Application Note

Autonomous Smart Battery Guide

Wyatt Keller *Battery Management Solutions*

ABSTRACT

Using a System Management Bus (SMBus) compatible charger and gauge can reduce the cost and complexity of a simple Battery Management System (BMS). Texas Instruments SMBus gauges and chargers are Smart Battery System (SBS) compliant[(1)], which eliminates the need for a system MCU in low-cost applications that do not require complex monitoring, or interfacing with other systems.

An SBS can be setup without the need for custom firmware, all required setup is done using TI's BQStudio GUI. Using the resources TI supplies can help reduce the design time of a BMS. TI SMBus gauges allow for accurate State of Charge (SOC) reported using LEDs, passive cell balancing, and integrated battery protection. An example using the BQ25710[(2)] and BQ40Z50[(3)] Evaluation Modules (EVMs) will be used to provide more insights on how to setup this kind of autonomous BMS.

Some I2C based TI battery gauges, like the BQ28Z610-R1[(4)], can be configured to broadcast the charging current and charging voltage directly to an I2C based charger.

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1 Introduction

Including only the gauge and charger reduces cost and size of simple BMS systems. The battery gauge replaces the functionality of the host MCU for a conventional system. Most standard battery systems would also use an MCU to communicate with other ICs, this increases the flexibility of the BMS, but also increases the BOM and cost. Using the battery gauge as the host is best for applications that are fairly simple and only require a State of Charge (SOC) readout with LEDs, safety protections, and passive cell balancing.

A power supply capable of supplying high enough current and voltage to charge the batteries is required. A load capable of discharging the batteries at a rate between C/5 and C/10 through the SYS pin on the charger is another requirement. The data line (SMBD), clock line (SMBC), and GND are the needed between the gauge and charger for communication. The power connections required are PACK– to GND, then PACK+ to BAT.

A conventional BMS with MCU controls the charger from the information read from the gauge along with other peripherals, compared to the smart battery system connections which do not include an MCU. The MCU for the conventional system reads the *ChargingVoltage()* and *ChargingCurrent()* from the gauge to then program the charger, or perform its own modifications to the charge profile before programming the charger.

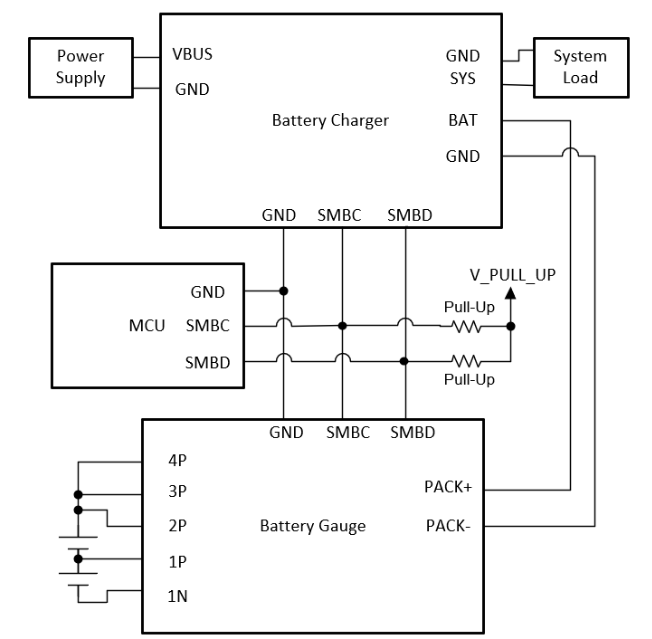

Figure 1-1. Conventional BMS Configuration

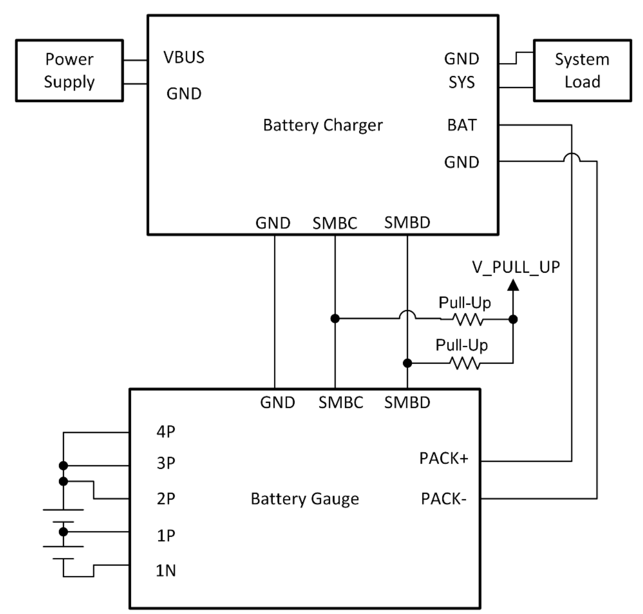

Figure 1-2. Smart Battery System

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2 Smart Battery Setup

The specific setup process for broadcast mode following the Smart Battery System guidelines is minimal. The gauge and charger follow the default settings for the device address, charge current, and charge voltage using the SBS specification. The I2C system requires slightly more setup in flash memory.

2.1 Gauge Setup

For the tests in this application note, the gauges were calibrated following the guidelines in the Technical Reference Manual (TRM) of the respective gauge. A Relax Discharge Relax (RDR) cycle was performed on the batteries to gather data which was submitted to the Gauge Parameter Calculator Chemistry ID tool (GPCCHEM) [(5)] to find the corresponding chemistry ID. Finally, a learning cycle was run on the batteries to complete the gauge setup[(6)]. After these steps are finished, the application-specific functions can be enabled, like LED SOC display formatting, protection thresholds, and charging profiles in the Advanced Charge Algorithm section[(7)].

The final golden image can be exported from the gauge and uploaded to new gauges during production after the gauge setup is completed. Only one learning cycle is required. Voltage and current calibration can be performed on several gauges and the values can be averaged for the final golden image if the variations are low between packs.

More of the broadcast information is found in the gauge's TRM:

Charge Control SMBus Broadcasts

If the ***[HPE]*** bit is enabled, MASTER mode broadcasts to the host address are PEC enabled. If the ***[CPE]*** bit is enabled, MASTER mode broadcasts to the smart-charger address are PEC enabled. The ***[BCAST]*** bit enables all broadcasts to a host or a smart charger. When the ***[BCAST]*** bit is enabled, the following broadcasts are sent:

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

After the initial setup, place the gauge thermistor as close as possible to the battery to get the most accurate temperature reading during battery cycling. The gauge thermistor is the only thermistor needed, the charger thermistor is not necessary.

Following the specifications from the battery manufacturer, the Advanced Charging Algorithm section of dataflash can be setup to match the battery and application-specific needs. Usually in the Constant Current (CC) mode the charge current is higher in the medium to high voltage ranges, compared to the low or precharge voltage range. During cold temperatures the charge current can be reduced, and in hot temperatures the final charge voltage can be reduced to increase the battery longevity. Further explanations are found in Appendix A.

With R2 or newer firmware on the BQ40Z50, the charge current and charge voltage can also be reduced depending on the cell degradation. The degradation thresholds can be based on either State of Health (SOH) or cycle count. This feature is helpful for battery safety and longevity.

Many of the charging parameters that can be modified using the Advanced Charge Algorithm settings in the TI battery gauges. The precharge, low voltage, medium voltage, and high voltage thresholds are all adjustable as well. T1–T6 indicate the temperature range thresholds that can also be modified following the *Advanced Charge Algorithm* application report.

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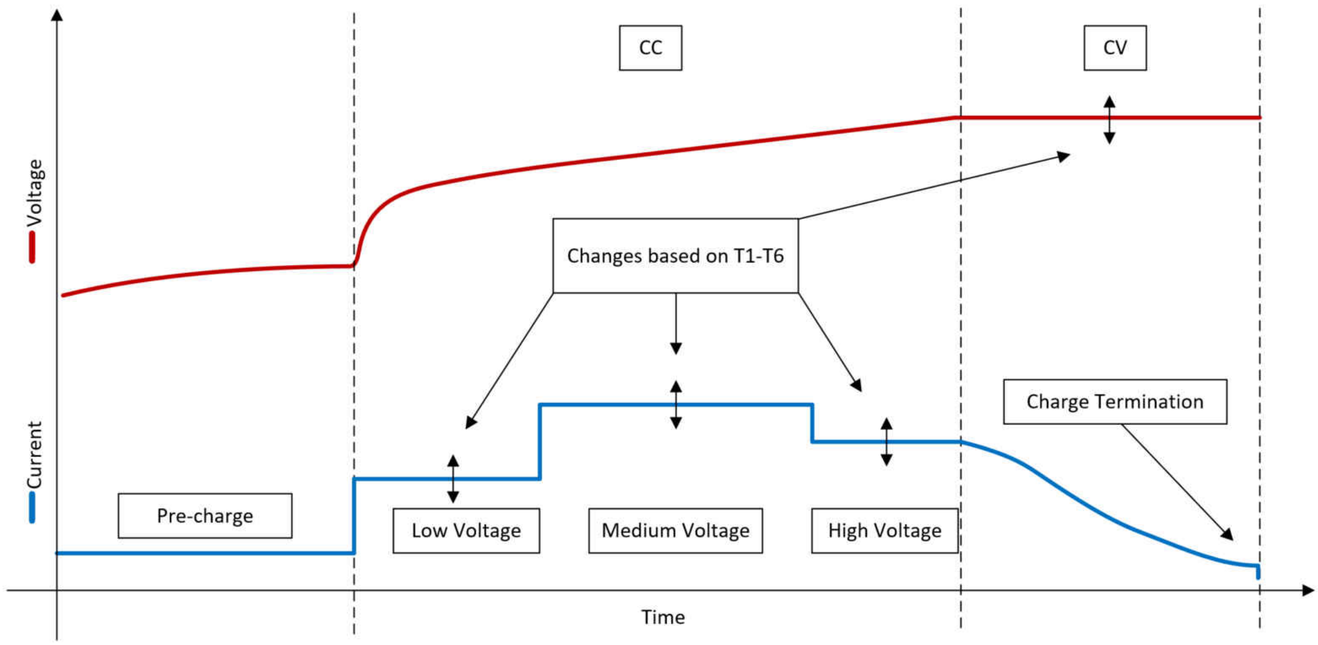

Figure 2-1. Charging Profile Using Advanced Charging Algorithm

2.1.1 I2C System Differences

The setup process is slightly more involved for I2C broadcast mode. The charger device address, charge current register, charge voltage register, and broadcast pacing need to be programmed to the flash memory of the gauge.

The BQ28Z610-R1 is currently a unique case, it can broadcast *ChargingCurrent()* and *ChargingVoltage()* in a 2-byte format to chargers that meet its broadcast mode transmission formatting and use I2C for communication. More information is found in the gauge TRM:

BROADCAST Mode

NOTE: BROADCAST mode is available in the latest firmware version in the BQ28Z610-R1 product folder on TI.com. BROADCAST mode is not included in the shipped version.

The BQ28Z610-R1 gauge enables a smart battery to become the I^{2}C master to broadcast the charging voltage and current to a smart battery charger. This allows the charger and gauge to operate autonomously to adjust the charging conditions dynamically without requiring the host or system to be booted or active. For more information, see *Charger*.

The *[BCAST]* bit enables all broadcasts to a host or a smart charger. When the *[BCAST]* bit is enabled, the following broadcasts are sent:

- *ChargingVoltage()* and *ChargingCurrent()* broadcasts are sent to the smart-charger ***Device Address***, and the broadcast period is set in ***Broadcast Pacing***. The target registers accessed for writing *ChargingVoltage()* and *ChargingCurrent()* values to the charger device are configured in the data flash register***Voltage Register*** and the data flash register ***Current Register***, respectively.

For the correct formatting, the charger must have a 2-byte charge current and charge voltage register, and it must not have any other bits in the same register used to configure the charger. The gauge will write the whole 2-byte register, so any configuration information would be overwritten. If the bits are reserved for a TI charger, like the BQ25730[8], it does not matter what the gauge writes to the register, the reserved values are not modified. Refer to Appendix A for more specific information about the gauge setup for I2C.

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2.2 Charger Setup

Since the SBS specification defines the registers for charge current and charge voltage, there is no setup needed on the charger side. Voltage, current, and temperature are sensed by the gauge and the appropriate charge current and charge voltage is sent to the charger based on the Advanced Charge Algorithm settings.

The control loops in the charger will limit the current to the programmed *ChargingCurrent()*from the gauge during the Constant Current (CC) phase of charging, and then the charger will limit the charging voltage during the Constant Voltage (CV) phase based on the programmed *ChargingVoltage()* from the gauge.

Most TI chargers that use SMBus are SBS compliant and considered level 2 smart chargers. This requires them to accept *ChargingCurrent()* and *ChargingVoltage()* commands to the 0x14 and 0x15 addresses respectively.

The SBS Specification[1] states the *ChargingVoltage()* data range is from 0 to 65,534 mV with +1% to –9% accuracy in voltage regulation while there is a good power supply attached. The *ChargingCurrent()* has the data range from 0 to 65,534 mA with ±5% accuracy. This must be for both the gauge and charger. See the *ChargingCurrent() (0x14)* section and *ChargingVoltage() (0x15)* section of the SBS Specification for more information on exceptions.

For the I2C-based system using the BQ28Z610-R1, the charger also does not need to be configured for the application. The gauge will write directly to the charging voltage and charging current registers in the charger after they are set in the gauge.

The BQ25730 is an I2C-based charger that has 2-byte charge current and voltage registers, the BQ28Z610-R1 can be configured to work with the BQ25730 charger because of its 2-byte registers that do not have any other configuration information in the registers. Refer to Appendix A for more information on the charger setup.

3 Communication Protocol

Using the register bit definitions outlined in the data sheet of the charger, the charge current and voltage writes can be verified using a logic analyzer or oscilloscope. For the BQ40Z50 and other SMBus devices, the communications in broadcast mode can be PEC enabled with the *SBS configuration[CPE]* bit. *SBS configuration[HPE]* does not affect this system because there is no host. If both *SBS configuration[HPE]* and *SBS configuration[CPE]* are disabled the gauge will not transmit a PEC byte during any communication. The current and voltage are transmitted from the gauge in little endian, so the format of transmission is the following when the *SBS configuration[CPE]* bit is set:

Charger address (write) -> Register to write -> Least significant byte -> Most significant byte -> PEC Byte.

For the I2C-based system the package structure is the same, except the Packet Error Checking (PEC) byte is not used for I2C-based systems so there are no PEC enable options for the BQ28Z610-R1.

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4 Data Collected

All data collected was using the BQ40Z50 device with R4 firmware and the BQ25710 device which follow the SBS guidelines. Both of the data sets collected used the system outlined in the block diagram, with the EV2400 tied on the SMBus as well.

Relax Discharge Relax (RDR) cycle to find the chemistry ID using the Gauge Parameter Calculator Tool.

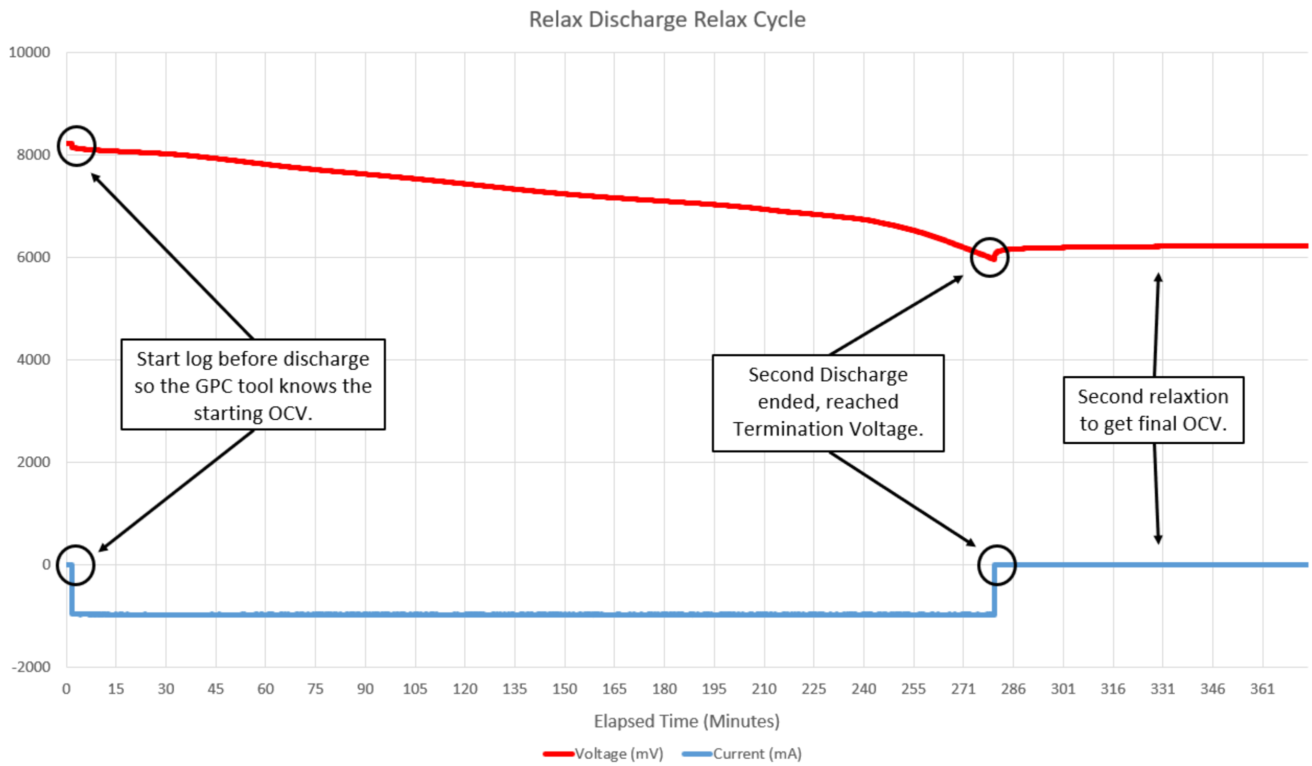

Figure 4-1. RDR Cycle for the GPCCHEM Tool

During the next charge cycle after a relax period, the Update Status (LStatus in the bqStudio log) changed from 0x04 to 0x05, indicating that two valid Open Circuit Voltage (OCV) readings were taken and the gauge updated Qmax. On the next discharge, the gauge will update the resistance table (Ra table) to complete the learning process[6].

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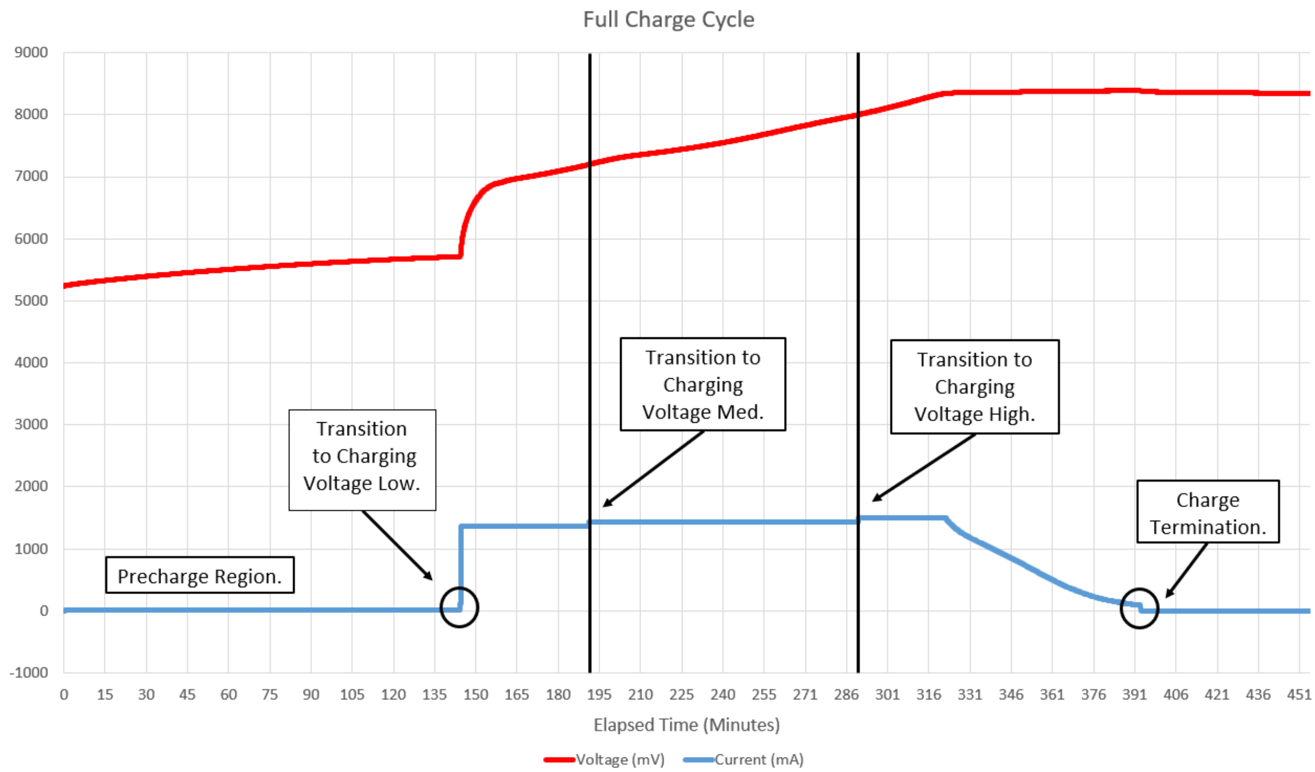

Figure 4-2. Full Charge Cycle Using SMBus SBS

The voltage thresholds are seen during charging between precharge voltage, low voltage, medium voltage, high voltage as the current changes in each voltage region.

In the precharge region when the voltage is slowly rising in Figure 4-2, the set charge current is 100 mA, but 10 mA is being supplied. That is because the *FET Options[PCHG_COMM]* = 0 by default, which enables the precharge FET and not the charge FET. For the charge current to directly reflect the broadcasted value, *FET Options[PCHG_COMM]* must be set to 1. With the precharge FET enabled, the current is limited by the series resistor.

5 Summary

TI's SMBus gauge and charger can be setup to communicate together for a simple solution for a BMS. This method can reduce the overall cost of a BMS which can still report accurate SOC, provide protection, and send charging information to the charger. The gauge operates as the simple MCU of the system to stop charge or discharge in the case of any fault conditions, and complete a desired charging profile following any JEITA or custom temperature profile.

The system can be setup using the SMBus compliant gauge and charger, or by using the I2C based BQ28Z610-R1 as long as the I2C-based charger conforms to the broadcast formatting of the gauge.

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A Appendix

The appendix is designed to show more detailed implementation than previously explained.

A.1 General Setup

The battery used in this example is the LG INR21700 M50T. The battery manufacturer specifications were used for programming the gauge with the recommended charging current, charging voltage, charge termination, and discharge termination.

Some of the battery specifications used for this example, from the manufacturer:

Item	Notes	Specification
Energy	By standandard Charge or Discharge	Nominal 18.2 Wh
Nominal Voltage	Average through standard charge and discharge	3.63 V
Standard Charge	Constant current Constant voltage End current (cut off)	0.3C (1,455 mA) 4.2 V 50 mA
Minimum Discharge Voltage	In all operations, the minimum closed voltage circuit value for a cell	2.5 V

Following the specifications for the battery chosen, the following modifications were made to the flash memory of the gauge:

1. Design Capacity mAh = 4850 mAh
2. Design Capacity cWh = 3640 cWh
3. Design Voltage = 8400 mV
4. Taper Current = 100 mA
5. Quit Current = 20 mA
6. DA Configuration register to match number of cells and set NR bit
7. Any values updated from calibration
8. The advanced charge algorithm described in this section.

The parameters described in the General Setup section are needed for most gauges to start the learning cycle and are dependent on the battery being used.

The EV2400 can be used as shown in the block diagram to log data during charge and discharge cycles. The EV2400 is essentially the MCU of the system, but just for logging. The EV2400 can be added to the SMBus lines so the charger, gauge, and EV2400 will all be on the same bus. Logging and configuration changes can then be done to both the charger and gauge during testing using bqStudio.

To configure the charger with all three devices on the same bus, bqStudio must be opened with the chargers designated bqz file before connecting the EV2400, otherwise bqStudio will auto-connect to the gauge. The advanced communication tab in the BQ40Z50 GUI can also be used to communicate with the charger.

Multiple primary devices on the same communication bus is not recommended because it can lead to arbitration errors. This is why broadcast mode should only be used when the gauge is the only primary device.

A.2 Gauge Setup - SMBus

Follow the *bq40z50EVM Li-Ion Battery Pack Manager Evaluation Module* user's guide to get started with hardware connections and basic gauge setup.

The first step is to set the number of cells used to change the *DA configuration[CC0,1]* bits (bqStudio -> data memory -> settings -> *DA configuration[CC0,1]*) the gauge may shutdown due to low voltage, if not configured correctly. The WAKE button may need to be held during this step. The Non-removable bit *DA configuration[NR]* also must be set to 1 to ignore the PRES pin.

Set the number of cells and *DA configuration[NR]* bit, then the voltage and current calibration needs to be completed. Applying a known voltage and current to the gauge, as described in the EVM users guide, is the best

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way to calibrate the gauge. The next step is to find the chemistry ID using the GPCCHEM tool and complete a learning cycle. After these two steps, the gauge needs to be configured for the more specific parameters for the application.

Follow the Appendix A.1 section for details on the battery setup and the parameters to set in the gauge. After the general gauge setup, the most important configuration is to set the *SBS Configuration[BCAST]* bit to transmit data from the gauge to the charger. As an example, Figure A-1 is the Advanced Charge Algorithm setup page in bqStudio for the information the gauge broadcasts to the charger. Set the custom temperature profile or JEITA standard in the gauge registers. The temperature profile can widely vary, it is dependent on the cell manufacturer's ratings and the specific application needs.

Name	Private	Value	Unit	Physical S...	Data Length	Row Numb...	Row Offset	Native Units
Temperature Ranges								
T1 Temp		15.0	°C	0x4f03	2	120	3	0.1 K
T2 Temp		20.0	°C	0x4f05	2	120	5	0.1 K
T5 Temp		25.0	°C	0x4f07	2	120	7	0.1 K
T6 Temp		30.0	°C	0x4f09	2	120	9	0.1 K
T3 Temp		35.0	°C	0x4f0b	2	120	11	0.1 K
T4 Temp		40.0	°C	0x4f0d	2	120	13	0.1 K
Hysteresis Temp T1		1.0	°C	0x4f0f	2	120	15	0.1 K
Hysteresis Temp T2		1.0	°C	0x4f11	2	120	17	0.1 K
Hysteresis Temp T5		1.0	°C	0x4f13	2	120	19	0.1 K
Hysteresis Temp T6		1.0	°C	0x4f15	2	120	21	0.1 K
Hysteresis Temp T3		1.0	°C	0x4f17	2	120	23	0.1 K
Hysteresis Temp T4		1.0	°C	0x4f19	2	120	25	0.1 K
Pre-Charging								
Current		64	mA	0x4f1b	2	120	27	mA
Maintenance Charging								
Current		64	mA	0x4f1d	2	120	29	mA
Voltage Range								
Precharge Start Voltage		2500	mV	0x4f1f	2	120	31	mV
Charging Voltage Low		2850	mV	0x4f21	2	121	1	mV
Charging Voltage Med		3600	mV	0x4f23	2	121	3	mV
Charging Voltage High		4000	mV	0x4f25	2	121	5	mV
Charging Voltage Hysteresis		0	mV	0x4f27	1	121	7	mV

Figure A-1. Example Temperature and Voltage Range Settings.

Now the current ranges must be set, the values are arbitrary just to show the feature can be used to setup many different charging profiles:

Name	Private	Value	Unit	Physical S...	Data Length	Row Numb...	Row Offset	Native Units
Low Temp Charging								
Voltage		4000	mV	0x4744	2	58	4	mV
Current Low		1000	mA	0x474e	2	58	14	mA
Current Med		1100	mA	0x4750	2	58	16	mA
Current High		1100	mA	0x4752	2	58	18	mA
Standard Temp Low Charging								
Voltage		4200	mV	0x4746	2	58	6	mV
Current Low		1350	mA	0x4754	2	58	20	mA
Current Med		1455	mA	0x4756	2	58	22	mA
Current High		1400	mA	0x4758	2	58	24	mA
Standard Temp High Charging								
Voltage		4200	mV	0x4748	2	58	8	mV
Current Low		1350	mA	0x475a	2	58	26	mA
Current Med		1455	mA	0x475c	2	58	28	mA
Current High		1400	mA	0x475e	2	58	30	mA
High Temp Charging								
Voltage		4000	mV	0x474a	2	58	10	mV
Current Low		1250	mA	0x4760	2	59	0	mA
Current Med		1355	mA	0x4762	2	59	2	mA
Current High		1300	mA	0x4764	2	59	4	mA
Rec Temp Charging								
Voltage		4100	mV	0x474c	2	58	12	mV
Current Low		1350	mA	0x4766	2	59	6	mA
Current Med		1455	mA	0x4768	2	59	8	mA
Current High		1400	mA	0x476a	2	59	10	mA

Figure A-2. Example Current Settings Based on Temperature and Voltage

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If degradation to charging current and charging voltage over the lifetime of the battery is desired, the SOH or cycle count can be used to reduce the reported charging voltage and current to the charger. Newer BQ40Z50 firmware versions are adding features like runtime-based degradation as well for more flexibility depending on the end-application.

Note

- The gauge writes all the bits of the charge current and charge voltage registers, but the reserved bits will remain unchanged. For example, the lowest charge current that can be supplied is 64 mA, because the charger has 64-mA resolution.
- If a lower precharge current is required than 64 mA, the *FET Options[PCHG_COMM]* bit can be used to charge at a lower rate while the voltage is within the precharge voltage region.

A.3 Gauge Setup - I2C

Follow the *bq28z610EVM 1- to 2-Series Li-Ion Battery Pack Manager Evaluation Module* users guide to get started with hardware connections and basic gauge setup.

The charger must have a 2-byte charge current and charge voltage register, it must not have any other bits in the same register used to configure the charger. The gauge will write the whole 2-byte register, so any configuration information would be overwritten. If the bits are reserved, it does not matter what the gauge writes to the register.

The BQ25730 is an I2C-based charger that has 2-byte charge current and voltage registers, the BQ28Z610-R1 can be configured to work for this charger.

The BQ25730 is compatible with the BQ28Z610-R1 broadcast mode because the register is 2-bytes and the unused bits are reserved, not configuration bits. The device address should be set to the 7-byte address without the read/write bit. Set the Voltage and Current registers to the beginning register value. For example, if charge current is 0x02-0x03, set it to 0x02. The pacing should be set to prevent a charger watchdog from clearing the values written by the gauge.

To setup the BQ28Z610-R1 to communicate with the BQ25730, the Device Address should be set to 0x6B, which is the 7-bit address without the read/write bit. The current register should be set to address 0x02, and the voltage register to address 0x04. The watchdog resets the charger every 175 seconds by default, so the pacing should be less than that value.

Charger

NOTE: The BROADCAST mode feature is available in the latest firmware version in the BQ28Z610-R1 product folder on TI.com: It is not included in the shipped version.

The following data flash parameters enable the configuration of the BROADCAST mode feature. This feature is disabled by default because not all host MCU/CPUs are compatible with multi-master I^{2}C operation, and collisions could hang the host's comm engine.

Class	Subclass	Name	Type	Min	Max	Default	Unit	Description
Settings	Charger	Device Address	H1	0	FF	D4	hex	Sets the address of slave device for BROADCAST mode
Settings	Charger	Voltage Register	H1	0	FF	0C	hex	BROADCAST mode: Sets the 2-byte address and data information to transmit to the slave device for charger output voltage setting
Settings	Charger	Current Register	H1	0	FF	0A	hex	BROADCAST mode: Sets the 2-byte address and data information to transmit to the slave device for charger output current setting
Settings	Charger	Broadcast Pacing	U1	0	255	15	s	BROADCAST mode: Period for broadcast

A.4 Charger Setup

Follow the *BQ2571x Evaluation Module* users guide for basic charger hardware setup.

The SMBus based charger uses the predefined charge current address (0x14) to comply with the SBS guidelines. There is no further setup on the charger side required, the gauge handles everything.

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Figure 9-13. ChargeCurrent Register With 10-mΩ Sense Resistor (SMBus address = 14h) [reset = 0h]

15	14	13	12	11	10	9	8
Reserved			Charge Current, bit 6	Charge Current, bit 5	Charge Current, bit 4	Charge Current, bit 3	Charge Current, bit 2
R/W			R/W	R/W	R/W	R/W	R/W
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Charge Current, bit 1	Charge Current, bit 0	Reserved	Reserved				
R/W	R/W	R/W	R/W				

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

Table 9-25. Charge Current Register (14h) With 10-mΩ Sense Resistor (SMBus address = 14h) Field Descriptions

SMBus BIT	FIELD	TYPE	RESET	DESCRIPTION
15-13	Reserved	R/W	000b	Not used. 1 = invalid write.
12	Charge Current, bit 6	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 4096 mA of charger current.
11	Charge Current, bit 5	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 2048 mA of charger current.
10	Charge Current, bit 4	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 1024 mA of charger current.
9	Charge Current, bit 3	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 512 mA of charger current.
8	Charge Current, bit 2	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 256 mA of charger current.

Table 9-26. Charge Current Register (14h) With 10-mΩ Sense Resistor (SMBus address = 14h) Field Descriptions

SMBus BIT	FIELD	TYPE	RESET	DESCRIPTION
7	Charge Current, bit 1	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 128 mA of charger current.
6	Charge Current, bit 0	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 64 mA of charger current.

Figure A-3. BQ25710 SMBus Charge Current Register (0x14)

Follow the *BQ2573X Evaluation Module* user's guide for basic charger hardware setup.

The I2C-based charger charge current register configuration is essentially the same format as SMBus, except the I2C-based charger uses a different address. Any I2C-based charger with a similar register format to the BQ25730 will work with the I2C broadcast mode.

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Figure 9-14. ChargeCurrent Register (I^2C address = 03/02h) [reset = 0000h]

7	6	5	4	3	2	1	0
Reserved			Charge Current, bit 6	Charge Current, bit 5	Charge Current, bit 4	Charge Current, bit 3	Charge Current, bit 2
R/W			R/W	R/W	R/W	R/W	R/W
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Charge Current, bit 1	Charge Current, bit 0	Reserved	Reserved				
R/W	R/W	R/W	R/W				

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

Table 9-10. Charge Current Register with 5-mΩ Sense Resistor (I^2C address = 03h) Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
7-5	Reserved	R/W	000b	Not used. 1 = invalid write.
4	Charge Current, bit 6	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 8192 mA of charger current.
3	Charge Current, bit 5	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 4096 mA of charger current.
2	Charge Current, bit 4	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 2048 mA of charger current.
1	Charge Current, bit 3	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 1024 mA of charger current.
0	Charge Current, bit 2	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 512 mA of charger current.

Table 9-11. Charge Current Register with 5-mΩ Sense Resistor (I^2C address = 02h) Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
7	Charge Current, bit 1	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 256 mA of charger current.
6	Charge Current, bit 0	R/W	0b	0 = Adds 0 mA of charger current. 1 = Adds 128 mA of charger current.
5-0	Reserved	R/W	000000b	Not used. Value Ignored.

Figure A-4. BQ25730 I2C Charger Current Register

A.5 Charge Voltage Example

An example of the charging voltage communication with the packet structure follows:

`0x12 (write) 0x15 0xD0 0x20 0x73`

Charging voltage is transmitted in little endian as well, so the bytes must be swapped:

Voltage: `0x20D0 = 0010 0000 1101 0000`

Comparing the register bit definitions, the charge voltage can be calculated:

8192 + 128 + 64 + 16 = 8400 mV

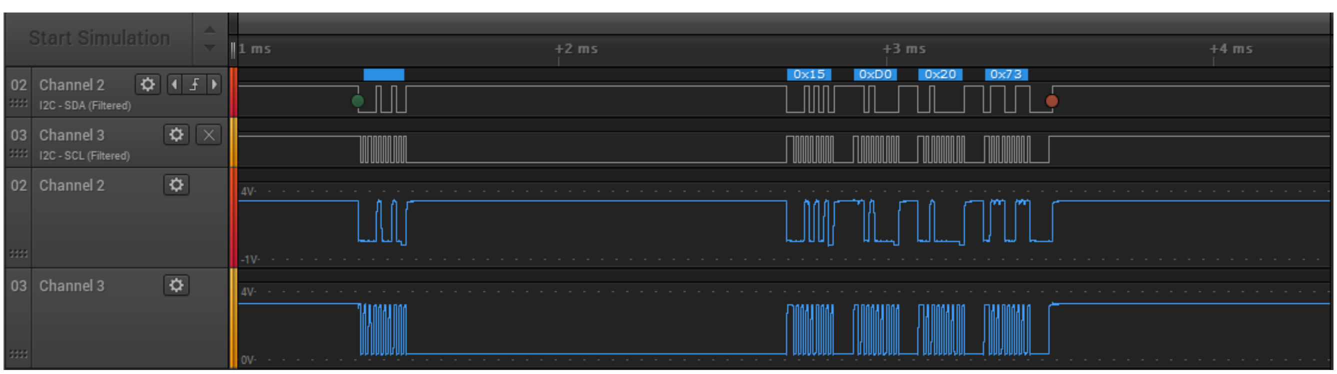

Figure A-5. Voltage Write From Gauge to the Charger in Broadcast Mode

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A CRC-8 calculator can be used for verifying the PEC byte of the voltage and current examples, the PEC byte can be calculated using the data sent previously as a type of checksum[9]. To check the PEC byte, use the bytes 0x12, 0x15, 0xD0, and 0x20 as the CRC calculator input. The calculated byte should be the PEC byte.

A.6 Charge Current Example

An example of the charging current communication with the packet structure follows:

`0x12 (write) 0x14 0xC4 0x09 0xC4`

Current: `0x09C4 = 0000 1001 1100 0100`

Comparing the register bit definitions from the Charger Setup section, the charge current can be calculated:

2048 + 256 + 128 + 64 + (4) = 2500 mA

The desired programmed charge current is 2500 mA, but 4 mA does not exist in the bq25710 register definitions, it is reserved. Reserved bits cannot be written to on the charger, so whatever the gauge writes the charger will not update the reserved bits.

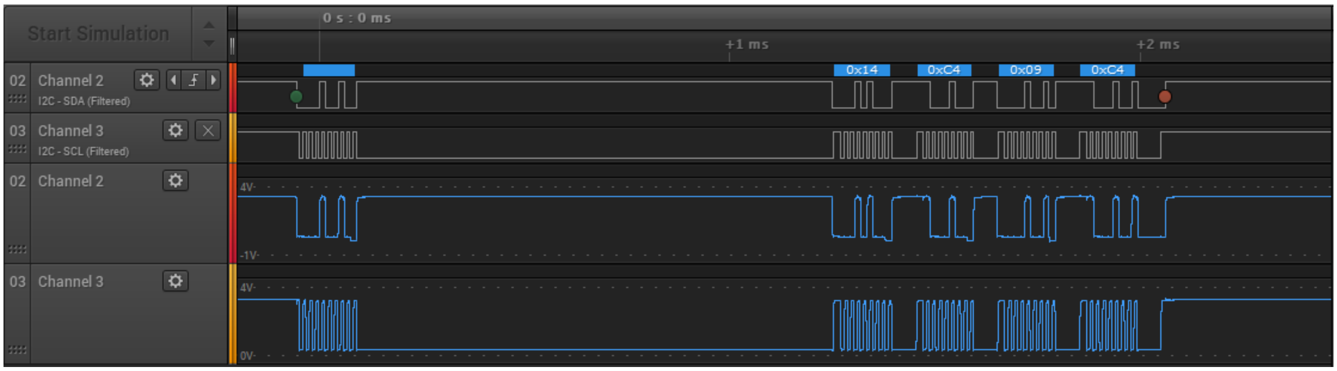

Figure A-6. Current Write From the Gauge to the Charger in Broadcast Mode

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