Quickstart Guide for bq34210-Q1

The bq34210-Q1 is an automotive-qualified AEC-Q100 level 3 gauge targeted for rarely discharged battery systems using a Compensated End-of-Discharge (CEDV) algorithm. The bq34210-Q1 supports 1-series cell applications for Li-Ion, LiFePO4, and 1-series pack applications for NiMH (3 cells). This device can notify the system when the rarely discharged battery is nearing its end of life, thus allowing the user to replace the battery before the system relies on the battery to perform its key purpose. This document outlines the minimum procedure required. Once assembled into the end-system, only a few simple registers must be configured before gauging results are read from the device. This document outlines the minimum procedure required. For more configuration options and details, see the *bq34210-Q1, Technical Reference Manual* (TRM).

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: *[CFGUPDATE]*

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

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

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1 Overview

The bq34210-Q1 fuel gauge supports Li-Ion, LiFePO4, and NiMH chemistries. The device is programmed with 2 standard configurations, but many applications require modification of the characteristics. The *Data Memory* table in the TRM contains information that is loaded into memory at initial battery connection. The "CEDV Profile 1" information in the Gas Gauging section of the table includes the full charge capacity (in mAh), design voltage (in mV), a voltage level indicating depth-of-discharge (in %), and JEITA charge currents. The bq34210-Q1 does not control the battery charging, but with a smart charger, can assist in the charging cycle.

Predicting the aging and life of a rarely discharged battery requires a periodic small discharge which enables the bq34210-Q1 to learn the characteristics of the battery. This is known as the learning load.

Taking consideration for aging which is calculated by the bq34210-Q1 allows the end-system battery to be sized properly to continue operation for the intended lifetime. Using larger batteries than required adds cost to the system and using smaller batteries results in poor user experience – mainly inadequate capacity at the time where the system is most needed. Full details are found in *bq34210-Q1 Automotive 1-Series Cell System-Side CEDV Fuel Gauge for Rarely Discharged Batteries* and the *bq34210-Q1 Technical Reference Manual*.

NOTE: *Battery Management Studio (bqStudio)* offers a full suite of robust tools to assist with the process of evaluating, designing with, configuring, testing, or otherwise utilizing TI Battery management products. The *Related Documentation From TI* section has links to bqStudio, other documents, and tools to assist with development.

The bq34210-Q1 evaluation module works directly with bqStudio to allow fast ramping on understanding and using this device.

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2 Hardware

The bq34210-Q1 comes in a 14-pin PW package (5 mm × 4.4 mm × 1 mm). In addition to the device and battery, full functionality is generally achieved with one sense resistor, two capacitors, a thermistor and the learning load (synchronized with the bq34210-Q1 and controlled by the host).

The sense resistor is placed between the battery and the pack minus (for low-side gauging) or the battery and pack plus (for high-side gauging). The two capacitors are used on the REGIN pin (attached to the battery) and the REG18 pin (internal 1.8-V LDO). The thermistor is used to measure the battery temperature to allow for accurate lifetime predictions. Additionally, the host must provide the pullup resistors for the I^2C SDA and SCL lines.

Connections to the host include the ALERT (interrupt) pin which indicates when an alert or a warning is sent to the host. These interrupts are included for Battery Status, EOS Learn Status, EOS Status, EOS Safety Status, and Operation Status. Each alert and warning function is able to be independently enabled and disabled.

3 Programming the Configuration

A number of configuration parameters are available in the bq34210-Q1 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 a few important parameters that should be configured to achieve accurate gauging of the target battery. These parameters are ***Design Capacity***, ***Charge Termination Voltage***, ***Taper Current***, and ***EOS Configuration***. If you are using the bq34210-Q1 EVM, then use *bqStudio* to configure the gauge to fit the target battery and system.

The fuel gauge contains two default 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 can be modified with simple I^2C commands.

Set ***Design Capacity*** to the nominal battery capacity printed on the battery label or found in the battery data sheet. The ***Design Capacity*** gives a starting point for the predictions of the gauge.

Set ***Charge Termination Voltage*** should be set to be the maximum charging voltage of the battery. ***Taper Current*** is used to assist in charge termination.

The most efficient method for starting involves the *Gauge Parameter Calculator* (GPC). GPC is a math calculation and simulation tool that helps the battery designer to obtain matching CEDV coefficients for the specific battery profile. The tool allows the user to increase the accuracy of the fuel gauge IC over temperature. See *Simple Guide to CEDV Data Collection for Gauging Parameter Calculator (GPC)*, and *Related Documentation From TI* for other links.

Comparing the data from this tool with the two profiles stored in the bq34210-Q1 ROM allows the user to either pick one of the two profiles, or modify one of the profiles for the final configuration. Each device must be programmed with the new data. The configuration is stored in volatile memory so any power removal requires the configuration to be rewritten.

The process for updating the RAM can also be handled through parsing the data contents in a *.fs file generated by bqStudio. A *.fs is a series of I^2C commands that can be processed by the host. Using the *.fs file allows the host an alternative route to updating the RAM instead of following the flow outlined in Figure 1. The "Golden Image" button in bqStudio allows the user to create the *.fs file once the data is written to Data Memory. A portion of the output (text file) from the 0210_0_03-bq34210.gm.fs file follows:

```
;--------------------------------------------------------
;Verify Existing Firmware Version
;--------------------------------------------------------
W: AA 3E 02 00
C: AA 3E 02 00 02 10 00 03
;--------------------------------------------------------
;Data Block
;--------------------------------------------------------
W: AA 3E F2 91 00 00 00 00 00 00 00 00 CB D4 1A 05 D4 86 4A C6 B4 C2 6E 2B 03 7C 01 48 FD A3 F6
75 12 58 2D B7
W: AA 60 24 24
X: 10
```

The syntax for this file is:

- ";" starts a comment line
- "W:" is a write command in the format W: [device address] [command] [data] [data]...[data]
- "C:" is a compare command in the format C: [device address] [command] [data] [data]...[data]
- "X:" is a delay in the format X: [delay in milliseconds]

The numbers in the W and C lines are hexadecimal and the X lines are decimal.

Editing the memory in the bq34210-Q1 is simple, but does require unsealing the device and entering the configuration mode before registers can be written. When in SEAL mode, the Data Memory cannot be read or written. The UNSEAL command allows reading of the registers. Enter CONFIG UPDATE mode to write the registers.

Note that doing manual entries can run into timing issues (too slow). When writing the device to enter UNSEAL mode of 2 pairs of 2 bytes (or 4 bytes), there is a timeout of approximately 4 seconds from the first pair to the second pair. If the write takes longer than that, a timeout occurs and the device remains in SEAL mode. Since typical code is not limited by typing, this timing is not an issue. Additionally, CONFIG UPDATE mode has a 4 minute time out. As with the entry into UNSEAL mode, this is not an issue during typical code execution.

The procedure and commands required to update the Design Capacity configuration parameter are shown in the flowchart of Figure 1. The "Calculate New CHKSUM" block is shown in Figure 2.

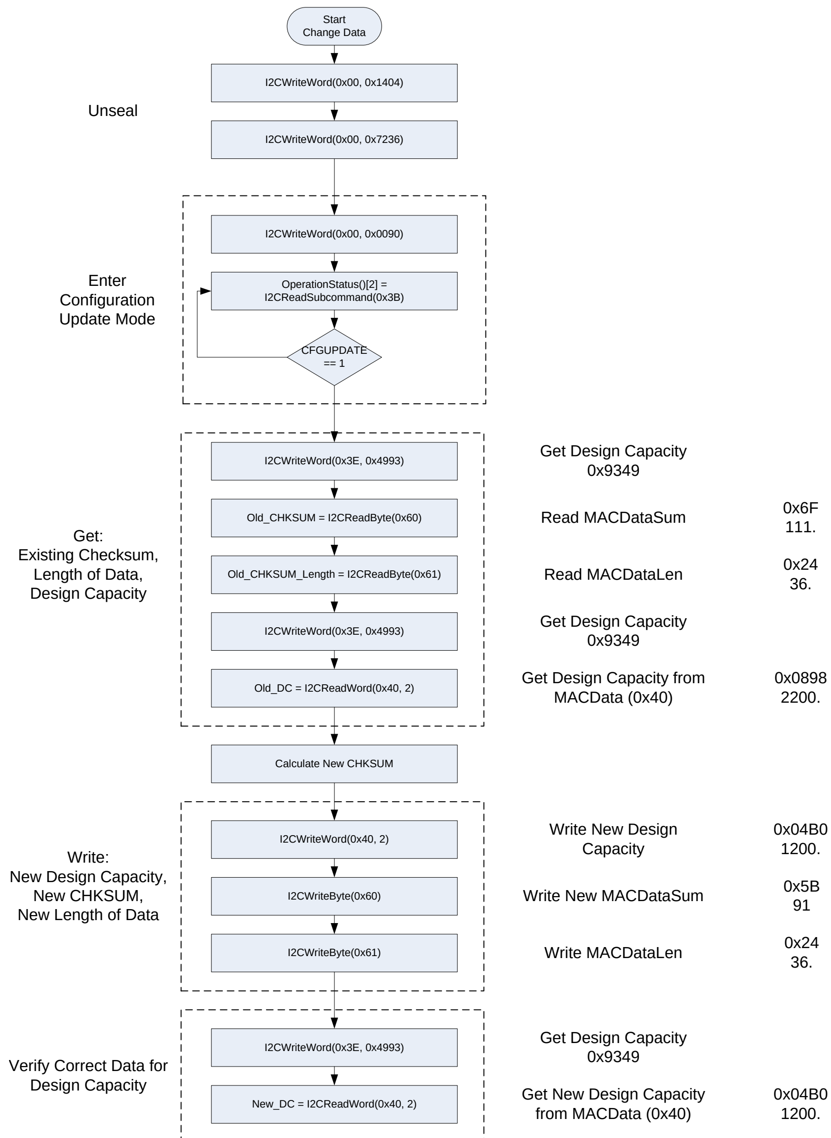

Figure 1. Flowchart for Updating the Design Capacity Configuration Parameter

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NOTE: For information on the complete sealing process with the bq34210-Q1, see the *bq34210-Q1 Technical Reference Manual*.

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4 Calculating a New Checksum (CHKSUM)

When a change is made to the configuration parameters, a checksum is used to make sure the changes are intentional before they are written to the appropriate registers. When the parameters are read, a checksum is generated, along with a length of the number of bytes used to create the checksum. The checksum is a simple addition of each individual byte with a single byte result. This is done by addition of the bytes and then taking the modulus (base 256) of the result. For example, if the result is less than 256, the checksum is that number. If the result is greater than 256, the number divided by 256 and the remainder is the checksum. For example, if the numbers (200., 100., 3, 58.) are added (361.) the result is divided by 256 giving 1R105. The Checksum is 105. If the result is 2904, the checksum is 88.

When a parameter is changed, the current checksum must be replaced with the new checksum which is now a function of the same numbers except the registers that were changed need to have the original checksum (byte by byte) subtracted and replaced with the new information (byte by byte) added to checksum. This change is illustrated by the calculation in Figure 2. The numbers used in this example are taken from the updating example shown in Figure 1.

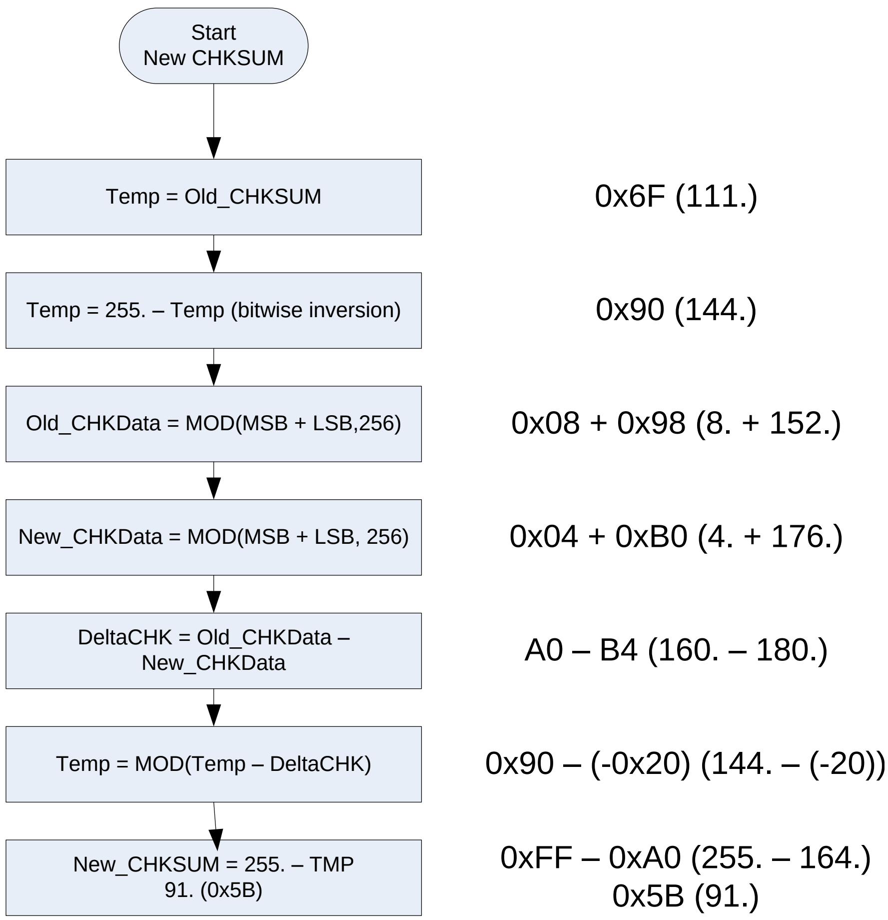

Figure 2. Checksum (CHKSUM) Calculation Example

5 Gauge Re-Initialization

Ideally, the system should be designed so that the bq34210-Q1 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, CONFIG UPDATE, or SLEEP 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 default Profile 1 is reloaded into RAM and any changes made to that profile must be rewritten.

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 *bq34210-Q1 Technical Reference Manual* for additional configuration options and details.

6.1 Zero Configuration Usage

This document has shown how the bq34210-Q1 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 is 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 bq34210-Q1 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 *bq34210-Q1 Technical Reference Manual*.

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 bq34210-Q1 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 Support Center at (512) 434-1560. 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. Texas Instruments, *bq34210-Q1, Automotive 1-Series Cell System-Side CEDV Fuel Gauge for Rarely Discharged Batteries Data Sheet*
2. Texas Instruments, *bq34210-Q1 Technical Reference Manual*
3. *Battery Management Studio (bqStudio)* is available from www.ti.com/tool/bqstudio
4. *Gauge Parametric Calculator (GPC)* is accessed at www.ti.com/tool/gaugeparcal
5. Texas Instruments, *Gauge Communication Application Report*
6. Texas Instruments, *Simple Guide to CEDV Data Collection for Gauging Parameter Calculator (GPC) User's Guide*

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8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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