User's Guide
SLUU287A–September 2007–Revised October 2013

bq2750xEVM System Side Single-Cell Impedance Track™ Technology Evaluation Module

This evaluation module (EVM) is a complete evaluation system for the bq2750x. The EVM includes one bq2750x circuit module, a current sense resistor, one thermistor, and Windows®-based PC software. An EV2300 board for gas gauge interface is required to interface this EVM with the PC and can be purchased separately. The circuit module includes one bq27500 or bq27501 integrated circuit (IC), one TPS71525 IC, and all other onboard components necessary to monitor and predict capacity for a system side fuel gauge solution. The circuit module connects directly across the battery pack. With the EV2300 interface board and software, the user can read the bq2750x data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq2750x solution under different charge and discharge conditions.

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1 Features

- Complete evaluation system for the bq2750x gas gauge with Impedance Track™ Technology
- Populated circuit module for quick setup
- PC software and interface board for easy evaluation
- Software that allows data logging for system analysis

1.1 Kit Contents

- bq2750x/TPS71525 circuit module (HPA291)
- Software CD with the evaluation software
- NTC103AT Thermistor
- Set of support documentation

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq27500EVM	Li-ion	1 cell	Any
bq27501EVM	Li-ion	1 cell	Any

2 bq2750x-Based Circuit Module

The bq2750x-based circuit module is a complete and compact example solution of a bq2750x circuit for battery management. The circuit module incorporates a bq2750x battery gas gauge IC, a TPS71525 LDO regulator, and all other components necessary to accurately predict the capacity of 1-series Li-Ion cell.

2.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- Direct connection to the battery pack (J8 or J9): PACK+, PACK-, T and RID (bq27501 only)
- To the serial communications port (J4): SDA, SCL and VSS
- The system load and charger connect across charger and load (J6 and J7): CHARGER+/LOAD+ and CHARGER-/LOAD-
- Access to signal outputs (J2): BAT_LOW and /BAT_GD
- Optional 2.5V input if powering IC from actual system power (J3): 2.5V INPUT and VSS

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2.2 Pin Descriptions

PIN NAME	DESCRIPTION
PACK+	Pack positive terminal
PACK-	Pack negative terminal
T	Pack thermistor input
NC/RID	Pack resistor ID input (bq27501 only)
SDA	I^2C communication data line
SCL	I^2C communication clock line
VSS	Signal return for communication line, shared with charger and ground
CHARGER+/LOAD+	High potential of load or charger connection
CHARGER-/LOAD-	Low potential of load or charger connection (System VSS)
BAT_LOW	Access to push-pull output that signals low State-of-charge
/BAT_GD	Access to open drain output that indicates that pack is ready to be connected to system

3 bq2750x Circuit Module Schematic

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 board layout, bill of materials, and assembly drawings for the bq2750x circuit module.

4.1 Board Layout

This section shows the PCB layers (Figure 1 through Figure 4), and assembly drawing for the bq2750x module.

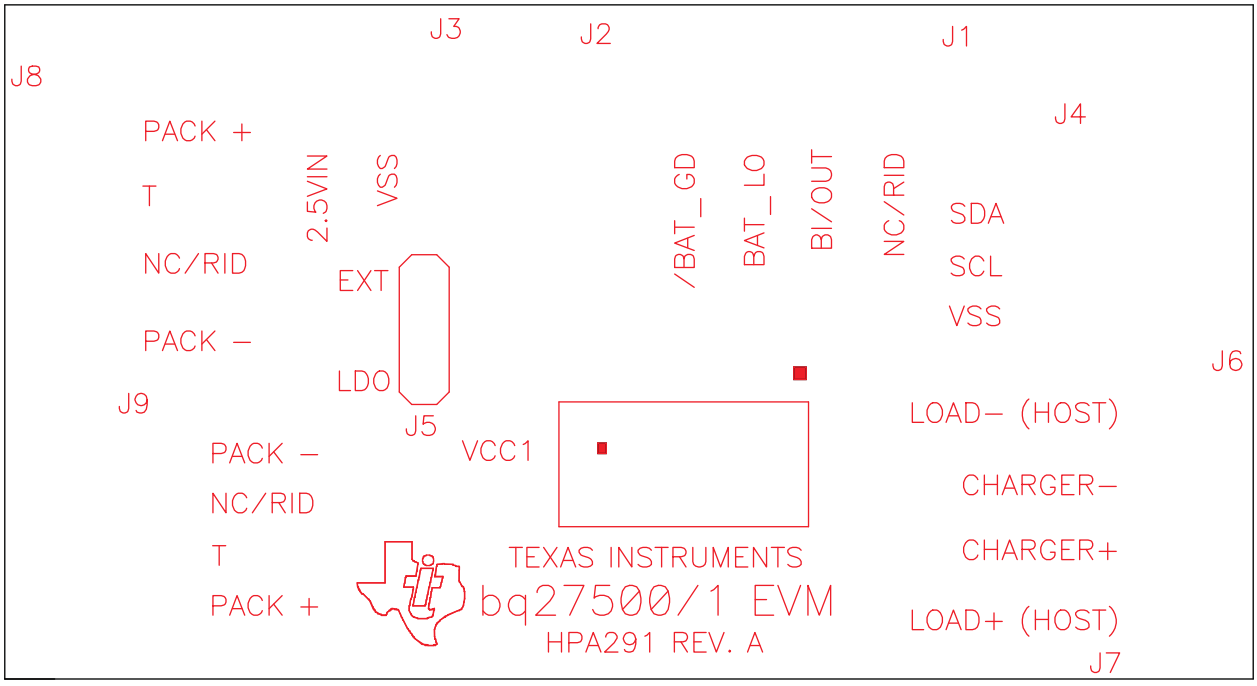


Figure 1. bq27500EVM-001 Layout (Silk Screen)

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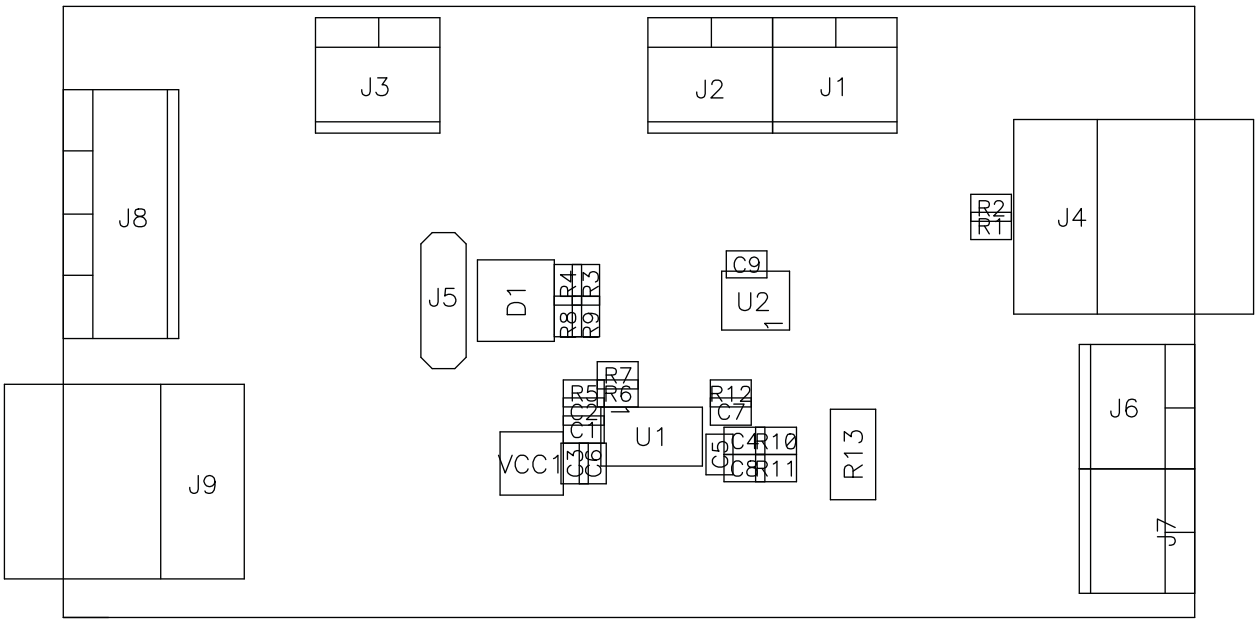


Figure 2. Top Assembly

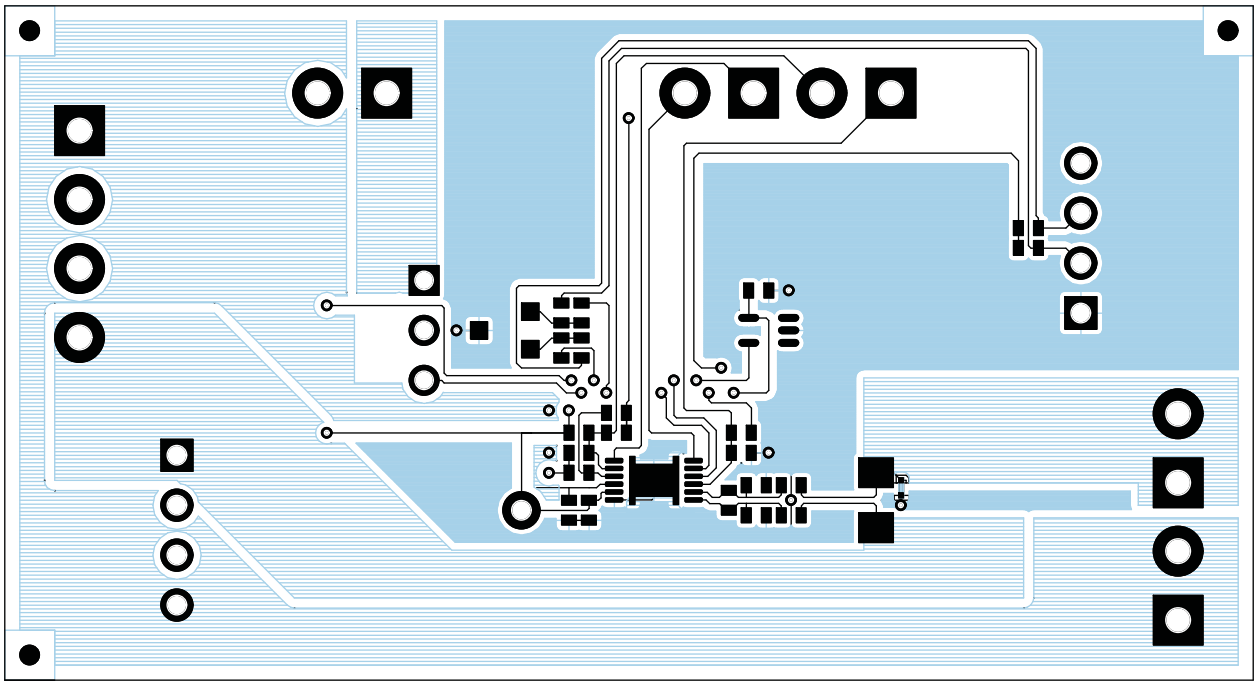


Figure 3. Top Layer

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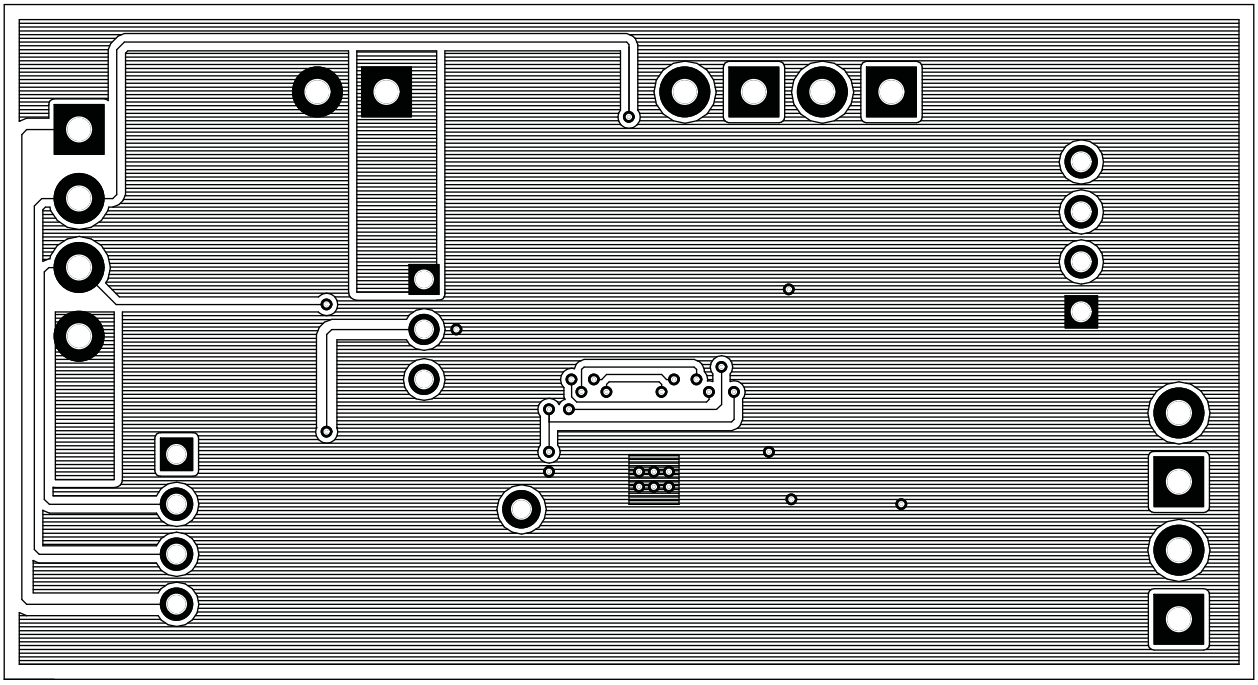


Figure 4. Bottom Layer

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4.2 Bill of Materials and Schematic

Table 2. Bill of Materials

'500 Count	'501 Count	Ref Des	Description	Size	MFG	Part No.
7	7	C1, C3, C4, C5, C7, C8, C9	Capacitor, Ceramic, 0.1uF, 10V, X5R	402	Murata	GRM155R61A104KA01D
1	1	C2	Capacitor, Ceramic, 0.033uF, 10V, X7R, +/-10%	402	Murata	GRM155R71A333KA01D
1	1	C6	Capacitor, Ceramic, 0.47uF, 6.3V, X5R	402	Murata	GRM155R60J474KE19D
1	1	D1	Diode, Dual, Zener, 5.6V, 300mW	SOT23	Diodes	AZ23C5V6
4	4	J2, J3, J6, J7	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	OST	ED555/2DS
0	1	J1	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	OST	ED555/2DS
2	2	J4, J9	Header, Friction Lock Assy, 4-pin Right Angle	0.400 x 0.500	Molex	22-05-3041
1	1	J5	Header, Male 3-pin, 100mil spacing, (36-pin strip)	0.100 inch x 3	Sullins	PTC36SAAN
1	1	J8	Terminal Block, 4-pin, 6-A, 3.5mm	0.55 x 0.25 inch	OST	ED555/4DS
2	2	R1, R2	Resistor, Chip, 10k-Ohms, 1/16-W, 5%	402	Std	Std
0	1	R12	Resistor, Chip, 300-Ohms, 1/16-W, 5%	402	Std	Std
1	1	R13	Resistor, Chip, 0.01-Ohms, 0.25W, 1%	1206	Vishay	WSL1206R0100FEA
6	6	R3, R4, R8, R9, R10, R11	Resistor, Chip, 100-Ohms, 1/16-W, 5%	402	STD	STD
1	1	R5	Resistor, Chip, 1.80-MOhms, 1/16-W, 5%	402	Std	Std
1	1	R6	Resistor, Chip, 18.2-kOhms, 1/16-W, 5%	402	Std	Std
1	1	R7	Resistor, Chip, 1-kOhms, 1/16-W, 5%	402	Std	Std
1	0	U1	IC, Host-Side Impedance-Track Fuel Gauge	QFN12	TI	BQ27500DRZ
0	1	U1	IC, Host-Side Impedance-Track Fuel Gauge	QFN12	TI	BQ27501DRZ
1	1	U2	IC, High Input Voltage, Micropower, 3.2 µA @ 50 mA LDO, 2.5V	SOP-5 (DCK)	TI	TPS71525DCKR
1	1	VCC1	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	Keystone	5001
1	1	RT1 (component not part of layout. It is added to board at PCB test)	Thermistor, 10k Ohms	0.095 x 0.150 inches	Semitec	NTC103AT

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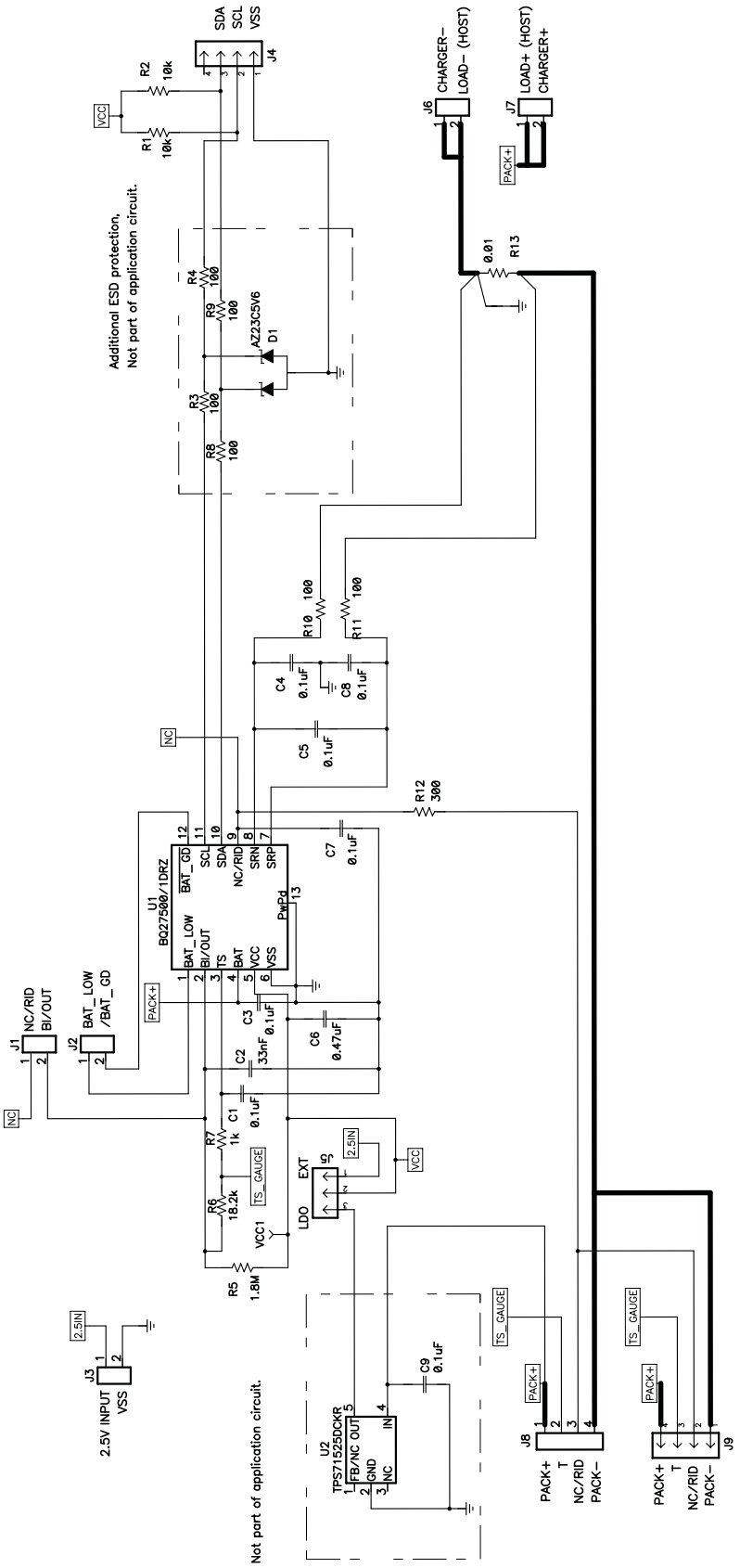


Figure 5. Schematic

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4.3 bq2750x Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq27500 circuit module.

Table 3. Performance Specification Summary

Specification	Min	Typ	Max	Units
Input voltage Pack+ to Pack–	2.7	3.6	4.3	V
Input voltage BAT+ to BAT–	2.7	3.6	4.3	V
Charge and discharge current	0	1	2	A

5 EVM Hardware and Software Setup

This section describes how to install the bq27500EVM-001 PC software and how to connect the different components of the EVM.

5.1 System Requirements

The bq27500EVSW software requires Windows 2000 or Windows XP. Drivers for Windows 98SE are provided, but Microsoft® no longer supports Windows 98; there may be issues in Windows 98 with USB driver support. The EV2300 USB drivers have been tested for Windows 98SE, but no assurance is made for problem-free operation with specific system configurations.

5.2 Software Installation

Find the latest software version in the bq27500 or bq27501 tool folder on power.ti.com. Use the following steps to install the bq27500EVSW software:

1. Ensure that EV2300 is not connected to PC through USB cable before staring this procedure.
2. Browse the included CD and go to the Software directory, and open the bqEV-EASYSetup00.09.38_bq27500v1.00_bqEasy1.00.exe file or obtain the latest version from the TI Web site.
3. Follow the instructions on screen until completing the software installation.
4. Before starting the evaluation software, connect the EV2300 to the computer using the USB cable.
5. Wait until system prompt “new hardware found” appears. Choose “select location manually”, and use the “browse” button to point to subdirectory TIUSBWin2K-XP-1.
6. Answer “continue” to the warning that drivers are not certified with Microsoft.
7. After installation finishes, another system prompt "new hardware found" appears. Repeat steps 1 through 5, but specify the directory as TIUSBWin2K-XP-2.
8. Answer "continue" to the warning that drivers are not certified with Microsoft. Driver installation is now finished.

If files were downloaded from the TI Web site:

1. Open the archive containing the installation package, and copy its contents into a temporary directory.
2. Follow the preceding steps 1–8.

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 bq27500EVM-001 comprises three hardware components: the bq2750x/TPS71525 circuit module, the EV2300 PC interface board (purchased separately), and the PC.

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7.1 Connecting the bq27500 Circuit Module to a Battery Pack

Figure 6 shows how to connect the bq27500 circuit module to the cells and system load/charger.

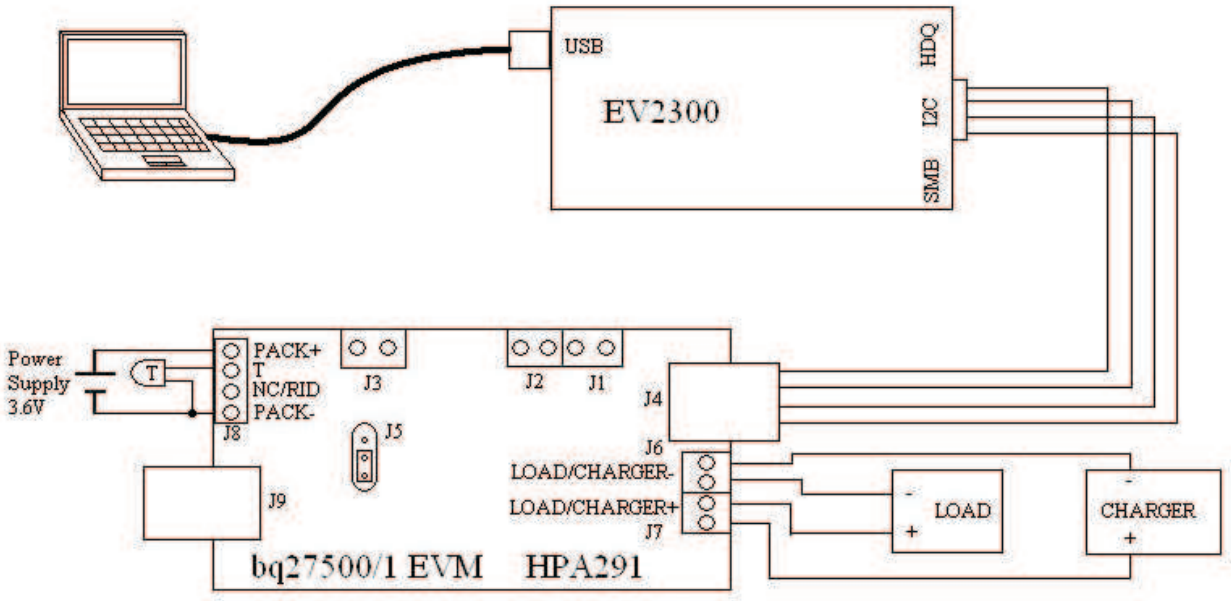


Figure 6. bq27500 Circuit Module Connection to Cell and System Load/Charger

7.2 PC Interface Connection

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

1. Connect the bq2750x-based EVM to the EV2300 using wire leads as shown in Table 4.

Table 4. Circuit Module to EV2300 Connections

bq2750x-Based Battery	EV2300
SDA	SDA
SCL	SCL
VSS	GND

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

The bq27500EVM-001 is now set up for operation.

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8 Operation

This section details the operation of the bq27500 EVSW software.

8.1 Starting the Program

Run bq27500 EVSW from the Start | Programs | Texas Instruments | bq Evaluation Software menu sequence. The DataRAM screen (Figure 7) appears. Data begins to appear once the <Refresh> (single time scan) button is clicked, or when the <Keep Scanning> check box is checked. To disable the scan feature, deselect <Keep Scanning>.

The continuous scanning period can be set via the | Options | and | Set Scan Interval | menu selections. The range for this interval is 0 ms to 65,535 ms. Only items that are selected for scanning are scanned within this period.

The bq27500 EVSW provides a logging function which logs the values that were last scanned by EVSW. To enable this function, select the *Start Logging* button; this causes the *Keep Scanning* button to be selected. When logging is *Stopped*, the keep scanning button is still selected and has to be manually unchecked.

The logging intervals are specified under the | Options | menu with the maximum value of 65,535 ms. The *Log* interval cannot be smaller than the scan interval because this results in the same value being logged at least twice.

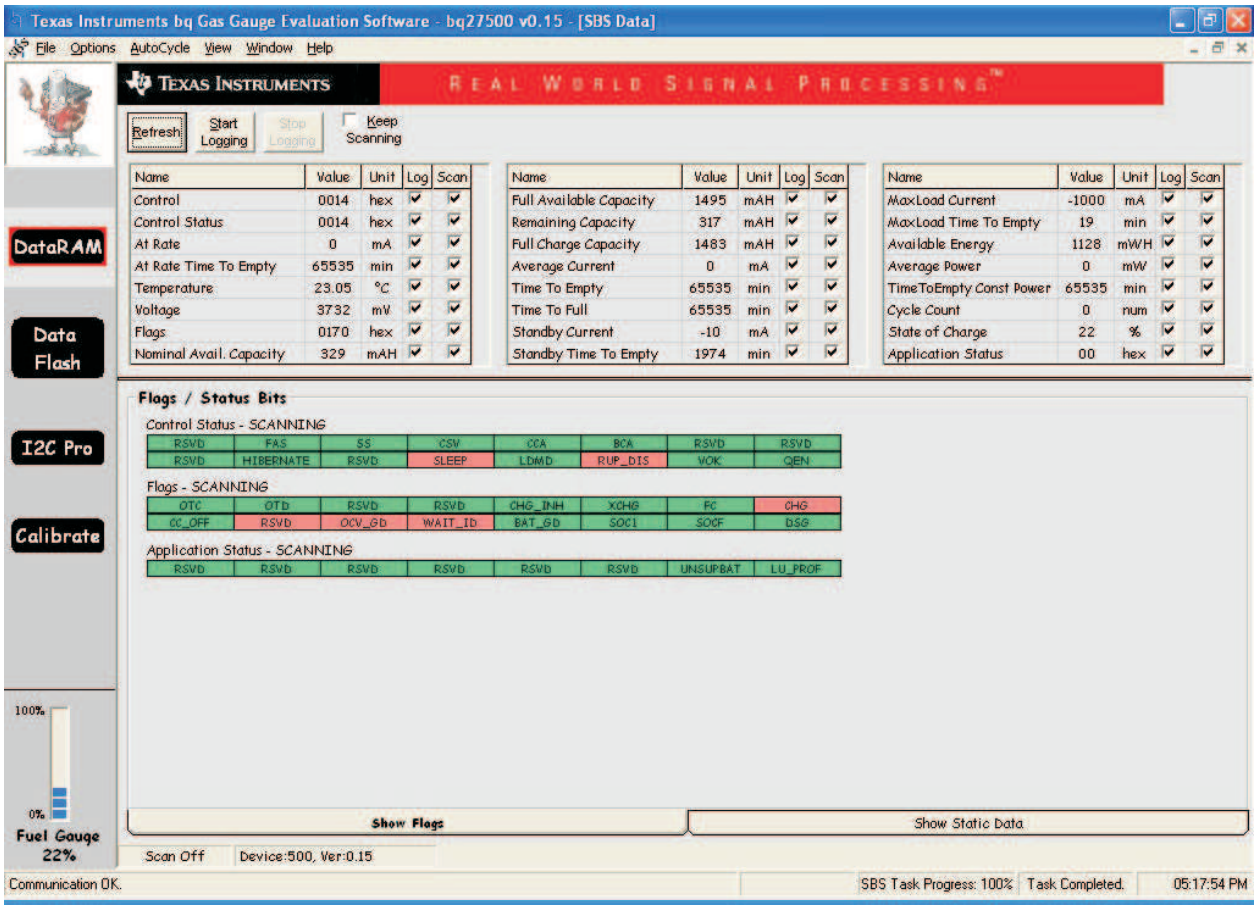


Figure 7. DataRAM Screen

This screen (Figure 7) shows the RAM data set Additional Flag and Status data can be viewed at the bottom of the DataRAM screen.

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Dragging the splitter bar (line that separates the Flags/Static data from SBS values) changes the height of the Flags/Static Data display. Selecting | View |, then | Auto Arrange | returns the splitter bar to its original location.

8.2 Setting Programmable bq27500 Options

The bq2750x data flash comes configured per the default settings detailed in the bq27500 data sheet. Ensure that the settings are correctly changed to match the pack and application for the bq2750x 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 Flash screen (Figure 8).

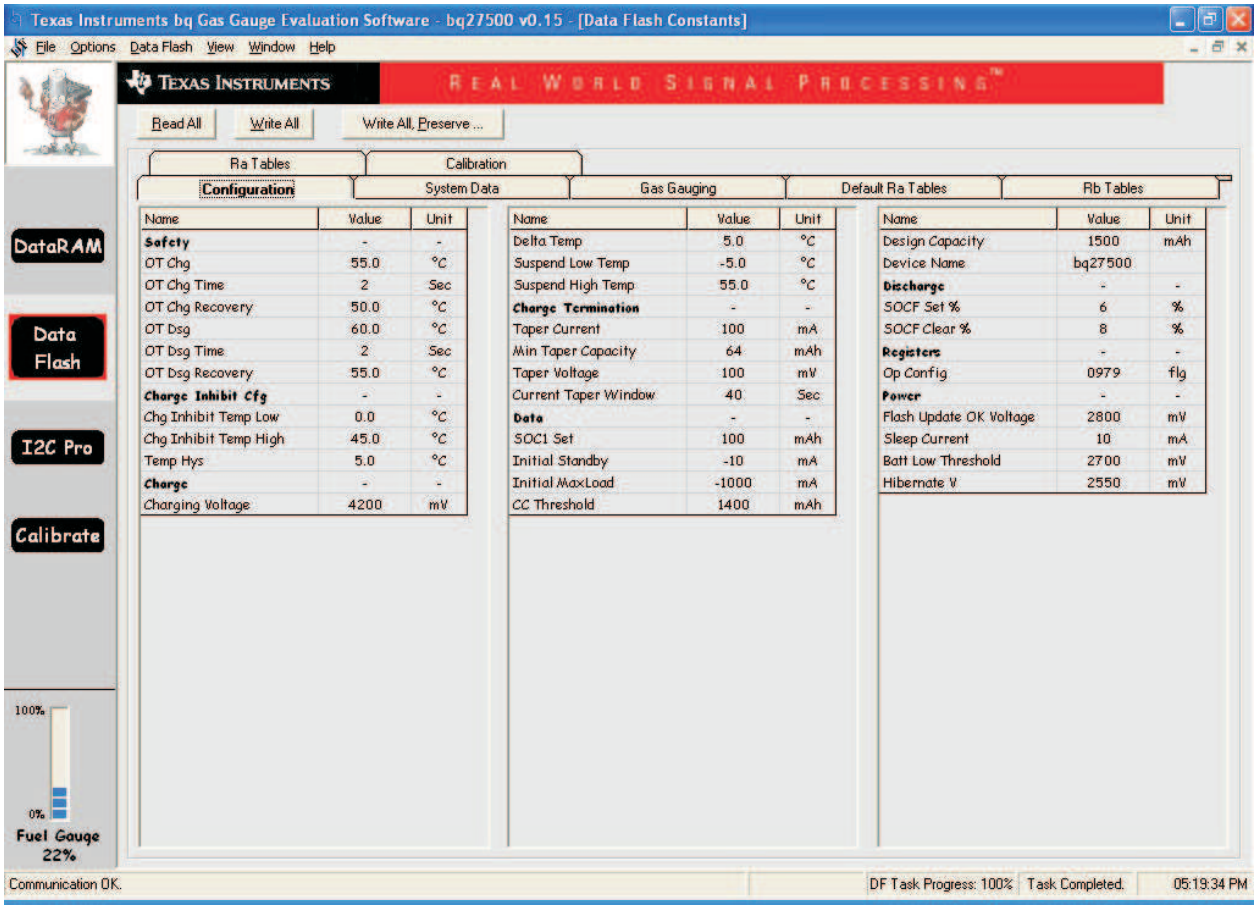


Figure 8. Data Flash Screen

To read all the data from the bq2750x data flash, click on menu option | Data Flash | 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 | File | Special Export | menu options allows the data flash to be exported, but it configures the exported data flash to a learned state ready for mass production use.

The data flash configuration can be saved to a file by selecting | File | Export | and entering a file name. A data flash file also can be retrieved in this way, imported, and written to the bq2750x using the | Write All | button.

The module calibration data is also held in the bq2750x data flash.

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The bq2750x allows for an automatic data flash export function, similar to the DataRAM logging function. This feature, when selected via | Options | Auto Export |, exports Data Flash to a sequential series of files named as *FilenameNNNNN.gg* where N = a decimal number from 0 to 9.

The AutoExport interval is set under the | Options menu | with a minimum value of 15 s. The AutoExport filename is also set under the | Options menu |.

When a check is next to | AutoExport |, the AutoExport is in progress. The same menu selection is used to turn on / off AutoExport.

If the data flash screen is blank, then the bq2750x that is being used may not be supported by the bqEVSW version that is being used. An upgrade may be required.

9 Calibrate Screen

To ensure proper calibration follow the order described below. These steps may or may not be required, depending on the type of calibration being performed.

9.1 To Calibrate the bq2750x

Select the types of calibration to be performed (see Figure 9).

Enter the measured values for the types selected.

If *Temperature Calibration* is selected, then select the sensor that is to be calibrated.

Press the *Calibrate Part as indicated below* button.

9.2 CC Offset Calibration

This performs the internal calibration of the coulomb counter input offset.

9.3 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 LOAD–.

Press the *CC Board Offset Calibration* button.

9.4 Temperature Calibration

- Measure the temperature for PACK.
- Type the temperature value into *Enter Actual Temperature*.
- Select if the temperature sensor to calibrate is the internal or external.
- Press the *Calibrate Part as indicated below* button.

9.5 Pack Current Calibration

- Connect a load to LOAD– and LOAD+ that draws approximately 1 A, or connect a current source to LOAD– and Pack-.
- Measure the current and type value into *Enter Actual Current* using (-) for current in discharge direction.
- Press the *Calibrate Part as indicated below* button.

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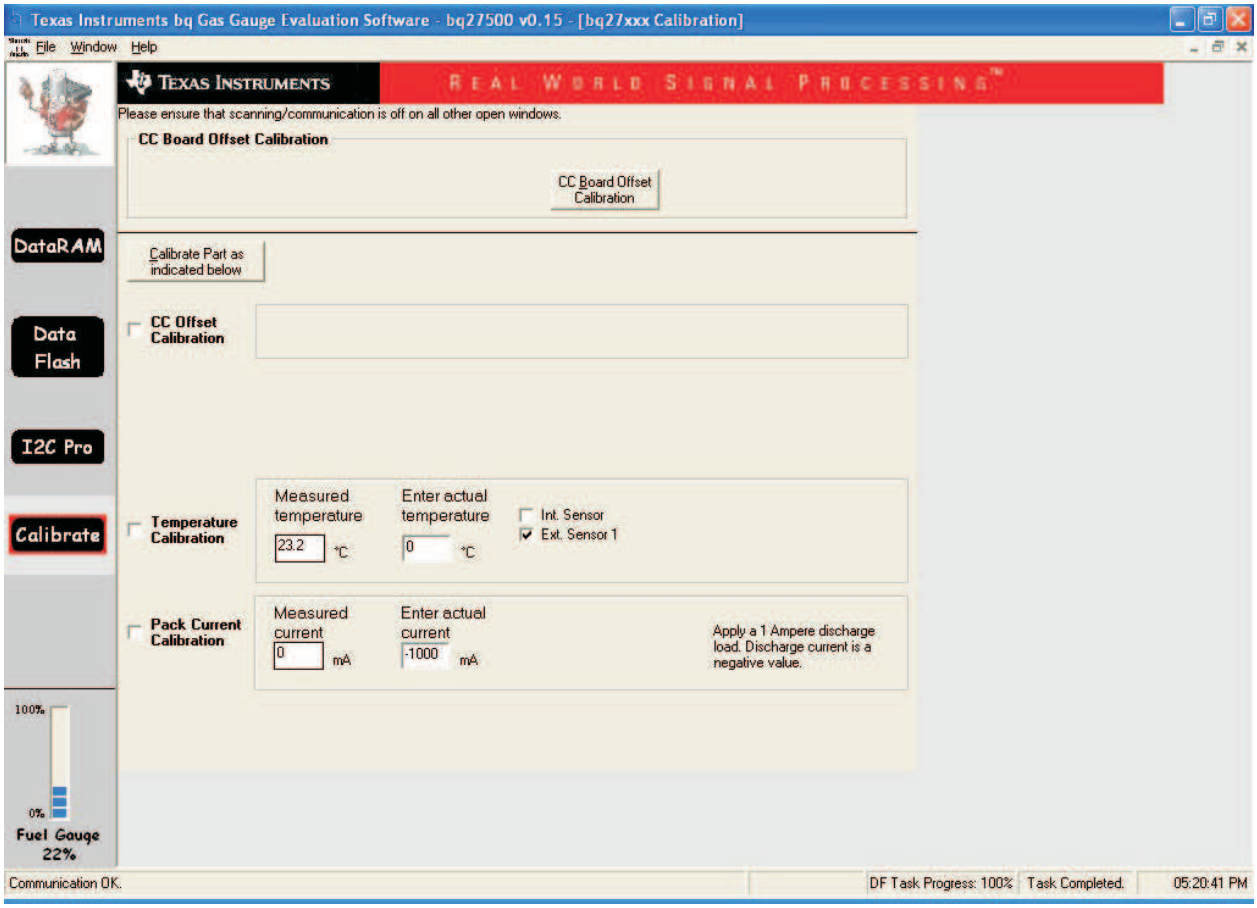


Figure 9. Calibration Screen

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10 I2C Pro Screen

10.1 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).

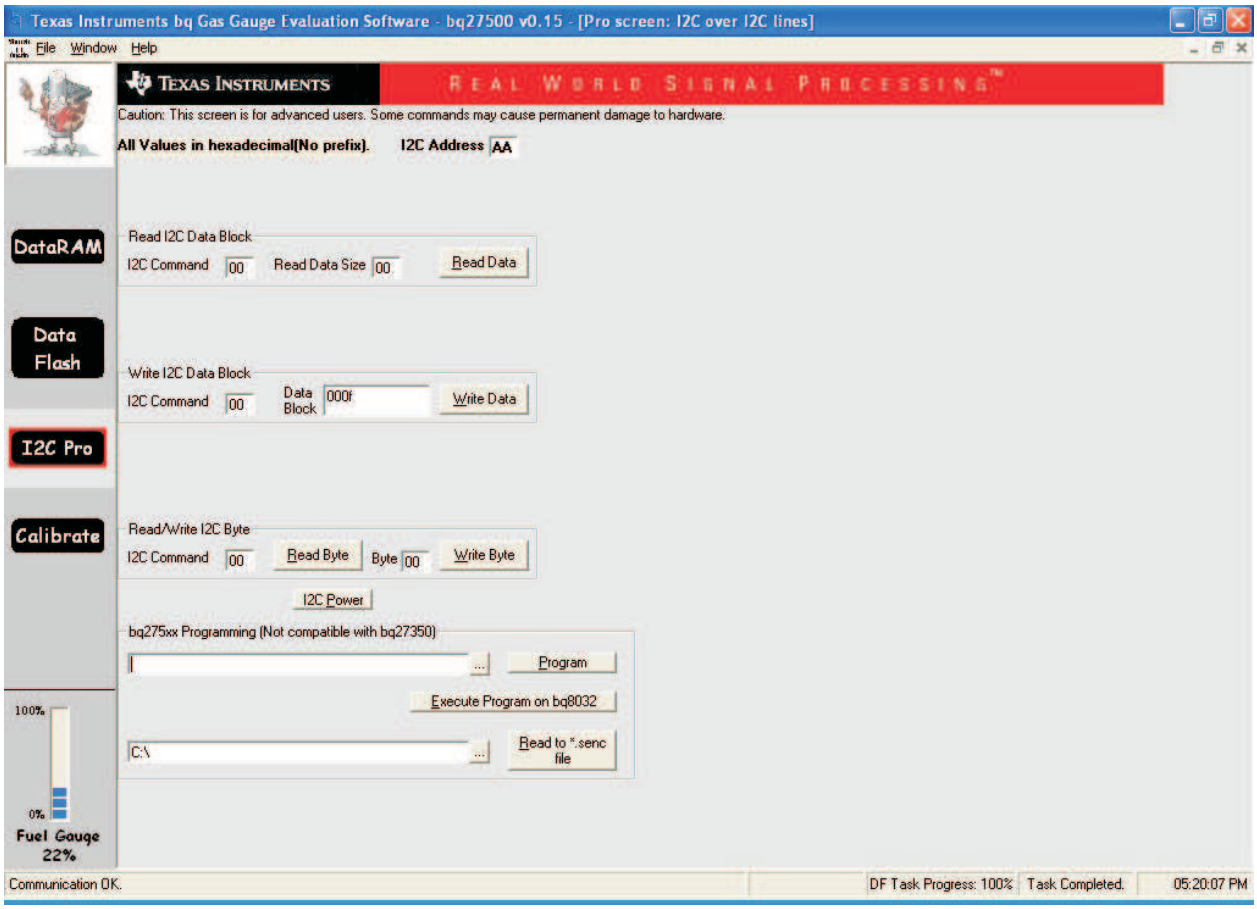


Figure 10. I2C Pro Screen

11 bqEasy

11.1 Introduction

Texas Instruments fuel gauges, employing the Impedance Track™ algorithm offer an unmatched array of features and benefits. Sometimes, however, the wide range of configuration settings can make it seem a bit challenging to get started with the evaluation process. In addition, determining the correct chemistry model and producing the 'golden image' file can be time consuming. The bqEASY program is designed to greatly simplify the process of configuring, calibrating, selecting chemistry and performing learning cycles through the step-by-step use of a wizard program.

The bqEasy software will run inside the current EV software when it is executed by clicking the bqEasy button in the left-hand column of buttons below the Calibrate button in the EV software.

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Figure 11. bqEasy Welcome Screen

11.2 Program Navigation and Flowchart

The sequence of operation of bqEASY can be understood by reviewing the basic flowchart in Figure 12 . Using the program is simple – just start a new project and follow the steps sequentially from 1A to 5C. You can use the Next button, or click on the top tabs and left subsection labels to move to any desired page. Some operations must be completed in sequence due to data dependencies, or to implement the proper flow. Therefore it is recommended that the prescribed sequence be followed, at least at first.

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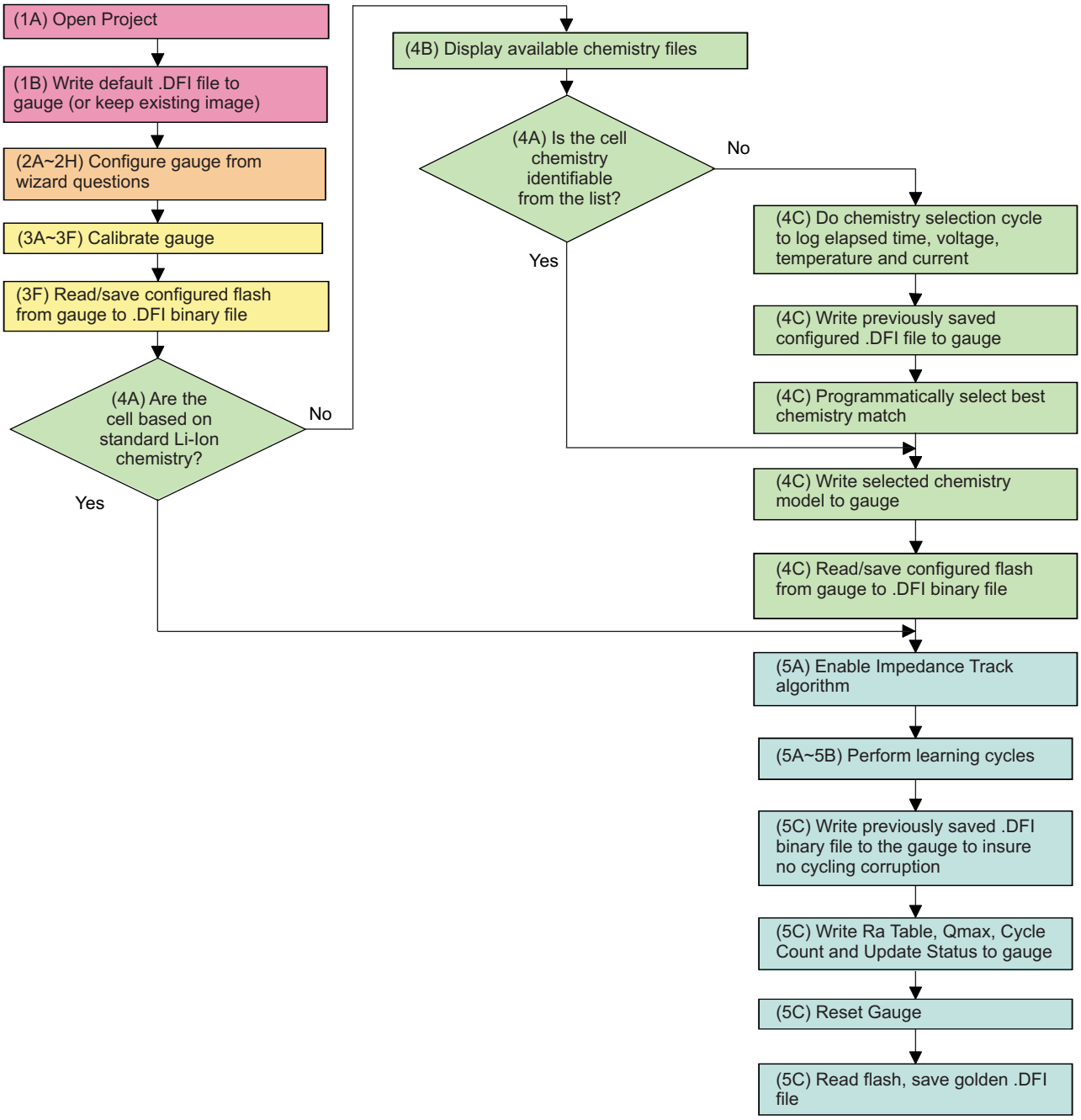


Figure 12. bqEasy Flowchart

11.3 Simplified Configuration Procedures

These simplified configuration procedures can be used to quickly set up the parameters without navigating through the entire user interface.

1. Simple configuration of the Gas Gauge with default or custom data:
   (a) Open the current EV software and click the bqEasy button in the left-hand column of buttons below the "Calibrate" button in the EV software.
   (b) Click the "2. Configure" tab at the top row of bqEASY tabs. (Note: You can skip the 1st tab)
   (c) Answer all questions or leave defaults for all of tab "2", but be sure to click the ok button at the

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bottom of each tab "2" page to ensure that a Completion Checkmark appears for each page.

(d) On page 2H, when you click the "OK" button, the software will ask you to write to the data flash memory. Click "Yes" for OK to write to the data flash.

Your Gas Gauge Module now has the data flash configured as you declared with all the information entered in tab "2. Configure".

2. Simple installation of the Chemistry data using bqEASY if the chemistry is a known chemistry available in the bqEASY software:

   (a) Open the current EV software and click the bqEasy button in the left-hand column of buttons below the "Calibrate" button in the EV software.

   (b) Click the "4. Chemistry" tab at the top row of bqEASY tabs. (Note: You can skip all tabs prior to this)

   (c) Either select "Use Default Chemistry", or click "Enable Chemistry Selection" and select the correct chemistry from the list.

   (d) If you cannot find the proper chemistry, check the device EVM tool folder on the TI Web site for any new bqChemistry file updates. These are updated more frequently than the EV software, so between EV software updates, we will create a self-extracting installer and post it in the EVM tool folder for the part being used. Install these updates if they are in the folder.

   The software will now configure all data flash locations on Your Gas Gauge Module that deal with chemistry functions. No other data flash locations will be modified.

11.4 Files

bqEASY uses four types of files to configure a fuel gauge.

1. **.ENCR –** These are default data-flash definition files found in the \bq_Evaluation_Software folder. The ENCR file is basically a copy of the entire data-flash from a fresh Gas Gauge prior to any data-flash updates either by the user or the Gas Gauge. They are unique for each version of each TI fuel gauge product. If you should be working with a new version fuel gauge and an older version of bqEASY, the correct file may not be present. This will require a new version of the EV software with bqEASY. Navigate to the TI Web site in the EVM tool folder for the device being used, and download the latest version, or contact TI. For bqEASY, the ENCR files act mainly as a dictionary to look up the address for a given data-flash location. For bqEVSW, they define screen parameters including address, display formulas and data type. An error message will appear if the correct .ENCR file cannot be found.
2. **.CHEM (Chemistry Files) –** These are read-only files found in the ..\bq_Evaluation_Software\Plugins\Chemistry folder of the application. When a new Li-Ion battery chemistry is developed, a new Impedance Track model is required to define the chemical model. During automated chemistry selection, each of these files is scanned in order to select the best match with the recorded data. If you are working with a newly developed chemistry, it is possible that an acceptable match will not be found. If this is the case, please check for updated bqEasy software or bqChemistry files on the TI Web site in the EVM tool folder for the part being used.
3. **.DFI (Data-Flash Image Files) –** These are binary images of the fuel gauge data-flash with modified values based on the application. Because of the binary format, it is quick and easy to transfer them to and from a gauge. Each fuel gauge model and firmware version has a unique read-only .DFI which is found in the ..\bq_Evaluation_Software\Plugins\Device_Defaults folder of the application. During the bqEASY process, intermediate versions of .DFI files are recorded with current updated data in order to prevent the possibility of corruption. Then, the final output of bqEASY is also a .DFI file which is the 'golden image' that will be programmed into each production unit. This output file will be placed in the ..\bq_Evaluation _Software\Plugins\Projects folder.
4. **.EZY (bqEASY Project Files)–** These are read-write text files which record header information regarding a project, answers to the wizard questions, and status regarding the stage of completion (the red check marks). They are kept in the ..\bq_Evaluation _Software\Plugins\Projects folder.

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11.5 Completion Checkmarks

As the wizard questions and tasks are completed, completion checkmarks appear in two places – along the task list on the left and on the category tabs on top. A checkmark on a top tab will only appear after all tasks in the category have been completed. For example, in **Figure 3** all of the Setup tasks and all of the Configure tasks have been completed. Completion marks are saved in the .EZY project text file. When a completed or partially-completed project file is opened, the user is given the chance to erase the checkmarks.

11.6 Device Detection

BqEASY is designed to work with a fuel gauge present and already communicating with the bqEVSW evaluation software through the EV2300 USB interface. When the Evaluation software is started, it reads the device type and displays it on the upper title block. This information is used by bqEASY to select the correct default data-flash image (.DFI) and data-flash configuration file (.ENCR) for this particular device. To ensure that the device has not changed, bqEASY also checks the device type when the bqEASY button is pressed. If the correct files are not found, first check the TI Web site in the EVM tool folder for the part being used, and download the latest version of EV software with bqEASY support. If that does not help, then contact TI.

1. **Setup**

   As the wizard questions and tasks are completed, completion checkmarks appear in two places – along the task list on the left and on the category tabs on top. A checkmark on a top tab will only appear after all tasks in the category have been completed. Completion marks are saved in the .EZY project text file. When a completed or partially-completed project file is opened, the user is given the chance to erase the checkmarks.

2. **Configure**

   A series of eight screens is used to collect information about the battery pack application to enable automatic configuration of the most critical data-flash parameters.

3. **Calibrate**

   If you wish to proceed with either automatic chemistry selection or 'golden' unit learning cycles, the Impedance Track fuel gauge must be accurately calibrated. The bqEASY screens simply ask the user to use the calibration screen of the bqEVSW for this purpose.

4. **Chemistry**

   The chemistry choices presented in section 4B are based on files in the \Chemistry folder of the bqEASY application. The latest files are available for downloading from the ti.com Web site. Automation of the chemistry-selection cycle is made possible using a simple load and switch as depicted in Figure 13. The switch can be implemented with either a low VGS-threshold FET or a small relay such as the OMICRON G6RN-1 with a 5-VDC coil. Multiple 2N7000 FETs can be paralleled if nothing else is available. The load can be either a power resistor or an electronic load set to a discharge rate of C/5. Hint: Follow the instructions exactly, or errors may result.

5. **Cycle**

   When preparing for mass production, cell learning is required, but only on one 'golden' pack. The chemical information learned from one pack will be quickly transferred to all production units prior to calibration. Doing this correctly requires a series of charge and discharge cycles. The discharge part can be automated with bqEASY if the simple load circuit for the chemistry selection is available. Follow the screen instructions.

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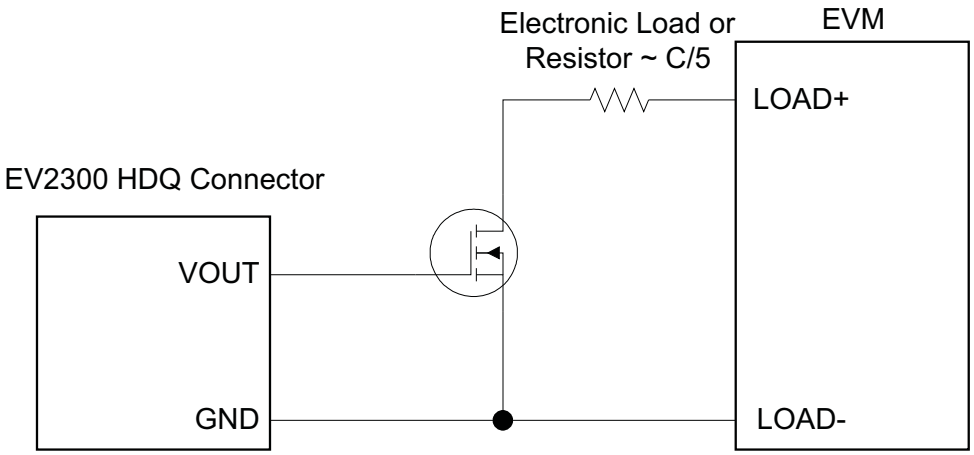


Figure 13. Load and Switch

12 Related Documentation from Texas Instruments

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

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