User's Guide
SLUUB71–November 2014

bq40z60EVM SBS 1.1 Impedance Track™ Technology Enabled Battery Management Solution Evaluation Module

This evaluation module (EVM) is a complete evaluation system for the bq40z60 /bq294700 battery management system. The EVM includes one bq40z60 /bq294700 circuit module and a link to Microsoft® Windows® based PC software. The circuit module includes one bq40z60 integrated circuit (IC), one bq294700 IC, and all other onboard components necessary to charge, monitor, and predict capacity, perform cell balancing, monitor critical parameters, protect the cells from overcharge, over-discharge, short-circuit, and overcurrent in 2-, 3- or 4-series cell Li-ion or Li-polymer battery packs. The circuit module connects directly across the cells in a battery. With the EV2300 or EV2400 interface board and software, the user can read the bq40z60 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the solution under different charge and discharge conditions.

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1 Features

- Complete evaluation system for the bq40z60 SBS 1.1-compliant advanced gas gauges with Impedance Track® technology and bq294700 independent overvoltage protection IC
- Populated circuit module for quick setup
- Software that allows data logging for system analysis

1.1 Kit Contents

- bq40z60 /bq294700 circuit module
- Cable to connect the EVM to an EV2300 or EV2400 communications interface adapter.

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq40z60EVM-578	Li-ion	2, 3, or 4 cell	Any

1.3 Documentation

See the device data sheets for bq40z60 and bq294700 and technical reference manuals (TRMs) on www.ti.com for information on device firmware and hardware.

1.4 bq40z60 /bq294700 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq40z60 /bq294700 circuit module.

Specification	Minimum	Typical	Maximum	Unit
Input voltage VAC to PGND	9	15	26	V
Charge and discharge current	0	2	5	A

2 bq40z60EVM Quick Start Guide

This section provides the step-by-step procedures required to take a new EVM and configure it for operation in a laboratory environment.

2.1 Items needed for EVM setup and Evaluation

- bq40z60 /bq294700 circuit module
- EV2300 or EV2400 communications interface adapter
- Cable to connect the EVM to an EV2300 or EV2400 communications interface adapter
- USB cable to the communications interface adapter to the computer
- Computer setup with Windows XP or higher operating system
- Access to the Internet to download the Battery Management Studio software setup program
- Two to four battery cells or 1-kΩ resistors to configure a cell simulator
- A DC power supply that can supply 20 V and 3 ampere. (Constant current and constant voltage capability is desirable.)

2.2 Software Installation

Find the latest software version in the bq40z60 tool folder on www.ti.com. Use the following steps to install the bq40z60 Battery Management Studio software:

1. Download and run the Battery Management Studio setup program from the bqStudio product folder on www.ti.com. See Battery Management Studio, for detailed information on using the tools.
2. If the communications interface adapter was not previously installed, after the Battery Management Studio installation, a TI USB driver installer pops up. Click *Yes* for the agreement message and follow its instructions. Two drivers are associated with the EV2300 and an additional file may be required for the EV2400. Follow the instructions to install both. Do not reboot the computer, even if asked to do so.
3. Plug the communications interface adapter into a USB port using the USB cable. The Windows system may show a prompt that new hardware has been found. When asked, *Can Windows connect to Windows Update to search for software?*, select *No, not this time*, and click the *Next* button. The next dialog window indicates *This wizard helps you install software for: TI USB Firmware Updater*. Select *Install the software automatically (Recommended)* and click the *Next*. It is common for the next screen to be the Confirm File Replace screen. Click *No* to continue. If this screen does not appear, then go to the next step. After Windows indicates that the installation was finished, a similar dialog window pops up to install the second driver. Proceed with the same installation preference as the first one. The second driver is the TI USB bq80xx driver.

2.3 EVM Connections

This section covers the hardware connections for the EVM (see Figure 1).

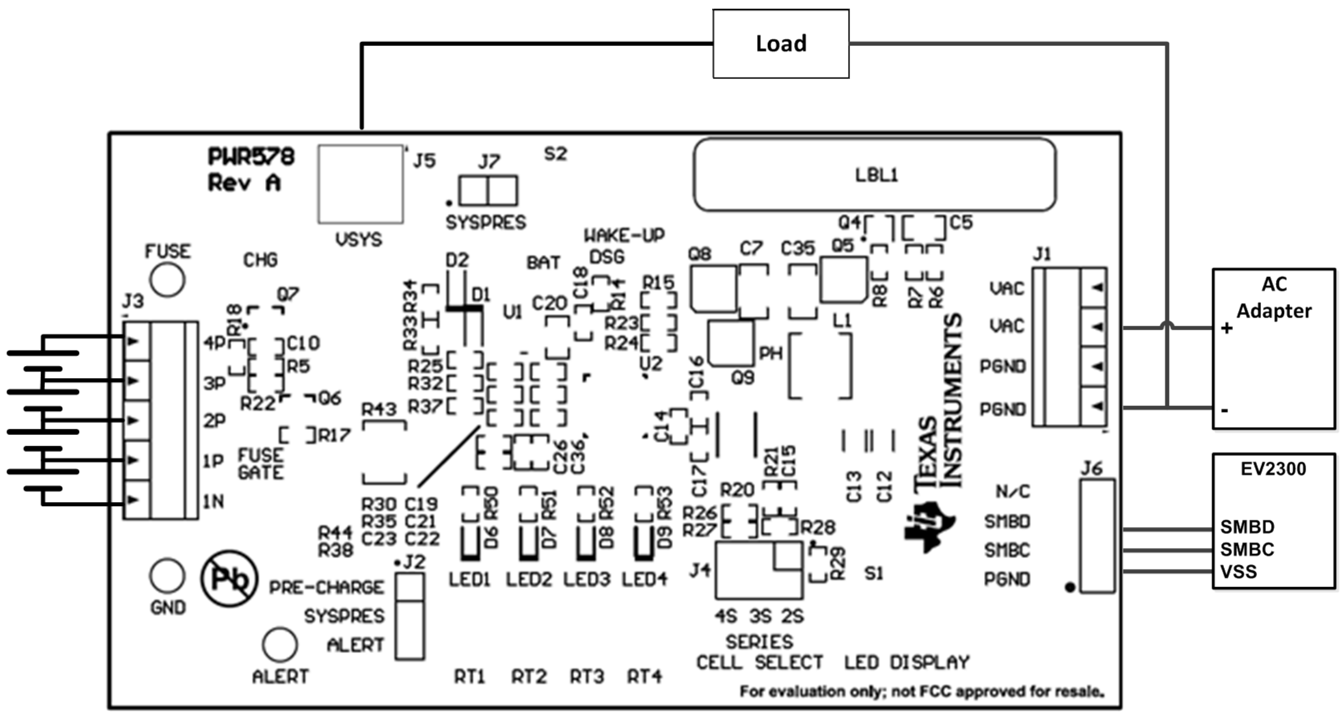


Figure 1. bq40z60 Circuit Module Connection to Cells, System Load and AC Adapter

- Direct connection to the cells: 1N (BAT–), 1P, 2P, 3P, 4P (BAT+)

  Attach the cells to the J3 terminal block. A specific cell connection sequence is not required; although, it is good practice to start with the lowest cell in the stack (cell 1), then attach cells 2 through 4 in sequence. The U1 and U2 devices should not be damaged by other cell connection sequences, but there is a possibility that the bq294700 could blow the fuse. Attaching cells starting with cell 1 should eliminate this risk. A short should be placed across unused voltage sense inputs (see Table 2).

Table 2. Cell Connection Configuration

Number of Cells	J3 Terminal Block Connections								
	1N		1P		2P		3P		4P
2	⊖	–cell1+	⊖	–cell2+	⊖	short	⊖	short	⊖
3	⊖	–cell1+	⊖	–cell2+	⊖	–cell3+	⊖	short	⊖
4	⊖	–cell1+	⊖	–cell2+	⊖	–-cell3+	⊖	–cell4+	⊖

A resistor cell simulator can be used instead of battery cells. Connect a resistor between each of the contacts on the J3 connector (for example, from 1N to 1P, from 1P to 2P, and so forth) until the desired number of cells has been achieved. A power supply can provide power to the cell simulator. Set the power supply to the desired cell voltage x the number of cells, and attach the ground wire to 1N and the positive wire to 4P, for example, for a 3S configuration with a 3.6-V cell voltage, set the power supply to 3 x 3.6 = 10.8 V.

- Serial communications port (SMBC, SMBD)

  Attach the communications interface adapter cable to the J6 terminal block (see Figure 1).
- System load connection across VSYS and PGND

  Attach the load to the J1/J5 terminal blocks. Connect the positive load wire to at least one of the two terminal block positions labeled VSYS. Connect the ground wire for the load to at least one of the two terminal block positions labeled PGND (see Figure 1).
- Charger supply voltage connection across VAC and PGND

  Attach the power supply for the charger to the J1 terminal block. Connect the positive load wire to at least one of the two terminal block positions labeled VAC. Connect the ground wire for the load to at least one of the two terminal block positions labeled PGND (see Figure 1).
- SYSPRES jumper

  The SYSPRES shunt should be placed on the J7 terminal, if the system present feature is enabled. The SYSPRES can be left open, if the non-removable (NR) bit is set to 1 in the DA configuration register.
- PRE-CHARGE / SYSPRES / ALERT (BTP INTERRUPT) jumper

  The shunt should be removed from the J2 jumper, if the system present feature is enabled. The shunt should be placed from the PRE-CHARGE pin to the SYSPRES pin, if the precharge feature is enabled. The shunt should be placed from the SYSPRES pin to the ALERT pin, if the BTP INTERRUPT feature is enabled.
- SERIES CELL SELECT jumper

  The shunt should be placed on the 4S, 3S or 2S pins of the J4 jumper to select the number of series cells configured in the DA configuration register. This selection block configures the charger for the proper output voltage corresponding to the number of series cells.
- Wake-up the device up from shutdown (WAKE-UP)

  Press the WAKE-UP pushbutton switch to temporarily connect BAT+ to VAC. This applies voltage to the ACP pin on the bq40z60 to power-up the regulators and start the initialization sequence.
- Parameter setup

  The default data flash settings configure the device for 3-series Li-Ion cells. Change the *Data Flash → Settings → DA Configuration* register to set up the number of series cells to match the physical pack configuration. This provides basic functionality to the setup. Other data flash parameters should also be updated to fine-tune the gauge to the pack. See the bq40z60 TRM (SLUUA04) for parameter settings.
- Charge and Discharge FET Control

  The Charge and Discharge FETs can be enabled by entering a 0x0022 command in the Manufacturing Access register on the Registers screen or by selecting the *FET_EN* button on the *Commands* panel.

3 Battery Management Studio

3.1 Registers Screen

Run Battery Management Studio from the *Start → Programs → Texas Instruments → Battery Management Studio* menu sequence, or the Battery Management Studio shortcut. The Registers screen (see Figure 2) appears. The Registers section contains parameters used to monitor gauging. The Bit Registers section provides a bit-level picture of status and fault registers. A green flag indicates that the bit is 0 (low state) and a red flag indicates that the bit is 1 (high state). Data begins to appear once the *Refresh* (single-time scan) button is selected, or it scans continuously, if the *Scan* button is selected.

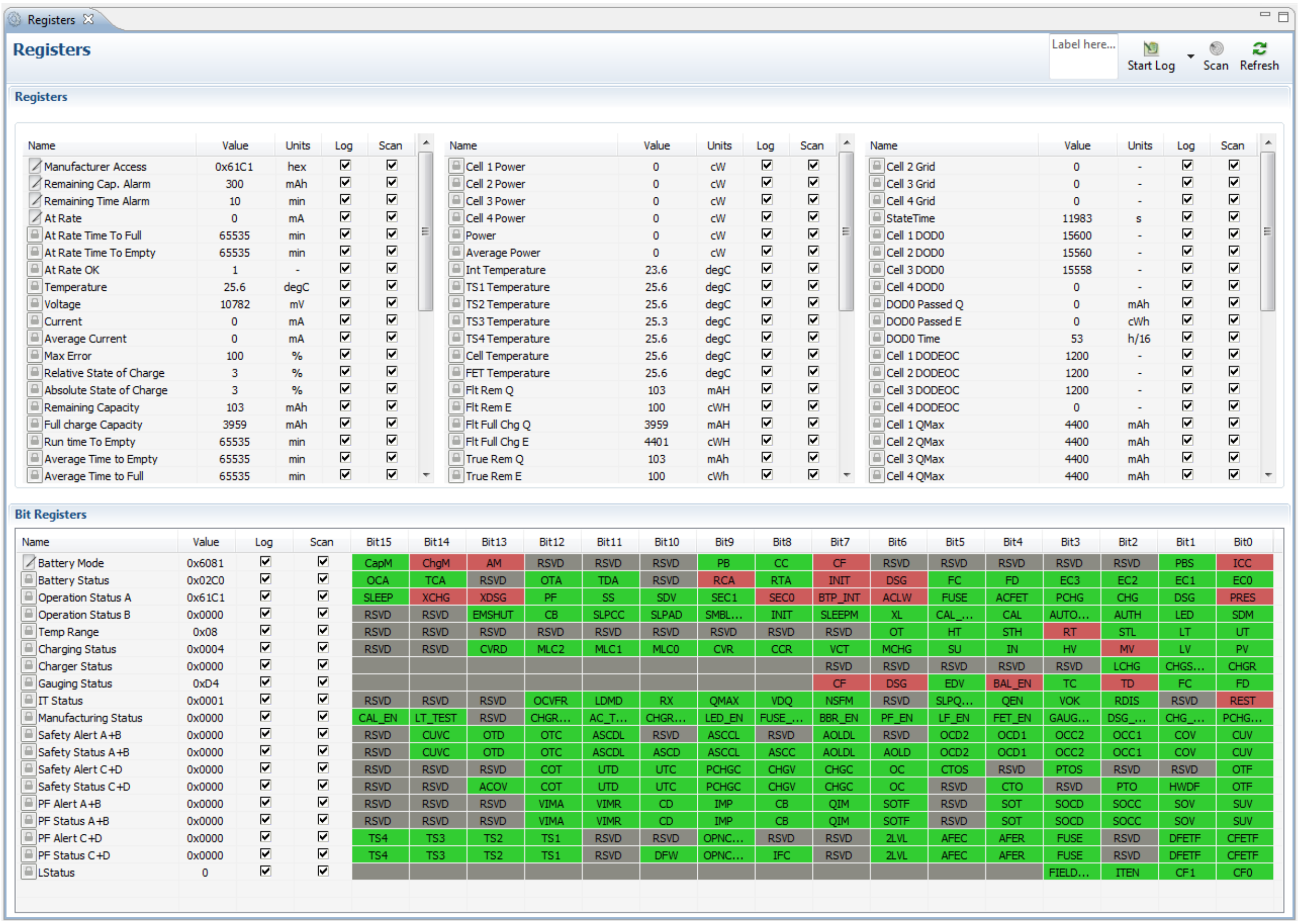


Figure 2. Registers Screen

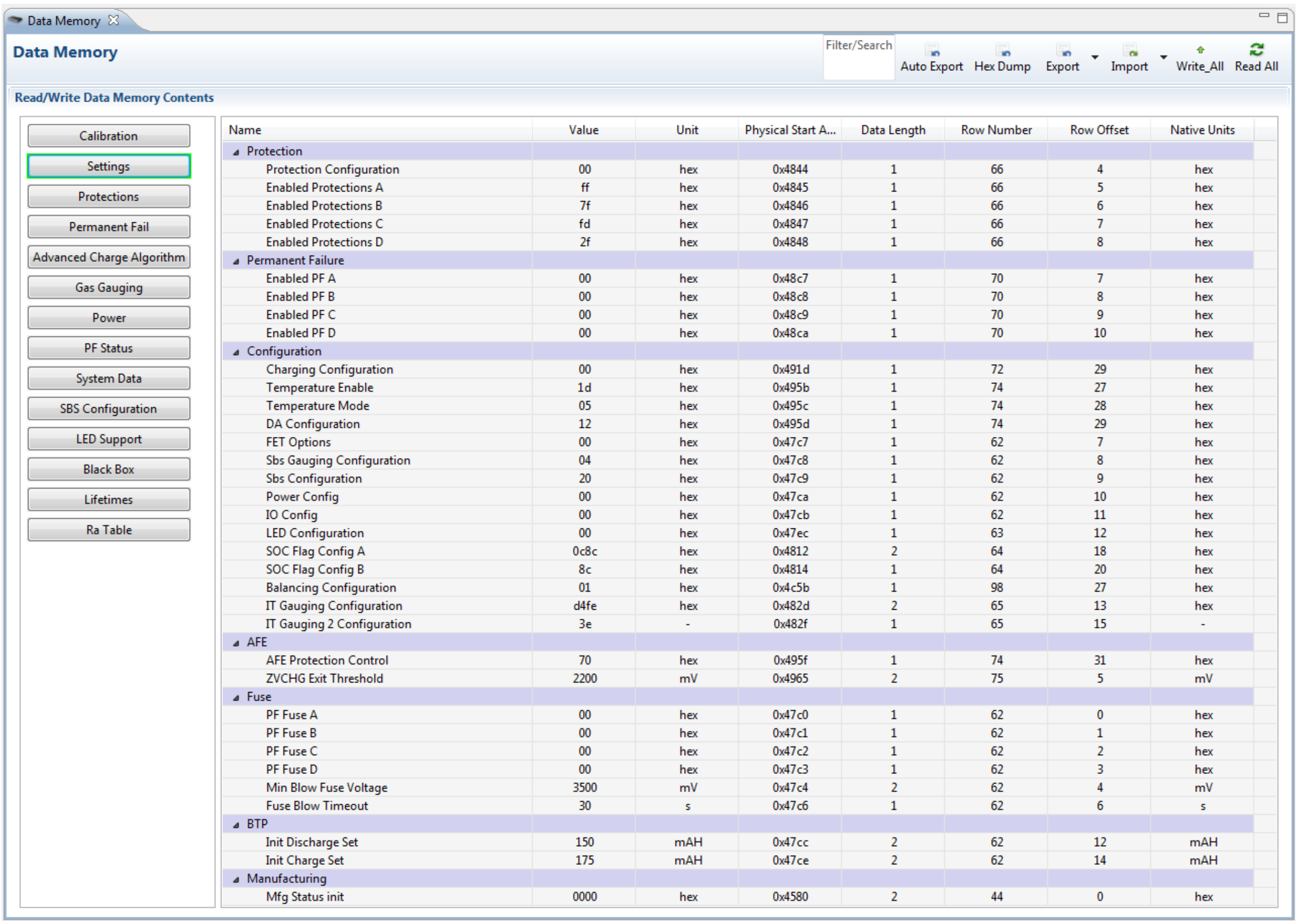
The continuous scanning period can be set via the *Window → Preferences → SBS → Scan Interval* menu selection.

The Battery Management Studio program provides a logging function which logs the values selected by the Log check boxes located beside each parameter in the Registers section. To enable this function, select the *Log* button; this causes the *Scan* button to be selected. When logging is stopped, the *Scan* button is still selected and has to be manually deselected.

3.2 Setting Programmable bq40z60 Options

The bq40z60 data flash comes configured per the default settings detailed in the bq40z60 TRM. Ensure that the settings are correctly changed to match the pack and application for the solution being evaluated.

NOTE: The correct setting of these options is essential to get the best performance. The settings can be configured using the Data Memory screen (see Figure 3).



Name	Value	Unit	Physical Start A...	Data Length	Row Number	Row Offset	Native Units
Protection							
Protection Configuration	00	hex	0x4844	1	66	4	hex
Enabled Protections A	ff	hex	0x4845	1	66	5	hex
Enabled Protections B	7f	hex	0x4846	1	66	6	hex
Enabled Protections C	fd	hex	0x4847	1	66	7	hex
Enabled Protections D	2f	hex	0x4848	1	66	8	hex
Permanent Failure							
Enabled PF A	00	hex	0x48c7	1	70	7	hex
Enabled PF B	00	hex	0x48c8	1	70	8	hex
Enabled PF C	00	hex	0x48c9	1	70	9	hex
Enabled PF D	00	hex	0x48ca	1	70	10	hex
Configuration							
Charging Configuration	00	hex	0x491d	1	72	29	hex
Temperature Enable	1d	hex	0x495b	1	74	27	hex
Temperature Mode	05	hex	0x495c	1	74	28	hex
DA Configuration	12	hex	0x495d	1	74	29	hex
FET Options	00	hex	0x47c7	1	62	7	hex
Sbs Gauging Configuration	04	hex	0x47c8	1	62	8	hex
Sbs Configuration	20	hex	0x47c9	1	62	9	hex
Power Config	00	hex	0x47ca	1	62	10	hex
IO Config	00	hex	0x47cb	1	62	11	hex
LED Configuration	00	hex	0x47ec	1	63	12	hex
SOC Flag Config A	0c8c	hex	0x4812	2	64	18	hex
SOC Flag Config B	8c	hex	0x4814	1	64	20	hex
Balancing Configuration	01	hex	0x4c5b	1	98	27	hex
IT Gauging Configuration	d4fe	hex	0x482d	2	65	13	hex
IT Gauging 2 Configuration	3e	-	0x482f	1	65	15	-
AFE							
AFE Protection Control	70	hex	0x495f	1	74	31	hex
ZVCHG Exit Threshold	2200	mV	0x4965	2	75	5	mV
Fuse							
PF Fuse A	00	hex	0x47c0	1	62	0	hex
PF Fuse B	00	hex	0x47c1	1	62	1	hex
PF Fuse C	00	hex	0x47c2	1	62	2	hex
PF Fuse D	00	hex	0x47c3	1	62	3	hex
Min Blow Fuse Voltage	3500	mV	0x47c4	2	62	4	mV
Fuse Blow Timeout	30	s	0x47c6	1	62	6	s
BTP							
Init Discharge Set	150	mAH	0x47cc	2	62	12	mAH
Init Charge Set	175	mAH	0x47ce	2	62	14	mAH
Manufacturing							
Mfg Status init	0000	hex	0x4580	2	44	0	hex

Figure 3. Data Memory Screen

3.3 Calibration Screen

The voltages, temperatures, and currents should be calibrated to provide good gauging performance. Press the *Calibration* button to select the *Advanced Calibration* window (see Figure 4).

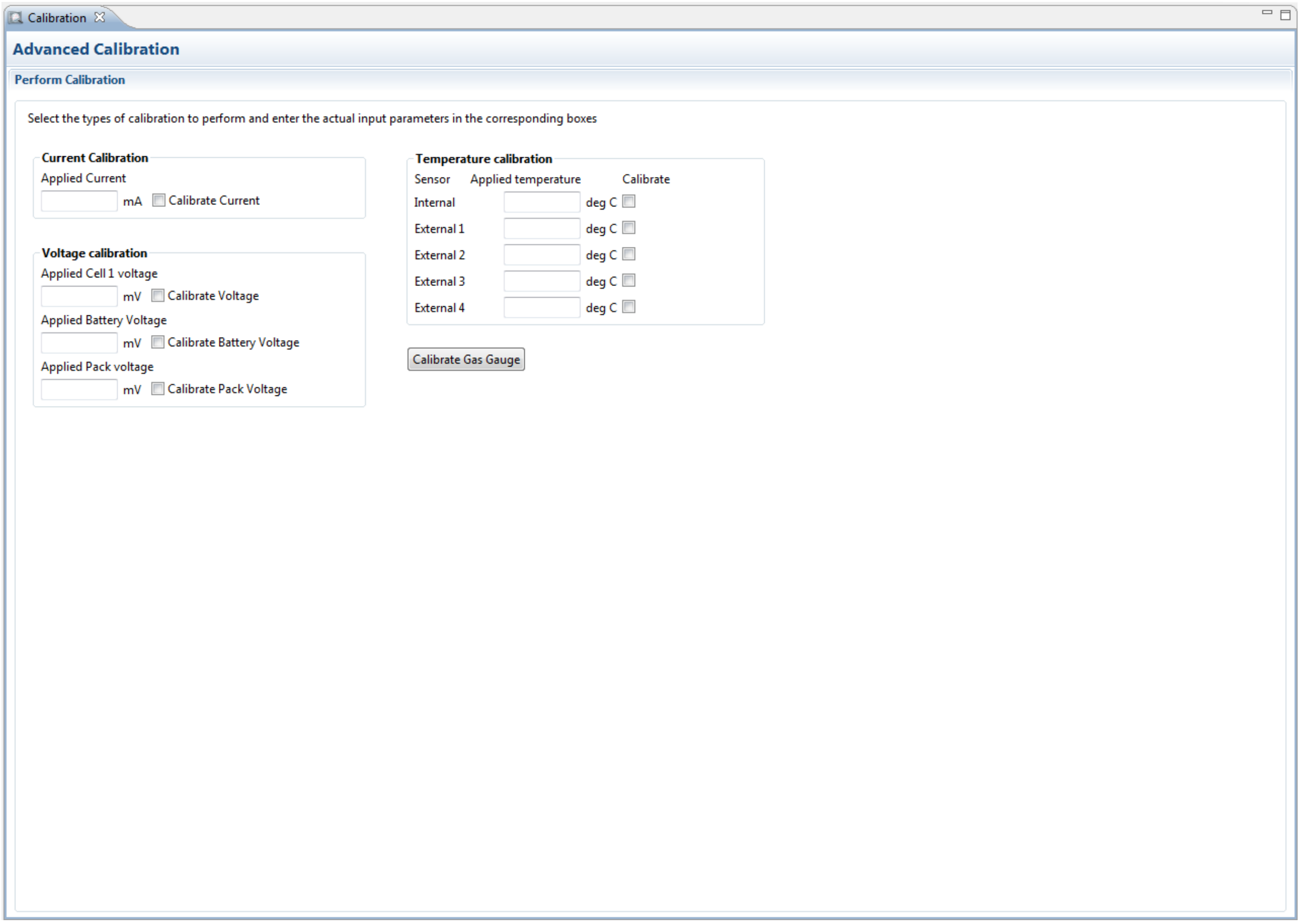


Figure 4. Calibration Screen

3.3.1 Voltage Calibration

- Measure the voltage from cell 1 to 1N and enter this value in the *Applied Cell 1 Voltage* field and select the *Calibrate Voltage* box.
- Measure the voltage from BAT+ to BAT– and enter this value in the *Applied Battery Voltage* field and select the *Calibrate Battery Voltage* box.
- Measure the voltage from VSYS to PGND and enter this value in the *Applied Pack Voltage* field and select the *Calibrate Pack Voltage* box. If the voltage is not present, then turn the charge and discharge FETs on by selecting the *FET_EN* button on the *Commands* window.
- Press the *Calibrate Gas Gauge* button to calibrate the voltage measurement system.
- Deselect the *Calibrate Voltage* boxes after voltage calibration has completed.

3.3.2 Temperature Calibration

- Enter the room temperature in each of the *Applied temperature* fields and select the *Calibrate* box for each thermistor to be calibrated. Enter temperature values in degrees Celsius.
- Press the *Calibrate Gas Gauge* button to calibrate the temperature measurement system.
- Deselect the *Calibrate* boxes after temperature calibration has completed.

3.3.3 Current Calibration

- The Board Offset calibration option is not offered in Battery Management Studio, because it is not required when using the bq40z60EVM. The Board Offset calibration option is available in bqProduction.
- Connect and measure a 2-A current source from 1N (–) and PGND (+) to calibrate without using the FETs. (TI does not recommend calibration using the FETs.)
- Enter –2000 in the *Applied Current* field and select the *Calibrate Current* box.
- Press the *Calibrate Gas Gauge* button to calibrate.
- Deselect the *Calibrate Current* box after current calibration has completed.

NOTE: Current can also be calibrated using the FETs. Measure the current in the discharge path and enter this value in the *Applied Current* field.

3.4 Chemistry Screen

The chemistry file contains parameters that the simulations use to model the cell and its operating profile. It is critical to program a Chemistry ID that matches the cell used in the pack. Some of these parameters can be viewed in the Data Flash section of the Battery Management Studio.

Press the *Chemistry* button to select the Chemistry window (see Figure 5).

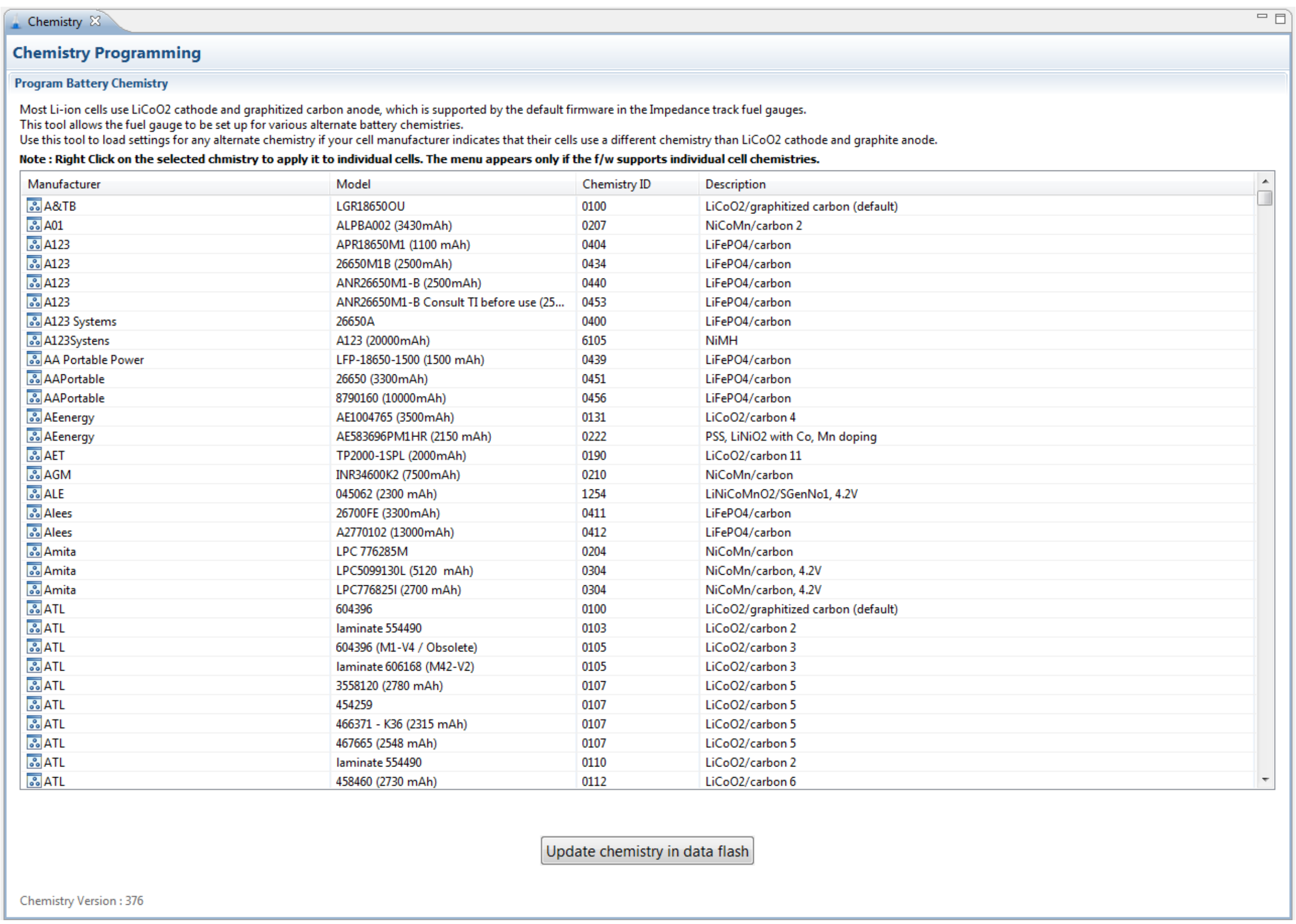


Figure 5. Chemistry Screen

- The table can be sorted by clicking the desired column, for example: click the *Chemistry ID* column header.

- Select the ChemID that matches your cell from the table (see Figure 5).
- Press the Update Chemistry in the *Data Flash* button to update the chemistry in the device.

3.5 Firmware Screen

Press the *Firmware* button to select the *Firmware Update* window. Device firmware is exported and imported in the *Firmware Update* window.

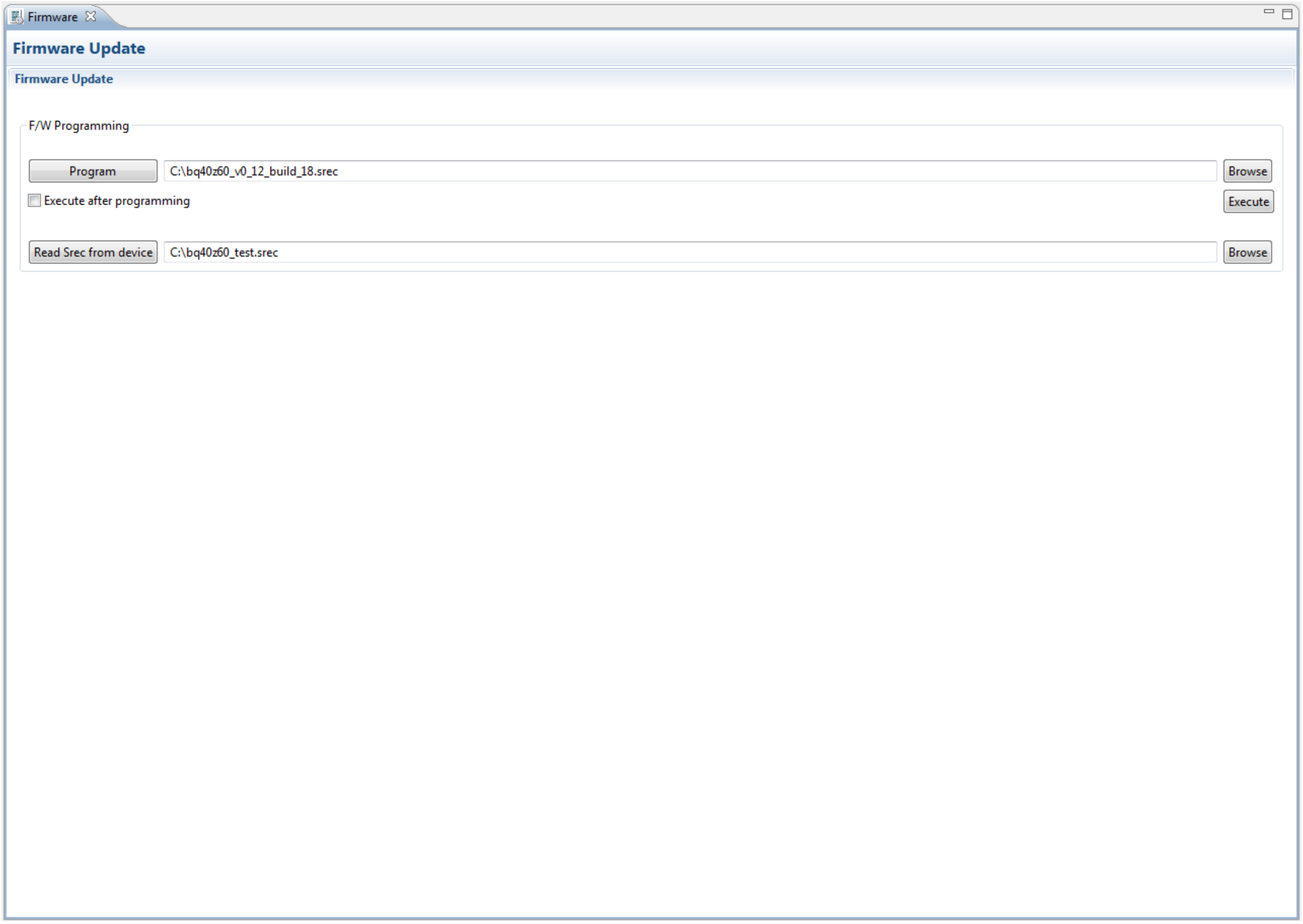


Figure 6. Firmware Screen

3.5.1 Programming the Flash Memory

The upper section of the Firmware screen is used to initialize the device by loading the default .srec into the flash memory (see Figure 6).

- Search for the .srec file using the *Browse* button.
- Select the *Execute after programming* box to automatically return the device to Normal mode after programming has completed.
- Press the *Program* button and wait for the download to complete.

3.5.2 Exporting the Flash Memory

The lower section of the Firmware screen is used to export all of the flash memory from the device (see Figure 6).

- Press the *Browse* button and enter an .srec filename.
- Press the *Read Srec* to save the flash memory contents to the file. Wait for the download to complete.

3.6 Advanced Comm SMB Screen

Press the *Advanced Comm SMB* button to select the Advanced SMB Comm window. This tool provides access to parameters using SMB and Manufacturing Access commands (see Figure 7).

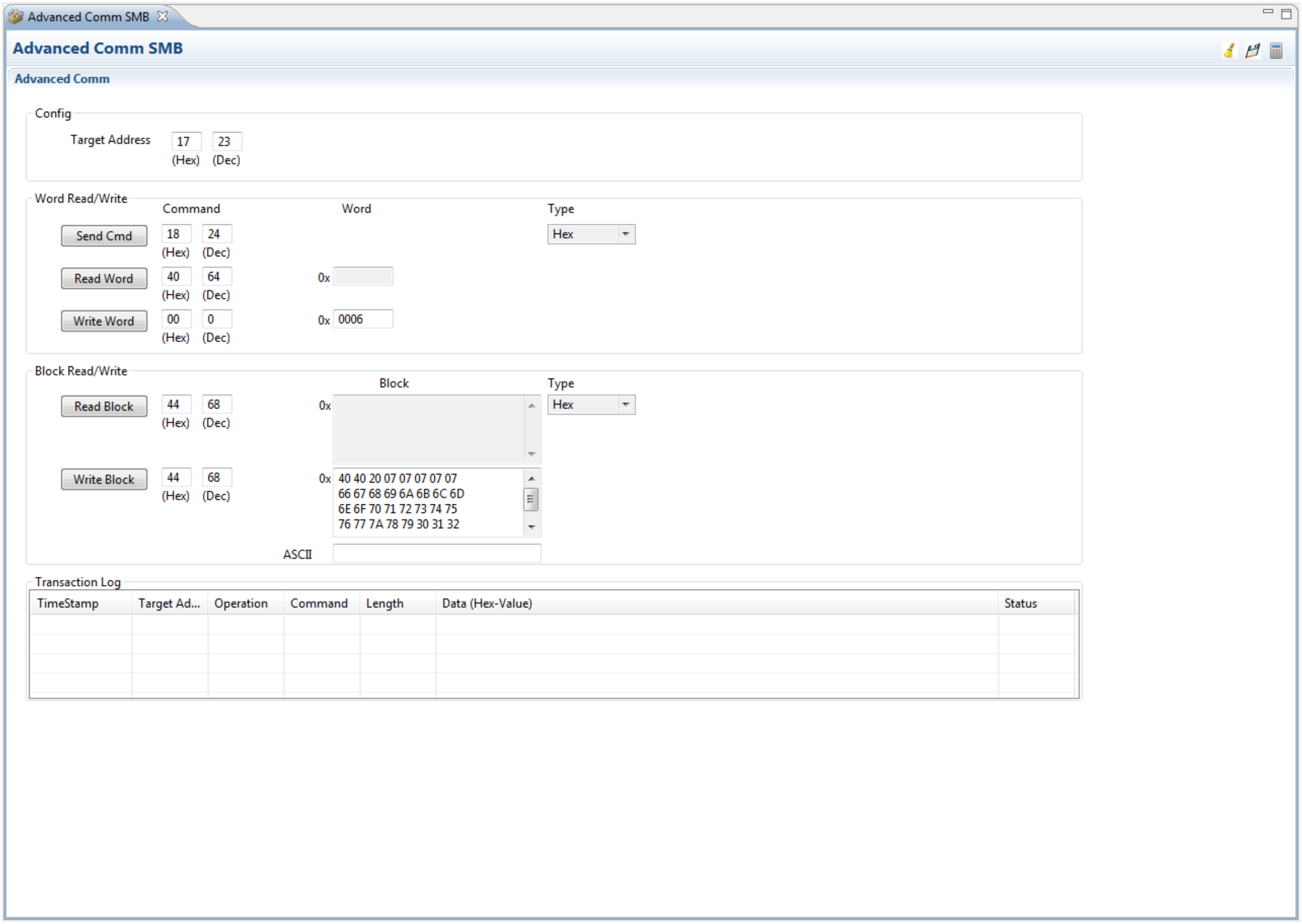


Figure 7. Advanced Comm Screen

Examples:

Reading an SMB Command.

- Read SBData Voltage (0x09)
  - SMBus Read Word. Command = 0x09
  - Word = 0x3A7B, which is hexadecimal for 14971 mV

Sending a MAC Gauging() to enable IT via ManufacturerAccess().

- With Impedance Track™ disabled, send Gauging() (0x0021) to ManufacturerAccess().
  - SMBus Write Word. Command = 0x00. Data = 00 21

Reading Chemical ID() (0x0006) via ManufacturerAccess()

- Send Chemical ID() to ManufacturerAccess()
  - SMBus Write Word. Command = 0x00. Data sent = 00 06
- Read the result from ManufacturerData()
  - SMBus Read Block. Command = 0x23. Data read = 00 01
  - That is 0x0100, chem ID 100

4 bq40z60EVM Circuit Module Schematic

This section contains information on modifying the EVM and using various features on the reference design.

4.1 System Present

The SYSPRES input is used to detect whether the pack is installed in, or removed from the system. The bq40z60 detects the BATTERY PACK REMOVED mode if the [NR] bit is set to 0 AND the SYSPRES input is high. The bq40z60 exits the BATTERY PACK REMOVED state if the [NR] flag is set to 0 **and** the PRES input is low. The SYSPRES input is ignored if the [NR] flag is set to 1.

The System Present function is enabled by installing the shunt on the J7 jumper and removing the shunt from the J2 jumper. Configure the data flash parameters for SYSPRES (see Table 3).

Table 3. SYSPRES / PRE_CHARGE / ALERT (BTP INTERRUPT) Data Flash Configuration

Function	NR	EMSHUT_EN	PCHGBTP	BTP_EN
System Present	0	x	x	x
Pre-charge	1	0	0	x
Alert	1	0	1	1

4.2 Pre-charge

The EVM provides a power resistor and FET to support a reduced current pre-charge path to charge the pack when cell voltages are below the pre-charge voltage threshold. This reduces heating that could lead to cell damage or reduced operating lifetime. The resistor (R1) is set up to limit the charging current. Change R1 to setup the pre-charge current to a different value.

The pre-charge function is enabled by removing the shunt from the J7 jumper and installing a shunt from PRE_CHARGE to SYSPRES on the J2 jumper. Configure the data flash parameters for Precharge (see Table 3).

4.3 Battery Trip Point (BTP)

The Battery Trip Point (BTP) feature indicates when the Remaining State of Charge (RSOC) of a battery pack has depleted to a certain value set in a DF register. The BTP feature allows the host to program two capacity-based thresholds that govern the triggering of a BTP interrupt on the GPIO0 output pin. The BTP interrupt can be monitored on the ALERT test point.

The BTP interrupt function is enabled by removing the shunt from the J7 jumper and installing a shunt from SYSPRES to ALERT on the J2 jumper. Configure the data flash parameters to enable BTP and the BTP interrupt (see Table 3).

4.4 LED Control

The EVM is configured to support four LEDs to provide state-of-charge information for the cells. The LED interface is enabled by entering a 0x0027 command in the *Manufacturing Access* register on the *Registers* screen or by selecting the LED_EN button on the *Commands* panel. Press the *LED DISPLAY* button to illuminate the LEDs for approximately 5 seconds.

The EVM includes a 3.3-V regulator to power the LEDs. This regulator is powered by the batteries and it can be disabled by removing R48 (see the bq294700 /bq294700 EVM schematic).

Configure the data flash parameters for LED enable and to select the LED button (see Table 4).

Table 4. LED / Emergency Shutdown Button Configuration

Function	LED_EN	EMSHUT_EN	EMSHUT_EN
LED Button	1	0	0
Emergency Shutdown Button	0	1	1

4.5 Emergency Shutdown

Use the Emergency Shutdown function to disable the charge and discharge FETs with an external GPIO pin. Press the SHUTDOWN pushbutton switch for one second to disable these FETs, and press it again for one second to enable them. Configure the data flash parameters for Emergency Shutdown (see Table 4).

4.6 Testing Fuse-Blowing Circuit

To prevent the loss of board functionality during the fuse-blowing test, the actual fuse is not installed on the EVM. FET Q7 drives the FUSE test point low if a fuse-blow condition occurs. FUSE is attached to an open drain FET, so a pull-up resistor is required to check whether the FUSE pulls low. A FUSEPIN test point is attached to the gate of Q7; so, monitoring FUSEPIN can be used to test this condition without adding a pull-up resistor. A chemical fuse can also be soldered to the EVM for in-system testing. A copper bridge is included on the PCB to bypass the chemical fuse, so it has to be cut to allow the fuse to open the power path. The cut is illustrated in yellow on Figure 8 with an arrow pointing to the location.

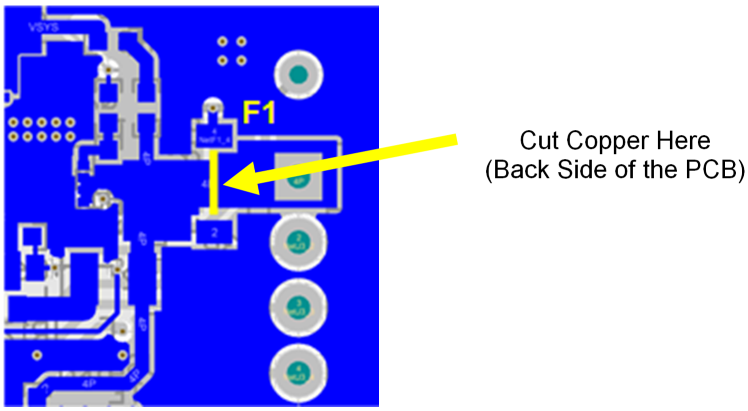


Figure 8. Fuse Trace Modification

4.7 Charger

The bq40z60 supports an integrated NVDC charger with a default configuration set up for three series cells. The charger can be reconfigured for 2S or 4S with the SERIES CELL SELECT jumper block. Three data flash parameters must be changed to reconfigure the number of series cells (see Table 5). The charger must be enabled with the Manufacturer Access Command (MAC) **C0**.

Table 5. Charger Configuration Setting

No. of Series Cells	CC1	CC0	Minimum Voltage Output	Voltage Resolution
2	0	1	4350 mV	17 mV
3	1	0	6500 mV	25 mV
4	1	1	8644 mV	34 mV

4.8 Thermistors

The bq40z60 supports up to four external NTC thermistors. Each thermistor can be enabled using the data flash Temperature Enable register and they can be assigned to cells or FETs using the *Temperature Mode* register.

5 Circuit Module Physical Layouts

This section contains the printed-circuit board (PCB) layout, assembly drawings, and schematic for the bq40z60 and bq294700 circuit modules.

5.1 Board Layout

This section shows the dimensions, PCB layers (Figure 9 through Figure 16), and assembly drawing for the bq40z60 modules.

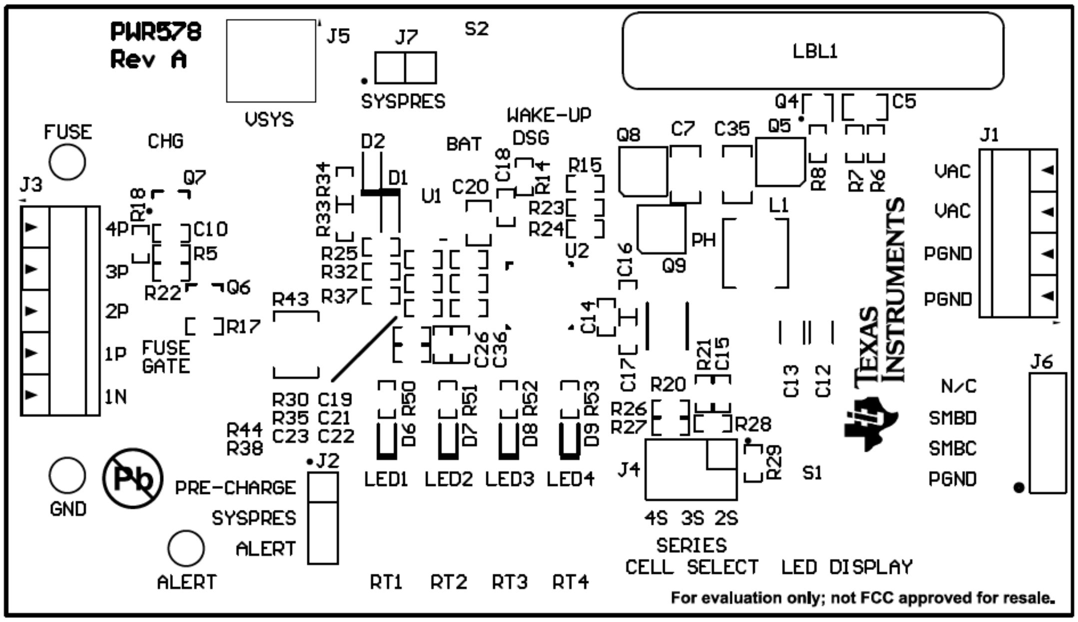


Figure 9. Top Silk Screen

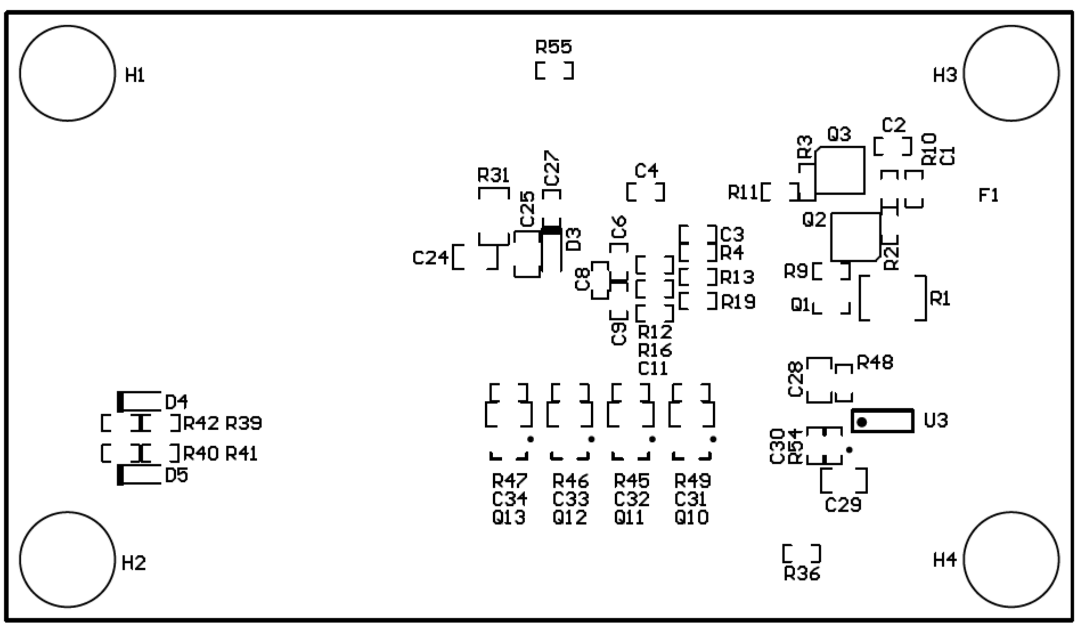


Figure 10. Bottom Silk Screen

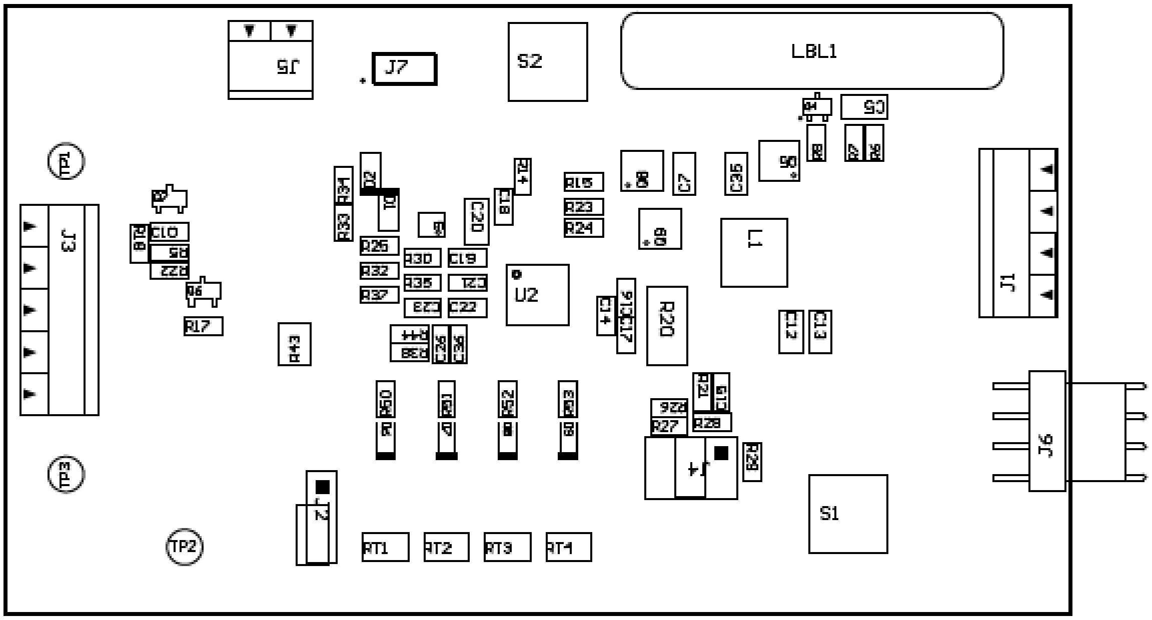


Figure 11. Top Assembly

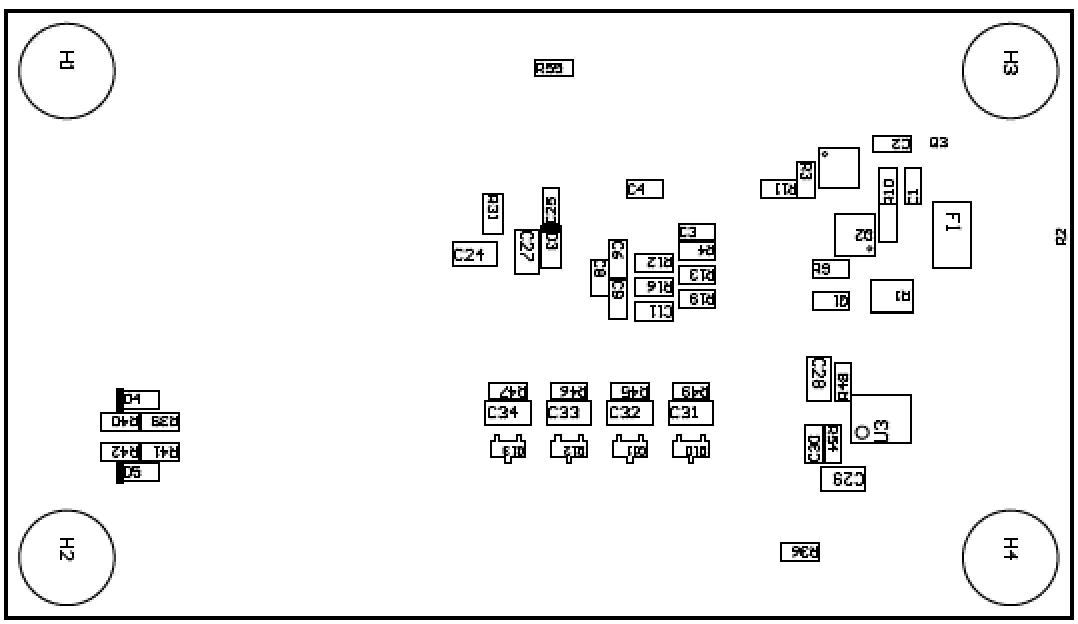


Figure 12. Bottom Assembly

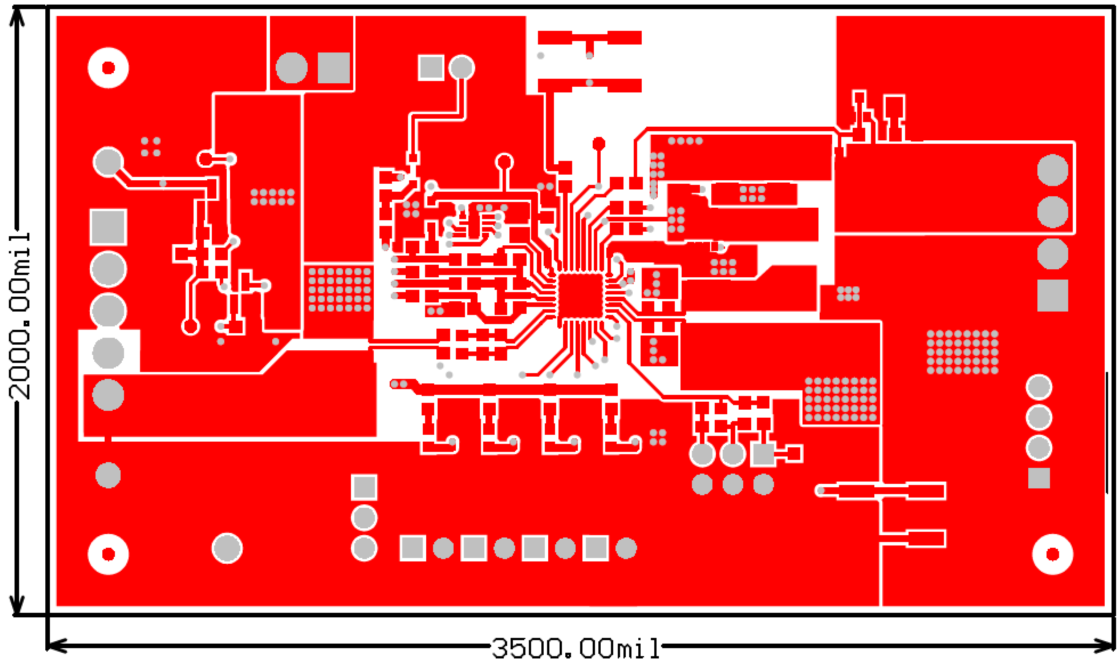


Figure 13. Top Layer

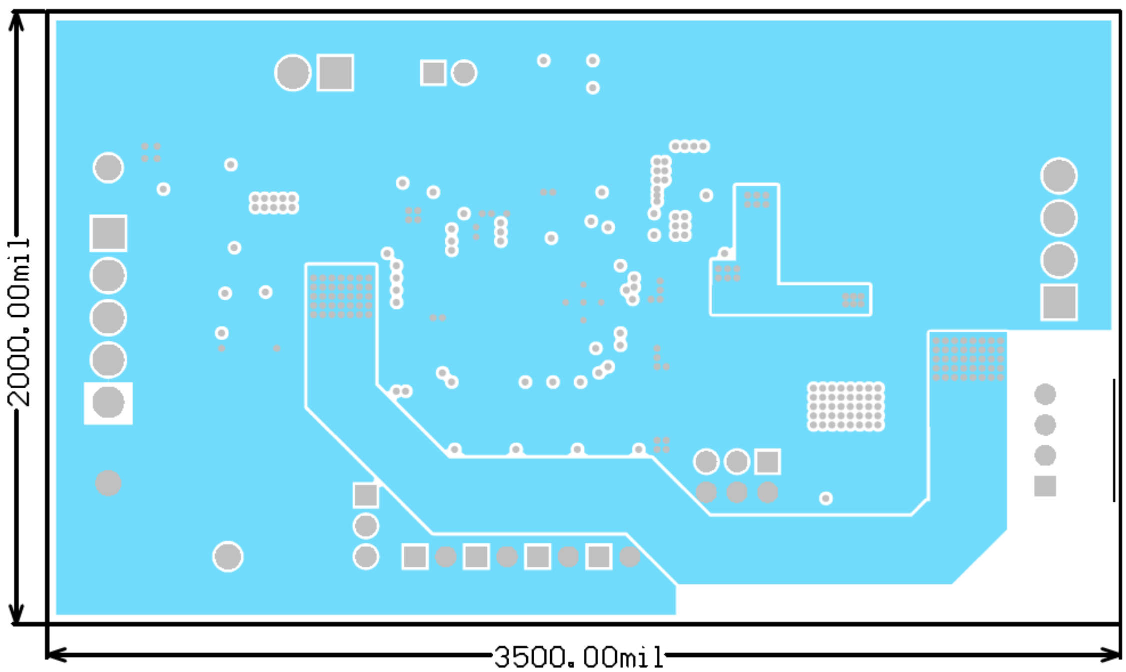


Figure 14. Internal Layer 1

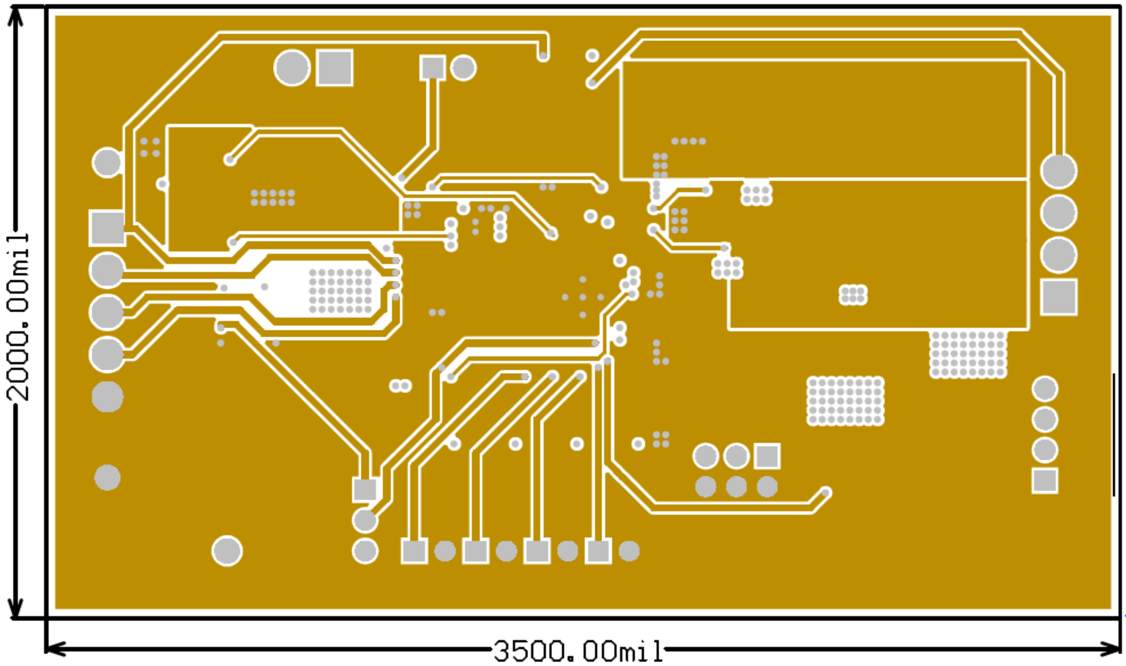


Figure 15. Internal Layer 2

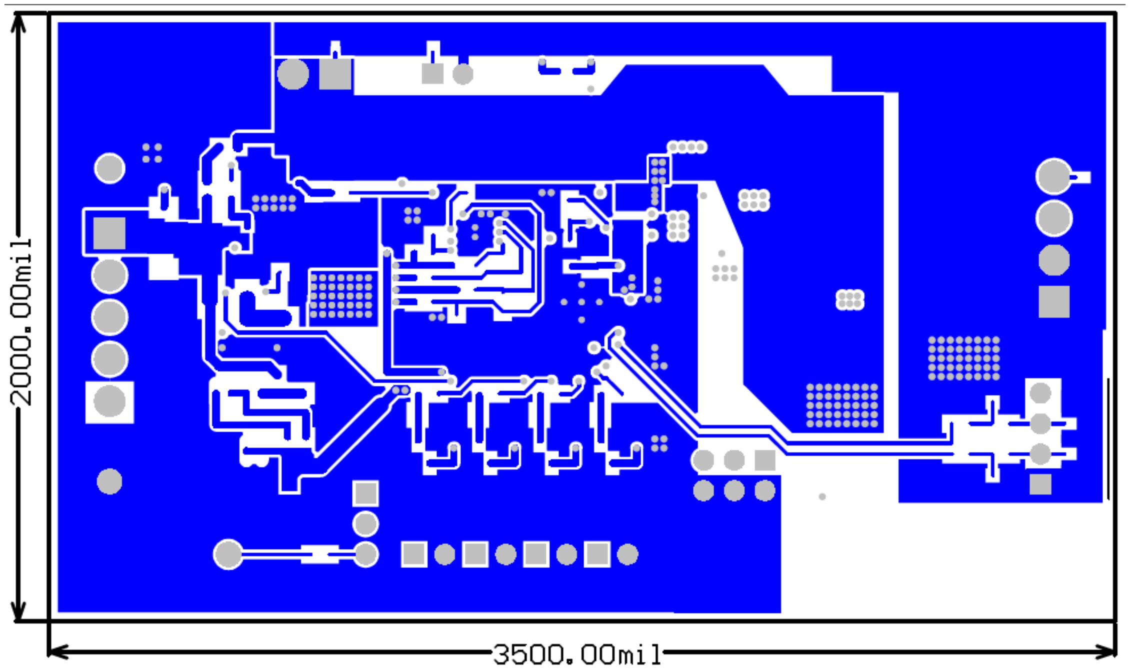


Figure 16. Bottom Layer

5.2 Schematic

Figure 17 illustrates the schematic for this EVM.

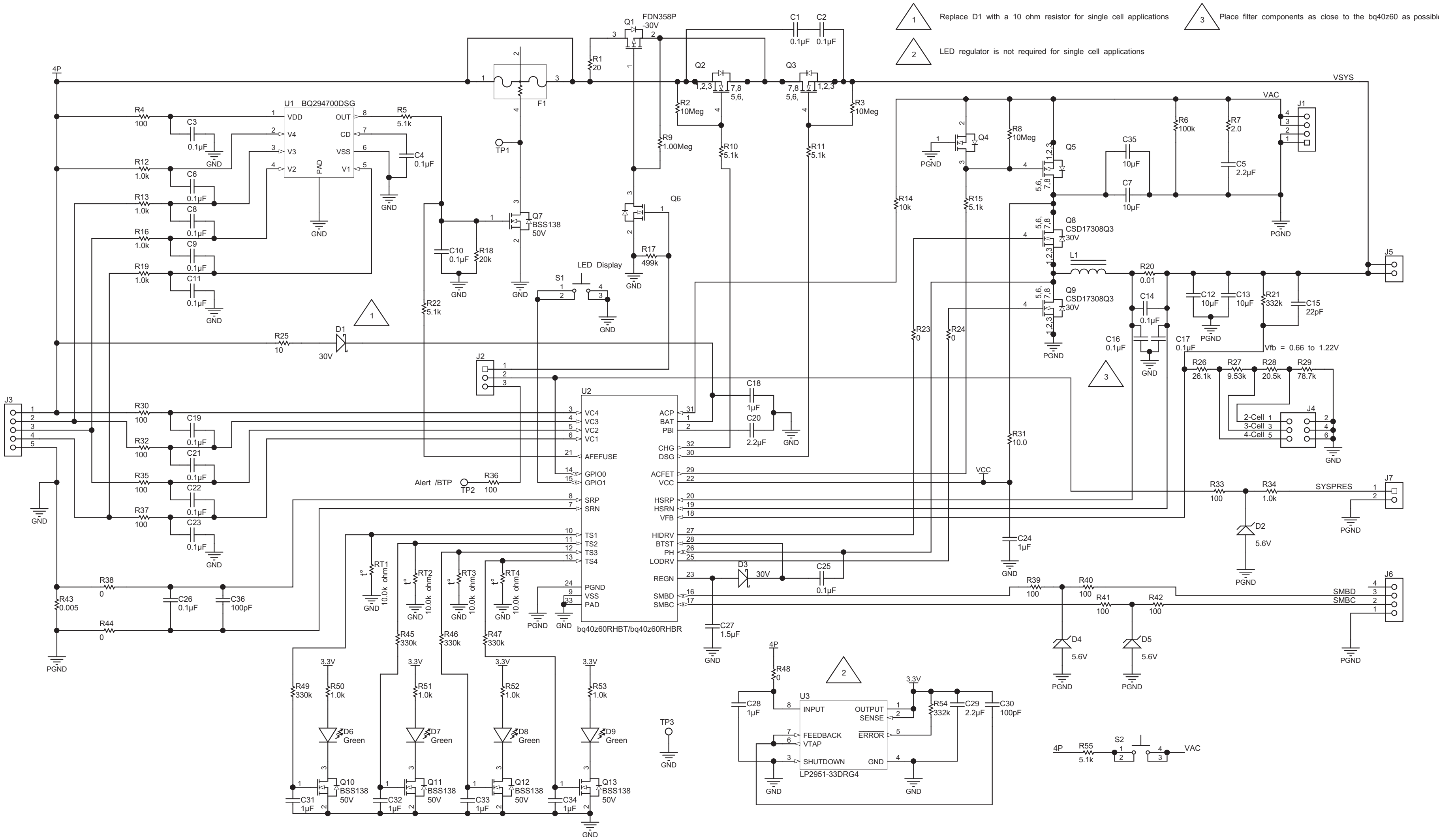


Figure 17. bq294700 /bq294700 EVM Schematic

6 Bill of Materials (BOM)

Table 6 lists the BOM for this EVM.

Table 6. Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	Manufacturer
1	PCB1		Printed Circuit Board		PWR578	Any
18	C1– C4, C6, C–C11, C14, C16, C17, C19, C21–C23, C25, C26	0.1µF	CAP, CERM, 0.1µF, 50V, ±10%, X7R, 0603	603	GRM188R71H104KA93D	Murata
3	C5, C20, C29	2.2µF	CAP, CERM, 2.2µF, 25V, ±10%, X7R, 0805	805	GRM21BR71E225KA73L	Murata
2	C7, C35	10µF	CAP, CERM, 10 µF, 35 V, ±10%, X7R, 1206	1206	GMK316AB7106KL	Taiyo Yuden
2	C12, C13	10µF	CAP, CERM, 10 µF, 50 V, ±10%, X5R, 1206_190	1206_190	CGA5L3X5R1H106K160AB	TDK
1	C15	22pF	CAP, CERM, 22pF, 50V, ±5%, C0G/NP0, 0603	603	06035A220JAT2A	AVX
1	C18	1µF	CAP, CERM, 1µF, 25V, ±10%, X5R, 0603	603	GRM188R61E105KA12D	Murata
6	C24, C28, C31–C34	1µF	CAP, CERM, 1µF, 50V, ±10%, X7R, 0805	805	GRM21BR71H105KA12L	Murata
1	C27	1.5µF	CAP, CERM, 1.5µF, 25V, ±10%, X7R, 0805	805	GRM21BR71E155KA88L	Murata
2	C30, C36	100pF	CAP, CERM, 100pF, 50V, ±5%, C0G/NP0, 0603	603	C0603C101J5GAC	Kemet
2	D1, D3	30V	Diode, Schottky, 30V, 0.2A, SOD-323	SOD-323	BAT54HT1G	ON Semiconductor
3	D2, D4, D5	5.6V	Diode, Zener, 5.6V, 200mW, SOD-323	SOD-323	MMSZ5232BS-7-F	Diodes Inc.
4	D6–D9	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
1	F1	SFH-1412B	Fuse, 12A, 36V, SMD	5.4x1.35x3.2mm	SFH-1412B	Dexerials Corporation
4	H1, H2, H3, H4	SJ61A1	Bumpon, Cylindrical, 0.312 × 0.200, Black	Black Bumpon	SJ61A1	3M
1	H5	CBL002	Cable	Used in PnP output	CBL002	Any
1	J1	ED555/4DS	Terminal Block, 6A, 3.5mm Pitch, 4-Pos, TH	14x8.2x6.5mm	ED555/4DS	On-Shore Technology
1	J2	TSW-103-07-G-S	Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
1	J3	ED555/5DS	Terminal Block, 6A, 3.5mm Pitch, 5-Pos, TH	17.5x8.2x6.5mm	ED555/5DS	On-Shore Technology
1	J4	TSW-103-07-G-D	Header, TH, 100mil, 3x2, Gold plated, 230 mil above insulator	3x2 Header	TSW-103-07-G-D	Samtec
1	J5	ED555/2DS	Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
1	J6	22-05-3041	Header, 100mil, 4x1, R/A, TH	4x1 R/A Header	22-05-3041	Molex
1	J7	TSW-102-07-G-S	Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
1	L1	2.2µH	Inductor, Shielded Drum Core, Powdered Iron, 2.2 µH, 5 A, 0.0377 Ω, SMD	5.49x2x5.18mm	IHLP2020BZER2R2M11	Vishay-Dale
1	Q1	–30V	MOSFET, P-CH, -30V, -1.5A, SSOT-3	SSOT-3	FDN358P	Fairchild Semiconductor
5	Q2, Q3, Q5, Q8, Q9	30V	MOSFET, N-CH, 30V, 47A, SON 3.3x3.3mm	SON 3.3x3.3mm	CSD17308Q3	Texas Instruments
1	Q4	60V	MOSFET, N-CH, 60V, 0.31A, SOT-323	SOT-323	2N7002KW	Fairchild Semiconductor
6	Q6, Q7, Q10–Q13	50V	MOSFET, N-CH, 50V, 0.22A, SOT-23	SOT-23	BSS138	Fairchild Semiconductor
1	R1	20	RES, 20 Ω, 5%, 0.5W, 1210	1210	ERJ-14YJ200U	Panasonic
3	R2, R3, R8	10Meg	RES, 10MΩ, 5%, 0.1W, 0603	603	CRCW060310M0JNEA	Vishay-Dale

Table 6. Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	Manufacturer
11	R4, R30, R32, R33, R35–R37, R39–R42	100	RES, 100 Ω, 5%, 0.1W, 0603	603	CRCW0603100RJNEA	Vishay-Dale
6	R5, R10, R11, R15, R22, R55	5.1k	RES, 5.1kΩ, 5%, 0.1W, 0603	603	CRCW06035K10JNEA	Vishay-Dale
1	R6	100k	RES, 100Ω, 5%, 0.1W, 0603	603	CRCW0603100KJNEA	Vishay-Dale
1	R7	2	RES, 2.0 Ω, 5%, 0.1W, 0603	603	CRCW06032R00JNEA	Vishay-Dale
1	R9	1.00Meg	RES, 1.00MΩ, 1%, 0.1W, 0603	603	CRCW06031M00FKEA	Vishay-Dale
9	R12, R13, R16, R19, R34, R50–R53	1.0k	RES, 1.0kΩ, 5%, 0.1W, 0603	603	CRCW06031K00JNEA	Vishay-Dale
1	R14	10k	RES, 10kΩ, 5%, 0.1W, 0603	603	CRCW060310K0JNEA	Vishay-Dale
1	R17	499k	RES, 499kΩ, 1%, 0.1W, 0603	603	CRCW0603499KFKEA	Vishay-Dale
1	R18	20k	RES, 20kΩ, 5%, 0.1W, 0603	603	CRCW060320K0JNEA	Vishay-Dale
1	R20	0.01	RES, 0.01 Ω, 1%, 1W, 2512	2512	ERJ-M1WSF10MU	Panasonic
2	R21, R54	332k	RES, 332kΩ, 1%, 0.1W, 0603	603	CRCW0603332KFKEA	Vishay-Dale
5	R23, R24, R38, R44, R48	0	RES, 0, 5%, 0.1 W, 0603	603	CRCW06030000Z0EA	Vishay-Dale
1	R25	10	RES, 10 Ω, 5%, 0.1W, 0603	603	CRCW060310R0JNEA	Vishay-Dale
1	R26	26.1k	RES, 26.1kΩ, 1%, 0.1W, 0603	603	CRCW060326K1FKEA	Vishay-Dale
1	R27	9.53k	RES, 9.53kΩ, 1%, 0.1W, 0603	603	CRCW06039K53FKEA	Vishay-Dale
1	R28	20.5k	RES, 20.5kΩ, 1%, 0.1W, 0603	603	CRCW060320K5FKEA	Vishay-Dale
1	R29	78.7k	RES, 78.7kΩ, 1%, 0.1W, 0603	603	CRCW060378K7FKEA	Vishay-Dale
1	R31	10	RES, 10.0, 1%, 0.25 W, 1206	1206	ERJ-8ENF10R0V	Panasonic
1	R43	0.005	RES, 0.005 Ω, 1%, 1W, 1210	1210	PMR25HZPFU5L00	Rohm
4	R45–R47, R49	330k	RES, 330kΩ, 5%, 0.1W, 0603	603	CRCW0603330KJNEA	Vishay-Dale
4	RT1–RT4	10.0kΩ	Thermistor NTC, 10.0kΩ, 1%, Disc, 5x8.4 mm	Disc, 5x8.4 mm	103AT-2	SEMITEC Corporation
2	S1, S2		Switch, Tactile, SPST-NO, SMT	Switch, 6.2X5X6.2 mm	KST221JLFS	C&K Components
3	SH-J1, SH-J2, SH-J3	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M
3	TP1, TP2, TP3	White	Test Point, Miniature, White, TH	White Miniature Test point	5002	Keystone
1	U1		Overvoltage Protection for 2-Series to 4-Series Cell Li-Ion Batteries with External Delay Capacitor, DSG0008A	DSG0008A	BQ294700DSG	Texas Instruments
1	U2		Programmable Battery Pack Manager, RHB0032E	RHB0032E	bq40z60RHBT/bq40z60RHBR	Texas Instruments
1	U3		Fixed Regulator with 1 to 30 V Input and 1.2 to 30 V Output, -40 to 125°C, 8-Pin SOIC (D), Green (RoHS & no Sb/Br)	D0008A	LP2951-33DRG4	Texas Instruments

7 Related Documentation from Texas Instruments

- bq40z60 Programmable Battery Pack Manager data sheet, SLUSAW3.
- bq40z60 Technical Reference Manual, SLUUA04.
- bq294700, Overvoltage Protection for 2-Series to 4-Series Cell Li-Ion Batteries With External Delay Capacitor, SLUSB15.

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