

# bq27410EVM: Single-Cell Impedance Track™ Technology

This evaluation module (EVM) is a complete evaluation system for the bq27410. The EVM includes one bq27410 circuit module. The circuit module includes one bq27410 integrated circuit 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 or EV2400 interface board and software, the user can read the bq27410 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq27410 solution under different charge and discharge conditions. The latest Windows<sup>™</sup>− based PC software can be downloaded from the product folder on the Texas Instruments Web site.

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#### 1 Features

- Complete evaluation system for the bq27410 gas gauge with Impedance Track<sup>™</sup> technology
- Populated circuit module for quick setup
- Personal computer (PC) software and interface board for easy evaluation
- · Software that allows data logging for system analysis
- Ability to upgrade to the latest firmware version by flash reprogramming

### 1.1 Kit Contents

• bq27410 circuit module (HPA707)

This EVM is used for the evaluation of different bq27410-based products. Ensure that you visit the product Web folder at <u>www.ti.com</u> to download the latest firmware version for the associated product to be evaluated. EV2300 and EV2400 can also be ordered from TI Website seperately.

#### 1.2 Ordering Information

#### **Table 1. Ordering Information**

EVM Part Number	Chemistry	Configuration	Capacity
bq27410EVM	Li-ion	1 Cell	Any

# 2 bq27410-Based Circuit Module

The bq27410-based circuit module is a complete and compact example solution of a bq27410 circuit for battery management. The circuit module incorporates a bq27410 battery gas gauge integrated circuit (IC) 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 (J1 or J6): PACK+, PACK-
- To the serial communications port (J3): SDA, SCL, and VSS
- The system load and charger connect across charger and load (J5 and J4): CHARGER-/LOAD- and CHARGER+/LOAD+.
- · Access to signal outputs (J2): BIN, and GPOUT

#### 2.2 Pin Description

Pin Name	Description
PACK+	Pack positive terminal
PACK-	Pack negative terminal
SDA	I <sup>2</sup> C <sup>™</sup> communication data line
SCL	I <sup>2</sup> C communication clock line
VSS	Signal return for communication line, shared with charger and ground
CHG+/LOAD+	High potential of load or charger connection
CHG-/LOAD-	Low potential of load or charger connection (system VSS)
BIN	Battery insertion detection input
GPOUT	General purpose output



# 3 bq27410 Circuit Module Schematic

#### 3.1 Schematic

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

#### 4 Circuits Module Physical Layout and Bill of Material

This section contains the board layout, bill of materials, and assembly drawings for the bq27410 circuit module.

### 4.1 Board Layout

This section shows the printed-circuit board (PCB) layers (Figure 1 through Figure 4), and assembly drawing for the bq27410 module.

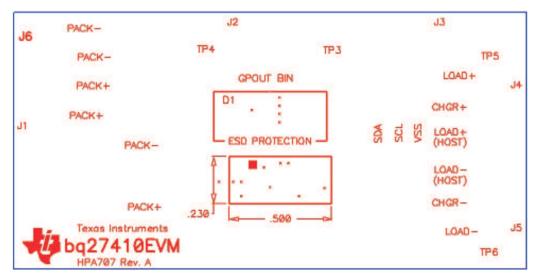


Figure 1. bq27410EVM Layout – Silk Screen

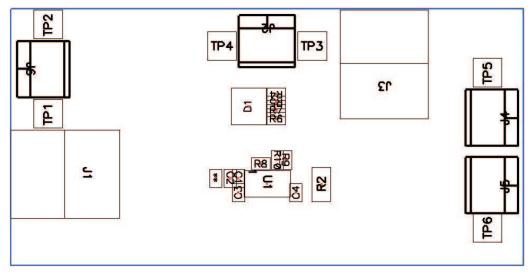


Figure 2. bq27410EVM Layout – Top Assembly



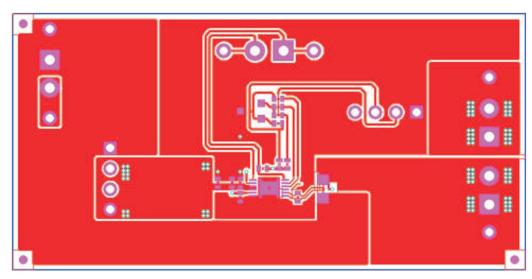


Figure 3. bq27410EVM Layout – Top Layer

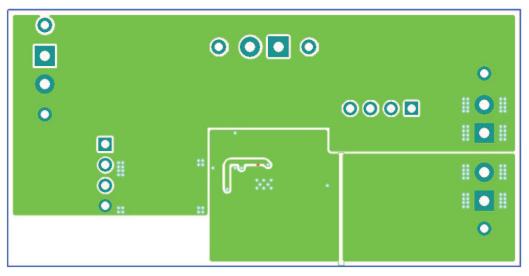


Figure 4. bq27410EVM Layout – Bottom Layer

# 4.2 Bill of Materials

Table 2. Bill of Materials

Coun t	RefDes	Value	Description	Size	Part Number	Mfr
3	C1, C2, C4	0.1 µF	Capacitor, Ceramic, 0.1 µF, 10V, X5R	0402	GRM155R61A104KA01D	Murata
1	C3	0.47 µF	Capacitor, Ceramic, 0.47 µF, 6.3V, X5R	0402	GRM155R60J474KE19D	Murata
1	D1	AZ23C5V6-7	Diode, Dual, Zener, 5.6 V, 300mW	SOT23	AZ23C5V6-7	Diodes
2	J1, J3	22-05-3041	Header, Friction Lock Ass'y, 4-pin Right Angle	0.400 x 0.500	22-05-3041	Molex
4	J2, J4, J5, J6	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	ED555/2DS	OST
1	R2	0.01	Resistor, Chip, 1/10W, 1%, <75ppm/C	0805	CRCW0805-xxxx-F	Vishay
4	R4, R5, R6, R7	100	Resistor, Chip, 1/16-W, 5%	0402	Std	Std
3	R8, R9, R10	10k	Resistor, Chip, 1-kΩ, 1/16-W, 5%	0402	Std	Std
2	TP1, TP5	5000	Test Point, Red, Thru Hole Color Keyed	0.100 x 0.100 inch	5000	Keystone

				Jillindedj		
Coun	RefDes	Value	Description	Size	Part Number	Mfr
4	TP2, TP3, TP4, TP6	5001	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	5001	Keystone
1	U1	BQ27410DRZ	IC, Single-Cell Impedance Track™ Gas Gauge	QFN12	BQ27410DRZ	ТІ

Table 2. Bill of Materials (continued)

# 4.3 Schematic

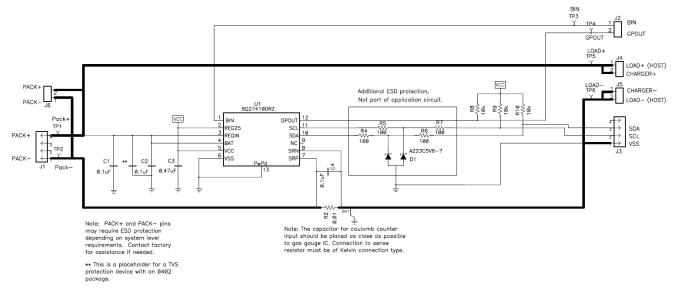


Figure 5. bq27410EVM Schematic

# 4.4 bq27410 Circuits Module Performance Specification Summary

This section summarizes the performance specifications of the bq27410 circuit module.

#### **Table 3. Performance Specification Summary**

Specification	Min	Тур	Max	Units
Input voltage Pack+ to Pack-	2.7	3.6	4.3	V
Charge and discharge current	0	1	2	А

# 5 EVM Hardware and Software Setup

This section describes how to install the bq27410EVM PC software and how to connect the different components of the EVM.

# 5.1 System Requirements

The bq27410EVSW software requires Windows 2000 or Windows XP. Drivers for Windows 98SE are provided, but Microsoft<sup>™</sup> no longer supports Windows 98; therefore, Windows 98 can have issues with USB driver support. The EV2300 or EV2400 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 bq27410 tool folder on <u>power.ti.com</u>. Make a search by Part Number for bq27410 to access the tool folder. Use the following steps to install the bq27410EVSW software:

1. Ensure that the EV2300 or EV2400 is not connected to the personal computer (PC) through the USB cable before starting this procedure.

Troubleshooting Unexpected Dialog Boxes

- 2. Open the archive containing the installation package, and copy its contents into a temporary directory.
- 3. Open the software file that was downloaded from the TI Web site.
- 4. Follow the instructions on screen until completing the software installation.
- 5. Before starting the evaluation software, connect the EV2300 or EV2400 to the computer using the USB cable.
- 6. Wait until system prompt "new hardware found" appears. Choose "select location manually", and use the "browse" button to point to subdirectory TIUSBWin2K-XP-1.
- 7. Answer "continue" to the warning that drivers are not certified with Microsoft™.
- 8. After installation finishes, another system prompt "new hardware found" appears. Repeat steps 1 through 5, but specify the directory as TIUSBWin2K-XP-2.
- 9. Answer "continue" to the warning that drivers are not certified with Microsoft. Driver installation is now finished.

# 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 bq27410EVM comprises three hardware components: the bq27410 circuit module, the EV2300 or EV2400 PC interface board, and the PC.

# 7.1 Connecting the bq27410 Circuit Module to a Battery Pack

Figure 6 shows how to connect the bq27410 circuit module to the cells and system load/charger.

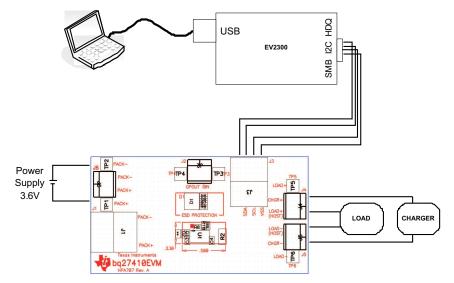


Figure 6. bq27410 Circuit Module Connection to Pack and System Load/Charger

Operation

### 7.2 PC Interface Connection

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

• Connect the bq27410-based EVM to the EV2300 using wire leads as shown in Table 4.

bq27410EVM	EV2300
SDA	SDA
SCL	SCL
VSS	GND

#### Table 4. Circuit Module to EV2300 Connections

- · Connect the PC USB cable to the EV2300 and the PC USB port.
- For battery insertion detection configuration, see the data sheet for details.

The bq27410EVM is now set up for operation.

### 8 Operation

This section details the operation of the bq27410 EVSW software.

### 8.1 Starting the Program

Run bq27410 EVSW from the Start | Programs | Texas Instruments | bq Evaluation Software menu sequence. The DataRAM screen (see 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 with 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 bq27410 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.



In the second s second second sec	nents bq Gas Gauge Evalu AutoCycle View Window		bq27410G1	v1.01 - [SBS	Data]								_ D × _ 8 ×
	TEXAS INSTRUM	ents	Rе	AL W	ORLD <u>G</u> raphs	SIGN	AL	PR	OCES	SIN G <sup>™</sup>			
DataR <i>AM</i>	Name Control Control Status Temperature Voltage Flags Nominal Avail. Capacity	0000 hex 009E hex 21.75 degC 3800 mV	<u>र</u> र र र र र	Name Full Availal Remaining Full Charge Average Cl Standby Cu MaxLoad C	Capacity urrent urrent	Value 133 53 128 0 -10 -500	Unit mAH mAH mAA mA mA	र र र	Ava Ave Sta Sta	ne ilable Energy rage Power te of Health te of Charge Femp eration Config	Value         Unit           194         mWH           0         mW           9         %           42         %           21.75         degC           1A         hex	दा दा दा दा दा दा दा	
Flash	Flags / Status Bits Control Status - SCANN HIBE FAS INITCOMP HIBERNY Flags - SCANNING OTC OTD OVITAKEN RSVD	SS	RSVD SLEEP RSVD RSVD	CCA RSVD CHG_INH BAT_DET	RSVD RUP_DIS RSVD SOC1	QMAXU VOK FC SOCF		RESU RSVD CHG DSG					
Calibrate bqEA5Y	Operation Config - SC/ RESCAP RSVD		SLEEP	RMFCC	BIE	GPIO_POL	- V	VRTEMP	I				
100%													
0% Fuel Gauge 42%	Scan Off Device:4	<b>Sho</b> i 110, Ver:1.01	v Flags							Show Static <u>D</u> ate	a		
							_			SBS Task Progress: 100			01:40:14 PM

Figure 7. DataRAM Screen

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

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

# 8.2 Setting Programmable bq27410 Options

The bq27410 data flash comes configured per the default settings detailed in the bq27410 data sheet. Ensure that the settings are correctly changed to match the pack and application for the bq27410 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 (see Figure 8).



Operation

TEXAS INSTRUMENT	s	RE	AL WORLD	SIGNAI	. Pro	) C E S S I N G <sup>™</sup>		
Read All Write All	Write A	All, <u>P</u> reserve		name for more infor	mation			
Security								
Configuration	ľ	System	n Data	Gas Gauging	<u> </u>	Ra Table	) Ca	libration
Name	Value	Unit	Name	Value	Unit	Name	Value	Uni
Charge		-	Cycle Count	0	num	SOCI Delta	2	%
Charging Voltage	4300	mV	Design Capacity	1500	mAh	Power	-	-
Charge Termination	-	-	Design Energy	5550	mWH	Sleep Current	10	mA
Taper Current	50	mA	Registers	-	-	Hibernate I	8	mA
Taper Voltage	100	mV	Op Config	1A	flg	Hibernate V	2550	mV
Data	-							

Figure 8. Data Flash Screen

To read all the data from the bq27410 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 bq27410 using the | Write All | button.

The module calibration data is also held in the bq27410 data flash.

The bq27410 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 also is 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 bq27410 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, 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 once.

# 9.1 To Calibrate the bq27410

- Select the types of calibration to be performed (see Figure 9).
- Enter the measured values for the types selected.
- 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 Voltage Calibration

- Measure the voltage across Pack+ and Pack-.
- Type the voltage value in mV into Enter Actual Voltage.
- Press the Calibrate Voltage and Temperature as indicated below 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 Voltage and Temperature as indicated below button.

#### 9.5 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 *Calibrate Board Offset* button.

# 9.6 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 Pack Current button.



I2C Pro Screen

www.ti.com

Texas Instruments by Gas Gauge Eval           Pile         Window         Help	uation Software - bq27410G1 v1.01 - [Host Calibration]	
	ents Real World Signal Processing™	
Please ensure that scanning/	communication is off on all other open windows.	Version: 0.0.0.7
DataRAM	Ensure that no load current is flowing.	
Data Flash	re Calibration-Step 2	
I2C Pro	Measured Enter actual voltage voltage	
Calibrate	Measured Enter actual temperature temperature	
Board Offset Calibration Calibrate Board Offset	Step 3 Ensure that no load current is flowing. CC Offset is Updated with this command	
Pack Current Calibratio     Calibrate Pack     Current	Measured     Enter actual     Apply a discharge load. Discharge       0     mA     1000     mA	
0% Fuel Gauge 42%	SBS Task Progress:	100% Task Completed. 01:44:10 PM

Figure 9. Calibration Screen

### 10 I2C Pro Screen

# 10.1 12C Communication

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



h Texas Instruments bg Gas Gauge Evaluation Software - bg27410G1 v1.01 - [Pro screen: I2C over I2C lines]	_ 🗆 ×
File Window Help	
Image: Control in the sector of the secto	
DataRAM     Read I2C Data Block       I2C Command     06       Read Data Size     20	
Data     -Write I2C Data Block       I2C Command     00       Data     Block	
Calibrate Read/Write I2C Byte I2C Command 00 Read Byte Byte 00 Write Byte	
bqEASY       - bq275xx Programming (Not compatible with bq27350)         C:\Userdata\Product\27410\Fw\bq27410G1_1_01.srec	
100%. Fuel Gouge 42%	
Communication DK. SBS Task Progress: 100% Task Completed	01:47:56 PM

Figure 10. I2C Pro Screen

# 11 bqEASY<sup>™</sup> Software

### 11.1 Introduction

Texas Instruments fuel gauges, employing the Impedance Track<sup>™</sup> algorithm, offer an unmatched array of features and benefits. Sometimes, however, the wide range of configuration settings can seem 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<sup>™</sup> 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<sup>™</sup> software runs inside the current EV software when it is executed by clicking the bqEASY button in the left column of buttons below the Calibrate button in the EV software



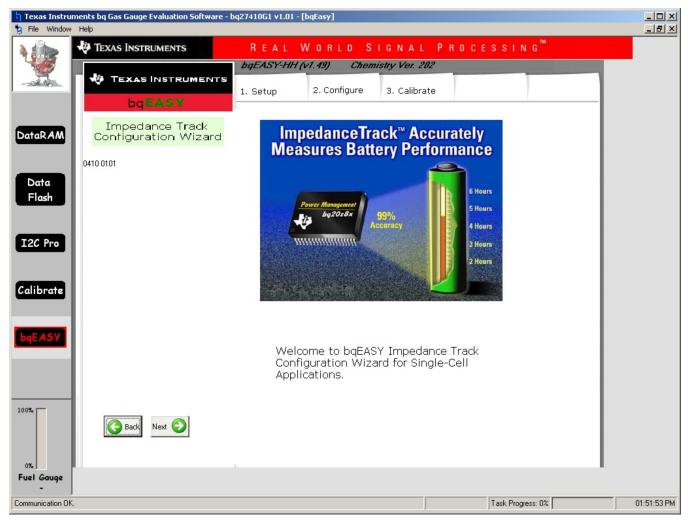


Figure 11. bqEASY<sup>™</sup> Welcome Screen

# 11.2 Program Navigation and Flowchart

The sequence of operation of the bqEASY<sup>™</sup> program 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.



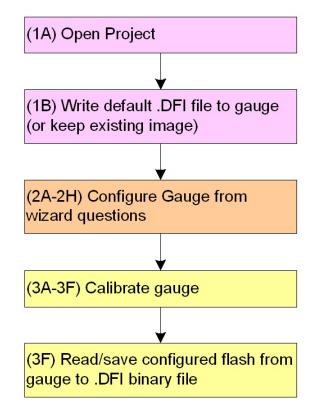


Figure 12. bqEASY<sup>™</sup> Flow Chart

# 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 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 first tab.)
  - (c) Answer all questions, or leave defaults for all of tab "2", but be sure to click the OK button at the 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 asks 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".

# 11.4 Files

The bqEASY™ software 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 are working with a new version fuel gauge and an older version of bqEASY™ software, the correct file may not be present. This requires a new version of the EV software with bqEASY™ software. 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 the bqEASY™ program, 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 appears if the correct .ENCR file

#### cannot be found.

- 2. 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 the bqEASY™ software is also a .DFI file which is the 'golden image' that is programmed into each production unit. This output file is placed in the ..\bq\_Evaluation\_Software\Plugins\Projects folder.
- 3. EZY (bqEASY<sup>™</sup> 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.

#### 11.5 Completion Checkmark

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 only appears 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.

#### 11.6 Device Detection

The bqEASY<sup>™</sup> program is designed to work with a fuel gauge present and already communicating with the bqEVSW evaluation software through the EV2300 or EV2400 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 the bqEASY<sup>™</sup> program 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, the bqEASY<sup>™</sup> software 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<sup>™</sup> support. If that fails to help, 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 only appears 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<sup>™</sup> fuel gauge must be accurately calibrated. The bqEASY<sup>™</sup> screens simply ask the user to use the calibration screen of the bqEVSW for this purpose.

# 12 Related Documentation from Texas Instruments

To obtain a copy off 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 also can be obtained through the TI Web site at <u>www.ti.com</u>.

1. bq27410, System-Side Impedance Track™ Fuel Gauge data sheet (SLUSAF4)

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