

bq27546EVM Single-Cell Impedance Track™ Technology Evaluation Module

This evaluation module (EVM) is a complete evaluation system for the bq27546. The EVM includes one bq27546 circuit module, with a current sense resistor, and thermistor. The circuit module includes one bq27546 integrated circuit (IC), and all other onboard components necessary to monitor and predict capacity. The circuit module connects directly across the cell in a battery. With the EV2300/EV2400 interface board and software, the user can read the bq27546 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq27546 solution under different charge and discharge conditions.

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 I²C is a trademark of NXP.

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1 Features

- Complete evaluation system for the bq27546 gas gauge with Impedance Track™ Technology
- Populated circuit module for quick setup
- PC software (available at power.ti.com) and interface board for easy evaluation
- Software that allows data logging for system analysis

1.1 Kit Contents

- bq27546 circuit module

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq27546EVM-702	Li-ion	1 cell	≤ 14, 500 mAh

2 bq27546-Based Circuit Module

The bq27546-based circuit module is a complete and compact example solution of a bq27546 circuit for battery management. The circuit module incorporates a bq27546 battery gas gauge IC, and all other components necessary to accurately predict the capacity of a 1-series Li-Ion cell.

2.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- Direct connection to the cells: CELL+ and CELL-
- To the serial communications ports (SDA, SCL) or HDQ
- The system load and charger connect across PACK+ and PACK-

2.2 Pin Descriptions

PIN NAME	DESCRIPTION
PACK+	Pack positive terminal
PACK-	Pack negative terminal
CELL+	Cell positive terminal
CELL-	Cell negative terminal
SDA	I ² C™ communication data line
SCL	I ² C communication clock line
HDQ	Single wire communication line

3 bq27546 Circuit Module Schematic

This section contains schematic information.

3.1 Schematic

The schematic follows the bill of materials in this user's guide.

4 Circuit Module Physical Layouts and Bill of Materials

This section contains the printed-circuit board (PCB) layout, bill of materials, and assembly drawings for the bq27546 circuit module.

4.1 Board Layout

This section shows the PCB layers ([Figure 1](#) through [Figure 4](#)), and assembly drawing for the bq27546 module.

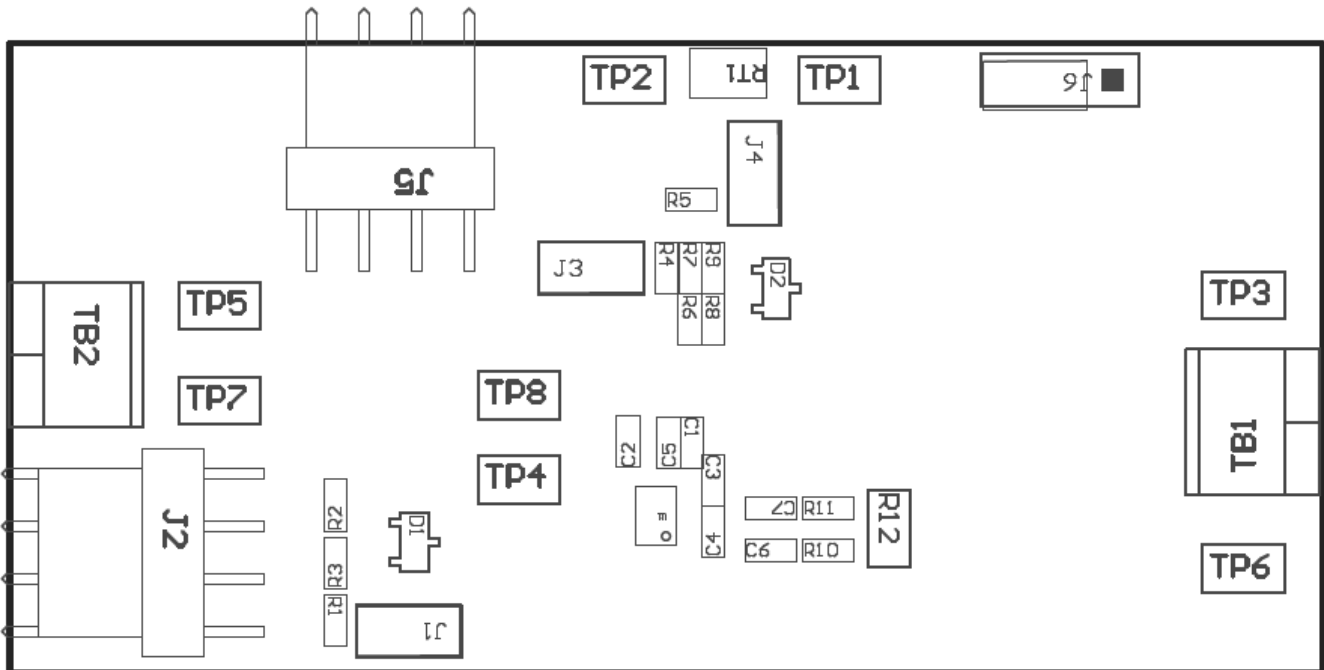


Figure 1. bq27546EVM Layout, Silkscreen

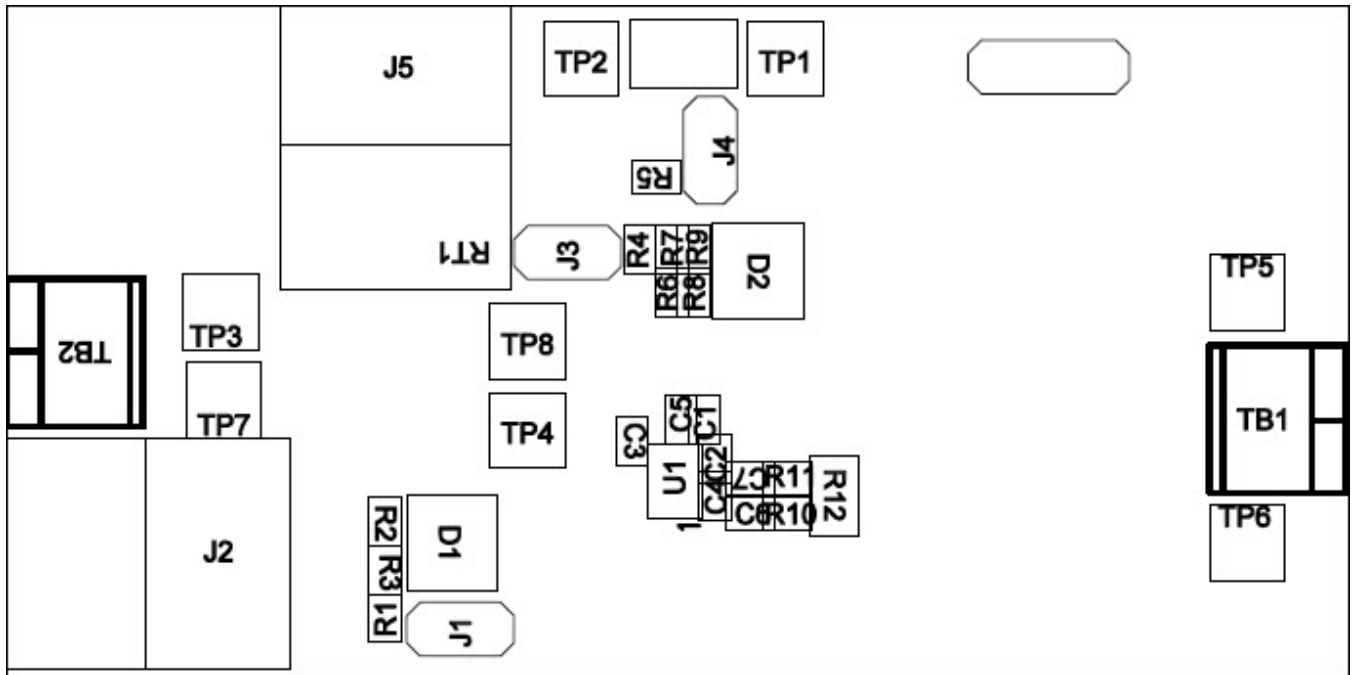


Figure 2. Top Assembly

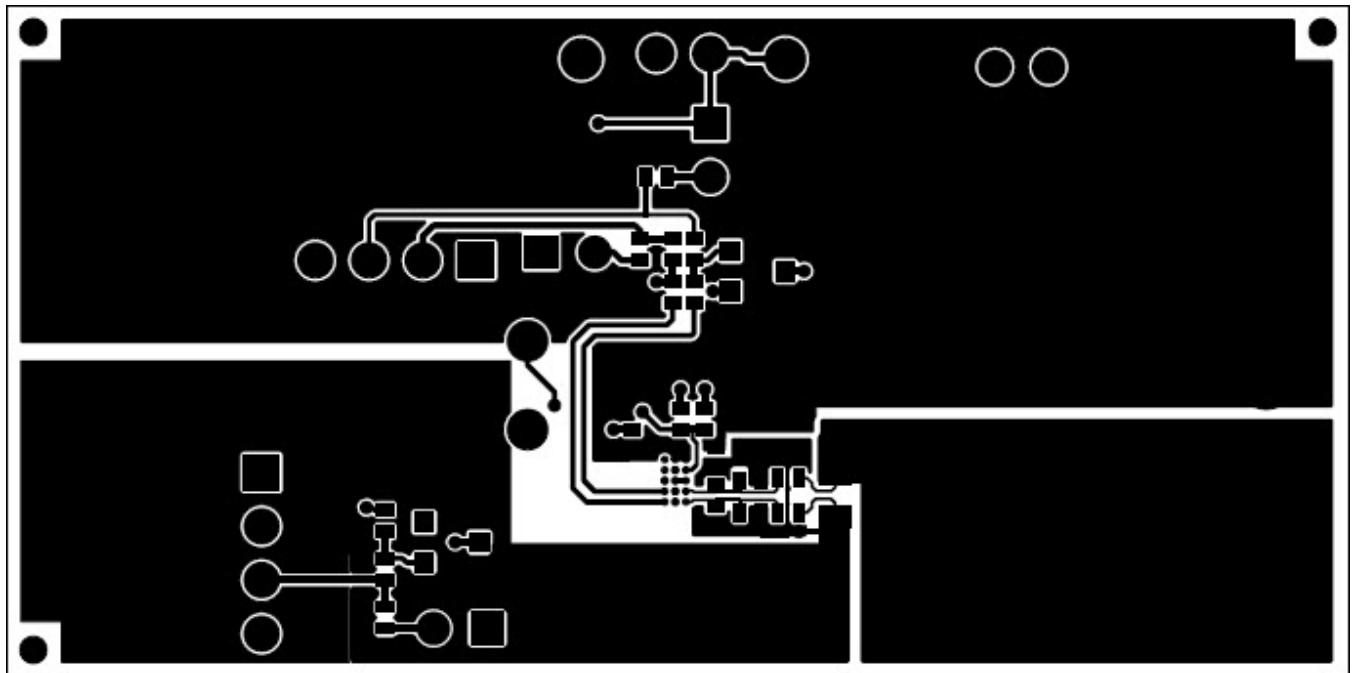
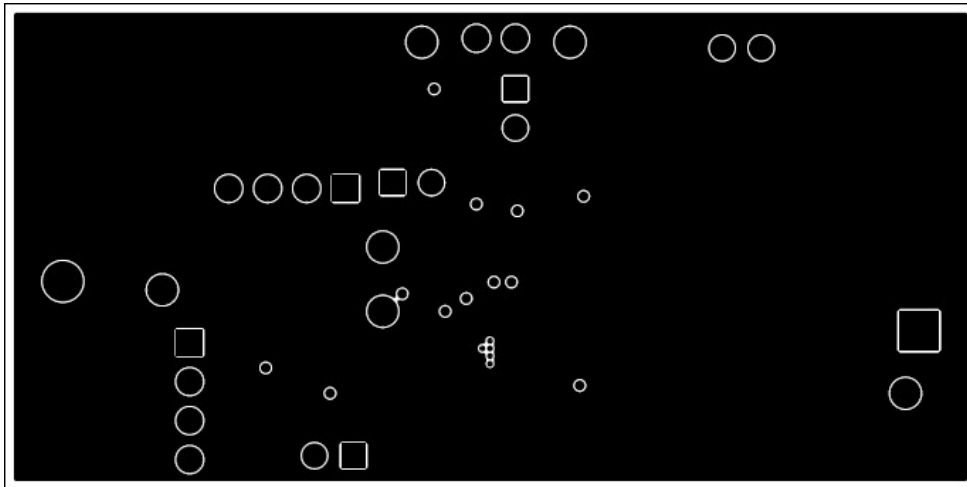
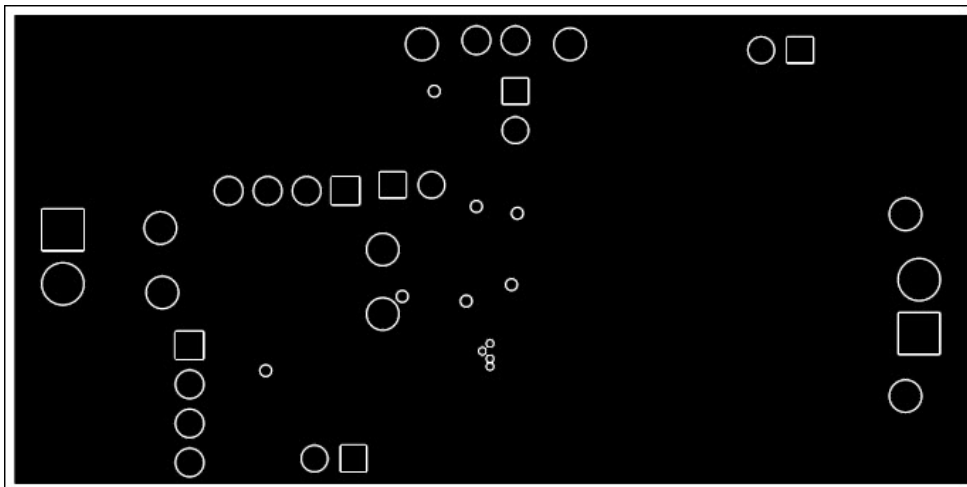


Figure 3. Top Layer



Layer 2



Layer 3

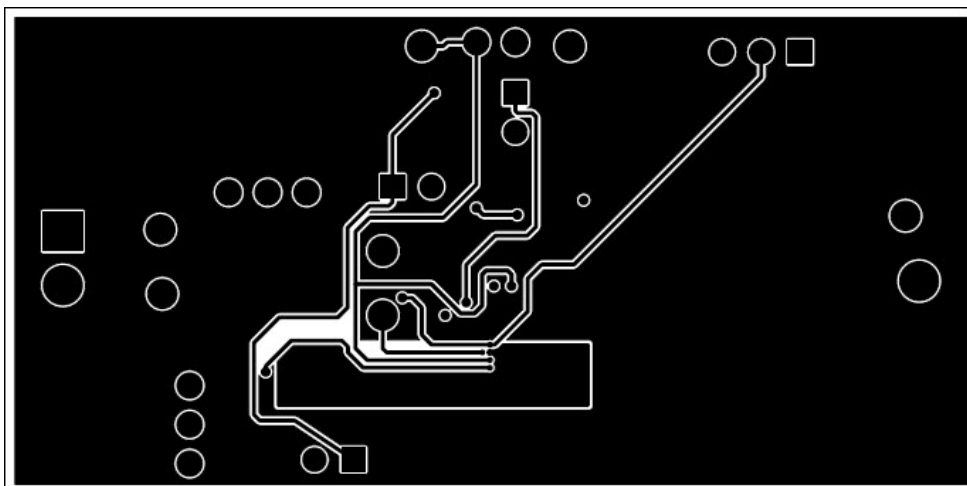


Figure 4. Bottom Layer

4.2 Bill of Materials and Schematic

Table 2. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
C1	1	0.47uF	CAP, CERM, 0.47 μ F, 16 V, +/- 10%, X5R, 0402	0402	GRM155R61C474KE01	MuRata		
C2, C3, C4, C6, C7	5	0.1uF	CAP, CERM, 0.1 μ F, 10 V, +/- 10%, X5R, 0402	0402	GRM155R61A104KA01D	MuRata		
C5	1	1uF	CAP, CERM, 1 μ F, 16 V, +/- 10%, X5R, 0402	0402	C1005X5R1C105K050BC	TDK		
D1, D2	2	5.1V	Diode, Zener, 5.1 V, 300 mW, SOT-23	SOT-23	AZ23C5V1-7-F	Diodes Inc.		
J1, J3, J4	3		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions		
J2, J5	2		Header (friction lock), 100mil, 4x1, R/A, TH	4x1 R/A Header	22-05-3041	Molex		
J6	1		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions		
R1	1	4.7k	RES, 4.7 k, 5%, 0.063 W, 0402	0402	CRCW04024K70JNED	Vishay-Dale		
R2, R3, R6, R7, R8, R9, R10, R11	8	100	RES, 100, 5%, 0.063 W, 0402	0402	CRCW0402100RJNED	Vishay-Dale		
R4, R5	2	10k	RES, 10 k, 5%, 0.063 W, 0402	0402	CRCW040210K0JNED	Vishay-Dale		
R12	1	0.01	RES, 0.01, 1%, 0.25 W, 0805	0805	WSL0805R0100FEA18	Vishay-Dale		
RT1	1	10.0k ohm	Thermistor NTC, 10.0k ohm, 1%, Disc, 5x8.4 mm	Disc, 5x8.4 mm	103AT-2	SEMITEC Corporation		
SH-J1, SH-J3, SH-J4, SH-J6	4	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions		
TB1, TB2	2		Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology		
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8	8	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone		
U1	1		Single Cell Li-Ion Battery Fuel Gauge for Battery Pack Integration, YZF0015BBBBP	YZF0015BBBBP	BQ27546YZFR-G1	Texas Instruments	BQ27546YZFT-G1	Texas Instruments

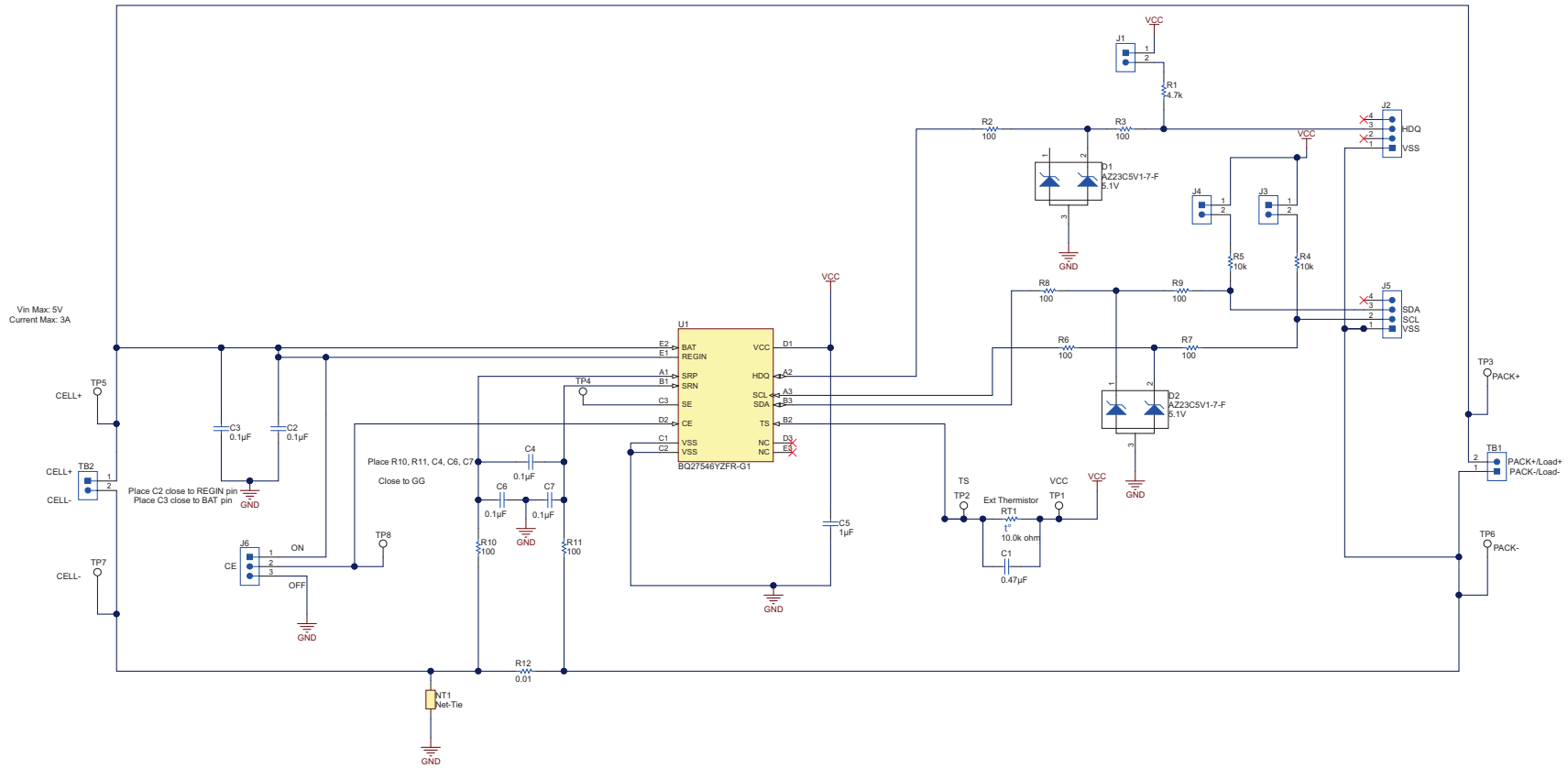


Figure 5. Schematic

4.3 bq27546 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq27546 circuit module.

Table 3. Performance Specification Summary

Specification	Min	Typ	Max	Units
Input voltage Pack+ to Pack-	2.7	3.6	5	V
Input voltage CELL+ to CELL-	2.7	3.6	5	V
Charge and discharge current	0	1	2	A

5 EVM Hardware and Software Setup

This section describes how to install the bq27546 PC software, and how to connect the different components of the EVM.

5.1 Software Installation

Find the latest software version in the bq27546 tool folder on www.ti.com. Make a search by Products for bq27546 to access the product folder. Use the following steps to install Battery Management Studio.

5.1.1 Using EV2300

Use the following steps to install the bq27546EVSX software when using EV2300:

1. Ensure that the EV2300/EV2400 is not connected to the PC through a USB cable before starting this procedure.
2. Select the Tool and Software tab in the product folder.
3. Under the Software section click on [Battery Management Studio \(bqStudio\) Software Suite](#), or click the link.
4. Click the Download button to download the software.
5. Download software to hard drive.
6. Double-click the software executable and follow all instructions and prompts.

5.1.2 Using EV2400

Use the following steps to install the bq27546EVSX software when using EV2400:

1. Ensure that the EV2400 is not connected to the PC through a USB cable before starting this procedure.
2. Browse for the supported software link within the bq27546 TI web site product folder to find the downloadable EVSX installation files.
3. Open the software file that was downloaded from the TI web site.
4. Follow the instructions on screen until the software installation is completed.
5. Before starting the EVSX, connect the EV2400 to the computer using the USB cable.
6. Wait for 20 seconds or until windows installs the driver.

6 Troubleshooting Unexpected Dialog Boxes

The user that is downloading the files must be logged in as the administrator. The driver is not signed, so the administrator must allow installation of unsigned drivers in the operating system policy.

7 Hardware Connection

The bq27546EVM comprises three hardware components: the bq27546 circuit module, the EV2300/EV2400 PC interface board, and the PC.

7.1 Connecting the bq27546 Circuit Module to a Battery Cell

Figure 6 shows how to connect the bq27546 circuit module to the cell and system load or charger.

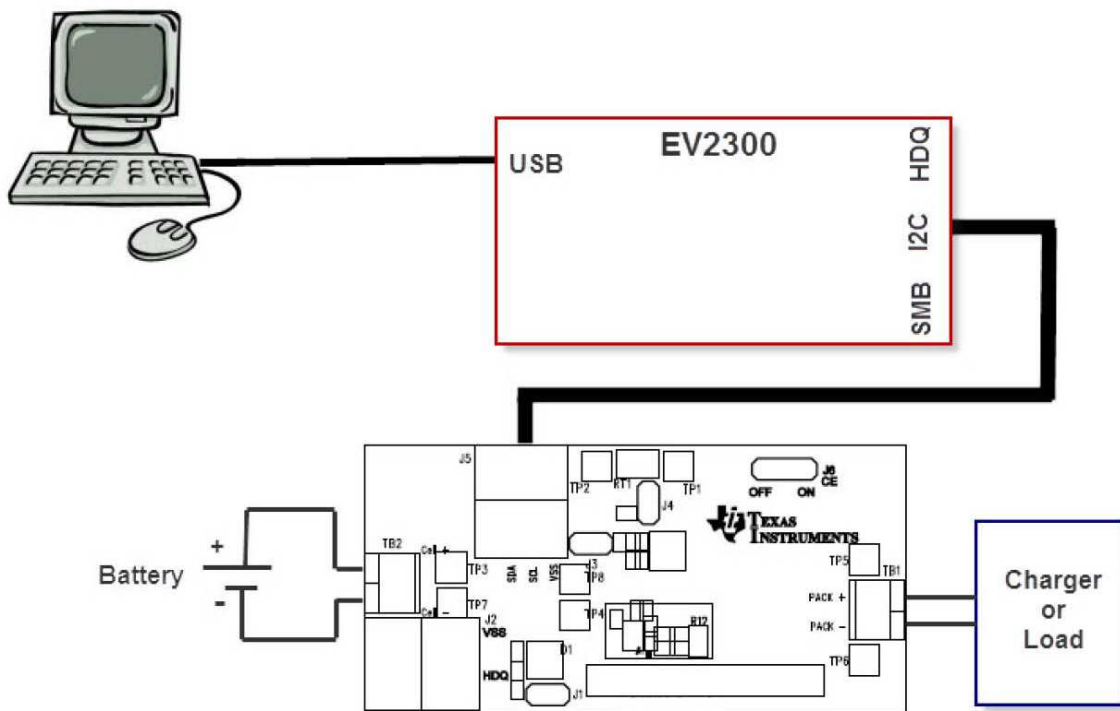


Figure 6. bq27546 Circuit Module Connection to Cell and System Load or Charger

7.2 PC Interface Connection

The bq27546 can be configured as an HDQ communication device or left in default as an I²C device. Once the bq27546 is configured for HDQ communication, it cannot be reverted to I²C mode. Refer to chapter 12 of this document for information on configuring the bq27546 to HDQ mode.

The following steps configure the hardware for interfacing to the PC:

1. Connect the bq27546-based pack to the EV2300/EV2400 using wire leads as shown in Table 4.

Table 4. Circuit Module to EV2300/EV2400 Connections – I²C

bq27546-Based Battery (I ² C mode)	EV2300 (I ² C port)	EV2400 (Port 2, I ² C)
SDA	SDA 3	SDA 2.3
SCL	SCL 2	SCL 2.2
VSS	GND 1	VSS 2.1

Table 5. Circuit Module to EV2300/EV2400 Connections – HDQ

bq27546-Based Battery (HDQ mode)	EV2300 (HDQ port)	EV2400 (Port 3, HDQ)
HDQ	HDQ 3	SDA 3.3
VSS	GND 1	VSS 3.1

2. Connect the PC USB cable to the EV2300/EV2400 and the PC USB port.

The bq27546EVM is now set up for operation.

8 Operation

This section details the operation of the bq27546 evaluation software.

8.1 Starting the Program

Run bqStudio from the Start | All Programs | Texas Instruments | Battery Management Studio. The main screen (Figure 7) appears. Data begins to appear once the <Refresh> (single-time scan) button is clicked, or when the Scan button is clicked. To disable the scan feature, simply click the Scan button again.

The continuous scanning period can be set by opening Window | Preferences → Registers section. The range for this interval is 0 ms to 65,535 ms. Only items that are selected for scanning are scanned within this period.

Battery Management Studio provides a logging function which logs the values that were last scanned. To enable this function, select the Start Log button; this causes the Scan button to be pressed. When logging is Stopped, the Scan button will still be selected and has to be manually clicked again.

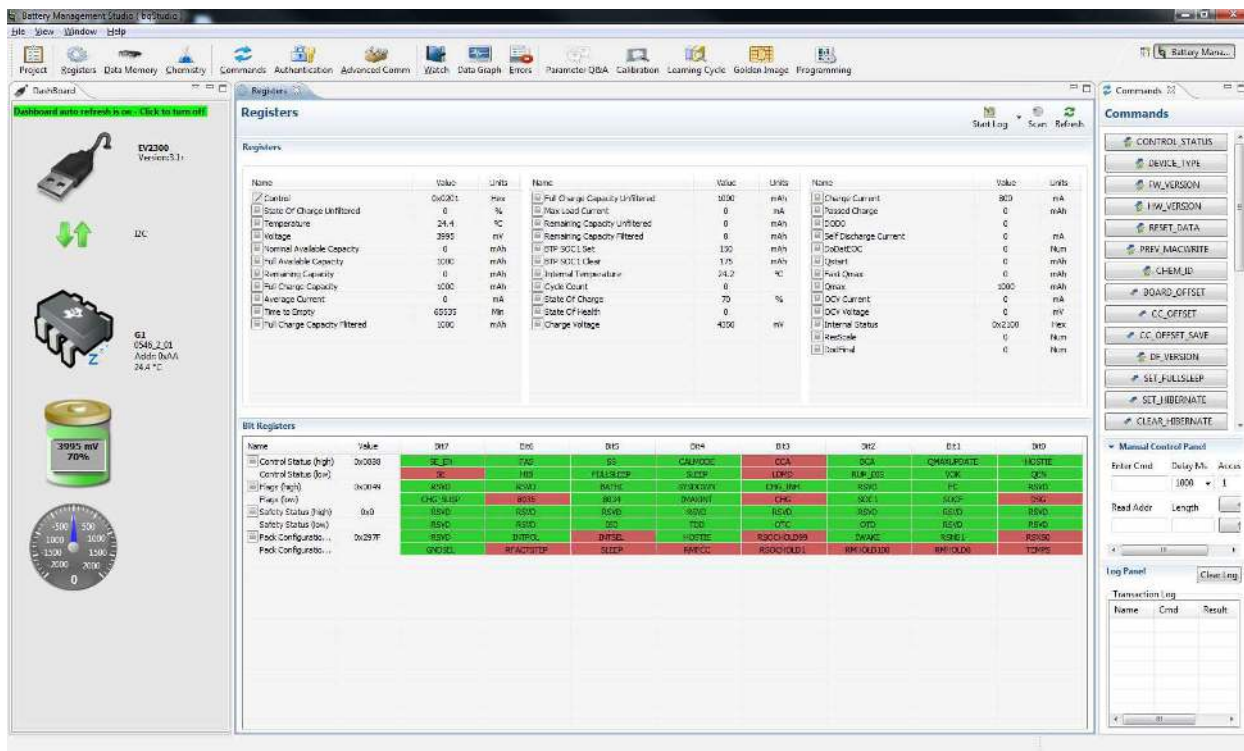


Figure 7. Registers Screen

This screen (Figure 7) shows the RAM data in the bq27546 device. Additional Flag and Status data can be viewed at the bottom of the Registers screen.

8.2 Setting Programmable bq27546 Options

The bq27546 data memory comes configured per the default settings detailed in the bq27546 technical reference manual (SLUUB74). Ensure that the settings are correctly changed to match the pack and application for the bq27546 solution being evaluated.

IMPORTANT: The correct setting of these options is essential to get the best performance.

The settings can be configured using the Data Memory screen (Figure 8).

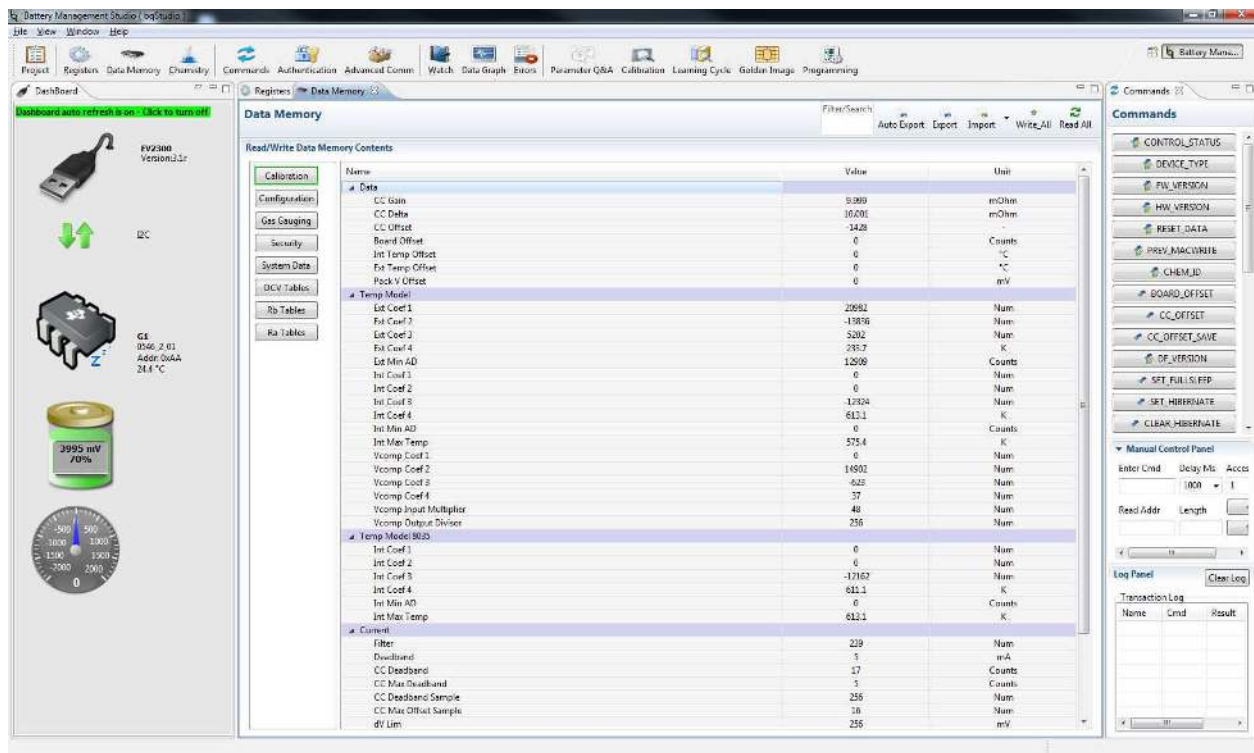


Figure 8. Data Memory Screen

To read all the data from the bq27546 data flash, click on menu option | Data Memory | Read All |.

To write to a data flash location, click on the desired location, enter the data and press <Enter>, which writes the entire tab of flash data, or select menu option | Data Flash | Write All |. The data flash must be read before any writes are performed to avoid any incorrect data being written to the device.

The data-flash configuration can be saved to a file by clicking | Export | and entering a file name. A data-flash file also can be retrieved in this way, | Import |, and written to the bq27546 using the | Write All| button.

The module calibration data is also held in the bq27546 data flash.

Battery Management Studio allows for an automatic data-flash export function, similar to the Registers logging function. This feature, when selected via | Auto Export | button, exports Data Flash to a sequential series of files named as *FilenameNNNNN.gg.csv* where N = a decimal number from 0 to 9.

The AutoExport interval is set under the | Window | Preferences → Data Memory | window with a default value of 1800 seconds. There is also the ability to select Classic or Default style. Classic is the standard .gg file that can be opened with typical notepad editors. Default style is the gg.csv which is a comma delimited file.

When AutoExport is pressed, the Auto Export is in progress. The same button is used to turn on/off AutoExport. AutoExport is typically used for troubleshooting experiments, but is highly recommended for any experiment. The standard AutoExport interval is typically 30 minutes.

9 Calibrate Screen

To ensure proper calibration, perform the following steps. These steps may or may not be required, depending on the type of calibration being performed. Only one calibration item can be selected and calibrated at a time.

9.1 To Calibrate the bq27546 EVM

Calibrate each item one at a time in the order presented in this document. Select the types of calibration to be performed by selecting the corresponding checkbox (see [Figure 9](#)).

Enter the measured values for the types selected, if necessary.

Then press the *Calibrate Part as indicated below* button. After all calibration is complete, close the Calibrate subwindow. While the Calibrate subwindow is open, even in the background, the calibration routines are running in firmware. Close the subwindow to ensure that they are stopped before proceeding with configuration or testing.

9.2 CC Offset Calibration

This performs the internal calibration of the coulomb counter input offset. Press the *Calibrate Coulomb Counter* button.

9.3 Voltage Calibration

- Measure the voltage across Pack+ and Pack– with a calibrated meter.
- Type the voltage value in mV into *Enter Actual Voltage* .
- Measure the temperature for PACK.
- Type the temperature value into *Enter Actual Temperature*.
- Press the *Calibrate Voltage and Temperature as indicated below* button.

9.4 Board Offset Calibration

This performs the offset calibration for the current offset of the board. It is expected that no current is flowing through the sense resistor while performing this calibration step.

- Remove load and short PACK– to GND.
- Press the *Calibration Board Offset* button.

9.5 Pack Current Calibration

- Connect a load to GND and SYS that draws approximately 1 A, or connect a current source to GND and Pack–. Ensure that the Measured Current reported is negative, or else reverse the connections.
- Measure the current with a calibrated meter, and type the value into *Enter Actual Current* using (–) for current in discharge direction.
- Press the *Calibrate Pack Current* button.

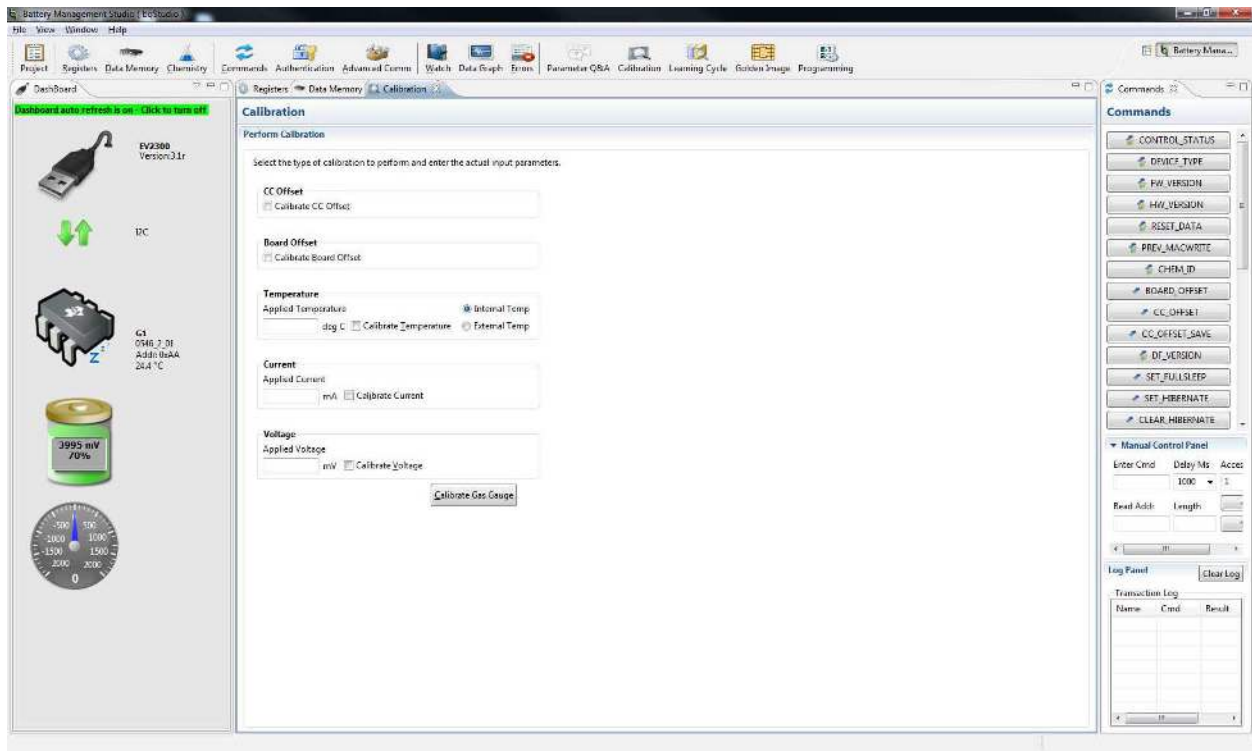


Figure 9. Calibration Screen

10 Advanced Communication I2C

I²C Communication

The read-write operations of the I2C Pro function is not specific to any gas gauge. These operations serve as general-purpose communication tools (Figure 10).

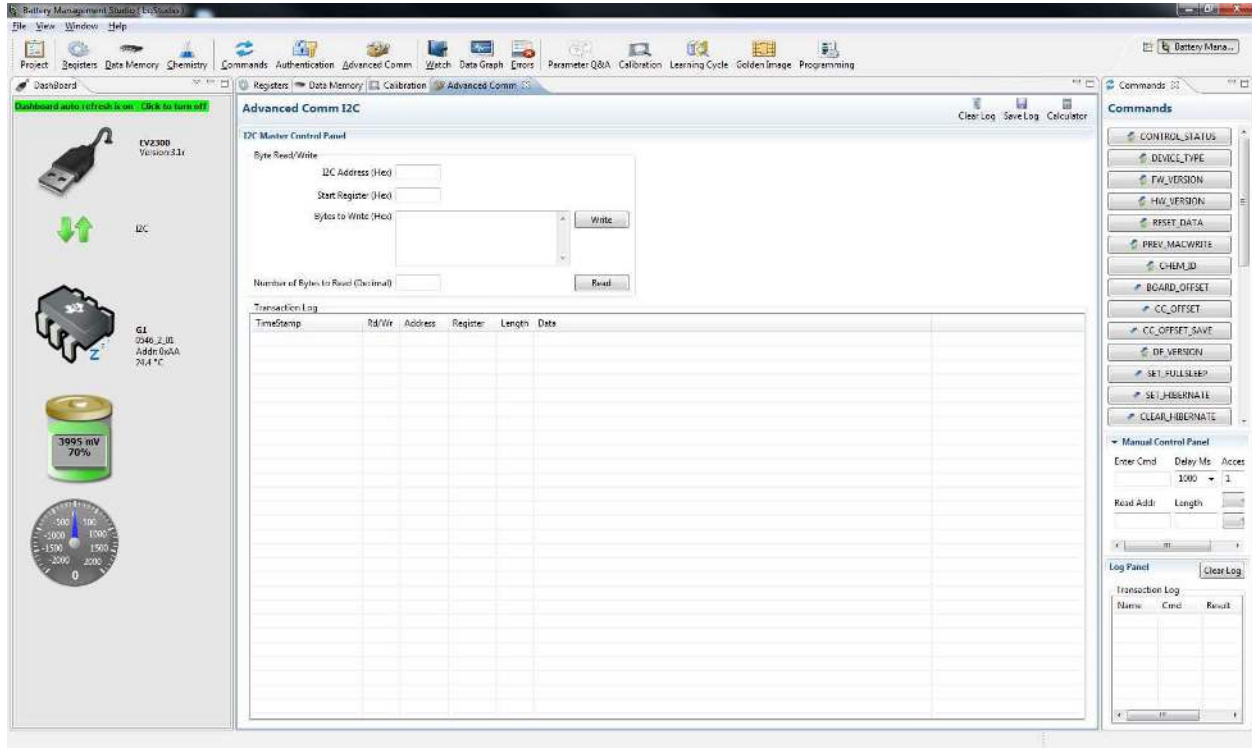


Figure 10. Advanced Comm I²C Screen

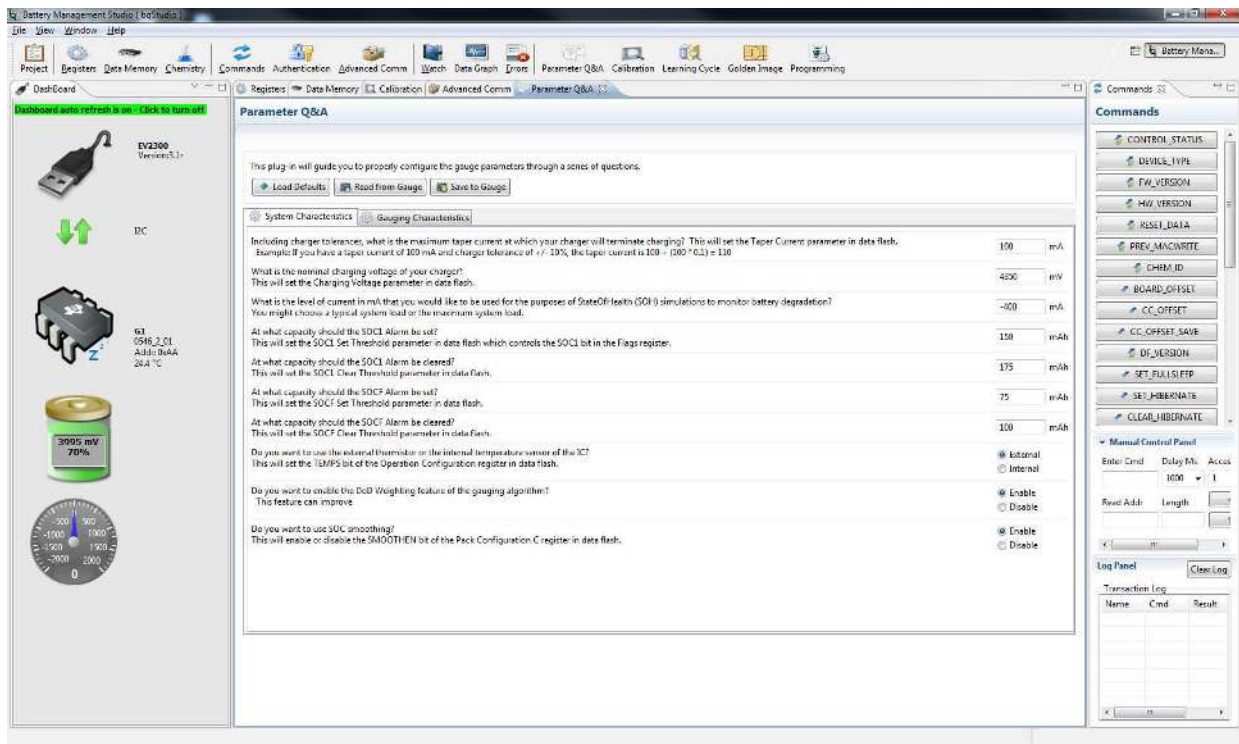


Figure 11. Parameter Q&A Screen

Golden Image

Golden Image Export

This plug-in will allow you to export image files. It will read the data memory contents of the connected gauge and save it to your hard drive in various formats.

Output Location

Output Directory: C:\ti\BatteryManagementStudio\OutputFiles Browse

Base File Name: 0546_2_01-bq27546-G1 Open Directory

Output Formats

<input checked="" type="checkbox"/> SREC File (.srec)	0546_2_01-bq27546-G1.srec	Options
<input checked="" type="checkbox"/> BQFS File (.fs)	0546_2_01-bq27546-G1.bq.fs	Options
<input checked="" type="checkbox"/> DFFS File (.fs)	0546_2_01-bq27546-G1.dff.fs	Options

Create Image Files

Figure 12. Golden Image Output Screen

Programming

Perform Programming

This plug-in will allow you to program image files to a device.

Select Programmable File

Browse...

Program

Figure 13. Perform Programming Screen

11 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.

- bq27546, *Single Cell Li-Ion Battery Fuel Gauge for Battery Pack Integration* data sheet ([SLUSC53](#))

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
 - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.
3. *Regulatory Notices:*
 - 3.1 *United States*
 - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.
 - 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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