Quickstart Guide for bq27621-G1

The bq27621-G1 is the easiest-to-use rechargeable lithium battery gauge in the industry. For fast time-to-market, virtually no development effort, battery characterization, nor learning cycle is required. Once assembled into the end-system, only a few simple registers need to be configured before gauging results can be read from the IC. This document outlines the minimum procedure required. For more configuration options and details, please see the *bq27621-G1, Technical Reference Manual* (SLUUAD4).

NOTE:

Formatting conventions used in this document:

Commands: *italics* with *parentheses* and no breaking spaces, for example: *RemainingCapacity( )*

Data Memory Configuration Parameter: *italics*, **bold**, and *breaking spaces*, for example: **Design Capacity**

Register bits and flags: brackets and *italics*, for example: *[ITPOR]*

Data Memory Configuration Parameter bits: brackets, *italics* and **bold**, for example: ***[BIE]***

Modes and states: ALL CAPITALS, for example: UNSEALED mode

Contents

List of Figures

1 Overview

The bq27621-G1 fuel gauge utilizes standard lithium battery profiles that match typical batteries available in the market. The fuel gauge contains multiple battery profiles that fit a wide range of consumer rechargeable lithium chemistries. On IC power-up, default settings are loaded into the gauge RAM. These should be over-written by the system to match the actual battery capacity. Additionally, the full and empty battery conditions should be updated to match the system requirements. Also, if the default battery profile does not match the battery in use, a command can be sent to switch to the appropriate alternate profile. By configuring only a handful of parameters, the battery capacity predictions can be utilized with confidence.

2 Hardware

The bq27621-G1 fuel gauge comes in a tiny 9-pin, 1,62 mm × 1,58 mm, CSP package. A single 0.47-µF capacitor to be connected between the V_{DD} and V_{SS} pins.

The fuel gauge has the ability to provide interrupts to the system when State of Charge (SOC) changes through the GPOUT pin. The GPOUT pin is an open-drain output and should be pulled up, typically with a 4.7-kΩ or 10-kΩ resistor. It should not be left floating, even if unused. The GPOUT pin can also be configured to simply change polarity when SOC drops below a specific threshold. The polarity of the GPOUT pin can also be configured. For more details on configuration options, see the bq27621-G1 Technical Reference Manual (SLUUAD4).

For accurate gauging the fuel gauge needs to be able to detect that the battery has been inserted into the system. The fuel gauge will not be actively gauging unless the *[BAT_DET]* bit in the *Flags( )* register is set. By default, *[BAT_DET]* is set if the BIN pin is low. Alternatively, the gauge can be configured to rely on the host to inform it when the battery is inserted and removed, thereby setting and clearing the *[BAT_DET]* bit.

If ***Operation Configuration*** bit ***[BIE]*** = 1 (default), a logic low on the pin is detected as battery insertion. For a removable pack, the BIN pin can be connected to V_{SS} through a pulldown resistor on the pack, typically the 10-kΩ thermistor in the battery pack; the system board should use a 1.8-MΩ pullup resistor to V_{DD} to ensure the BIN pin is high when a battery is removed. If the battery is embedded in the system, it is recommended to leave ***[BIE]*** = 1 and use a 10-kΩ (or the battery thermistor) pulldown resistor from BIN to V_{SS}.

If ***[BIE]*** = 0, then the host must inform the gauge of battery insertion and removal with the *BAT_INSERT* and *BAT_REMOVE* subcommands. A 10-kΩ pulldown resistor should be connected to the BIN pin, even if the pin is not used.

NOTE: The BIN pin should not be shorted directly to V_{CC} or V_{SS}, and any pullup resistor on the BIN pin should only be connected to the bq27621 V_{DD} and not an external voltage rail.

NOTE: The fuel gauge needs accurate measurements of the battery pack voltage. The BAT and V_{SS} pins should be Kelvin-connected directly to the battery terminals for maximum gauging accuracy, with system current flowing through separate traces. Any I×R drop caused by current flowing through voltage measurement traces between the fuel gauge and the battery will reduce accuracy. Typically, the fuel gauge should be placed as close to the battery as possible to ensure its on-board temperature sensor is reflecting the battery temperature. However, since no sense resistor is required, more flexibility in layout is allowed as long as a Kelvin connection is ensured.

3 Programming the Configuration

A number of configuration parameters are available in the bq27621-G1 so that it can be tuned to match the target battery as well as the system requirements. Most of the defaults can be left alone if desired, but there are five important parameters that should be configured to achieve accurate gauging of the target battery. These parameters are ***Toggle Power Min***, ***Design Capacity***, ***Design Energy***, ***Terminate Voltage***, and ***Taper Rate***. If you are using the bq27621-G1 EVM, then use Battery Management Studio (bqStudio) to configure the gauge to fit the target battery and system. You can download Battery Management Studio at www.ti.com/product/bq27621-g1.

The fuel gauge contains multiple battery profiles that fit a wide range of consumer rechargeable lithium chemistries. Depending on the actual chemistry used by the target battery, the profile used by the gauge (also known as a chemID) can be changed with a simple I^2C command. The chemIDs available are 1202 (4.2 V maximum charge voltage), 1210 (4.3 V maximum charge voltage), and 354 (4.35 V maximum charge voltage). The default chemID is 1202 and is automatically used by the gauge upon reset. If a different battery type is used, then during the initialization sequence the host must send 0x0031 to *Control( )* to use chemID 1210 or 0x0032 to *Control( )* for chemID 354.

Toggle Power Min is an I^2C command which is sent to *Control()* to toggle the bq27621-G1 minimum power mode. It is enabled when the *[POWERMIN]* bit in *Control Status* is set. The minimum power mode configures the gauge to consume the lowest power in all power modes. By default, it is not enabled. To toggle it, send 0x0010 to *Control()*. If the bq27621-G1 goes through a POR or hard reset, it will exit this mode. Using the minimum power mode can result in longer clock stretch during I^2C communications.

Design Capacity should be set to the nominal battery capacity printed on the battery label or found in the battery datasheet. It gives a starting point for the gauge's predictions.

Design Energy should be set to be ***Design Capacity*** × 3.7. ***Design Energy*** is used when the gauge is operating in constant-power model. The bq27621-G1 defaults to constant-current model and this is reflected by the *[LDMD]* bit in the *Control()* register being cleared.

NOTE: When updating the fuel gauge on an EVM using the Q/A plug-in of Battery Management Studio, ***Design Energy*** is automatically calculated based on the ***Design Capacity***.

Terminate Voltage should be set to the minimum operating voltage of your system. This is the target where the gauge typically reports 0% capacity. It is not usually necessary to include a guard band when selecting this value, because the gauge also learns the level of load spikes in the system and automatically uses a higher voltage when necessary to ensure that load spikes and low temperatures do not allow sudden voltage drops below ***Terminate Voltage*** before 0% is reported. The actual point at which 0% is reported is therefore dynamic, so ***Terminate Voltage*** should be set to the minimum operating voltage supported by the system. If additional reserve capacity is desired between the 0% point and the actual ***Terminate Voltage***, then the optional ***Reserve Capacity*** memory parameter can also be configured. This ensures that a known amount of energy is available for shutdown activities once 0% SOC is reported, but before ***Terminate Voltage*** is actually reached.

Taper Rate should be set to the current threshold in mA below which your charger IC is set to stop charging once it considers the battery to be full. The ***Taper Rate*** is stored in units of 0.1-hr rate and can be derived from the taper current value in mA by the following equation:

Taper Rate = Design Capacity / (0.1 * ***Taper Current***)

This is simply a way to store the taper current value with respect to ***Design Capacity***. The ***Taper Rate*** value allows the gauge to synchronize its full charge detection point with that of the charger. The gauge ***Taper Rate*** should be set to a value slightly higher than the taper current detection threshold of the charger (including charger tolerances).

For example, if using a 1000-mA battery and the charger is set to stop charging when the voltage is 4.2 V and the current tapers to less than 100 mA (±15%), then the bq27621-G1 ***Taper Rate*** should be set to 87 (***Taper Rate*** = 1000 / (0.1 × 115 mA) where Taper Current = 115 mA) to give a slight guard band. It is important that the gauge detect full charge (*StateOfCharge()* = 100%) before the charger shuts off. An alternative system design to improve synchronization is to have the system read the *[FC]* (full charge) bit from the *Flags()* register and then disable the charger when it is set.

Because the gauge is estimating current, it is possible for it to report 100% SOC slightly early during charging. If the host processor can detect when the charger actually shuts off, then it can continue reporting 99% to the user until charge termination is detected, even if the gauge is reporting 100%.

NOTE: When updating the fuel gauge on an EVM using the Q/A plugin of Battery Management Studio, ***Taper Rate*** is calculated automatically based on the Taper Current value.

The procedure and commands required to update the configuration parameters are shown in the flowchart of Figure 1.

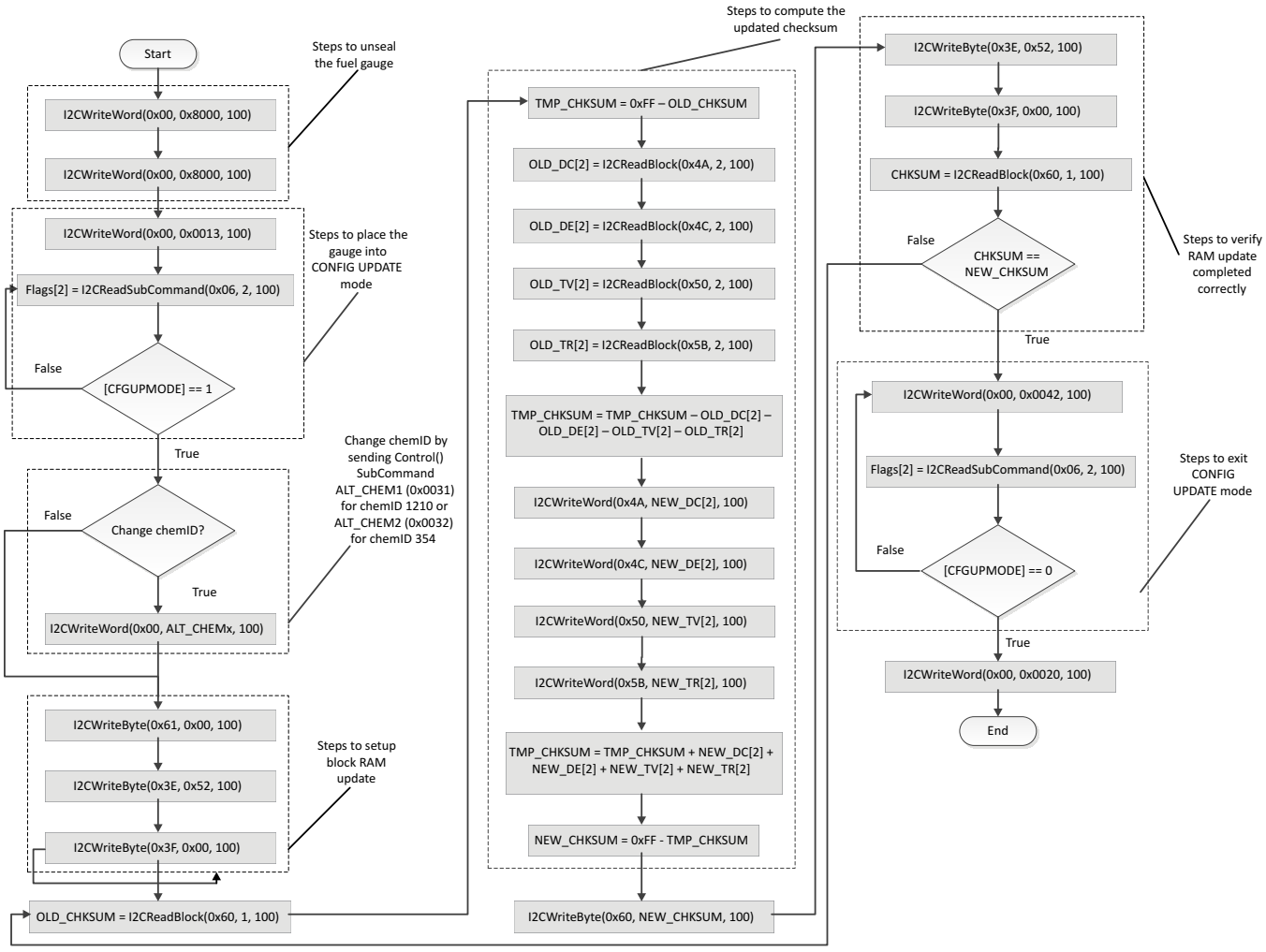

Figure 1. Flowchart for Updating the Gauge Configuration Parameters

NOTE: For information on the complete sealing process with the bq27621, see the TRM (SLUUAD4).

NOTE: The process for updating the RAM can also be handled through parsing the data contents in a *.fs file generated by Battery Management Studio. A *.fs is a series of I^2C commands that can be processed by the host. Using the *.fs file will allow the host an alternative route to updating the RAM instead of following the flow outlined in Figure 1.

4 Reading the Gauge Registers

There are a total of 18 registers available for the system to read from the bq27621. The registers most commonly used are *Voltage( )*, *Temperature( )*, *EstimatedCurrent( )*, and *StateOfCharge( )*. The commands to read these registers are shown in Figure 2. Other useful registers include *Control()*, *Flags()*, and the estimate of *RemainingCapacity()*.

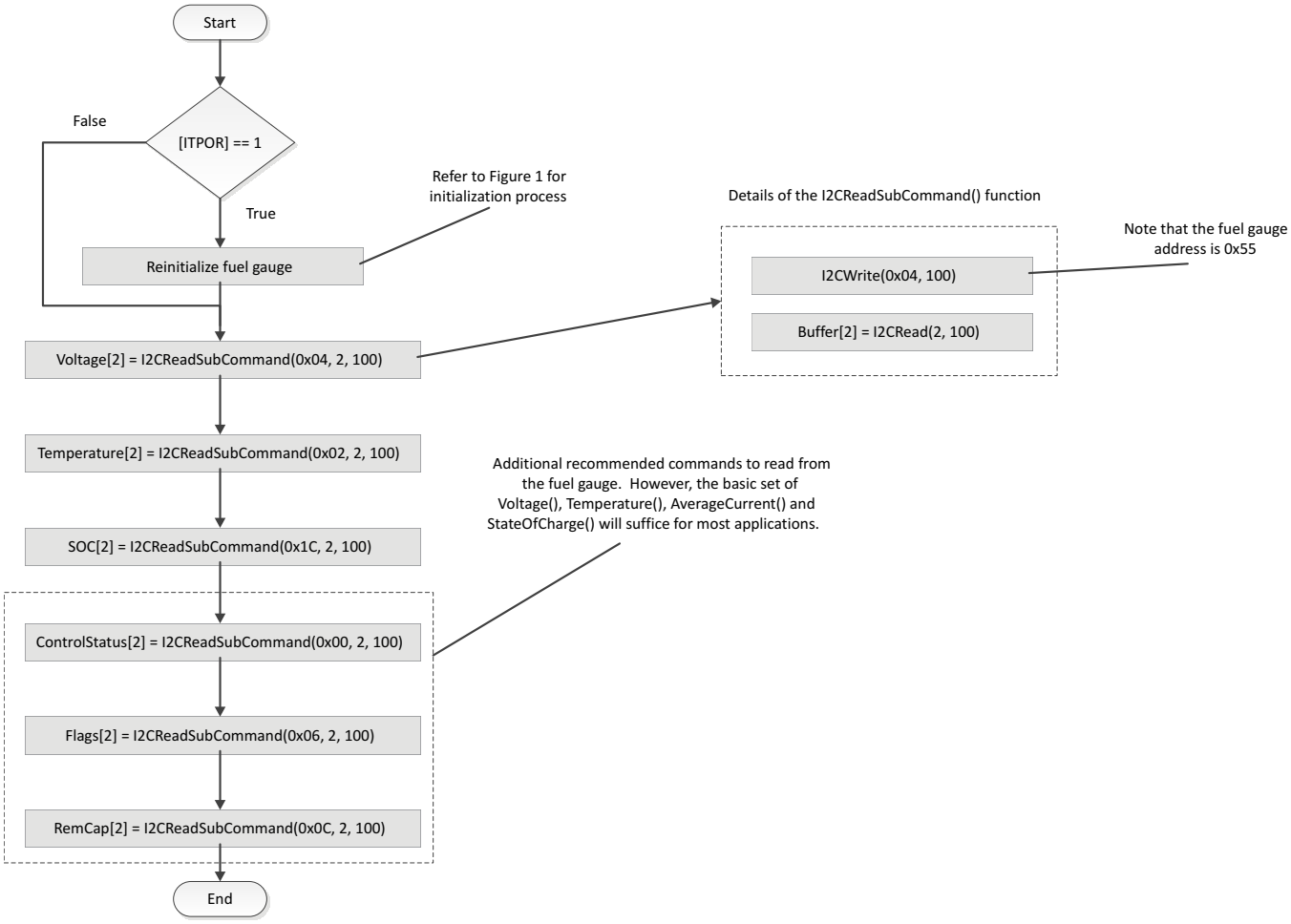

Figure 2. Gauge Register Commands

5 Gauge Re-Initialization

Ideally, the system should be designed so that the bq27621-G1 is always powered by the battery, even during system shutdown. The gauge maintains the values in RAM as long as it is powered and operates in NORMAL, SLEEP, or HIBERNATE mode. The gauge automatically transitions to SLEEP mode when the system current is low to minimize power consumption.

If the battery is removed or the gauge is put into SHUTDOWN mode, the values stored in RAM are lost. Once powered up again, the *[ITPOR]* bit in the *Flags()* register is set indicating that all values are initialized to the defaults, including ***Design Capacity***, ***Design Energy***, ***Terminate Voltage***, ***Taper Current***, and the *[POWER_MIN]* bit. The *[ITPOR]* bit indicates one of the following:

- The fuel gauge has been reset due to loss in power.
- A full *RESET* (0x0041) *Control()* subcommand has been sent to the gauge.
- The gauge has exited the SHUTDOWN mode.

Sending a *SOFT_RESET* (0x0042) *Control()* subcommand to the gauge clears the *[ITPOR]* bit. The host can use the *[ITPOR]* bit to determine if the gauge memory parameters need to be reloaded. If the *[ITPOR]* bit is set, at a minimum the ***Design Capacity***, ***Design Energy***, ***Terminate Voltage***, and ***Taper Rate*** values should be reloaded to the gauge.

NOTE: The *SOFT_RESET* subcommand is used to exit the RAM update process. Therefore, the *[ITPOR]* bit clears after the RAM has been updated.

See Figure 1 for more details on the RAM update process.

6 Other Configuration Options

The previous instructions outlined the minimum registers to update for accurate fuel gauging. Other registers are available for configuration to enable different options (such as interrupt conditions). See the *bq27621-G1 Technical Reference Manual* (SLUUAD4) for additional configuration options and details.

6.1 Very Small or Very Large Battery Capacities

When using batteries that have capacity less than 150 mAh, it is recommended that a scale factor of 10× be applied. For example, if the fuel gauge is used with an 89-mAh battery, then ***Design Capacity*** and ***Design Energy*** should be set to 890 mAh and 3293 mWh, respectively. Then all registers with units of mA, mAh, or mW read back from the gauge, such as *EstimatedCurrent( )* or *RemainingCapacity( )*, can be divided by 10 to get the original value if desired. Since SOC = *RemainingCapacity( )* / *FullChargeCapacity( )*, this factor of 10 will be canceled out and there is no need to scale *StateofCharge( )*. Conversely, for use with extremely large batteries, a scaling factor of ÷10 or ÷100 may be used to keep the ***Design Capacity*** below 6 Ah, which is the maximum recommended value.

6.2 Zero Configuration Usage

This document has shown how the bq27621-G1 fuel gauge can be configured for use through a few simple configuration parameters. In fact, for some applications it may be allowable to use the gauge with zero configuration. If only the *StateOfCharge( )* register is needed by the system, the battery capacity does not need to be configured. This is because SOC = *RemainingCapacity( )* / *FullChargeCapacity( )* and any scaling error will be canceled out. Furthermore, the default Terminate Voltage (3.2 V) and charger termination conditions may be close enough to the actual system requirements that they could be left unchanged in some situations. If these settings are sufficient, then the bq27621-G1 can truly be used with no configuration and the SOC can be immediately read from the gauge. On the other hand, if fine-tuning of the gauge behavior and settings is required, there are many more options detailed in the *bq27621-G1 Technical Reference Manual* (SLUUAD4).

7 Summary

By requiring no battery characterization and typically only needing a minimum of five registers to be updated on power-on reset (POR), the bq27621-G1 fuel gauge allows system designers to quickly incorporate fuel gauging functionality into their design with minimal effort.

8 Related Documentation from Texas Instruments

To obtain a copy of any of the following TI documents, call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center (PIC) at (972) 644-5580. When ordering, identify this document by its title and literature number. Updated documents also can be obtained through the TI Web site at www.ti.com.

1. *bq27621-G1, System-Side Fuel Gauge with Dynamic Voltage Correlation* Data Sheet (SLUSBB3)
2. *bq27621-G1, Technical Reference Manual* (SLUUAD4)

9 Revision History

Version	Change Date	Description
—	December 2013	Initial Release
A	March 2014	In Figure 2, changed AverageCurrent() to EstimatedCurrent(). Streamlined instructions.

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