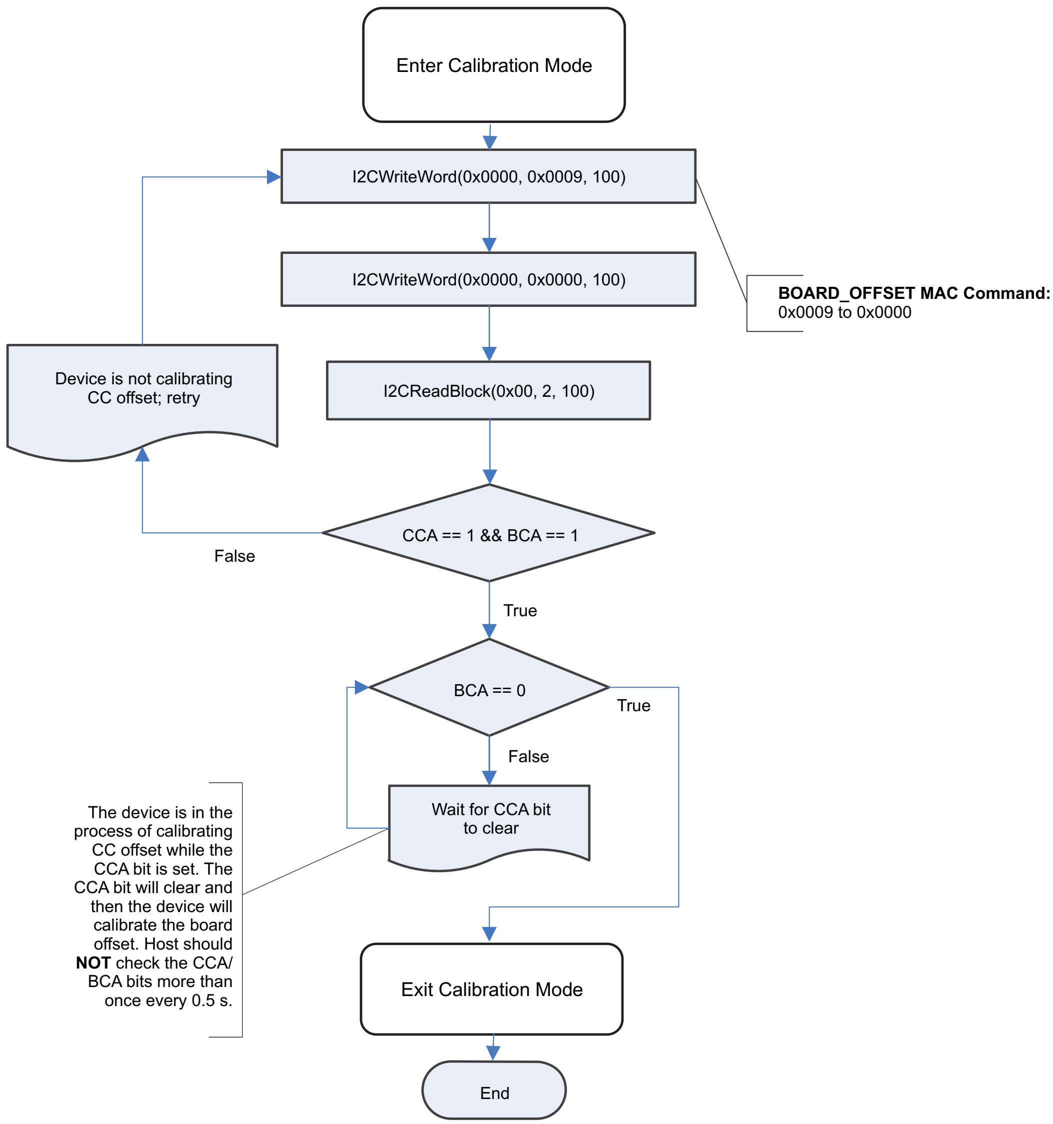


Figure 3-4. Board Offset Flow

3.7 Obtain Raw Calibration Data

The following flowchart demonstrates how the host system obtains the raw data to calibrate current, voltage, and temperature. The host system uses this flow in conjunction with the current, voltage, and temperature flows described in this chapter. It is recommended that the host system samples the raw data multiple times at a rate of once per second to obtain an average of the raw current, voltage, and temperature. The host system must ensure that the fuel gauge is UNSEALED.

NOTE: The step labeled **Enter CALIBRATION Mode** refers to Section 3.3, *Enter CALIBRATION Mode*.

The step labeled **Exit CALIBRATION Mode** refers to Section 3.11, *Exit CALIBRATION Mode*.

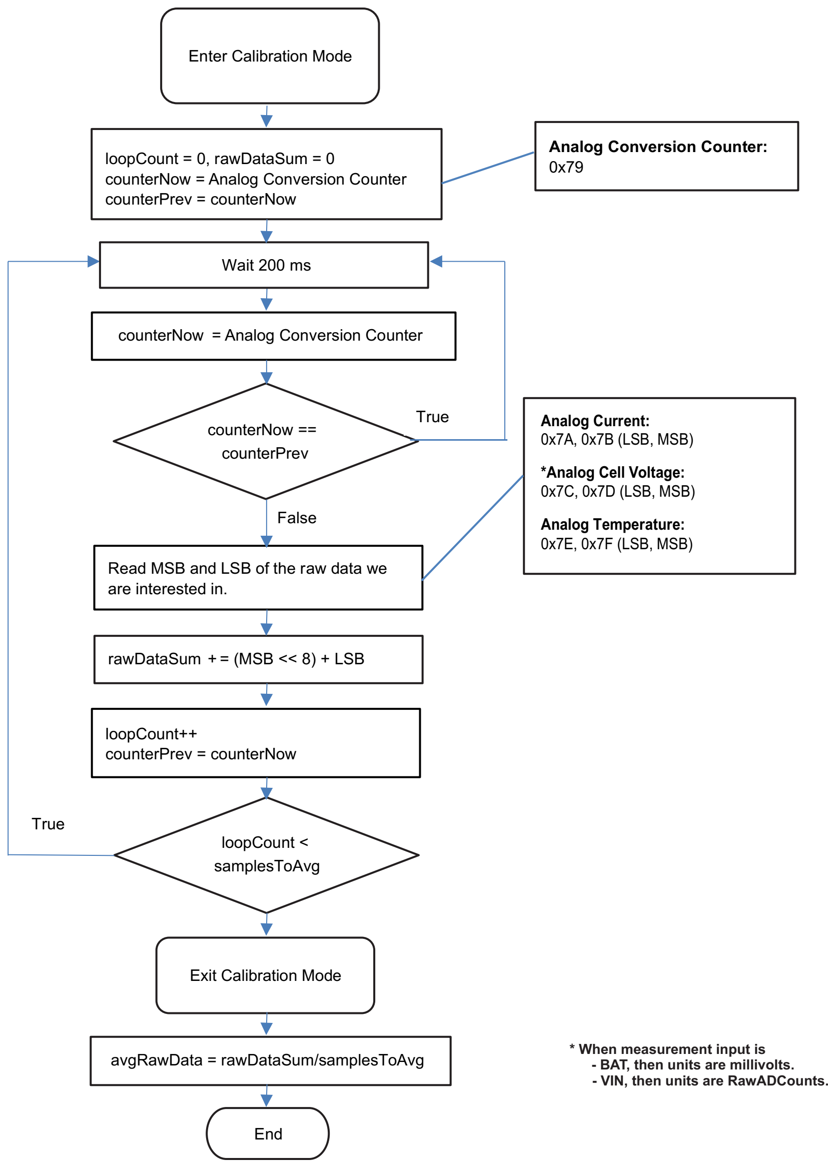


Figure 3-5. Obtain Raw Calibration Data Flow

3.8 Current Calibration

CC Gain and ***CC Delta*** are two calibration parameters of concern for current calibration. A known load, typically 1000 mA, is applied to the device during this process. Details on converting the ***CC Gain*** and ***CC Delta*** to floating point format are in *Floating Point Conversion*. The host system must ensure that the fuel gauge is UNSEALED.

NOTE: The step labeled **Obtain avgRawCurrent** refers to Section 3.7, *Obtain Raw Calibration Data*.

The step labeled **Convert ccGain and ccDelta to Gauge's floating point representation and write to DF** refers to Section 3.10, *Floating Point Conversion*.

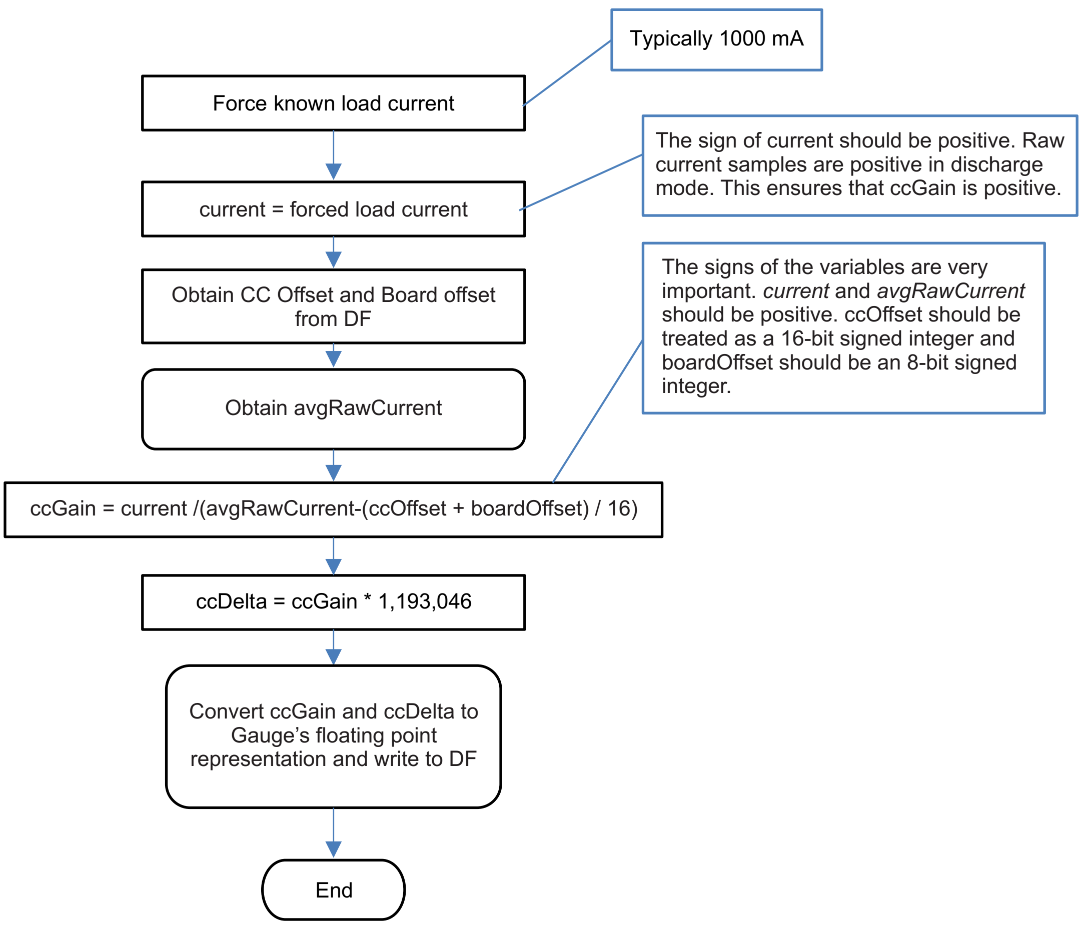


Figure 3-6. Current Calibration Flow

3.9 Temperature Calibration

This feature calibrates the internal temperature and the external temperature sensor if the source is set by ***Operation Config A [TEMPS]***. A known temperature must be applied to the device for temperature calibration. The calculated temperature offset is written to the corresponding location in DF. The temperature offset is represented by an integer that is a single byte in size and can be written to the appropriate location in DF without any intermediate steps. The host system must ensure that the fuel gauge is UNSEALED.

NOTE: a) The step labeled **Obtain avgRawTemp** refers to Section 3.7, *Obtain Raw Calibration Data*.

b) When using bqStudio, ensure that the selected calibration of Internal or External temperature matches the setting on the ***[TEMPS]*** selection.

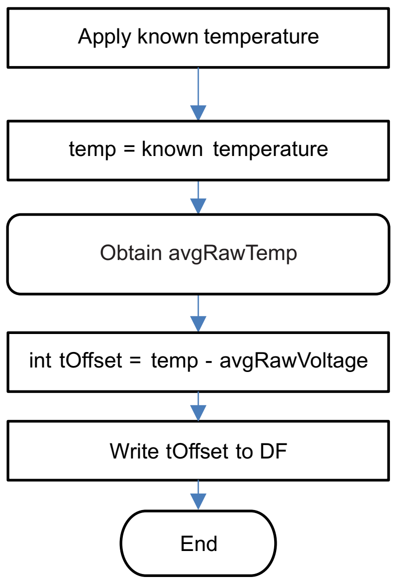
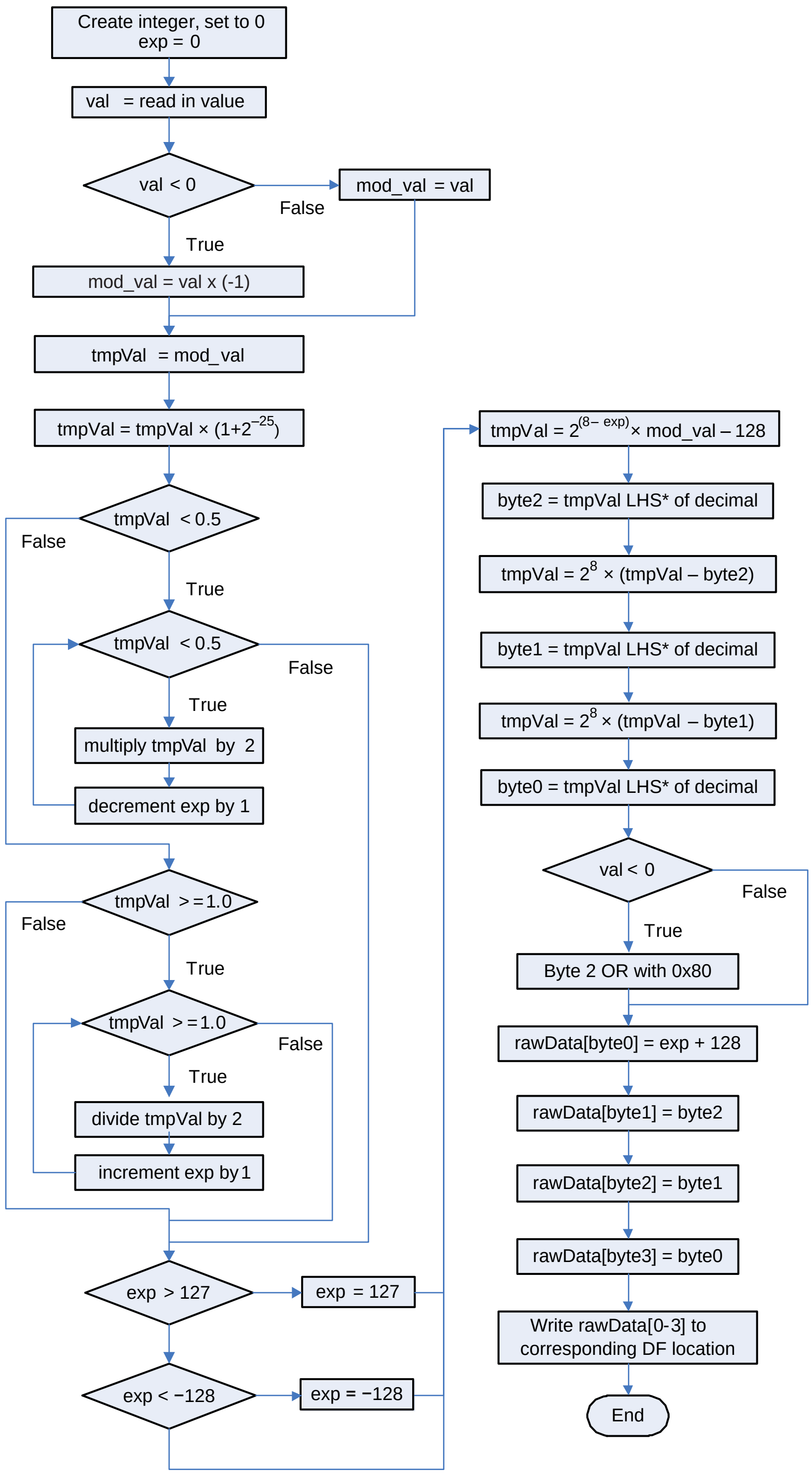


Figure 3-7. Temperature Calibration Flow

3.10 Floating Point Conversion

This section details how to convert the floating point ***CC Gain*** and ***CC Delta*** values to the format recognized by the gauge.



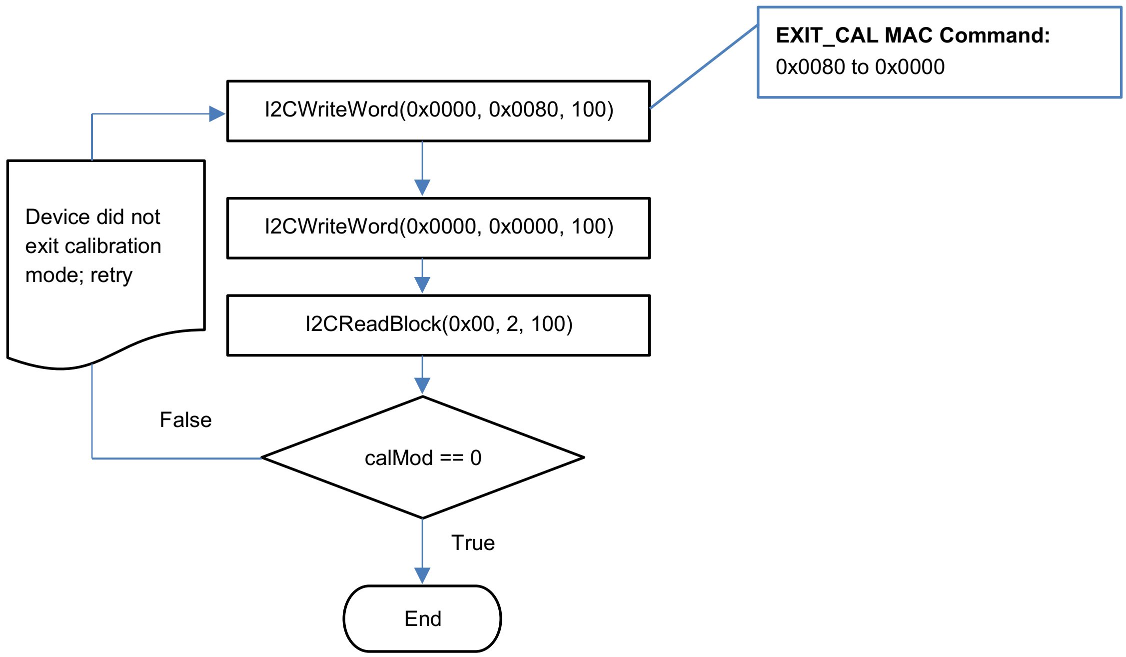
* LHS is an abbreviation for Left-Hand Side. This refers to truncating the floating point value by removing anything to the right of the decimal point.

Figure 3-8. Floating Point Conversion Flow

3.11 Exit CALIBRATION Mode

This sequence takes the gauge out of CALIBRATION mode. These steps must be performed when the gauge is in UNSEALED mode.

NOTE: It is recommended to reset the gauge after calibration is completed to ensure all measurements are taken using the new calibration.



Basic Configuration

4.1 Operation Config A

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Registers	Operation Config A	Hex	1	0x00	0xff	0x80	—

7	6	5	4	3	2	1	0
TEMPS	EXTVCELL	WRTEMP	LF_EN	RSVD	GNDSEL	GMSEL1	GMSEL0

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

TEMPS (Bit 7): Enables the external temperature sensor (TS)
1 = External Temperature Sensor is enabled.
0 = Internal temperature sensor is enabled.

EXTVCELL (Bit 6): Enables the external cell voltage translation measurement (VEN, VIN)
1 = External cell voltage translation measurement is used.
0 = Internal cell voltage translation measurement is used.

WRTEMP (Bit 5): Enables host to write the temperature to the gauge
1 = Enabled
0 = Disabled

LF_EN (Bit 4): Enables the Lifetime Data gathering feature
1 = Enabled
0 = Disabled

RSVD (Bit 3): Reserved. Do not use.

GNDSEL (Bit 2): Enables the use of SRN as GND for the ADC conversions
1 = ADC Ground is SRN.
0 = ADC Ground is SRP.

GMSEL1:0 (Bit 1, Bit 0): Enables specific gauging mode
0 0 = Enables ACCUMULATOR mode
0 1 = Enables STATE-OF-HEALTH VOLTAGE CORRELATION mode for $LiMnO_2$
1 0 = Enables END-OF-SERVICE RESISTANCE CORRELATION mode for $LiSOCl_2$
1 1 = Invalid setting, do not use.

Battery Gauging

The bq35100 device can operate in three distinct modes: ACCUMULATOR (ACC) mode, STATE-OF-HEALTH (SOH) mode, and END-OF-SERVICE (EOS) mode. The device can be configured and used for only one of these modes in the field, as it is not intended to be able to actively switch between modes when in normal use.

5.1 ACCUMULATOR Mode

In this mode, the bq35100 device measures and updates cell voltage, cell temperature, and load current every 1 s and begins accumulating after *GAUGE_START* is received. This data is provided through the I^2C interface while *ControlStatus() [GA]* is set.

This mode is enabled when ***[GMSEL1:0]*** in ***Operation Config A*** = 00.

5.1.1 Total Capacity Update

When in ACCUMULATOR mode, the bq35100 device tracks and then stores the total accumulated capacity to its internal data flash.

> **CAUTION**
>
> Care should be taken when enabling and using this feature to ensure that the maximum number of writes, which is 200,000, is not exceeded. For example, this translates to no more than 25 writes per day over 20 years.

When the GE pin is asserted, the device will update *AccumulatedCapacity()* from the value stored in data flash. When *ControlStatus() [GA]* is set, the device adds each coulomb counter measurement to the value of *AccumulatedCapacity()*.

Sending the *GAUGE_STOP()* command prior to the GE pin being pulled low initiates the latest value of *AccumulatedCapacity()* to be written to data flash memory. As this operation takes a finite amount of time, the gauge will assert *[G_DONE]* in *ControlStatus()* and can optionally trigger the $\overline{\text{ALERT}}$ pin to inform the host when the operation is complete.

5.2 STATE-OF-HEALTH (SOH) Mode

This mode is enabled when ***[GMSEL1:0]*** in ***Operation Config A*** = 01. This mode is suitable for determining SOH for Lithium Manganese Dioxide ($LiMnO_2$) chemistry. In this mode, cell voltage and temperature are precisely measured immediately after the GE pin is asserted. The gauge uses this data to compute SOH.

SOH = DOD(***TermV***) – DOD(OCV, temperature)

Where:

TermV is a DF constant determined by the manufacturer to be discharge voltage below which the cell cannot provide the power required by the device.

5.2.1 Low State-Of-Health Alert

BatteryStatus() [SOH_LOW] is set when *StateOfHealth()* is less than or equal to the value programmed in ***SOHLOW*** for a period of ***SOH Set Time***.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Discharge	SOHLOW	Integer	1	0	100	10	%
Configuration	Discharge	SOH Set Time	Integer	1	0	60	0	s
Configuration	Discharge	SOH Clear Threshold	Integer	1	0	100	10	%

When *BatteryStatus() [SOH_LOW]* is set, the device can optionally trigger the $\overline{\text{ALERT}}$ pin. *SOH_LOW* is cleared if *StateOfHealth()* is greater than ***SOH Clear Threshold***. See *Alert Signal* for more information.

The *GAUGE_START()* and *GAUGE_STOP()* commands can be used in this mode to detect a Battery Low Alert condition during a continuous discharge.

5.3 End-Of-Service (EOS) Mode

This mode is enabled when ***[GMSEL1:0]*** in ***Operation Config A*** = 10. This mode is suitable for gauging Lithium Thionyl Chloride ($LiSOCl_2$) cells. The End-Of-Service gauging algorithm uses voltage, current, and temperature data to determine the resistance (R) and rate of change of resistance of the battery. The resistance data is then used to find Depth of Discharge (DOD) = DOD(R). As above, SOH is determined and in turn used to determine the EOS condition.

When in this mode, a *GAUGE_START()* command should be issued prior to any major discharge activity. This will ensure that any major discharge pulses are used in the determination of the battery's condition.

Upon completion of any major discharge, the *GAUGE_STOP()* command should be sent to the device. The gauge will continue to collect data in a low power state for the number of seconds determined by ***R Data Seconds***. The device then completes any calculations and flash writes. Once these tasks are completed, then *[G_DONE]* is set and the device can be powered down.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
EOS Data	Values	R Data Seconds	U1	1	0	255	15	s

5.3.1 *Initial EOS Learning*

For optimal accuracy, the first event where the device updates its impedance value is required to be when the battery is full (a fresh battery). If the battery was partially discharged, then the accuracy of the EOS detection is compromised.

When a new battery is inserted, then the *NEW_BATTERY()* command should be sent to the device to ensure the initial learned resistance ***RNEW*** is refreshed correctly.

In some cases, it may be necessary to compensate for anode passivation effects if there is a delay between when the battery was conditioned for use and when the device is put into service. Several initial impedance readings can be discarded (to remove passivation effects) by setting an appropriate value for ***New Batt R Scale Delay***.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
EOS Data	Values	New batt R scale delay	Unsigned Integer	1	0	255	2	Readings
EOS Data	Values	R Table Scale	Integer	2	–1	–1	–1	—
EOS Data	Values	R Table Scale Update Flag	Hex	1	0x00	0xff	0xff	—

NOTE: Do not update ***R Table Scale*** and ***R TableScaleUpdateFlag***.

5.3.2 End-Of-Service Detection

The bq35100 device can detect when a sharp increase in the trend of tracked impedance occurs, indicating that the battery is reaching its end-of-service condition.

When in this mode, each time the *GAUGE_START()* command is received, then the internal counter "EOS Detection Pulse Count" is incremented. This internal value is stored to ***EOS Detection Pulse Count*** once *GAUGE_STOP()* is received.

NOTE: ***EOS Detection Pulse Count*** must be programmed to 0 prior to final system installation.

When the device has enough information to update ***Impedance***, the present value of ***Impedance*** is copied to ***Previous Impedance*** in preparation for the new ***Impedance*** value to be updated.

Using this data, the device monitors the trend through a moving average algorithm. For improved accuracy, it is recommended to gather new data on a fixed periodic base: for example, every 24 hours. As the device is powered down when not needed for EOS monitoring, it has no "time" information.

There are two moving average trends that are calculated after an ***Impedance*** update:

Short Trend Average = ***Impedance*** × 1/DF1 + ***Previous Impedance*** × (1–1/DF1) (1)

Long Trend Average = ***Impedance*** × 1/DF2 + ***Previous Impedance*** × (1–1/DF2) (2)

Where:

DF1 (50) and DF2 (100) are the time constants of the moving average.

The trend detection equation is:

Short Trend Average > ***Long Trend Average*** × (1 + ***EOS Trent Detection*** / 100) (3)

When this occurs the ***Battery Status [EOS]*** flag is set and cannot be cleared.

Where:

EOS Trent Detection is the % increase of ***Short Trend Average*** over ***Long Trend Average***.

For example: If ***EOS Trent Detection*** = 20, then the ***[EOS]*** flag is set when ***Short Trend Average*** is 120% × ***Long Trend Average***.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
EOS Data	Values	R short trend filter	Unsigned Int	1	1	255	251	—
EOS Data	Values	R long trend filter	Unsigned Int	1	1	255	253	—
EOS Data	Values	EOS trend detection	Unsigned Int	1	1	100	20	—
EOS Data	Values	EOS detection pulse count	Unsigned Int	2	1	20000	120	—
EOS Data	Values	EOS detection pulse count Thrhd	Unsigned Int	2	1	20000	120	—
EOS Data	Values	Short trend average	Unsigned Int	4	1	8355712	0	—
EOS Data	Values	Long trend average	Unsigned Int	4	1	8355712	0	—

5.3.3 End-Of-Service Smoothing

In EOS mode, the *State-Of-Health()* output is smoothed to provide a more stable output value that will converge, and not jump, at the terminate voltage. Smoothing occurs when *Voltage()* < ***EOS SOH Smooth Start Voltage***. The value of ***EOS SOH Smooth Start Voltage*** must be higher than ***Cell Terminate Voltage***.

NOTE: When EOS Smoothing is enabled, Lifetime Data gathering must also be enabled. This can be done by sending (*Control()* 0x002E *[LT_EN]*) and confirming that it is enabled when *OperationStatus()[LTEN]* = 1.

In EOS mode, the accuracy of the SOH reported value can vary significantly with a load profile. Perform in-system evaluation to determine the reported value at the desired EOS level. In some instances, the value of SOH should be ignored.

The ***Smoothing Margin*** can be set to control the rate of smoothing, but it is recommended to not change it.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Gas Gauging	Design	Cell Terminate Voltage	Integer	2	0	5000	2900	mV
EOS	Values	EOS SOH Smooth Start Voltage	Integer	2	0	5000	2800	mV
EOS Data	Values	EOS SOH Smoothing Margin	Integer	1	0	255	128	

Power Control

The bq35100 device has only one active power mode that is enabled through the GAUGE ENABLE (GE) pin. The power consumption of the bq35100 device can change significantly based on host commands that it receives and its default configuration, specifically with respect to data flash updates.

6.1 Device Functional Modes

The bq35100 device is intended for systems where the battery electronics are required to consume a very low average current. To achieve this, the device is intended to be fully powered off when not required through control of the GAUGE ENABLE pin.

When this pin is low, then the device is fully powered down where no measurements are made and no data, unless in flash, is retained. In this state, the power consumption of the device is a few 10s of nA. This value is primarily leakage of the device and other components on the board, but also includes measurement errors. Due to the level of possible variations, use a conservative value of 50 nA for example calculations.

An example system current profile is shown along with the state of GE to reduce the average power consumption of the battery electronics.

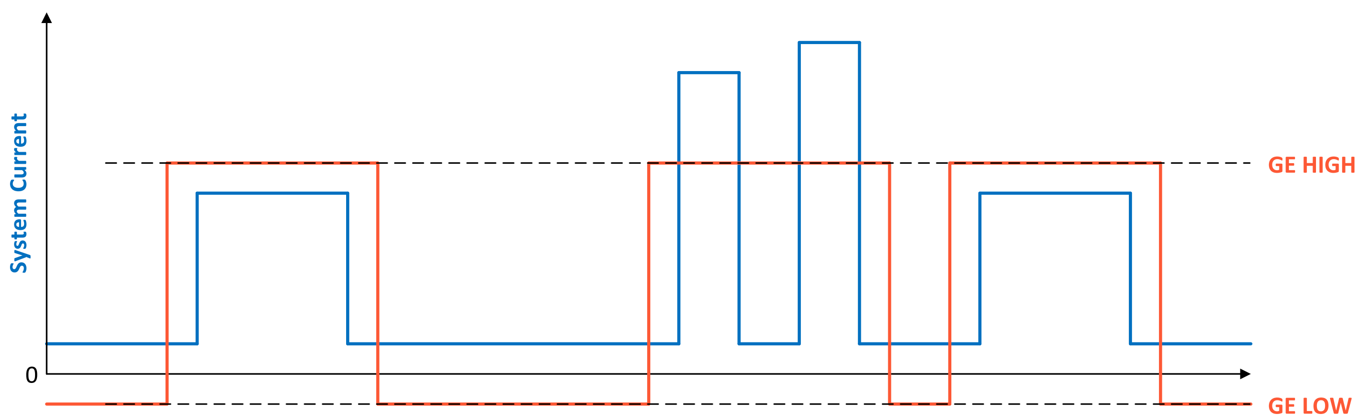


Figure 6-1. System Current Profile Example

The average power consumption of the bq35100 device is an average of the periods where GAUGE ENABLE is high AND low over a given period.

For example, if the system enters a high power state (315 µA) for 30 s every 4 hours, the average current will be:

$$315\ \mu A \times 30\ s / 4\ hrs = 0.66\ \mu A \quad (4)$$

When GAUGE ENABLE is low (GE = Low), then the device is powered off and the current is nominally I_{CC_GELOW} and is the leakage current into the REGIN pin. Other components connected to this node should also be evaluated to determine the "System Off" current total.

When the device is used for gas gauging, it transitions through several power states based on the selection of ***Operation Cfg A[GMSEL]***.

Figure 6-2 highlights the operational flow and conditional decisions.

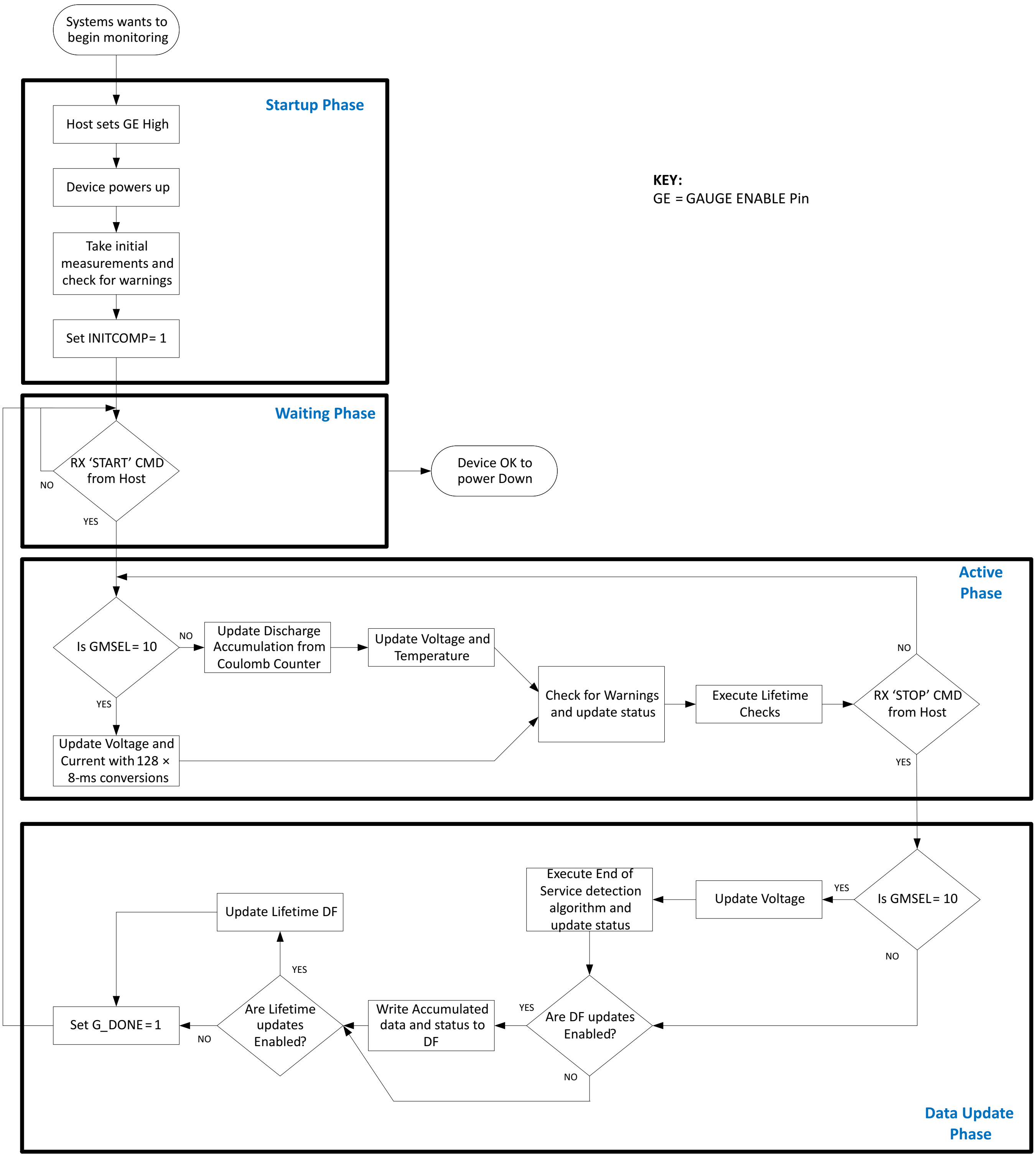


Figure 6-2. Operational Flow

6.2 Flash Updates

If enabled, data flash can only be updated if either of the two following conditions is true:

1. *ControlStatus() [GA]* = 1 AND *Voltage()* ≥ ***Flash Update OK Voltage***.
2. *ControlStatus() [GA]* = 0.

If enabled, data flash can only be updated if *Voltage()* ≥ ***Flash Update OK Voltage***. Flash programming current can cause an increase in LDO dropout. The value of ***Flash Update OK Voltage*** should be selected such that the device V_{CC} voltage does not fall below its minimum of 2.4 V during Flash write operations.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Power	Flash Update OK Voltage	Integer	2	0	4200	2800	mV

Battery Condition Warnings

7.1 Battery Low Warning

The bq35100 device can indicate and optionally trigger the $\overline{\text{ALERT}}$ pin when the primary battery voltage falls below a programmable threshold.

STATUS	CONDITION	ACTION
Normal	*Voltage()* > ***BatLow Voltage Set Threshold***	*BatteryAlert()[BATLOW]* = 0
Trip	*Voltage()* ≤ ***BatLow Voltage Set Threshold*** for ***BATLOW:Delay duration BatLow Voltage Set Time***	*BatteryAlert()[BATLOW]* = 1

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Discharge	BatLow Voltage Set Threshold	Integer	2	0	5000	2800	mV
Configuration	Discharge	BatLow Voltage Set Time	Integer	1	0	255	10	s

7.2 Temperature Low Warning

The bq35100 device can indicate and optionally trigger the $\overline{\text{ALERT}}$ pin when the primary battery temperature falls below a programmable threshold.

Status	Condition	Action
Normal	*Temperature()* > ***Under Temperature Set Threshold***	*BatteryAlert()[TEMPLOW]* = 0
Trip	*Temperature()* ≤ ***Under Temperature Threshold*** for ***TEMPLOW:Delay duration*** for ***Under Temperature Set Time duration***	*BatteryAlert()[TEMPLOW]* = 1
Recovery	*Temperature()* > ***Under Temperature Clear Threshold***	*BatteryAlert()[TEMPLOW]* = 0

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Discharge	Under Temperature Set Threshold	Signed Integer	2	–400	850	–200	0.1°K
Configuration	Discharge	Under Temperature Set Time	Integer	1	0	255	4	s
Configuration	Discharge	Under Temperature Clear Threshold	Integer	2	0	255	100	0.1°K

7.3 Temperature High Warning

The bq35100 device can indicate and optionally trigger the $\overline{\text{ALERT}}$ pin when the primary battery temperature rises above a programmable threshold.

STATUS	CONDITION	ACTION
Normal	*Temperature()* < ***OT Dsg Threshold***	*BatteryAlert()[TEMPHIGH]* = 0
Trip	*Temperature()* ≥ ***OT Dsg Threshold*** for ***OT Dsg Time duration***	*BatteryAlert()[TEMPHIGH]* = 1
Recovery	*Temperature()* < ***OT Dsg Recovery***	*BatteryAlert()[TEMPHIGH]* = 0

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Discharge	OT Dsg	Signed Integer	2	–400	850	450	0.1°K
Configuration	Discharge	OT Dsg Time	Integer	2	0	255	4	s
Configuration	Discharge	OT Dsg Recovery	Integer	2	0	255	100	0.1°K

7.4 Battery Low SOC Warning

The bq35100 device can indicate and optionally trigger the $\overline{\text{ALERT}}$ pin when the primary battery state-of-health (SOH) falls below a programmable threshold.

STATUS	CONDITION	ACTION
Normal	*StateOfHealth()* > ***SOH Low***	*BatteryStatus()[SOHLOW]* = 0
Trip	*StateOfHealth()* ≤ ***SOH Low***	*BatteryStatus()[SOHLOW]* = 1

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Discharge	SOH Low	Signed Integer	1	0	100	10	%
Configuration	Discharge	SOH Set Time	Signed Integer	1	0	100	10	%
Configuration	Discharge	SOH Clear Threshold	Signed Integer	1	0	100	10	%

7.5 Battery EOS OCV BAD Warning

The device assumes that when GE is asserted, the cell is at rest and uses the initialization voltage reading to determine the Open Circuit Voltage (OCV). If the cell was not fully relaxed at that point, then the voltage after the pulse could rise above the OCV. This causes an incorrect impedance to be calculated.

If the device measures a voltage value above the initial OCV, then it increments an internal counter. When this counter increments up to ***EOS Relax V Hi Max Counts***, then *[EOS_OCV_BAD]* is set in *CONTROL_STATUS()*.

If *[EOS_OCV_BAD]* becomes set, then the battery requires a longer time to rest and the device should be powered down (GE driven low). As a guideline, from the last major discharge, a rest of 5 hours should allow full relaxation.

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
EOS Data	Values	EOS Relax V Hi Max Counts	Integer	1	1	255	3	counts

ALERT Signal

The ALERT signal can be configured to be triggered by a variety of status conditions. When the ***ALERT Configuration*** bit is set AND the corresponding bit in *BatteryStatus()* or *ControlStatus()* is set, then the corresponding *BatteryAlert()* bit is set, triggering the ALERT signal.

For example: If *BatteryStatus() [BATLOW]* AND ***ALERT Configuration [BATLOW]*** = 1, then *BatteryAlert() [BATLOW]* is set and the ALERT pin is triggered.

The ALERT signal is cleared upon a read of *BatteryStatus()*.

Table 8-1. Data Flash ALERT Configuration

CLASS	SUBCLASS	NAME	TYPE	SIZE	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
Configuration	Registers	ALERT Configuration	Hex	1	0x00	0xff	0x00	—

7	6	5	4	3	2	1	0
BATLOW	TEMPLOW	TEMPHIGH	SOH_LOW	EOS	RSVD	G_DONE	INITCOMP

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

BATLOW (Bit 7): Battery voltage low condition
- 0 = ALERT is not triggered when BATLOW becomes set (default).
- 1 = ALERT is triggered when BATLOW becomes set.

TEMPLOW (Bit 6): Battery temperature low condition
- 0 = ALERT is not triggered when TEMPLOW becomes set (default).
- 1 = ALERT is triggered when TEMPLOW becomes set.

TEMPHIGH (Bit 5): Battery temperature high condition
- 0 = ALERT is not triggered when TEMPHIGH becomes set (default).
- 1 = ALERT is triggered when TEMPHIGH becomes set.

SOH_LOW (Bit 4): Low SOH State detected
- 0 = ALERT is not triggered when SOH_LOW becomes set (default).
- 1 = ALERT is triggered when SOH_LOW becomes set.

EOS (Bit 3): End-Of-Service state detected
- 0 = ALERT is not triggered when EOS becomes set (default).
- 1 = ALERT is triggered when EOS becomes set.

RSVD (Bit 2): Reserved. Do not use.

G_DONE (Bit 1): Gauge Done State reached
- 0 = ALERT is not triggered when G_DONE becomes set (default).
- 1 = ALERT is triggered when G_DONE becomes set.

INITCOMP (Bit 0): Initialization Complete
- 0 = ALERT is not triggered when INITCOMP becomes set (default).
- 1 = ALERT is triggered when INITCOMP becomes set.

Lifetime Data Collection

The bq35100 device can be enabled by writing to *Control()* 0x002E *[LT_EN]* to gather data regarding the primary battery and to store it to data flash.

The following data is collected in RAM and only written to DF when the host sends the ***End*** command to the device.

- Min and Max Cell Voltage
- Min and Max Discharge Current
- Min and Max Temperature

CLASS	SUBCLASS	NAME	TYPE	MIN	MAX	DEFAULT	UNIT
LTFlash	Voltage	Max	I2	0	32767	0	mV
LTFlash	Voltage	Min	I2	0	32767	0	mV
LTFlash	Current	Max Discharge	I2	0	32767	0	mA
LTFlash	Current	Min Discharge	I2	0	32767	0	mA
LTFlash	Temperature	Max Cell	I2	–128	127	0	°C
LTFlash	Temperature	Min Cell	I2	–128	127	0	°C
LTFlash	Temperature	Max Gauge	I2	–128	127	0	°C
LTFlash	Temperature	Min Gauge	I2	–128	127	0	°C

SHA-1 Authentication

10.1 Overview

As of March 2012, the latest revision is FIPS 180-4. SHA-1, or secure hash algorithm, is used to compute a condensed representation of a message or data also known as hash. For messages < 2^{64}, the SHA-1 algorithm produces a 160-bit output called a digest.

In a SHA-1 one-way hash function, there is no known mathematical method of computing the input given, only the output. The specification of SHA-1, as defined by FIPS 180-4, states that the input consists of 512-bit blocks with a total input length less than 264 bits. Inputs that do not conform to integer multiples of 512-bit blocks are padded before any block is input to the hash function. The SHA-1 algorithm outputs the 160-bit digest.

The device generates a SHA-1 input block of 288 bits (total input = 160-bit message + 128-bit key). To complete the 512-bit block size requirement of the SHA-1 function, the device pads the key and message with a 1, followed by 159 0s, followed by the 64-bit value for 288 (000...00100100000), which conforms to the pad requirements specified by FIPS 180-4.

- http://www.nist.gov/itl/
- http://csrc.nist.gov/publications/fips
- www.faqs.org/rfcs/rfc3174.html

10.2 HMAC Description

The SHA-1 engine calculates a modified HMAC value. Using a public message and a secret key, the HMAC output is considered to be a secure fingerprint that authenticates the device used to generate the HMAC.

To compute the HMAC: Let H designate the SHA-1 hash function, M designate the message transmitted to the device, and KD designate the unique 128-bit Unseal/Full Access/Authentication key of the device.

HMAC(M) is defined as: H[KD || H(KD || M)], where || symbolizes an append operation.

10.3 Authentication

The authentication feature is used in the following sequence:

1. MAC command 0x0000: Command = 0x0000, write the 20 bytes to 0x40, then write the checksum+len at 0x60. The response will be available as a MAC response, so 0x3E/0x3F will be 0x0000, 0x40 will have the SHA1 result, and 0x60/0x61 will have the checksum and length.
2. Generate 160-bit message M using a random number generator that meets approved random number generators described in FIPS PUB 140–2.
3. Generate SHA-1 input block B1 of 512 bytes (total input = 128-bit authentication key KD + 160-bit message M + 1 + 159 0s + 100100000).
4. Generate SHA-1 hash HMAC1 using B1.
5. Generate SHA-1 input block B2 of 512 bytes (total input = 128-bit authentication key KD + 160-bit hash HMAC1 + 1 + 159 0s + 100100000).
6. Generate SHA-1 hash HMAC2 using B2.
7. With no active *MACData()* data waiting, write 160-bit message M to *MACData()* in the format 0xAABBCCDDEEFFGGHHIIJJKKLLMMNNOOPPQQRRSSTT, where AA is LSB.
8. Wait 250 ms, then read *MACData()* for HMAC3.

9. Compare host HMAC2 with device HMAC3, and if it matches, both host and device have the same key KD and the device is authenticated.

10.4 AuthenticateData(): 0x40…0x53

UNSEALED Access—This data block has a dual function: It is used for the authentication challenge and response and is part of the 32-byte data block when accessing data flash.

SEALED Access—This data block has a dual function: It is used for authentication challenge and response, and is part of the 32-byte data block when accessing ***Manufacturer Data***.

10.5 AuthenticateChecksum(): 0x54

UNSEALED Access—This byte holds the authentication checksum when writing the authentication challenge to the device, and is part of the 32-byte data block when accessing data flash.

SEALED Access—This byte holds the authentication checksum when writing the authentication challenge to the device, and is part of the 32-byte data block when accessing ***Manufacturer Data***.

Data Commands

11.1 Command Summary

Table 11-1. Data Command Summary

CMD	MODE	NAME	FORMAT	SIZE IN BYTES	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
0x00...0x01	R/W	Control	Hex	2	0x00	0xff	—	—
0x02…0x05	R	AccumulatedCapacity	Signed Int	4	0	4.29E9	—	µAh
0x06…0x07	R	Temperature	Unsigned Int	2	–32768	32767	—	0.1°K
0x08...0x09	R	Voltage	Signed Int	2	0	65535	—	mV
0x0A	R	BatteryStatus	Hex	1	0x00	0xff	—	—
0x0B	R	BatteryAlert	Hex	1	0x00	0xff	—	—
0x0C…0x0D	R	Current	Signed Int	2	–32768	32767	—	mA
0x16…0x17	R	Scaled R	Unsigned Int	2	0	65535	—	mΩ
0x22…0x23	R	Measured Z	Unsigned Int	2	0	65535	—	mΩ
0x28…0x29	R	InternalTemperature	Unsigned Int	2	–32768	32767	—	0.1°K
0x2E	R	StateOfHealth	Unsigned Int	1	0	100	—	%
0x3C…0x3D	R	DesignCapacity	Unsigned Int	2	0	65535	—	mAh
0x79	R	Cal_Count	Hex	1	0x00	0xff	—	—
0x7A…0x7B	R	Cal_Current	Signed Int	2	0	65535	—	mA
0x7C…0x7D	R	Cal_Voltage	Signed Int	2	0	32767	—	mV or Counts (1)
0x7E…0x7F	R	Cal_Temperature	Unsigned Int	2	0	65535	—	°K

(1) mV when *[EXTVCELL]* = 0 and ADC counts when *[EXTVCELL]* = 1

11.2 Control(): 0x00/0x01

Issuing a *Control()* (or Manufacturer Access Control or MAC) command requires a 2-byte subcommand. The subcommand specifies the particular MAC function desired. The *Control()* command enables the system to control specific features of the gas gauge during normal operation and additional features when the device is in different access modes, as described below. On this device, *Control()* commands may also be sent to *ManufacturerAccessControl()*.

Any subcommand that has a data response will be read back on *MACData()*. Reading the *Control()* registers will always report the *CONTROL_STATUS()* data field, except after the *DEVICE_TYPE()* and *FW_VERSION()* subcommands. After these subcommands, *CONTROL_STATUS()* will report the value 0xFFA5 one time before reverting to the normal data response. This is a flag to indicate that the data response has been moved to *MACData()*. Writing a 0x0000 to *Control()* is not necessary to read the *CONTROL_STATUS()*; however, doing so is okay.

When executing commands that require data (such as data flash writes), the subcommand can be written to either *Control()* or *ManufacturerAccessControl()* registers; however, it is recommended to write using the *ManufacturerAccessControl()* registers as this enables performing the full command in a single I^2C transaction.

For example, the following return the same *CHEM_ID* data write:

```
0x0000 0x0800 ;
Read: 0x3e
Read: 0x3f

write: 0x3e 0x0800 ;
Read: 0x3e
Read: 0x3f
```

The *Control()* MAC command enables the host to control specific features of the device during normal operation, and additional features when the bq35100 device is in different access modes, as described in Table 11-2.

Table 11-2. Control MAC Subcommands

CNTL FUNCTION	CNTL DATA	SEALED ACCESS	DESCRIPTION
CONTROL_STATUS	0x0000	Yes	Reports the status of key features
DEVICE_TYPE	0x0001	Yes	Reports the device type of 0x100 (indicating bq35100)
FW_VERSION	0x0002	Yes	Reports the firmware (LSB) version on the device type
HW_VERSION	0x0003	Yes	Reports the hardware (MSB) version of the device type
STATIC_CHEM_CHKSUM	0x0005	Yes	Calculates chemistry checksum
CHEM_ID	0x0006	Yes	Reports the chemical identifier used by the gas gauge algorithms
PREV_MACWRITE	0x0007	Yes	Returns previous *Control()* command code
BOARD_OFFSET	0x0009	Yes	Forces the device to measure and store the board offset
CC_OFFSET	0x000A	Yes	Forces the device to measure the internal CC offset
CC_OFFSET_SAVE	0x000B	Yes	Forces the device to store the internal CC offset
GAUGE_START	0x0011	Yes	Triggers the device to enter ACTIVE mode
GAUGE_STOP	0x0012	Yes	Triggers the device to stop gauging and complete all outstanding tasks
SEALED	0x0020	No	Places the device in SEALED access mode
CAL_ENABLE	0x002D	No	Toggle CALIBRATION mode enable
LT_ENABLE	0x002E	No	Enables Lifetime Data collection
RESET	0x0041	No	Forces a full reset of the device
EXIT_CAL	0x0080	No	Exit CALIBRATION mode
ENTER_CAL	0x0081	No	Enter CALIBRATION mode
NEW_BATTERY	0xA613	Yes	Used to refresh the gauge when a new battery is installed and resets all recorded data.

11.3 CONTROL_STATUS: 0x0000

This command instructs the device to return status information to *Control* addresses 0x00/0x01. The status word includes the following information.

15	14	13	12	11	10	9	8
FLASHF	SEC1	SEC0	CalMode	BCA	CCA	LTEN	OCVFAIL

7	6	5	4	3	2	1	0
INITCOMP	G_DONE	SOH_ERR	SOH_MERIT	EOS_BAD _OCV	RSVD	RSVD	GA

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

FLASHF (Bit 15): Indicates the device has detected a failed write to data flash.
1 = Active
0 = Inactive

SEC1, SEC0 (Bit 14,13): Indicates which SECURITY mode the device is in 0.
0, 0 = Reserved
0, 1 = Full Access
1, 0 = Unsealed
1, 1 = Sealed

CalMode (Bit 12): Indicates the device is in CALIBRATION mode.
1 = Active
0 = Inactive

BCA (Bit 11): Indicates the device Board Calibration routine is active.
1 = Active
0 = Inactive

CCA (Bit 10): Indicates the device Coulomb Counter Calibration routine is active.
1 = Active
0 = Inactive

LTEN (Bit 9): Indicates that Lifetime Data collection has been enabled.
1 = Enabled
0 = Disabled

OCVFAIL (Bit 8): Indicates if too much current is detected when making the initial voltage measurement.
1 = Too much current detected
0 = Voltage measurement OK

INITCOMP (Bit7): Indicates the device initialization is complete.
1 = Initialization is complete.
0 = Initialization is not complete.

G_DONE (Bit 6): Indicates all tasks are complete and the device can be powered down.
1 = All tasks are complete.
0 = Some tasks have yet to complete.

SOH_ERR (Bit 5): Indicates the quality of the SOH calculation has overflowed.
1 = SOH Calculation has overflowed.
0 = SOH calculation has not overflowed.

SOH_MERIT (Bit 4): Indicates the quality of the SOH calculation was limited.
1 = SOH Calculation Limited
0 = SOH calculation was not limited.

EOS_BAD_OCV (Bit 3): Indicates the measured voltage exceeds the initial OCV voltage.
1 = Bad OCV measurements are made.
0 = Good OCV measurements are made.

GA (Bit 0): Indicates the device is in ACTIVE mode.

1 = Active
0 = Inactive

11.3.1 DEVICE_TYPE: 0x0001

When reading *DEVICE_TYPE()*, a block read is used. This requires that a write to 0x00 of 0x0200 should be followed by a read of 0x40 with 6 bytes to be read out. All In little-endian order, the first 2 bytes are *DEVICE_TYPE()*, then 2 bytes of *FW_VERSION()* and 2 bytes of FW BUILD.

11.3.2 FW_VERSION: 0x0002

When reading *FW_VERSION()*, a block read is used. This requires that a write to 0x00 of 0x0200 should be followed by a read of 0x40 with 6 bytes to be read out. All in little-endian order, the first 2 bytes are *DEVICE_TYPE()*, then 2 bytes of *FW_VERSION()* and 2 bytes of FW BUILD.

11.3.3 HW_VERSION: 0x0003

This command instructs the device to return the hardware version to addresses 0x00/0x01.

11.3.4 STATIC_CHEM_DF_CHKSUM: 0x0005

This command instructs the fuel gauge to calculate chemistry checksum as a 16-bit unsigned integer sum of all static chemistry data. The most significant bit (MSB) of the checksum is masked yielding a 15-bit checksum. This checksum is compared with the value stored in the data flash ***Static Chem DF Checksum***. If the value matches, the MSB will be cleared to indicate a pass. If it does not match, the MSB will be set to indicate a failure.

11.3.5 CHEM_ID: 0x0006

This command instructs the fuel gauge to return the chemical identifier for the programmed chemistry configuration to addresses 0x00/0x01. For evaluation purposes, the default *CHEM_ID* is a hybrid of a) Ra table for $LiSOCl_2$ and b) OCV table for $LiMnO_2$. The appropriate Chem ID for the cell to be used in the target application should be used in production.

11.3.6 PREV_MACWRITE: 0x0007

This command instructs the fuel gauge to return the previous command written to addresses 0x00/0x01. The value returned is limited to less than 0x0020.

11.3.7 BOARD_OFFSET: 0x0009

This command instructs the fuel gauge to calibrate board offset when is in ACTIVE mode. During board offset calibration, the *[BCA]* bit is set. This command only returns updated data after *GAUGE_START()* is received and prior to when *GAUGE_STOP()* is received.

11.3.8 CC_OFFSET: 0x000A

This command instructs the fuel gauge to calibrate the coulomb counter offset when in ACTIVE mode. During calibration, the *[CCA]* bit is set. This command only returns updated data after *GAUGE_START()* is received and prior to when *GAUGE_STOP()* is received.

11.3.9 CC_OFFSET_SAVE: 0x000B

This command instructs the fuel gauge to save the coulomb counter offset after calibration when it is in ACTIVE mode.

11.3.10 GAUGE_START: 0x0011

This command instructs the fuel gauge to enter ACTIVE mode.

11.3.11 GAUGE_STOP: 0x0012

This command instructs the fuel gauge to exit ACTIVE mode and complete all tasks.

11.3.12 SEALED: 0x0020

This command instructs the fuel gauge to transition from UNSEALED state to SEALED state. The fuel gauge should always be set to SEALED state for use in the customer's end equipment.

11.3.13 CAL_ENABLE: 0x002D

This command instructs the fuel gauge to enable entry and exit to CALIBRATION mode.

11.3.14 LT_ENABLE: 0x002E

This command instructs the fuel gauge to enable Lifetime Data collection.

11.3.15 RESET: 0x0041

This command instructs the fuel gauge to perform a full reset. This command is only available when the fuel gauge is UNSEALED.

11.3.16 NEW_BATTERY: 0xA613

This command instructs the fuel gauge to prepare itself for the next resistance update and EOS determination to be with a new cell.

11.4 AccumulatedCapacity(): 0x02/0x05

This read-word 4-byte command returns the accumulated coulombs since the coulomb counter was started. It provides an unsigned integer value with the range of 0 to 4.29E9 µAh. If the value reaches full, it will hold at the full count and not roll over.

11.5 Temperature(): 0x06/0x07

This read-only command pair returns an unsigned integer value of the temperature, in units of 0.1°K, measured by the device and has a range of 0 to 6553.5°K. The source of the measured temperature is configured by the ***[TEMPS]*** bit in ***Operation Config A***.

11.6 Voltage(): 0x08/0x09

This read-word command pair returns an unsigned integer value of the measured battery voltage in mV with a range of 0 V to 65535 mV.

11.7 BatteryStatus() 0x0A

This read-only register provides indications on the status of the battery.

SBS CMD.	NAME	ACCESS			PROTOCOL	TYPE	MIN	MAX	UNIT
		SE	US	FA					
0x0A	BatteryAlert	R	R	R	Word	HEX	0x00	0xff	—

7	6	5	4	3	2	1	0
RSVD	RSVD	RSVD	RSVD	RSVD	ALERT	RSVD	DSG

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

RSVD (Bits 7–3): Reserved. Do not use.

ALERT (Bit 2): ALERT output triggered
- 0 = ALERT is not active.
- 1 = ALERT is active.

RSVD (Bit 1): Reserved. Do not use.

DSG (Bit 0): Discharge current detection
- 0 = No discharge is detected.
- 1 = Discharge current is detected.

11.8 BatteryAlert() 0x0B

This read-only register provides indications on the cause of the $\overline{\text{ALERT}}$ pin trigger. An ALERT bit only clears if the condition for it is removed. Reading this register causes the $\overline{\text{ALERT}}$ pin to deassert and also clears the ALERT bit in *BatteryStatus()*. Note the $\overline{\text{ALERT}}$ pin is only asserted if it is configured to do so for a particular condition.

SBS CMD.	NAME	ACCESS			PROTOCOL	TYPE	MIN	MAX	UNIT
		SE	US	FA					
0x0B	BatteryAlert	R	R	R	Word	HEX	0x00	0xff	—

7	6	5	4	3	2	1	0
BATLOW	TEMPLOW	TEMPHIGH	SOH_LOW	EOS	RSVD	G_DONE	INITCOMP

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

BATLOW (Bit 7): $\overline{\text{ALERT}}$ is triggered because of BATLOW.

TEMPLOW (Bit 6): $\overline{\text{ALERT}}$ is triggered because of TEMPLOW.

TEMPHIGH (Bit 5): $\overline{\text{ALERT}}$ is triggered because of TEMPHIGH.

SOH_LOW (Bit 4): $\overline{\text{ALERT}}$ is triggered because of SOHLOW.

EOS (Bit 3): $\overline{\text{ALERT}}$ is triggered because of EOS.

RSVD (Bit 2): Reserved. Do not use.

G_DONE (Bit 1): $\overline{\text{ALERT}}$ is triggered because of G_DONE.

INITCOMP (Bit 0): $\overline{\text{ALERT}}$ is triggered because of INITCOMP.

11.9 Current(): 0x0C/0x0D

This read-only command pair returns a signed integer value that is the average current flowing through the sense resistor. It is updated every 1 second with units of 1 mA per bit.

11.10 ScaledR(): 0x16/0x17

This read-only command pair returns an integer value of the scaled resistance of the cell. It is updated upon a new resistance update in EOS mode only with a resolution of 1 mΩ per bit.

11.11 MeasuredZ(): 0x22/0x23

This read-only command pair returns an integer value of the measured impedance of the cell. It is updated upon a new resistance update in EOS mode only with a resolution of 1 mΩ per bit.

11.12 InternalTemperature(): 0x28/0x29

This read-only command pair returns an unsigned integer value of the internal temperature sensor in units of 0.1°K, measured by the device, and has a range of 0 to 6553.5°K.

11.13 StateOfHealth(): 0x2E/0x2F

This read-only command returns an unsigned integer value of the predicted state-of-health (SOH). Where state-of-health is predicted as ***Remaining Available Charge*** / ***Design Capacity*** × 100%.

The value is valid for both the SOH and EOS gauging modes. In both cases, the *StateOfHealth()* expression can be reduced to the simple expression of "DoD at Termination" – "Present DoD". In the SOH mode case, "Present DoD" is determined from the relaxed cell voltage and the EOS mode case is determined by the cell impedance measurement. The "DoD at Termination" is determined by finding the DoD at which MaxLoad causes the cell voltage to hit the ***Terminate Voltage*** threshold.

11.14 DesignCapacity(): 0x3C/3D

This read-only command pair returns the expected full charge capacity with units of 1 mAh per bit. The value is stored in ***Design Capacity***.

11.15 ManufacturerAccessControl(): 0x3E/0x3F

This read-write word function returns the subcommand that is currently active for reads on *MACData()*. Word writes to this function will set a subcommand. Commands that do not require data will execute immediately (identical to writes to *Control()*).

11.16 MACData(): 0x40 through 0x5F

This read-write block returns the result data for the currently active subcommand. It is recommended to start the read at *ManufacturerAccessControl()* to verify the active subcommand. Writes to this block are used to provide data to a subcommand when required.

11.17 MACDataSum(): 0x60

This read-write function returns the checksum of the current subcommand and data block. Writes to this register provide the checksum necessary in order to execute subcommands that require data. The checksum is calculated as the complement of the sum of the *ManufacturerAccessControl()* and the *MACData()* bytes. *MACDataLen()* determines the number of bytes of *MACData()* that are included in the checksum.

11.18 MACDataLen(): 0x61

This read-write function returns the number of bytes of *MACData()* that are part of the response and included in *MACDataSum()*. Writes to this register provide the number of bytes in *MACData()* that should be processed as part of the subcommand. Subcommands that require block data are not executed until *MACDataSum()* and *MACDataLen()* are written together as a word.

Data Flash

12.1 Accessing Data Flash

Accessing data flash (DF) is supported by accessing the actual physical memory in the address range 0x4000–0x43FF. This provides up to 1k of directly addressable DF. In this mode, the subcommand represents the actual base address in DF to access. Reads provide a 32-byte block (except if it runs off the end of DF). The length will identify if it is at the end (less than 32 bytes). Writes can have anywhere from 1 to 32 bytes, which provide the ability to write a single DF parameter without having to read a row first.

12.1.1 Write to DF Example

Assume data1 is located at address 0x4000 and data2 is located at address 0x4002, and both data1 and data2 are U2 type. To update data1 and data2 to 0x1234 and 0x5678, respectively, do the following:

- Write 0x00 0x40 (DF address in little endian format) to *ManufacturerAccessControl(0x3E, 0x3F)*.
- Write 0x12 0x34 0x56 0x78 (data in big endian format) to *MACData(0x40–0x43)*. The writes to *ManufacturerAccessControl()* and *MACData()* can be performed in a single transaction.
- Write 0xAB (complement of the sum of the *ManufacturerAccessControl()* and *MACData()* bytes) to *MACDataSum(0x60)*.
- Write 0x08 (4 + length of *MACData()* bytes) to *MACDataLen(0x61)*.
- The data flash write will execute when the *MACDataSum()* and *MACDataLen()* are written in order (word write) and are verified to be correct.

12.1.2 Read from DF Example

- Write 0x00 0x40 (DF address in little endian format) to *ManufacturerAccessControl(0x3E, 0x3F)*.
- Read *ManufacturerAccessControl(0x3E, 0x3F)* to verify.
- Read data from *MACData(0x40–0x5F)*.
- Read checksum and length from *MACDataSum(0x60)*, *MACDataLen()*.
- Verify checksum. All data above can be read in a single transaction by reading 36 bytes starting at *ManufacturerAccessControl()*.

12.1.3 Auto-Increment Reading

To support faster data flash dumps, the 0x4000–0x43FF commands will auto-increment after a successful read. This enables the host to skip the write word step, which increases throughput by at least 2x. After a word read of the *MACDataSum()* and *MACDataLen()* registers is detected, the gauge adds the current block size to the command (32 bytes). There is no auto-increment for the last block of DF.

12.2 Access Modes

As shown in Table 12-1, the bq35100 device provides three security modes that control data flash access permissions: FULL ACCESS, UNSEALED, and SEALED.

PUBLIC ACCESS refers to those data flash locations specified in *Data Flash Summary* that are accessible to the user.

PRIVATE ACCESS refers to reserved data flash locations used by the device system.

NOTE: Care should be taken to avoid writing to private data flash locations when performing block writes in FULL ACCESS mode using the procedure outlined in *Accessing Data Flash*.

Table 12-1. Data Flash Access

SECURITY MODE	DF—PUBLIC ACCESS	DF—PRIVATE ACCESS
BOOTROM	N/A	N/A
FULL ACCESS	R/W	R/W
UNSEALED	R/W	R/W
SEALED	R	N/A

Although FULL ACCESS and UNSEALED modes appear identical, FULL ACCESS mode enables the device to directly transition to BOOTROM mode and also write access keys. UNSEALED mode does not have these abilities.

12.2.1 Sealing/Unsealing Data Flash Access

The bq35100 device implements a key-access scheme to transition between SEALED, UNSEALED, and FULL ACCESS modes. Each transition requires that a unique set of two keys be sent to the device via the *Control()* command (these keys are unrelated to the keys used for SHA-1/HMAC authentication). The keys must be sent consecutively, with no other data being written to the *Control()* register in between.

NOTE: To avoid a conflict, the keys must be different from the codes presented in the CNTL DATA column of Table 11-2 subcommands.

When in SEALED mode, the *[SEC1,0]* bits of *ControlStatus()* are set, but when the Unseal Keys are correctly received by the device, it enters UNSEALED mode and *[SEC1,0]* are set to 1,0. When the full access keys are correctly received, the device enters FULL ACCESS mode and *[SEC1,0]* are set to 0,1.

Both sets of keys for each level are 2 bytes each in length and are stored in data flash. The Unseal Key (stored at ***Unseal Key 0*** and ***Unseal Key 1)*** and the FULL ACCESS key (stored at *Full Access Key 0* and *Full Access Key 1*) can only be updated when in FULL ACCESS mode. The order of the bytes entered through the *Control()* command is the reverse of what is read from the device. For example, if the 1st and 2nd word of the Unseal Key 0 returns 0x1234 and 0x5678, then *Control()* should supply 0x3412 and 0x7856 to unseal the device.

12.3 BlockDataChecksum(): 0x60

UNSEALED Access—This byte contains the checksum on the 32 bytes of block data read or written to data flash.

SEALED Access—This byte contains the checksum for the 32 bytes of block data written to ***Manufacturer Data***.

12.4 BlockDataLength(): 0x61

UNSEALED Access—This byte contains the length of the data block of data read or written to data flash.

SEALED Access—This byte contains the length of the data block of data read or written to data flash.

12.5 BlockDataControl(): 0x62

UNSEALED Access—This command is used to control data flash ACCESS mode. Writing 0x00 to this command enables *BlockData()* to access general data flash. Writing a 0x01 to this command enables the SEALED mode operation of *DataFlashBlock()*.

Data Flash Summary

Table 13-1. Data Flash Table

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Calibration	Data	0x4000	CC Gain	F4	2.00E–02	10.00E+00	.04768	—
Calibration	Data	0x4004	CC Delta	F4	2.98262E+04	5.677445E+06	5.677445e4	—
Calibration	Data	0x4008	CC Offset	I2	–32767	32767	–1400	mA
Calibration	Data	0x400A	AD I Offset	I2	–32767	32767	76	Num
Calibration	Data	0x400C	Board Offset	I1	–128	127	0	Counts
Calibration	Data	0x400D	Int Temp Offset	I1	–128	127	0	0.1°C
Calibration	Data	0x400E	Ext Temp Offset	I1	–128	127	0	0.1°C
Calibration	Data	0x400F	Pack V Offset	I1	–128	127	0	mV
Calibration	Data	0x4010	VIN Gain	U2	0	65535	29000	mV
Calibration	Temp Model	0x4012	Int Coeff 1	I2	–32768	32767	0	Num
Calibration	Temp Model	0x4014	Int Coeff 2	I2	–32768	32767	0	Num
Calibration	Temp Model	0x4016	Int Coeff 3	I2	–32768	32767	–12324	Num
Calibration	Temp Model	0x4018	Int Coeff 4	I2	–32768	32767	6131	0.1°K
Calibration	Temp Model	0x401A	Int Min AD	I2	–32768	32767	0	—
Calibration	Temp Model	0x401C	Int Max Temp	I2	–32768	32767	6131	0.1°K
Calibration	Temp Model	0x401E	Ext Coef 1	I2	–32768	32767	20982	Num
Calibration	Temp Model	0x4020	Ext Coef 2	I2	–32768	32767	–13836	Num
Calibration	Temp Model	0x4022	Ext Coef 3	I2	–32768	32767	5202	Num
Calibration	Temp Model	0x4024	Ext Coef 4	I2	–32768	32767	2337	Num
Calibration	Temp Model	0x4026	Ext rc0	I2	–32768	32767	12909	Counts
Calibration	Temp Model	0x4028	Vcomp Coeff 1	I2	–32768	32767	0	Num
Calibration	Temp Model	0x402A	Vcomp Coeff 2	I2	–32768	32767	14902	Num
Calibration	Temp Model	0x402C	Vcomp Coeff 3	I2	–32768	32767	–623	Num
Calibration	Temp Model	0x402E	Vcomp Coeff 4	I2	–32768	32767	37	Num
Calibration	Temp Model	0x4030	Vcomp Input Multiplier	U1	0	255	48	Num
Calibration	Temp Model	0x4031	Vcomp Output Divisor	I2	–32768	32767	256	Num
Calibration	Current	0x4033	Filter	U1	0	255	239	Num
Configuration	Registers	0x41B1	Operation Config A	H1	0x00	0xFF	0x80	Hex
Configuration	Registers	0x41B2	Alert Config	H1	0x00	0xFF	0xF3	Hex
Configuration	Registers	0x41B3	Clk Ctl Reg	H1	0x00	0x0F	0x09	Hex
Configuration	Registers	0x4254	Battery ID	H1	0x0	0x03	0x00	Hex
Configuration	Power	0x41B6	Flash Update OK Voltage	I2	0	4200	2800	mV
Configuration	Power	0x41B8	Offset Cal Inhibit Temp Low	I2	–400	1200	50	0.1°C
Configuration	Power	0x41BA	Offset Cal Inhibit Temp High	I2	–400	1200	450	0.1°C
Configuration	Data	0x4060	Device Name	S8	x	x	bq35100	—
Configuration	Data	0x4068	Data Flash Version	H2	0x0	0xFFFF	0xFFFF	—
Configuration	Data	0x41D4	Default Temperature	I2	2732	3732	2982	0.1°K
Configuration	Discharge	0x41D6	OT Dsg	I2	0	1200	600	0.1°C
Configuration	Discharge	0x41D8	OT Dsg Time	U1	0	60	2	s
Configuration	Discharge	0x41D9	OT Dsg Recovery	I2	0	1200	550	0.1°C
Configuration	Discharge	0x41DB	BatLow Voltage Set Threshold	I2	0	32767	2700	mV

Table 13-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Configuration	Discharge	0x41E0	Under Temperature Set Threshold	I2	–400	250	50	0.1°C
Configuration	Discharge	0x41E2	Under Temperature Set Time	U1	0	60	2	s
Configuration	Discharge	0x41E3	Under Temperature Clear	I2	–400	250	100	0.1°C
Configuration	Discharge	0x41E5	SOH Low	I2	0	100	5	%
Configuration	Integrity Data	0x4056	Static Chem DF Checksum	H2	0x0	0x7FFF	0x58D2	Hex
Configuration	Integrity Data	0x405C	IF Checksum	H4	0x0	0xFFFFFFFF	0x4C0B3D70	Hex
Configuration	Integrity Data	0x4253	Reset Counter WD	U1	0	255	0	Num
LTFlash	Voltage	0x4240	Primary Max	I2	0	32767	0	mV
LTFlash	Voltage	0x4242	Primary Min	I2	0	32767	32767	mV
LTFlash	Current	0x4244	Max Discharge	I2	–32768	0	–2000	mA
LTFlash	Current	0x4246	Min Discharge	I2	0	32767	0	mA
LTFlash	Temperature	0x4248	Max Cell	I2	–128	127	0	°C
LTFlash	Temperature	0x424A	Min Cell	I2	–128	127	20	°C
LTFlash	Temperature	0x424C	Max Gauge	I2	–128	127	0	°C
LTFlash	Temperature	0x424E	Min Gauge	I2	–128	127	20	°C
System Data	Manufacturer Data	0x4036	Manufacturer Info Block A01	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4037	Manufacturer Info Block A02	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4038	Manufacturer Info Block A03	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4039	Manufacturer Info Block A04	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x403A	Manufacturer Info Block A05	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x403B	Manufacturer Info Block A06	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x403C	Manufacturer Info Block A07	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x403D	Manufacturer Info Block A08	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x403E	Manufacturer Info Block A09	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x403F	Manufacturer Info Block A10	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4040	Manufacturer Info Block A11	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4041	Manufacturer Info Block A12	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4042	Manufacturer Info Block A13	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4043	Manufacturer Info Block A14	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4044	Manufacturer Info Block A15	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4045	Manufacturer Info Block A16	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4046	Manufacturer Info Block A17	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4047	Manufacturer Info Block A18	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4048	Manufacturer Info Block A19	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4049	Manufacturer Info Block A20	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x404A	Manufacturer Info Block A21	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x404B	Manufacturer Info Block A22	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x404C	Manufacturer Info Block A23	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x404D	Manufacturer Info Block A24	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x404E	Manufacturer Info Block A25	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x404F	Manufacturer Info Block A26	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4050	Manufacturer Info Block A27	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4051	Manufacturer Info Block A28	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4052	Manufacturer Info Block A29	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4053	Manufacturer Info Block A30	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4054	Manufacturer Info Block A31	H1	0x0	0xFF	0x0	Hex
System Data	Manufacturer Data	0x4055	Manufacturer Info Block A32	H1	0x0	0xFF	0x0	Hex
Gas Gauging	Design	0x41FE	Cell Design Capacity mAh	I2	0	32767	2200	mAh
Gas Gauging	Design	0x4202	Cell Design Voltage	I2	0	32767	3700	mV
Gas Gauging	Design	0x4204	Cell Terminate Voltage	I2	0	32767	2000	mV

Table 13-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Gas Gauging	Design	0x4206	Series Cell Count	I1	1	8	1	Counts
Gas Gauging	Design	0x4207	Max Load	I2	0	32767	50	mA
Gas Gauging	Design	0x4209	State of Health	I1	0	100	100	%
Gas Gauging	Design	0x420A	State of Health Max Delta	I1	0	100	2	%
Accum_Table	Table0	0x4280	page active	H1	0x0	0xFF	0xFF	—
Accum_Table	Table0	0x4281	Last Entry Code 0	H1	0x0	0xFF	0xFF	—
Accum_Table	Table0	0x4282	Last Entry Code 1	H1	0x0	0xFF	0xFF	—
Accum_Table	Table0	0x4283	Last Entry Code 2	H1	0x0	0xFF	0xFF	—
Accum_Table	Table0	0x4284	Last Entry Code 3	H1	0x0	0xFF	0xFF	—
Accum_Table	Table0	0x4285	Last Entry Code 4	H1	0x0	0xFF	0xFF	—
Accum_Table	Table0	0x4286	intPart 0	H2	0x0	0xFFFF	0x7FFF	mA
Accum_Table	Table0	0x4288	fractPart 0	H4	0x0	0xFFFFFF FF	0x0	mA
Accum_Table	Table0	0x428C	intPart 1	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x428E	fractPart 1	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table0	0x4292	intPart 2	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x4294	fractPart 2	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table0	0x4298	intPart 3	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x429A	fractPart 3	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table0	0x429E	intPart 4	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x42A0	fractPart 4	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table0	0x42A4	intPart 5	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x42A6	fractPart 5	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table0	0x42AA	intPart 6	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x42AC	fractPart 6	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table0	0x42B0	intPart 7	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x42B2	fractPart 7	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table0	0x42B6	intPart 8	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table0	0x42B8	fractPart 8	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table1	0x42C0	page active	H1	0x0	0xFF	0x55	—
Accum_Table	Table1	0x42C1	Last Entry Code 0	H1	0x0	0xFF	0xFF	—
Accum_Table	Table1	0x42C2	Last Entry Code 1	H1	0x0	0xFF	0xFF	—
Accum_Table	Table1	0x42C3	Last Entry Code 2	H1	0x0	0xFF	0xFF	—
Accum_Table	Table1	0x42C4	Last Entry Code 3	H1	0x0	0xFF	0xFF	—
Accum_Table	Table1	0x42C5	Last Entry Code 4	H1	0x0	0xFF	0xFF	—
Accum_Table	Table1	0x42C6	intPart 0	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42C8	fractPart 0	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table1	0x42CC	intPart 1	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42CE	fractPart 1	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table1	0x42D2	intPart 2	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42D4	fractPart 2	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table1	0x42D8	intPart 3	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42DA	fractPart 3	H4	0x0	0xFFFFFF FF	0xFFFFF FFF	mA
Accum_Table	Table1	0x42DE	intPart 4	H2	0x0	0xFFFF	0xFFFF	mA

Table 13-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Accum_Table	Table1	0x42E0	fractPart 4	H4	0x0	0xFFFFFFFF	0xFFFFFFF	mA
Accum_Table	Table1	0x42E4	intPart 5	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42E6	fractPart 5	H4	0x0	0xFFFFFFFF	0xFFFFFFF	mA
Accum_Table	Table1	0x42EA	intPart 6	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42EC	fractPart 6	H4	0x0	0xFFFFFFFF	0xFFFFFFF	mA
Accum_Table	Table1	0x42F0	intPart 7	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42F2	fractPart 7	H4	0x0	0xFFFFFFFF	0xFFFFFFF	mA
Accum_Table	Table1	0x42F6	intPart 8	H2	0x0	0xFFFF	0xFFFF	mA
Accum_Table	Table1	0x42F8	fractPart 8	H4	0x0	0xFFFFFFFF	0xFFFFFFF	mA
Ra Tables	Ra0 Table	0x4175	Ra 0	I2	0	32767	1126	2^{-10} Ω
Ra Tables	Ra0 Table	0x4177	Ra 1	I2	0	32767	1197	2^{-10} Ω
Ra Tables	Ra0 Table	0x4179	Ra 2	I2	0	32767	1186	2^{-10} Ω
Ra Tables	Ra0 Table	0x417B	Ra 3	I2	0	32767	1110	2^{-10} Ω
Ra Tables	Ra0 Table	0x417D	Ra 4	I2	0	32767	1157	2^{-10} Ω
Ra Tables	Ra0 Table	0x417F	Ra 5	I2	0	32767	1058	2^{-10} Ω
Ra Tables	Ra0 Table	0x4181	Ra 6	I2	0	32767	1121	2^{-10} Ω
Ra Tables	Ra0 Table	0x4183	Ra 7	I2	0	32767	1501	2^{-10} Ω
Ra Tables	Ra0 Table	0x4185	Ra 8	I2	0	32767	1646	2^{-10} Ω
Ra Tables	Ra0 Table	0x4187	Ra 9	I2	0	32767	1749	2^{-10} Ω
Ra Tables	Ra0 Table	0x4189	Ra 10	I2	0	32767	2898	2^{-10} Ω
Ra Tables	Ra0 Table	0x418B	Ra 11	I2	0	32767	5888	2^{-10} Ω
Ra Tables	Ra0 Table	0x418D	Ra 12	I2	0	32767	13825	2^{-10} Ω
Ra Tables	Ra0 Table	0x418F	Ra 13	I2	0	32767	18933	2^{-10} Ω
Ra Tables	Ra0 Table	0x4191	Ra 14	I2	0	26430	26303	2^{-10} Ω
EOSData	Values	0x4255	R Data Seconds	I2	0	5000	15	Num
EOSData	Values	0x4257	R Table Scale	I2	–1	–1	–1	Num
EOSData	Values	0x4259	New Batt R Scale Delay	U1	0	255	2	Num
EOSData	Values	0x425A	R Table Scale Update Flag	H1	0x00	0xFF	0xFF	Hex
EOSData	Values	0x425B	R Short Trend Filter	U1	1	255	251	Num
EOSData	Values	0x425C	R Long Trend Filter	U1	1	255	253	Num
EOSData	Values	0x425D	EOS Trend Detection %	U1	1	100	20	Num
EOSData	Values	0x425E	EOS Detection Pulse Count Thrshd	U2	1	20000	120	Num
EOSData	Values	0x4260	Short Trend Average	U4	0	8355712	0	Num
EOSData	Values	0x4264	Long Trend Average	U4	0	8355712	0	Num
EOSData	Values	0x4268	EOS Trend Detection Pulse Counts	U2	0	20000	0	Num
EOSData	Values	0x426A	EOS Not Detected Flag	H1	0x0	0xFF	0xFF	Hex
EOSData	Values	0x426B	EOS SOH smooth Start Voltage	I2	1	32767	2800	mV
EOSData	Values	0x426D	EOS SOH Smoothing Margin	U1	1	255	128	Num
EOSData	Values	0x426E	EOS Relax V Hi Max Counts	U1	1	255	10	Num
Security	Codes	0x41BC	Authen Key3 MSB	H2	0x0000	0xFFFF	0x0123	Hex
Security	Codes	0x41BE	Authen Key3 LSB	H2	0x0000	0xFFFF	0x4567	Hex
Security	Codes	0x41C0	Authen Key2 MSB	H2	0x0000	0xFFFF	0x89AB	Hex
Security	Codes	0x41C2	Authen Key2 LSB	H2	0x0000	0xFFFF	0xCDEF	Hex
Security	Codes	0x41C4	Authen Key1 MSB	H2	0x0000	0xFFFF	0xFEDC	Hex
Security	Codes	0x41C6	Authen Key1 LSB	H2	0x0000	0xFFFF	0xBA98	Hex

Table 13-1. Data Flash Table (continued)

Class	Subclass	Address	Name	Type	Min Value	Max Value	Default	Units
Security	Codes	0x41C8	Authen Key0 MSB	H2	0x0000	0xFFFF	0x7654	Hex
Security	Codes	0x41CA	Authen Key0 LSB	H2	0x0000	0xFFFF	0x3210	Hex
Security	Codes	0x41CC	Unseal Step1	H2	0x0000	0xFFFF	0x0414	Hex
Security	Codes	0x41CE	Unseal Step 2	H2	0x0000	0xFFFF	0x3672	Hex
Security	Codes	0x41D0	FullUnseal Step 1	H2	0x0000	0xFFFF	0xFFFF	Hex
Security	Codes	0x41D2	FullUnseal Step 2	H2	0x0000	0xFFFF	0xFFFF	Hex

Communications

14.1 I²C Interface

The gas gauge supports the standard I²C read, incremental read, one-byte write quick read, and functions. The 7-bit device address (ADDR) is the most significant 7 bits of the hex address and is fixed as 1010101. The 8-bit device address is therefore 0xAA or 0xAB for write or read, respectively.

The supported I²C formats are (a) 1-byte write, (b) quick read, (c) 1-byte read, and (d) incremental read.

Diagram Key: S = Start, Sr = Repeated Start, A = Acknowledge, N = No Acknowledge, and P = Stop

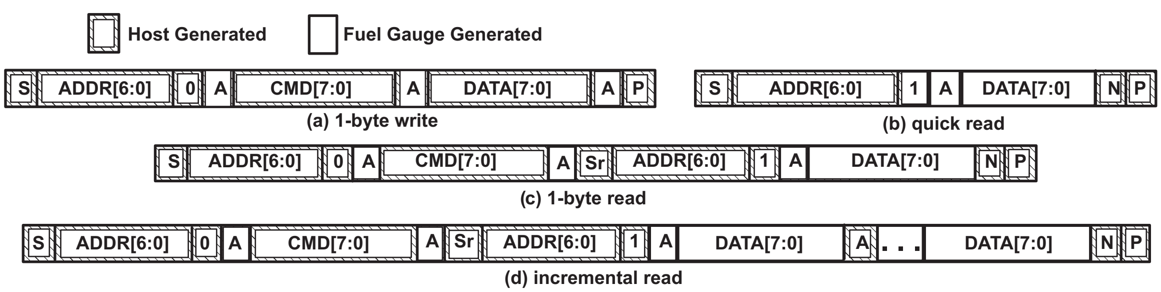
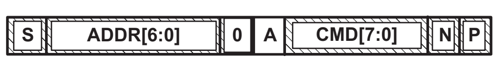


Figure 14-1. Supported I²C Formats

The "quick read" returns data at the address indicated by the address pointer. The address pointer, a register internal to the I²C communication engine, increments whenever data is acknowledged by the device or the I²C master. "Quick writes" function in the same manner and are a convenient means of sending multiple bytes to consecutive command locations (such as 2-byte commands that require two bytes of data).

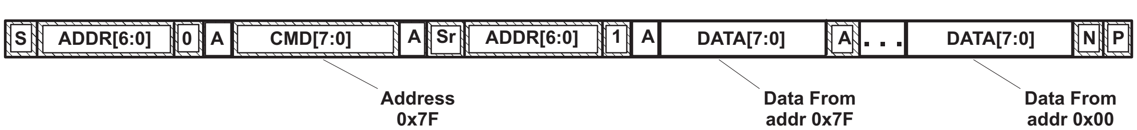
Attempt to write a read-only address (NACK after data sent by master):

Attempt to read an address above 0x7F (NACK command):



Attempt at incremental writes (NACK all extra data bytes sent):

Incremental read at the maximum allowed read address:



The I²C engine releases both SDA and SCL if the I²C bus is held low for ***Bus Low Time.*** If the gas gauge were holding the lines, releasing them frees the master to drive the lines.

Examples of generic I²C transactions can be found in the *Using I²C Communication with the bq275xx Series of Fuel Gauges Application Report* (SLUA467).

Revision History

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

Changes from B Revision (October 2016) to C Revision — Page

Changes from A Revision (September 2016) to B Revision — Page

Changes from Original (August 2016) to A Revision — Page

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