

# Quick-Start Guide for the bq27505 Family of Gas Gauges

Michael Vega

HVAL - Battery Management Solutions

## ABSTRACT

This application report provides a design process overview of the bq27505 family of gas gauges, procedures to use the evaluation module and software, and helpful troubleshooting techniques.

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## 1 Introduction

The Texas Instruments bq27505 series system-side, Li-ion battery fuel gauge is a microcontroller peripheral that provides fuel gauging for single-cell, Li-ion battery packs. The device requires little system microcontroller firmware development. The bq27505 resides on the system main board and manages an embedded battery (nonremovable) or a removable battery pack.

The bq27505 uses a patented Impedance Track™ algorithm for fuel gauging and provides information such as remaining battery capacity (mAh), state-of-charge (%), run-time to empty (min), battery voltage (mV), and temperature (°C).

Battery fuel gauging with the bq27505 requires only PACK+ (P+), PACK– (P–), and Thermistor (T) connections to a removable battery pack or embedded battery.

### 1.1 Related Documentation

TI recommends that you familiarize yourself with these documents before working with the Impedance Track™ gas gauge devices.

- *Single-Cell Impedance Track™ Gas Gauge for Novices* application report ([SLUA422](#))
- *bq27505EVM System-Side, Single-Cell Impedance Track™ Technology Evaluation Module* user's guide ([SLUU356](#))
- *Host-side gas-gauge-system design considerations for single-cell handheld applications* technical article ([SLYT285](#))
- *Configuring the bq27505 Data Flash* application report ([SLUA525](#))
- *bq27505-J2, System-Side Impedance Track™ Gas Gauge* data sheet ([SLUS924](#))
- *Using bqTester Single Site Software* application report ([SLUA352](#))
- *Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm* application report ([SLUA450](#))
- *Going to Production With the bq27505 Family* application report ([SLUA516](#))

## 1.2 Terminology

Term	Description	Term	Description
DF	Data Flash	IT	Impedance Track™
GG	Gas gauge	MAC	Manufacturer Access Command
SENC	Firmware file (encrypted)	DFI	Data Flash Image file (binary) with modified data
bqEASY™	bq27505 programming wizard	ENCR	EVSW configuration file specific to a gas gauge firmware version
CHEM	Chemical model files for different Li-ion batteries	EZY	bqEASY™ project file

## 1.3 Document Overview

This document covers procedures for evaluation module setup and working with bqEvaluation Software (bqEVSW). Additionally, the document highlights multiple approaches to troubleshooting the software connection, graphical user interface navigation, and key elements for the different configuration windows.

Example step-by-step procedures are described in [Section 6](#) for:

- Choosing the correct chemistry
- Resetting the pack
- Logging data during testing
- Sealing and unsealing a pack

## 2 Getting Started With the bq27505 Evaluation Module

To get started with the bq27505 evaluation module (EVM), perform the following:

1. Gather all needed components.
2. Acquaint yourself with the EVM board, pin descriptions, and basic EVM configuration.
3. Download the bqEVSW.
4. Install the bqEvaluation Software.
5. Install two USB drivers to communicate with the EV2300.
6. Make the circuit module connections.
7. Start the bqEvaluation Software.
8. Become familiar with key Li-Ion battery fuel gauge software procedures.

### 2.1 Necessary Components

To perform the bq27505 procedures described in this report, you need:

- bq27505EVM board (HPA386)
- EV2300 USB PC Interface Board
- Four-colored wire set connector (I<sup>2</sup>C communication from EVM **J8** to EV2300)
- USB cable (A-B type)
- NTC103AT Thermistor
- Latest documentation and software from the Texas Instruments Internet site (see [www.ti.com](http://www.ti.com))
- PC host running the Windows™ 98SE, Windows XP, or Windows 2000 operating system and an available USB port
- Power supply or single-cell in series Li-ion battery (Li-ion battery preferred)
- Electronic load or electronic system (range 3 V to 4.2 V)
- Single-cell Li-ion battery charger (optional)

## 2.2 bq27505EVM Board and Pin Description

Use this section to become familiar with the bq27505EVM module, pin/jumper descriptions, and the basic EVM configuration.

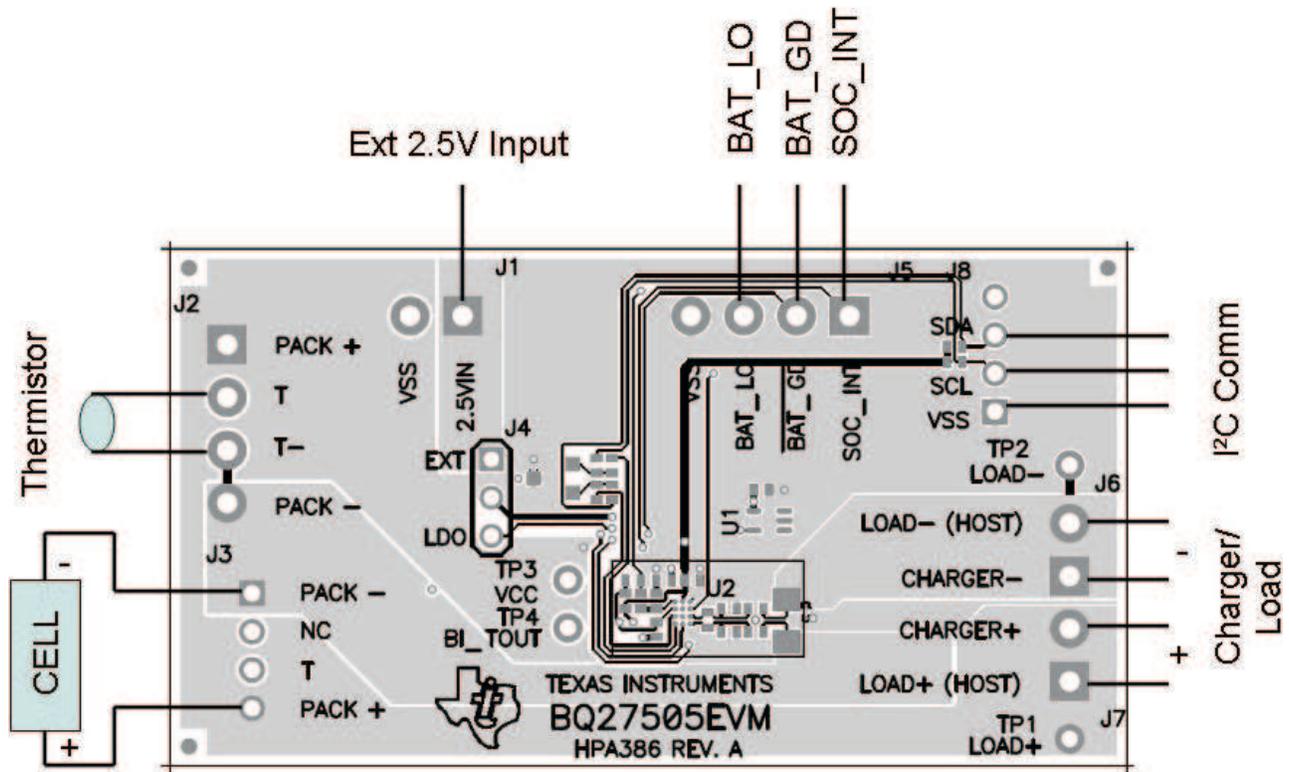


Figure 1. bq27505 Evaluation Module

Table 1. bq27505 Pin/Jumper Descriptions

PIN NAME / Jumper	DESCRIPTION
PACK+ (J2-1 and J3-4)	Pack positive terminal
PACK- (J2-4 and J3-1)	Pack negative terminal
T (J2-2 and J3-3)	Pack thermistor input
T- (J2-3)	Terminal connected to Pack- for making thermistor connection convenient
NC (J3-2)	No connect
SDA (J4-3)	I <sup>2</sup> C communication data line
SCL (J4-2)	I <sup>2</sup> C communication clock line
VSS (J4-1)	Signal return for communication line; shared with charger and ground
CHARGER+/LOAD+ (J7)	Power for load or charger connection
CHARGER-/LOAD- (J6)	Ground for load or charger connection (system VSS)
BAT_LOW (J5-3)	Access to push-pull output that signals low state-of-charge
BAT_GD (J5-2)	Access to open-drain output indicating pack is connected to the EVM
SOC_INT (J5-1)	State of Charge Interrupt

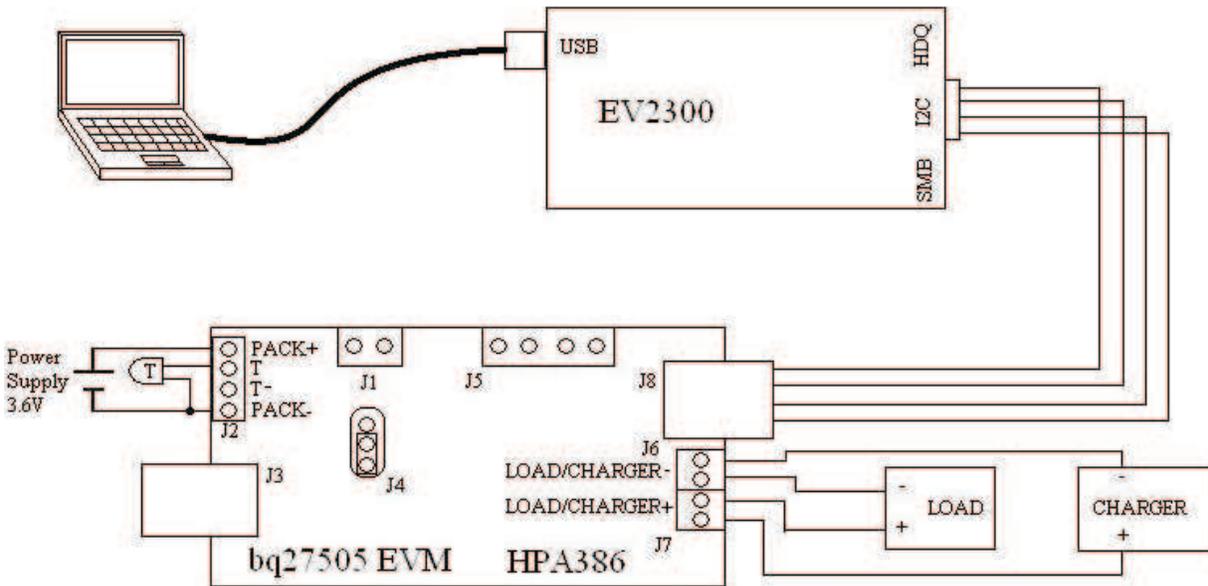


Figure 2. Basic bq27505EVM Configuration

### 2.3 Download the bq27505 Evaluation Software

This software can be downloaded from the device product folder or evaluation module product folder (use the keyword *bq27505* as the *Search by Part Number* keyword) from [www.ti.com](http://www.ti.com). Follow search result links to the corresponding product folders.

### 2.4 Install bq27505 Evaluation Software

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**Note:** Before installing the bq27505EVM software, ensure that the EV2300 communication box is disconnected from the PC Host.

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Using the zip file you downloaded from the TI Internet site:

1. Unzip the SLUC155.zip file to a temporary directory.
2. In your temporary directory, browse for the preliminary software installation file with the generic name: bqEV-EASY-HH SWSetup00.XX.yy\_bq27505v1.00\_bqEasyvz.zz.exe, where **XX**=major preliminary number, **yy**=minor preliminary number, and **z.zz**= version number.
3. Double-click and follow the standard installation instructions; accept license agreement, choose folder, and display Readme file.

### 2.5 Install USB Drivers for EV2300 Communication

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**Note:** Before installing the USB drivers, use the supplied USB cable to connect the EV2300 to the computer that has the bq27505 evaluation software installed.

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Installing the driver for the EV2300 communication box requires you to install two USB drivers for proper operation. Complete instructions for installing the USB drivers can be found in the *EV2300 Driver to USB Port Association* section of the *Using bqTester Single Site Software* document ([SLUA352](http://www.ti.com/lit/zip/slua352)).

Briefly, the required steps are:

1. When the operating system prompts you with a **Found New Hardware Wizard**, Choose the *No, not at this time* option.

2. On the next screen, select the *Install from a list or specific location* option and use the **Browse** button to navigate to the PC Host folder (XP system): C:\Windows\TI\USB1
3. Respond **Continue Anyway** to the warning that drivers are not certified by Microsoft.™  
You have successfully installed the *TI USB Firmware Updater*.
4. Once again, the operating system prompts you with a **Found New Hardware Wizard**, Choose the *No, not at this time* option.
5. On the next screen, select the *Install from a list or specific location* option and use the **Browse** button to navigate to the PC Host folder (XP system): C:\Windows\TI\USB2
6. Respond **Continue Anyway** to the warning that drivers are not certified by Microsoft.  
You have successfully installed the *TI USB bq27505 Driver*.

## 2.6 EVM Connection Setup

Refer to [Figure 2](#) when performing the EVM setup:

1. Connect one side of the 4-wire-set connector to the EV2300's I2C port (black wire aligned with GND pin) and the other side to the board's **J8** connector (black wire aligned with the VSS pin).
2. Ensure that jumper in **J4** of board is connected at the bottom position as shown [Figure 2](#).
3. Ensure that NTC103AT thermistor is connected to the T and T– terminals of the **J2** block of the board.
4. Ensuring proper polarity, connect the 3-V to 4.2-V power supply or single-cell Li-ion battery between the PACK+ and PACK– terminals (**J2**) of the board.
5. To see current measurements, apply a load to **J7** and **J6** board connectors.

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**Note:** **J6** is for host or charger *ground* and **J7** is for host or charger *power*.

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6. To properly configure the fuel gauge IC for a given application, proceed to the **bqEASY™** area of the evaluation software ([Section 4.5](#)) and the bq27505 EVM user's guide ([SLUU356](#)).

For detailed instructions on operating the fuel gauge system, see the bq27505 data sheet ([SLUS924](#)); the bqEASY™ software, see the *bqEASY™ for bq27505 Impedance Track™ Devices* user's guide ([SLUU372](#)); and the *bq27505EVM System Side Single-Cell Impedance Track™ Technology Evaluation Module* user's guide ([SLUU356](#)).

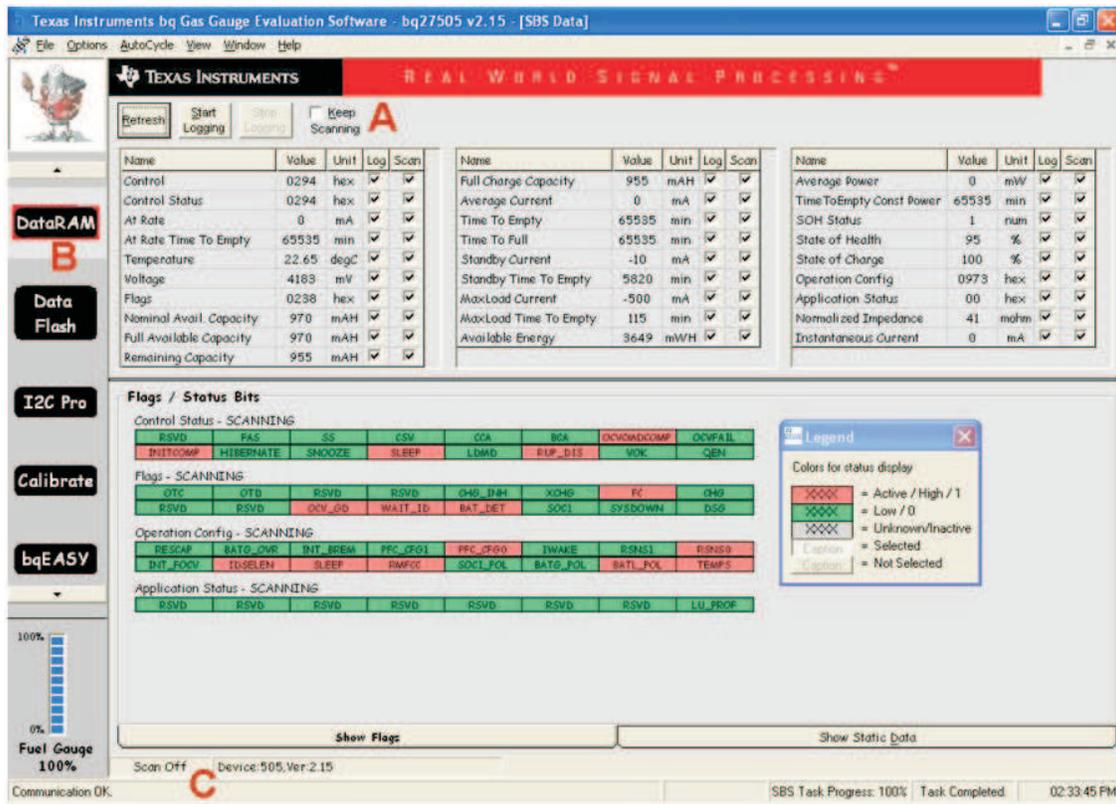
## 2.7 Starting the bq27505EVM Software

Beginning at the Windows Start menu, start the bq27505 evaluation software by selecting the application from the cascading menus: **Start** → **Programs** → **Texas Instruments** → **bq Evaluation Software**. To become familiar with the bq27505 evaluation module (EVM) you can simulate a battery cell with resistors and a power supply. You can vary the voltage across these resistors to simulate different states of charge. This configuration is shown in [Figure 2](#) and described in the *bq27505EVM System Side Single-Cell Impedance Track™ Technology Evaluation Module* application note ([SLUU356](#)).

## 2.8 bqEVSW Software Sections

The bq27505 evaluation software uses five major sections ([Figure 3](#)):

- **DataRAM**—standard I<sup>2</sup>C information you can read from the pack when it is sealed and important IC status registers.
- **Data Flash**—shows all the parameters you can change when designing your system. See the data flash value description found in the *Configuring the bq27505 Data Flash* ([SLUA525](#)) application report.
- **I2C Pro**—reads and writes data from any I<sup>2</sup>C-compatible gas gauge, plus can also load a new firmware file.
- **Calibrate**—performs temperature, coulomb counter (CC) input, board current, and pack current calibration tests.
- **bqEASY™**—software wizard that acts like a workflow to simplify the configuring, chemistry selection, and performing learning cycles needed to produce the final "golden image" file.



- A Checkbox to **Keep Scanning** while you make changes.
- B Switches you quickly between major software areas.
- C Area provides information on Communication status, device type, and firmware version number.

**Figure 3. bq27505 EVM Software Organization**

### 3 Software Communication and Troubleshooting

When you start the bq27505 EVM software (**bqEVS**W), it automatically recognizes the firmware and hardware version. If a EV2300 USB PC Interface board communication problem occurs, the message in [Figure 4](#) displays.



**Figure 4. bqEVS**W Unable to Communicate With EV2300

Click **OK** and the software requests you to choose a device in use. If you get to this point, you are not going to have proper communication with the EVM.

If you choose one of the devices and firmware revisions, you eventually can display the DataRAM window; however, key flags and status bits are grayed-out ([Figure 5](#)). The bq27505 EVM software uses color codes to describe the current status for the DataRam Flags and Status bits. Familiarize yourself with the legend in [Figure 3](#) and [Figure 8](#).

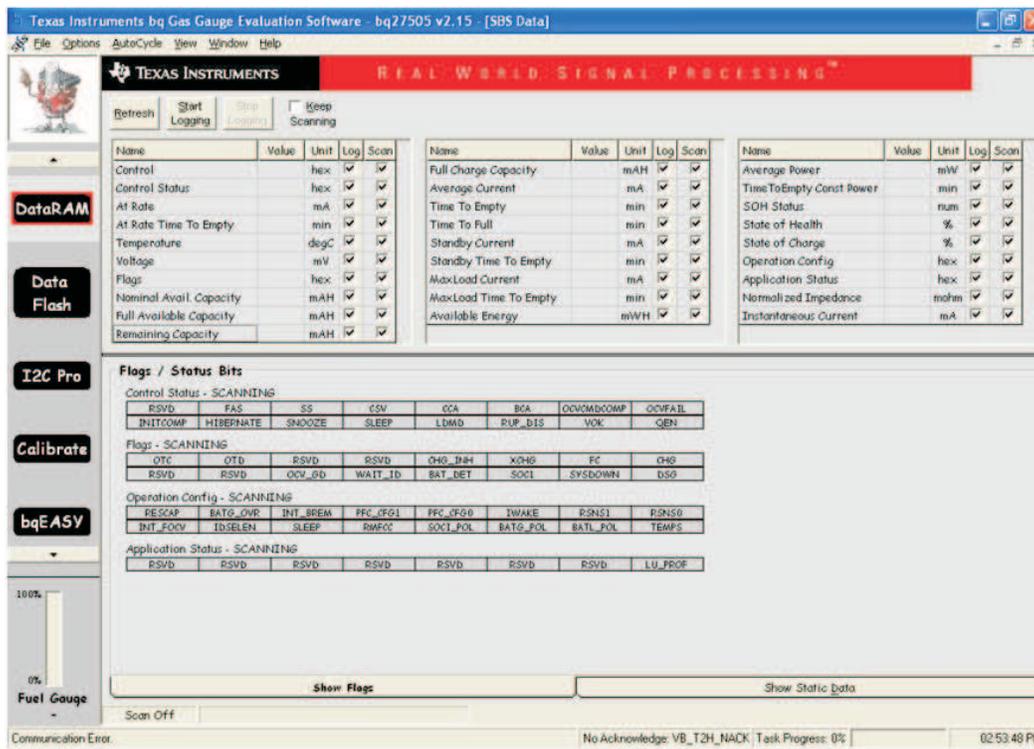


Figure 5. DataRAM Window Displaying No EV2300 Communication

### 3.1 Troubleshooting USB Communication Issues

If you are having EVM communication issues, try these steps:

- Do you have the EV2300 USB cable connected (Figure 6) as shown in the Figure 2?
- Have you properly installed the required *TI USB Firmware Updater* and the *TI USB bq27505* drivers, as discussed in Section 2.5?
- Did you *kick-start* the EVM by connecting power momentarily to PACK+ and PACK– to simulate a charger insertion?
- Are the I<sup>2</sup>C lines connected to the EVM (Figure 2)?
- Is another instance of the software already running? Press Ctrl+Alt+Delete keys to display the Task Manager, and look for another instance of the bq2750xEVM software (**bqEVSW**) running.
- Try restarting your computer if you do not see the *TI USB bq2750x driver* displayed in the **System Properties** → **Hardware dialog tab** → **Device Manager** window.

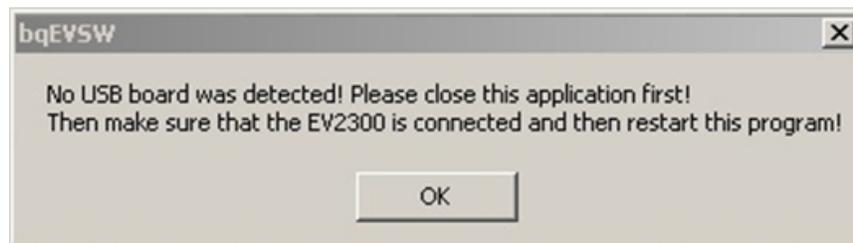
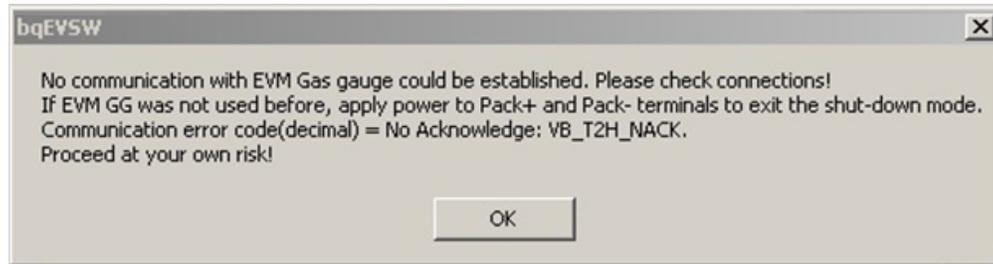


Figure 6. bqEVSW Software Shows No USB Board If EV2300 Is Not Connected



**Figure 7. bqEVSU Warns If No EVM or EVM Not Powered Up**

## 4 bq27505 Evaluation Software Sections

The DataRAM screen displays as the default window, providing you access to the context-sensitive help and the five windows used to organize the software GUI controls:

- [DataRAM](#)
- [Data Flash](#)
- [I2C Pro](#)
- [Calibrate](#)
- [bqEASY Wizard](#)

### 4.1 DataRam Window

If everything is working correctly, a DataRAM window similar to [Figure 8](#) displays with green/orange indicators in the status registers. Also, *Communication OK* is in the lower left corner. Click on the *Keep Scanning* box at the top of the window. The software continues to update these values throughout your testing process.

**The DataRAM window** shows the standard I<sup>2</sup>C information that you can read from the pack when it is sealed, or unsealed. The FAS and SS bits in Control Status indicate if the gauge is sealed. By default, the IC is configured in full access mode.

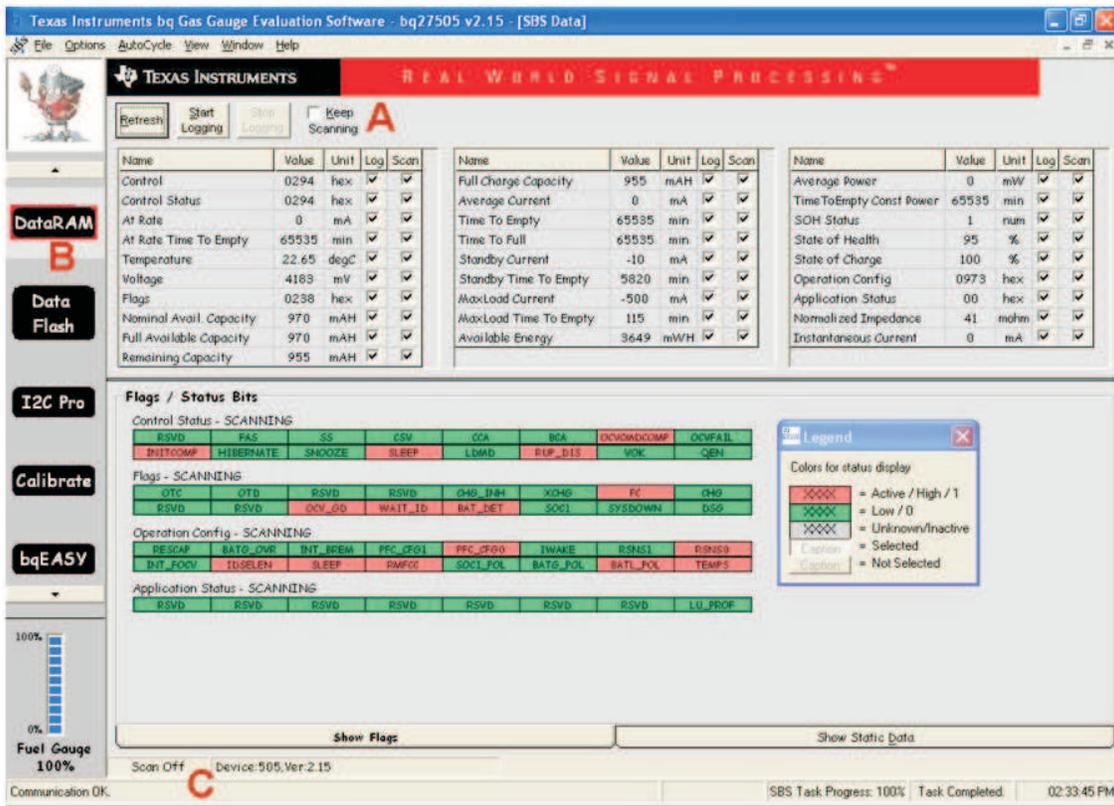


Figure 8. DataRAM Displaying Appropriate Communication With EV2300

You can issue Manufacturer Access commands (MAC) from this window by clicking in the **Control** field under the *Value* column (see Figure 15). For example, this issue arises when writing the Unseal or Full Access commands. Examples of how to complete these processes is included in Section 6.4.

## 4.2 Data Flash Window

The Data Flash window (Figure 9) shows all the parameters you can change when designing your system. To begin, you can load the default values stored which shows the single cell pack configuration.

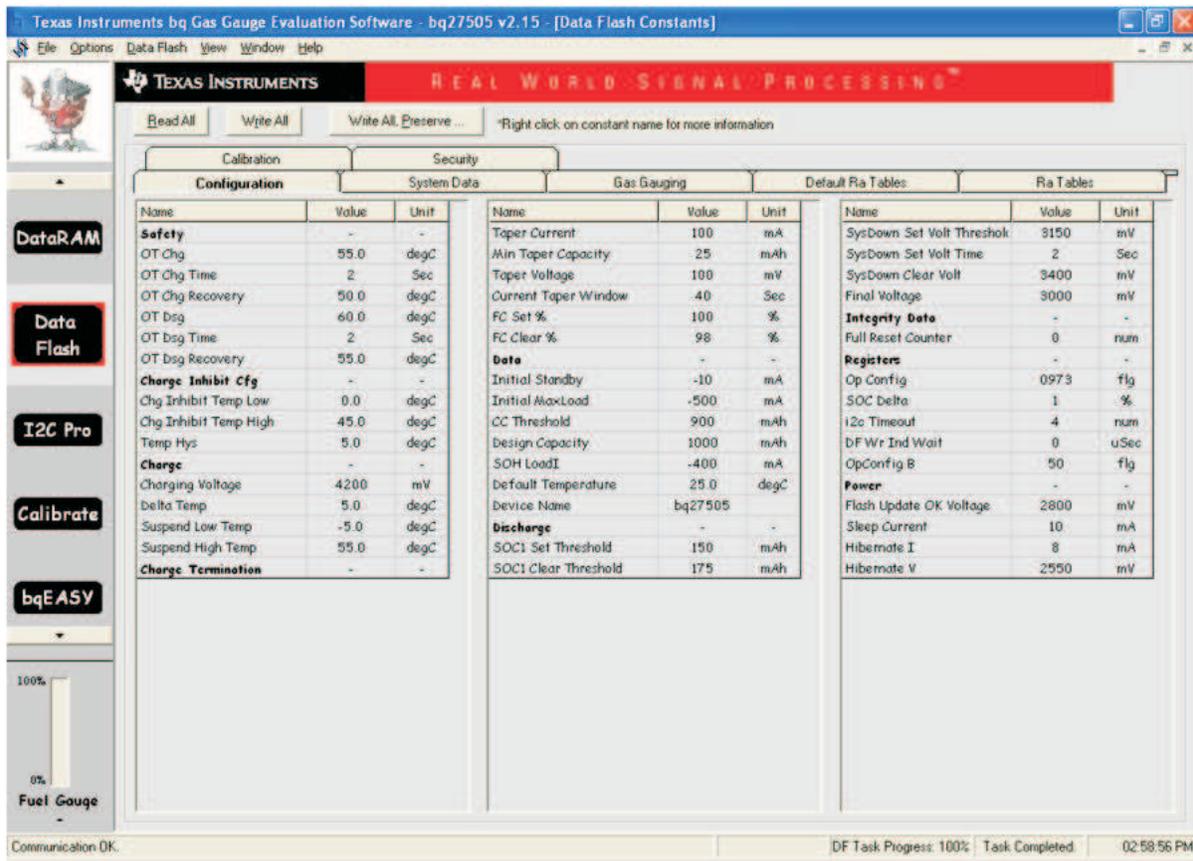


Figure 9. Data Flash Screen

For detailed information on configuring the Data Flash for your particular design, see the *Configuring the bq27505 Data Flash* application report ([SLUA525](#))—a comprehensive resource for all Data Flash parameters.

Remembering all the nuances of the Data Flash parameters is impractical. However, all of the Data Flash definitions are listed in the *bq27505 Technical Reference Manual*.

### 4.3 I2C Pro Window

The **I2C Pro window** helps you communicate with bq27505 IC. In this window, you can read and write byte, word, and block information. Also, you can upload a new **.SENC** file from this window.

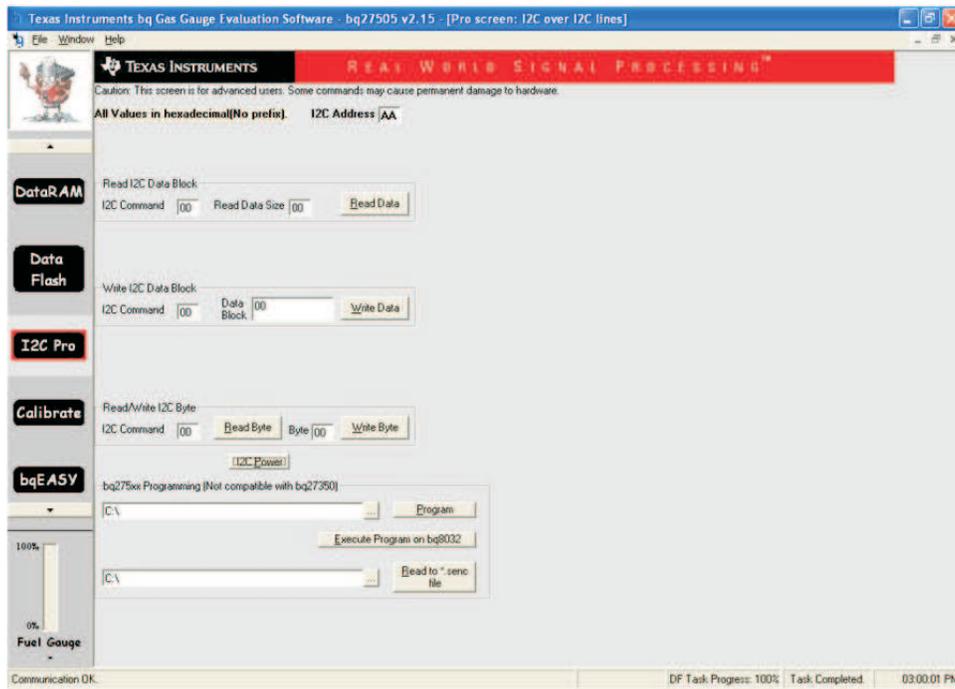


Figure 10. I2C Pro Window

## 4.4 Calibrate Window

The Calibrate window (Figure 11) helps you calibrate gas gauge voltage, current, temperature, and offsets.

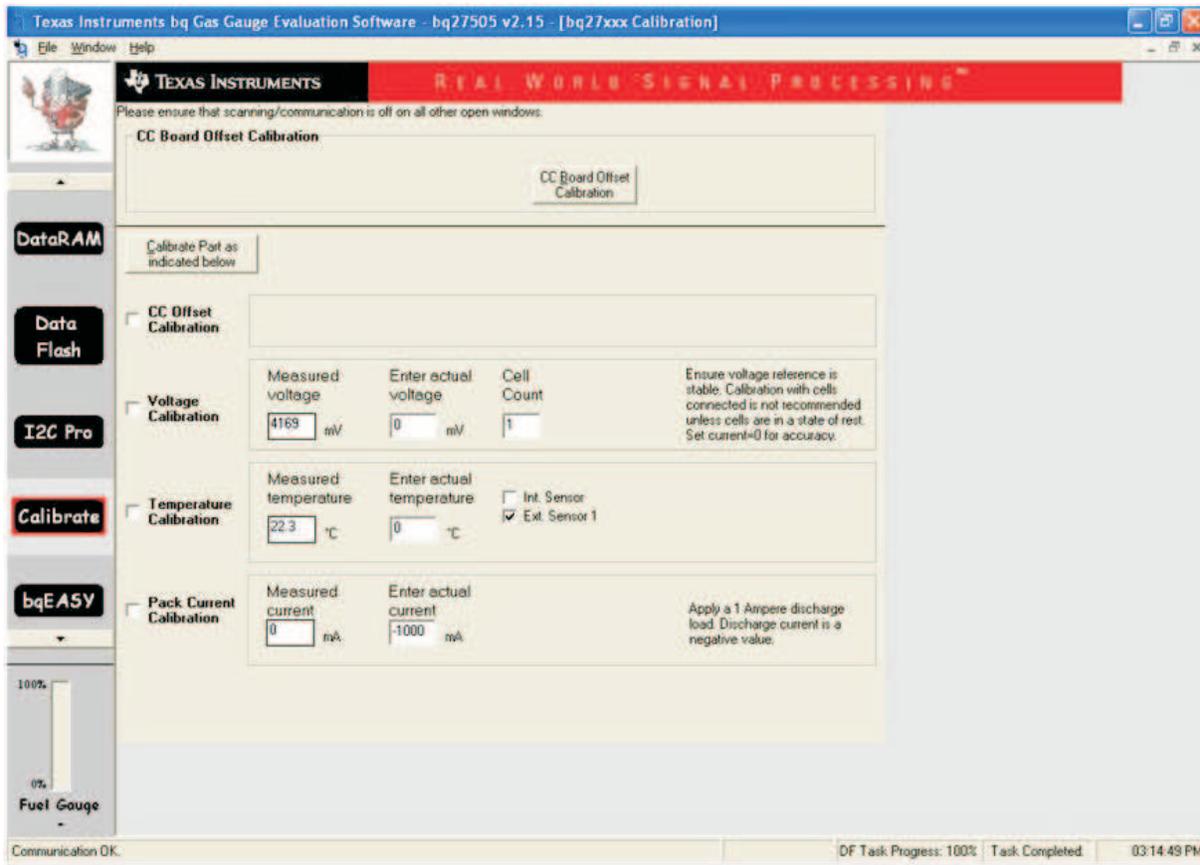


Figure 11. Calibrate Window

## 4.5 bqEASY™ Wizard

The bqEASY™ window (Figure 12) is a new feature in the bq Evaluation Software, used to program the Data Flash parameters, choose the proper battery chemistry, and perform the two cycle tests to create your Golden Image. If you are new to the Impedance Track™ technology, this is a great way to have a structured workflow to follow. (See details in Section 5.1.)

The bqEASY™ Wizard uses data entry dialogs to gather information and perform production tasks:

1. **Setup**—Impedance Track Configuration Wizard Splash screen
2. **Configure**—choose Data Flash parameters
  - a. Cell Characteristics
  - b. Charge Parameters
  - c. Discharge Parameters
  - d. Reserve Capacity
  - e. Load Characteristics
  - f. Application Configuration
  - g. Remaining Capacity Method
  - h. Miscellaneous Information
3. **Calibrate**
  - a. CC Offset

- b. Voltage
- c. Temperature
- d. Pack Current
- e. Board Offset
- f. Review / Read DFI file
4. **Chemistry**
  - a. Use Default Chemistry
  - b. Select Chemistry Manually
  - c. Do Chemistry Select Cycling
5. **Cycle**
  - a. Learning Cycle
  - b. Update Golden Pack



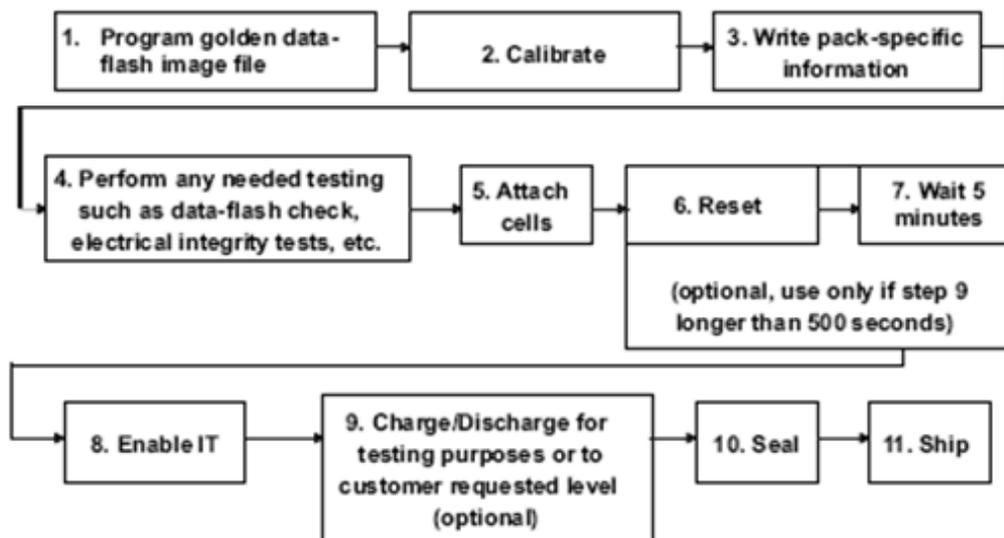
**Figure 12. bqEASY™ Wizard**

## 5 Creating Your Golden Image

One of the major benefits of using the Impedance Track™ technology, aside from the highly accurate gas gauging, is a simplified manufacturing process. No charge or discharge cycles are required after assembling the pack, which can take many hours.

### 5.1 Production Flow

Figure 13 is a procedure diagram showing the normal production flow of the bq2750x chipset. A detailed description of these states can be found in the *Going to Production with the bq27505* application report (SLUA516).



**Figure 13. Production Flow Diagram**

These are the different steps in design, preproduction, and production.

## 5.2 Design and Evaluation

1. Install the bqEVSU software ([Section 2.4](#)) and the EV2300 communication USB drivers ([Section 2.5](#)).
2. Connect resistors and power supply to simulate battery pack.
3. Kick-start the EVM (connect power momentarily to the PACK+ and PACK– to simulate charger insertion).
4. Start the bqEVSU software
5. Explore the different features of the software.
6. Load the correct .chem file corresponding to the chemistry of your battery cells using the bqEASY™ Wizard (see [Section 6.1](#)).
7. Program the necessary Data Flash constants specific to your design.
8. Connect a real battery cell to the EVM
9. Fully charge the cells and let reset for 2 hours.
10. Start Data Logging – both DataRAM parameters and the .GG gas gauge files.
11. Repeat these steps as often as necessary:
  - Enable the Impedance Track™ algorithm
  - Discharge Pack to termination voltage and let reset.
  - Repeat this process
12. Look for updated resistances and Update Status = 02 in the final .GG file.  
Once you have a properly cycled pack with updated values, you need to create a Golden image file that is programmed and incorporated into every pack coming off the production line.
13. Export the .GG file and make a few changes (disable IT and change cycle count to 0).
14. Reload the .DFI file to clear out Data Flash hidden values.
15. Import your changed .GG file.
16. Now you are ready to create the .DFI file used to program production packs.

## 5.3 The Gas Gauge File

The Gas Gauge (.GG) file stores all programmable Data Flash parameters as well as the updated cell resistance profile after doing the two cycle tests.

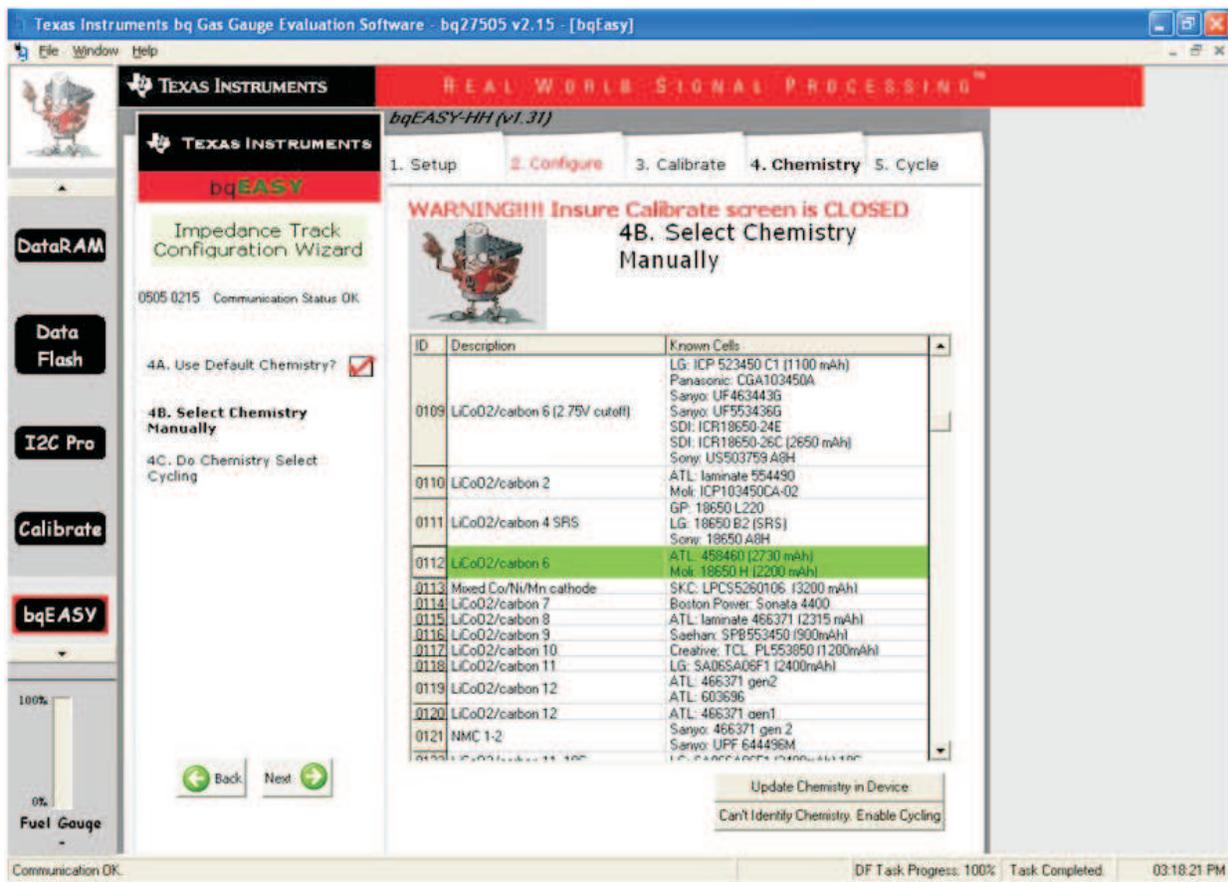
## 6 Example Procedures

### 6.1 Choosing the Correct Chemistry

For the Impedance Track™ algorithm to work properly, the exact chemistry of the lithium cells must be known and the correct .SENC file must be loaded.

The most updated chemistry files can be found installing the latest version of the bqEVS software (Section 2.4), which you can find on the TI Internet site in the [bq27505 Product folder](#). The files are stored in the folder named: C:\Program Files\Texas Instruments\bq Evaluation Software\Plugins\Chemistry The **Chem.ini** file describes the chemistry, manufacturer, and model numbers for the \*.CHEM files in this folder.

You can use the bqEASY™ Wizard (Figure 14) to display the chemistry information in an easy-to-use and organized manner. If you are using the bqEASY™ Wizard, it asks you to choose the correct chemistry from a list of manufacturers and model numbers. Alternatively, you can test for a compatible chemistry using a 4 point test.



A unique chemical ID indicates a different battery chemistry being used.

**Figure 14. Chemistry Selection Table in bqEASY™ Wizard**

### 6.2 Resetting the Pack

Vary the voltage of the power supply (being careful not to exceed maximum voltages), and issue a **RESET** Manufacturer Access Command (MAC) to the bq27505. The I<sup>2</sup>C double-word command is `0x00`, data `0x0041`.

This can be done in two ways (see Figure 15). The shortcut is to type 41 into the Manufacturer Access Value of the DataRAM window. Alternatively, use the I2C Pro window to issue a reset command 00, data 4100 from the Write I2C Data Block and click the Write Data button.

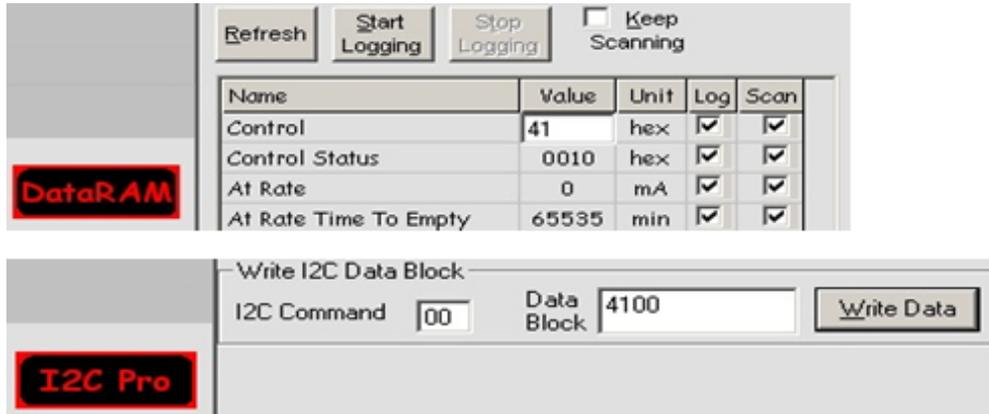


Figure 15. Sending MACs - DataRAM and I2C Pro Windows

### 6.3 Data Logging

While you are running your charge and discharge tests, you may want to log the DataRAM and gas gauge (.GG) flash data. This is done in two steps. The DataRAM data is logged by selecting the **File** → **Start Logging** menu command (Figure 16). The **Save As (Log File Name)** dialog asks what folder and what file name to use for the Log File.

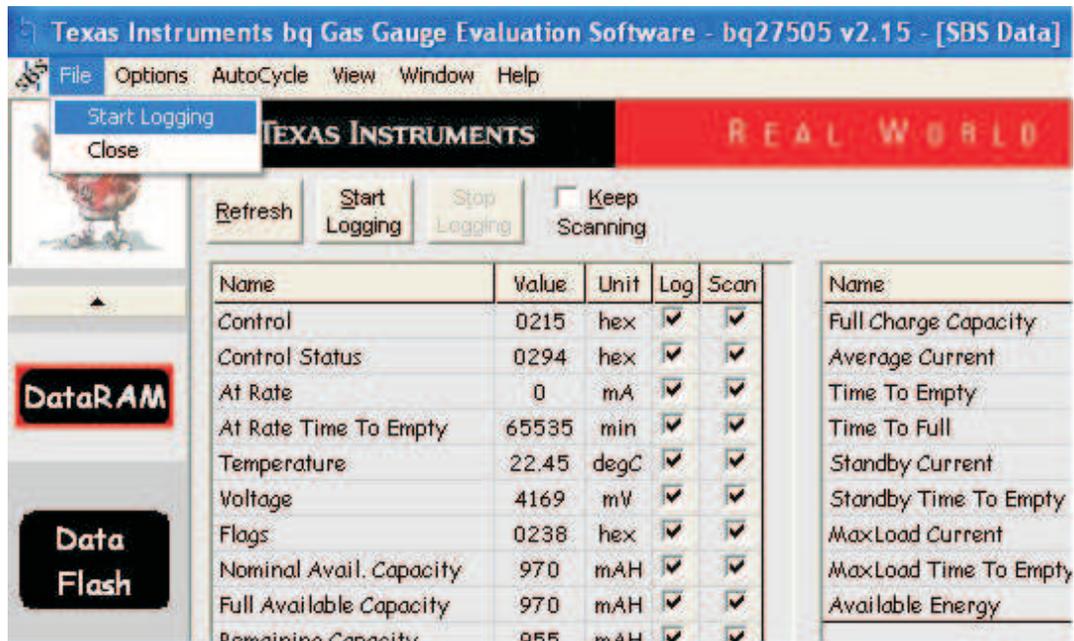
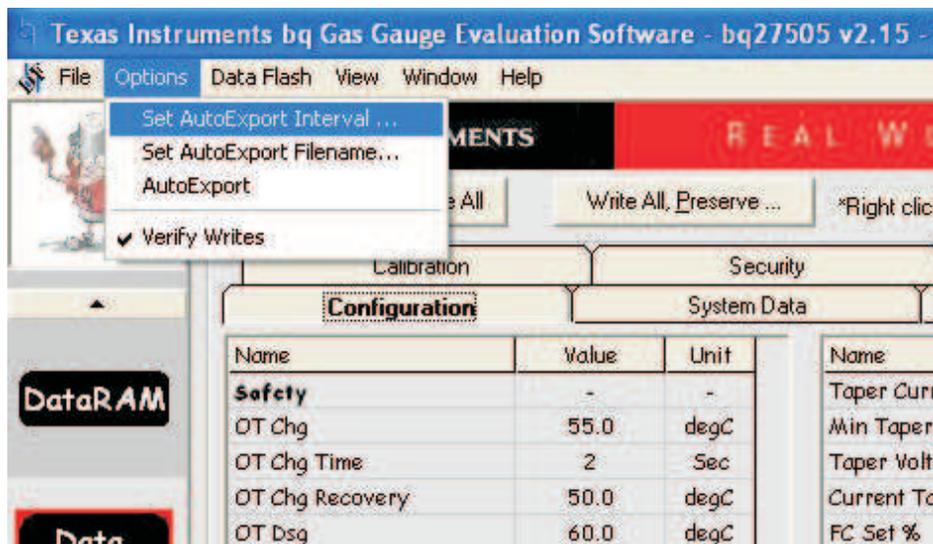


Figure 16. DataRAM Data Logging Command

To save the iterations of the Gas Gauge (.GG) file, go to the **Data Flash** window and select the **Options** → **Set AutoExport Filename** command. A series of Gas Gauge files is created in the folder specified throughout the testing. You can adjust the save interval of AutoExport (every 15 minutes is usually acceptable) using the **Options** → **Set Export Interval** command. To start the logging, select the **Options** → **AutoExport** command (Figure 17) to begin saving the Gas Gauge files.



**Figure 17. Gas Gauge Logging Setup and Start Commands**

## 6.4 Seal and Unseal Process

Once you are finished with the production flow (see [Figure 13](#)) and have programmed the correct gas gauge (.gg) file for your Golden Pack, seal the pack. If you do seal the pack, you can issue the Unseal command, followed by the Full Access command to make changes. However, if you removed power to the IC, it returns to sealed mode and you have to repeat this process to unseal and subsequently move to full access mode. The only way to *reset* the IC to automatically come up in full access mode is to reload the .SENC file with defaults.

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**Note:** Be careful when reloading the .SENC file as it can erase any Data Flash constants or resistance updates through cycling that you may have made.

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If you Seal your battery pack and later you decide to unseal it (for example, diagnosing a field failure), you must perform these steps to move from **Sealed**, to **Unsealed**, and finally to **Full Access** mode.

1. During production, change the default Unseal and Full Access Keys settings in the IC. To read the default Unseal and Full Access Key, the data flash portion of the device needs to be opened by the configuration file `.encr` and the *Security* dialog tab ([Figure 18](#)) can be accessed. The default Unseal Key and Full Access Key can be modified.
2. When the IC is sealed, and you connect the EV2300 and start the bq27505 evaluation software, the DataRAM window displays as in [Figure 19](#). Sealing the pack is done using Manufacturer Access `0x0020`.

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**Note:** Do **not** seal your pack until after production.

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3. The FAS (Full Access Seal mode) and SS (Sealed State) bits are set when the seal command is issued through the control register. To move from Sealed to Unsealed mode, write to the bq27505 device with the UNSEAL Key. You still need to move from Unsealed to Full Access mode using the FullAccessKey.

---

**Note:** The SS bit (Sealed) is cleared; however the FAS bit (Full Access) is still set in [Figure 21](#).

---

4. After issuing the two `0xFFFF` Full Access Key through control register, the FAS bit ([Figure 22](#)) is also cleared.

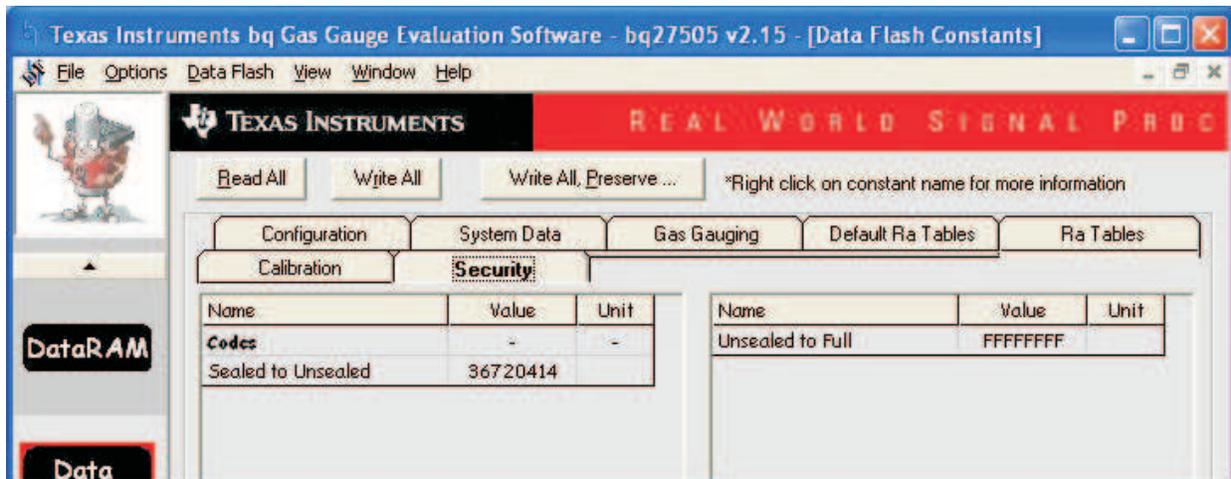


Figure 18. Default Unseal Key and Full Access Key



Figure 19. Sealed Mode for the bqEVSW DataRAM Window

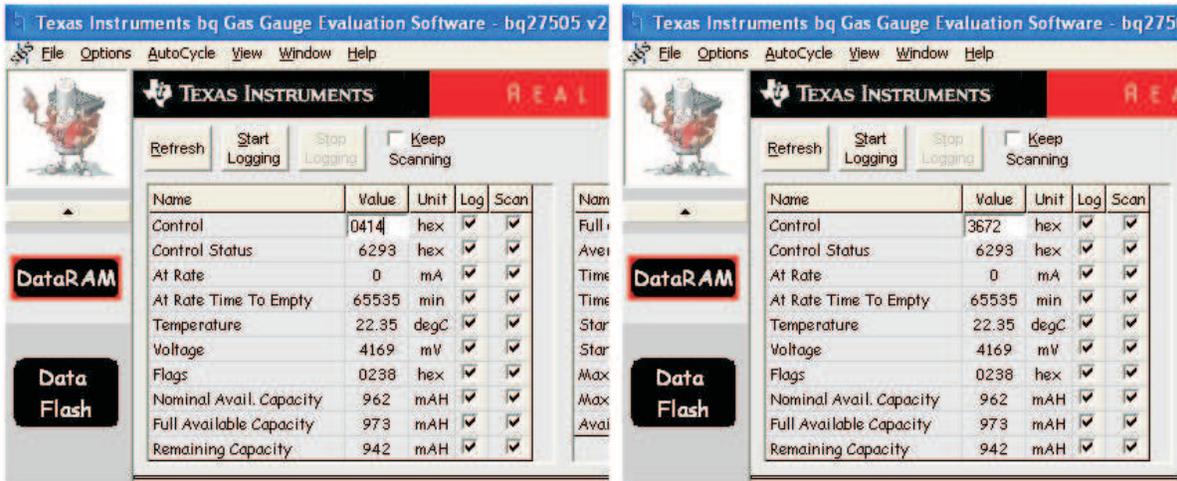


Figure 20. Default Unseal Command Using Control Register

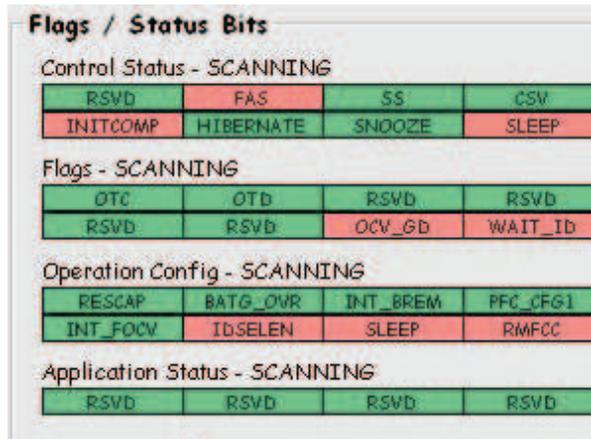


Figure 21. Status Showing Unsealed Mode With Full Access FAS Bit Set

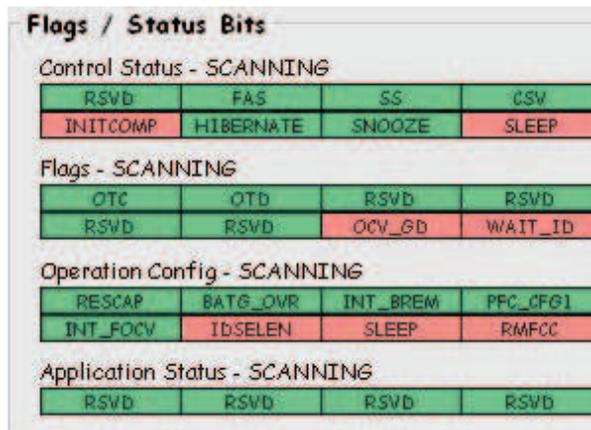


Figure 22. FAS and SS Bits Are Cleared

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
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