bq28550 Single Cell Li-Ion Battery Gas Gauge and Protection EVM

NOTE: BEFORE YOU START: Download the latest revision of the device firmware and the evaluation software from the TI bq28550 product page at http://www.ti.com. Go to the Tools and Software section. For step-by-step instructions on reprogramming the device firmware, refer to Section 10.3 of this document.

This evaluation module (EVM) is a complete evaluation system for the bq28550 battery management solution. The EVM includes one bq28550 circuit module, a current sense resistor, and one thermistor. An EV2300 or EV2400 PC interface board is required to interface to the gas gauge, and a PC USB cable is required for communication with a PC. Both can be ordered online at http://power.ti.com. Windows™-based PC software is available online as well. The circuit module includes one bq28550 IC, and all other onboard components necessary to monitor and predict capacity, monitor critical parameters, and protect the cell from overcharge, overdischarge, short circuit, and overcurrent in single-cell Li-Ion or Li-Polymer battery packs. With the EV2300 or EV2400 interface board and software, the user can read the bq28550 data registers, program the chipset for different configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq28550 solution under different charge and discharge conditions.

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1 Features

- Complete evaluation system for the bq28550 battery management IC
- Populated circuit module for quick setup
- Software that allows data logging for system analysis

1.1 Kit Contents

- bq28550EVM-001 circuit module
- Links to support documentation

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq28550EVM-001	Li-Ion, Li-Polymer	1 Cell	Any

2 bq28550EVM-001 Circuit Module

The bq28550EVM-001 circuit module is a complete and compact example solution of a bq28550 circuit for battery management and protection of Li-Ion or Li-Polymer packs. The circuit module incorporates a bq28550 battery monitor IC and all other components necessary to accurately predict the capacity of single-cell batteries.

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 communication port: SDA, SCL, GND
- The system load and charger connect across PACK+/LOAD+ and PACK–/LOAD–

PIN NAME	DESCRIPTION
CELL–	Negative connection of the cell
CELL+	Positive connection of the cell
SDA	Serial communication data port
SCL	Serial communication clock port
GND	Pack negative terminal
PACK–/LOAD–	Pack negative terminal
PACK+/LOAD+	Pack positive terminal

3 bq28550EVM-001 Circuit Module Schematic

This section contains the board layout, bill of materials, assembly drawings, and schematic for the bq28550EVM-001 circuit module.

3.1 Schematic

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

3.2 Configuring the Board for SMBus or I²C Communication

For successful SMBus or I²C communication, jumpers J2 and J3 must be shunted.

3.3 Board Layout

This section shows the printed-circuit board (PCB) layers (Figure 1 through Figure 4), assembly drawing, and schematic for the bq28550 module.

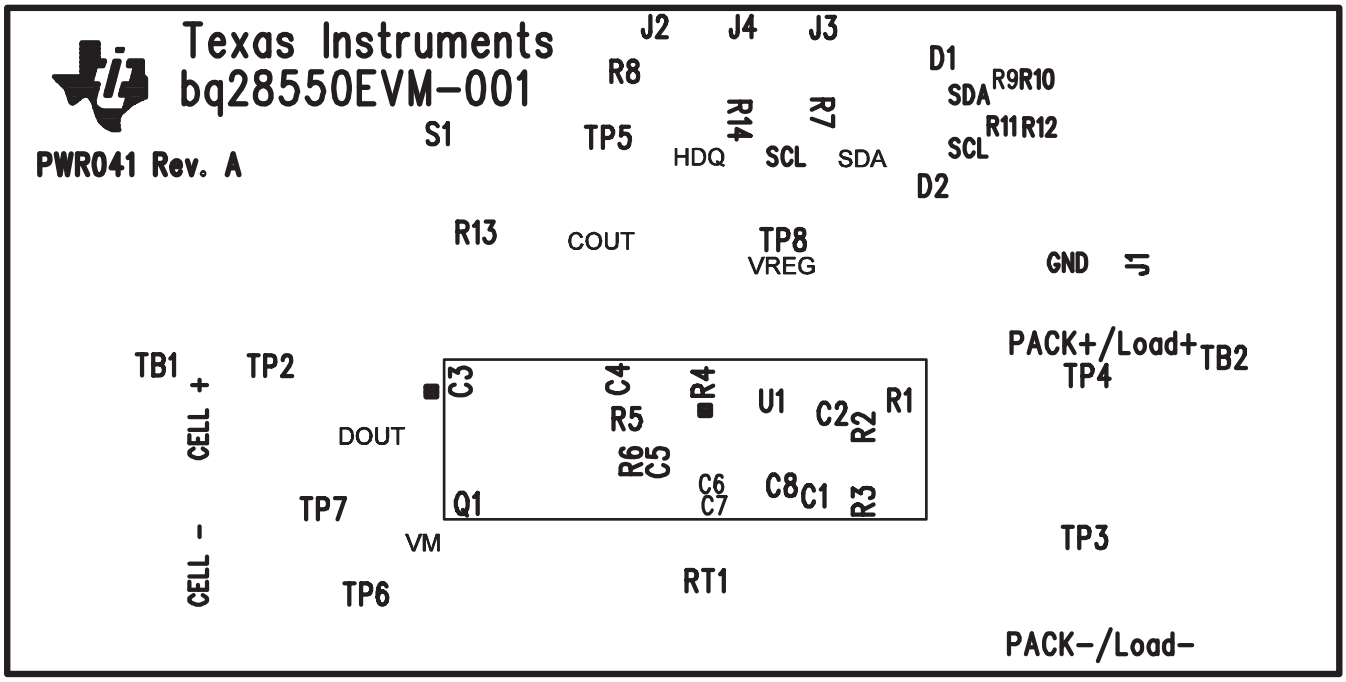


Figure 1. bq28550EVM-001 Layout (Silk Screen)

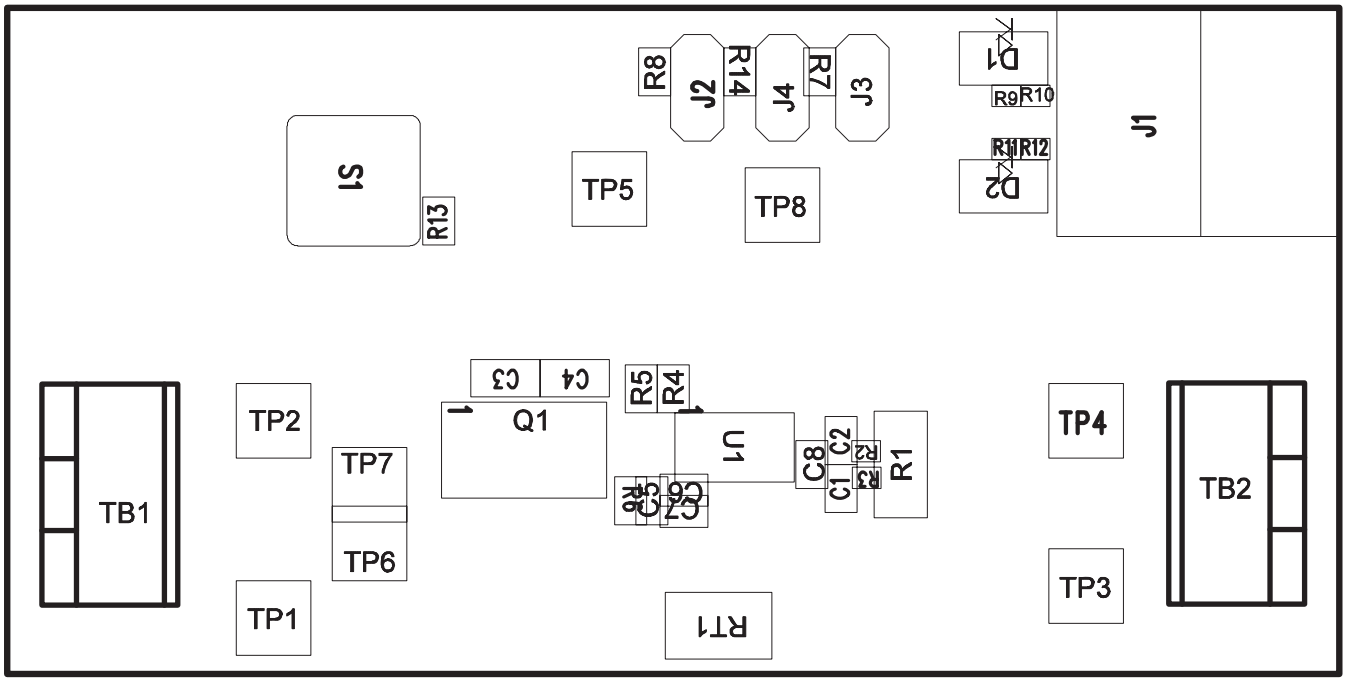


Figure 2. Top Assembly

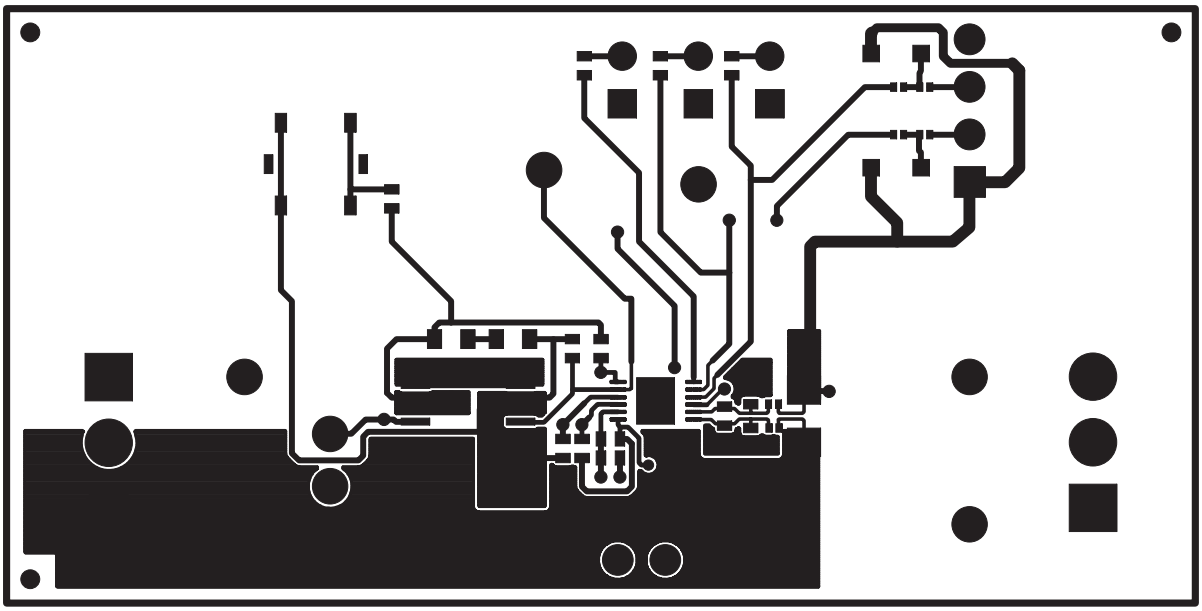


Figure 3. Top Layer

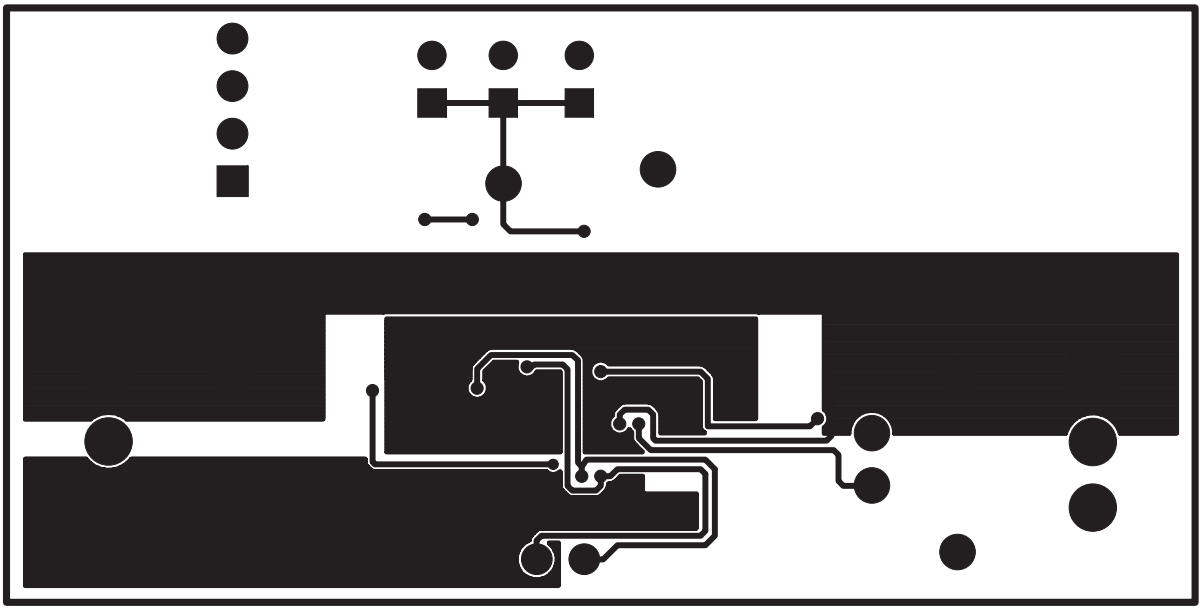


Figure 4. Bottom Layer

3.4 Bill of Materials and Schematic

Table 2. Bill of Materials

COUNT	RefDes	Value	Description	Size	Part Number	MFR
2	C1-2	0.1 µF	Capacitor, Ceramic, 16 V, X7R, 20%	0402	STD	Any
2	C3-4	0.1 µF	Capacitor, Ceramic, 16 V, X7R, 20%	0603	STD	Any
2	C5 C8	0.1 µF	Capacitor, Ceramic, 6.3 V, X5R, 20%	0402	STD	Any
1	C6	1 µF	Capacitor, Ceramic, 16 V, X7R, 20%	0402	STD	Any
1	C7	0.47 µF	Capacitor, Ceramic, 16 V, X7R, 20%	0402	STD	Any
2	D1-2	MM3Z5V6C	Diode, Zener, 5.6 V, 200 mw	SOD323	MM3Z5V6C	Fairchild
1	J1	22-05-3041	Header, Friction Lock Ass'y, 4-pin Right Angle	0.400 x 0.500 inch	22-05-3041	Molex
3	J2-4	PEC02SAAN	Header, Male 2-pin, 100 m spacing,	0.100 inch x 2	PEC02SAAN	Sullins
1	Q1	IRF8852TRPBF	FET, dual N channel, 25 V, 7.8 A, 11.3 mΩ	TSSOP8	IRF8852TRPBF	Int. Rect.
1	R1	0.005	Resistor, Metal Film, 1 W, 1%	1206	WSLP12065L000FEA	Vishay/Dale
1	R13	1 K	Resistor, Chip, 1/16 W, 5%	0402	STD	Any
6	R2–3 R9–12	100	Resistor, Chip, 1/16 W, 5%	0201	STD	Any
2	R4-5	3.01 M	Resistor, Chip, 1/16 W, 5%	0402	STD	Any
1	R6	510	Resistor, Chip, 1/16 W, 5%	0402	STD	Any
3	R7–8 R14	3.3 K	Resistor, Chip, 1/16 W, 5%	0402	STD	Any
1	RT1	10 K	Thermistor, NTC, 3 A	0.095 X 0.150 inch	103AT-2	Semitec
1	S1	EVQ-PLHA15	Switch, 1P1T, 50 mA, 12 V, 160 g	0.200 x 0.200 inch	EVQ-PLHA15	Panasonic
2	TB1-2	ED555/3DS	Terminal Block, 3-pin, 6-A, 3.5 mm	0.41 x 0.25 inch	ED555/3DS	OST
6	TP1 TP3 TP5-8	5001	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	5001	Keystone
2	TP2 TP4	5000	Test Point, Red, Thru Hole Color Keyed	0.100 x 0.100 inch	5000	Keystone
1	U1	BQ28550DRZ	IC, Single Cell Battery Management Controllers	QFN12	BQ28550DRZ	TI
2			Shunt, 100-mil, Black	0.100 inch	929950-00	3M

Table 2. Bill of Materials (continued)

COUNT	RefDes	Value	Description	Size	Part Number	MFR
1	—		PCB	2.5 inch x 1.25 inch	PWR041	Any
Notes:	1. These assemblies are ESD sensitive, ESD precautions shall be observed.					
	2. These assemblies must be clean and free from flux and all contaminants. Use of no-clean flux is not acceptable.					
	3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.					
	4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.					
	5. Make 1 connector wire assembly for each assembly produced, from J1 mate, 4–24 Awg wires and Crimp terminals. Wire colors for Pin numbers are listed below. The wire assemblies shall have a J1 mate respectively on each end.					
	Red—Pin # 4 (Signal USB_5V)					
	Brown—Pin # 3 (Signal SDA)					
	White—Pin # 2 (Signal SCL)					
	Black—Pin # 1 (GND)					

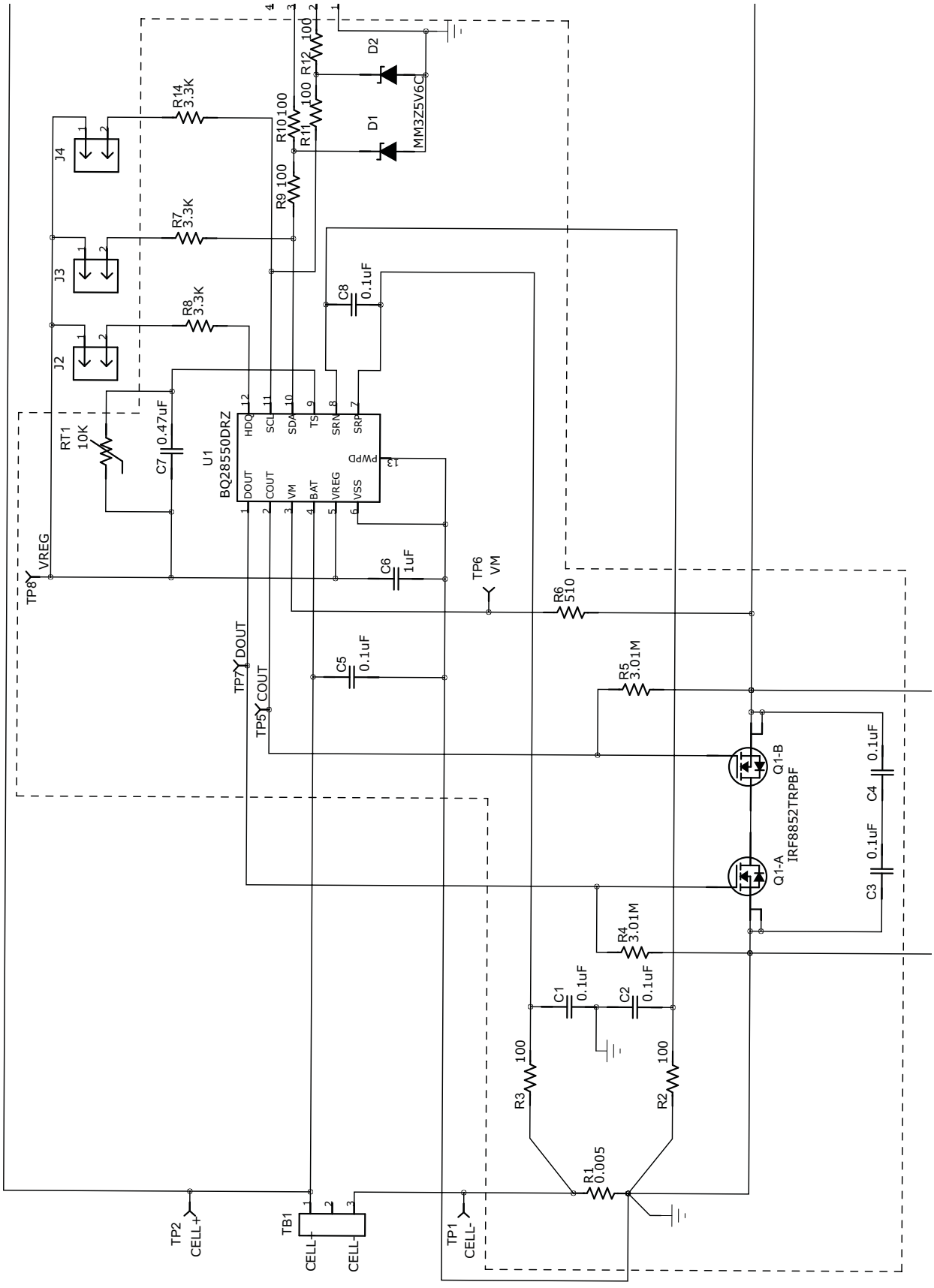


Figure 5. Schematic

3.5 bq28550EVM-001 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq28550EVM-001 circuit module.

Table 3. Performance Specification Summary

Specification	Min	Typ	Max	Units
Input voltage Pack+ to Pack–	2.7	3.6	4.3	V
Charge and discharge current	0	2	4	A

4 EVM Hardware and Software Setup

This section describes how to install the bq28550EVM-001 PC software, and how to connect the different components of the EVM.

4.1 System Requirements

The bq28550EVM-001 EVSW requires Windows™ 2000 or Windows XP™.

4.2 Software Installation

Get the latest software version in the bq28550 tool folder on www.ti.com, and follow these steps to install the bq28550EVM-001 EVSW:

1. Save the archive to a temporary directory. Open the archive containing the installation package, and copy its contents to a temporary directory. The executable filename can consist of several component names and versions. Double-click on the executable filename, and follow the installer instructions to complete the bq28550EVM-001 installation.
2. If an EV2300 or EV2400 was not previously installed, after bq28550EVM-001 installation, a TI USB DRIVER INSTALLER pops up. Click **Yes** for the agreement message and follow its instructions.
3. Plug the EV2300/EV2400 into a USB port.

5 Troubleshooting Unexpected Dialog Boxes

1. Ensure that the files were extracted from the zip file using the **Preserve Folder names** option.
2. Ensure that all the files were extracted from the zip file.

The user downloading the files must be logged in as the administrator.

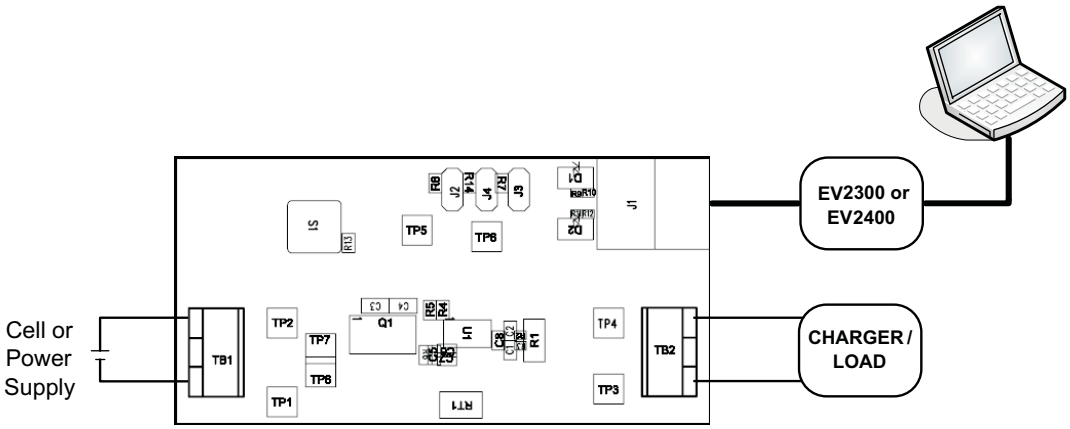
The driver is not signed, so the administrator must allow installation of unsigned drivers in the operating system policy.

6 Hardware Connection

The bq28550EVM-001 comprises three hardware components: the bq28550 circuit module, the EV2300 or EV2400 PC interface board, and the PC.

6.1 Connecting bq28550 Circuit Module to the Cell

Figure 6 shows an overview of how the bq28550EVM-001 circuit module connects to the cells and system load/charger.



bq28550 EVM PWR041

Figure 6. bq28550EVM-001 Circuit Module Connection to Cell and System Load/Charger

6.2 PC Interface Connection

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

1. Connect the bq28550EVM-001 circuit module to the EV2300 or EV2400 using wire leads as shown in Table 4.

Table 4. Circuit Module to EV2300 or EV2400 Connections

bq28550 Circuit Module	EV2300 or EV2400
SDA	SMBD
SCL	SMBC
GND	GND

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

The bq28550EVM-001 is now set up for operation.

7 Operation

This section details the operation of the bq28550 EVSW.

7.1 Starting the Program

Run bq Evaluation Software from the **Start** | **Programs** | **Texas Instruments** | **bq Evaluation Software** menu sequence. The **SBS Data** screen (Figure 7) appears. Data begins to appear once the **Refresh** (single time scan) button is clicked, or when the **Keep Scanning** checkbox 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 65535 ms. Only items that are selected for scanning are scanned within this period.

The bq Evaluation Software provides a logging function that logs the values that were last scanned by the EVSW. To enable this function, select the **Start Logging** button, which 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 65535 ms. The *Log* interval cannot be smaller than the *Scan* interval because this results in the same value being logged at least twice.

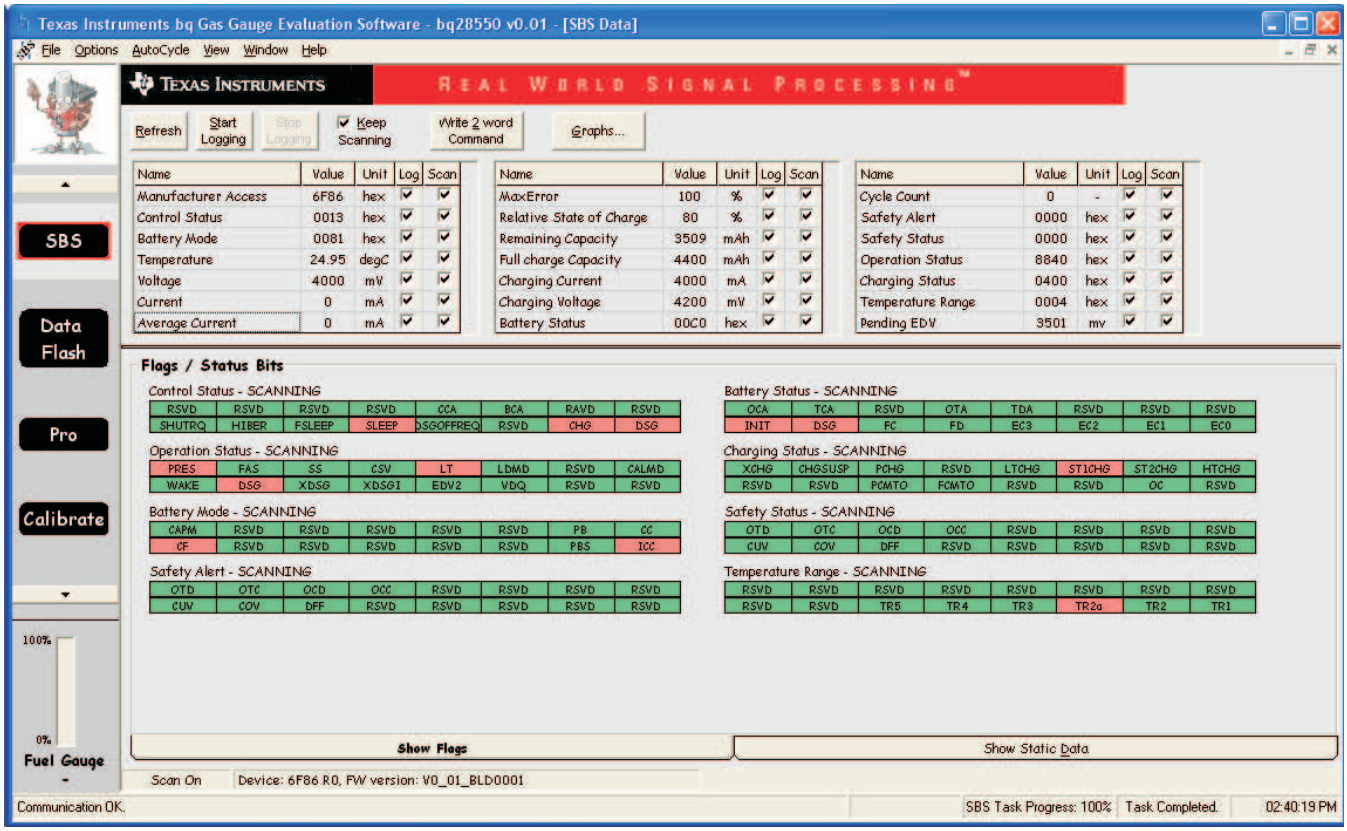


Figure 7. SBS Data Screen

This screen (Figure 7) shows the SBS data set along with additional ManufacturersAccess() command information, such as individual cell measurements. Additional Flag and Static data can be viewed by selecting the appropriate tab at the bottom of the **SBS** screen.

Data such as SBS.ManufacturerName( ) is static and does not change. This data is viewed separately using the **Static Data** tab available at the bottom of the screen.

Dragging the splitter bar (the 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.

7.2 Setting Programmable bq28550 Options

The bq28550 data flash comes configured per the default settings as detailed in the *bq28550 Single Cell Li-Ion Battery Gas Gauge and Protection Datasheet* (SLUSAJ2). Ensure that the settings are correctly changed to match the capacitor stack and application for the bq28550 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).

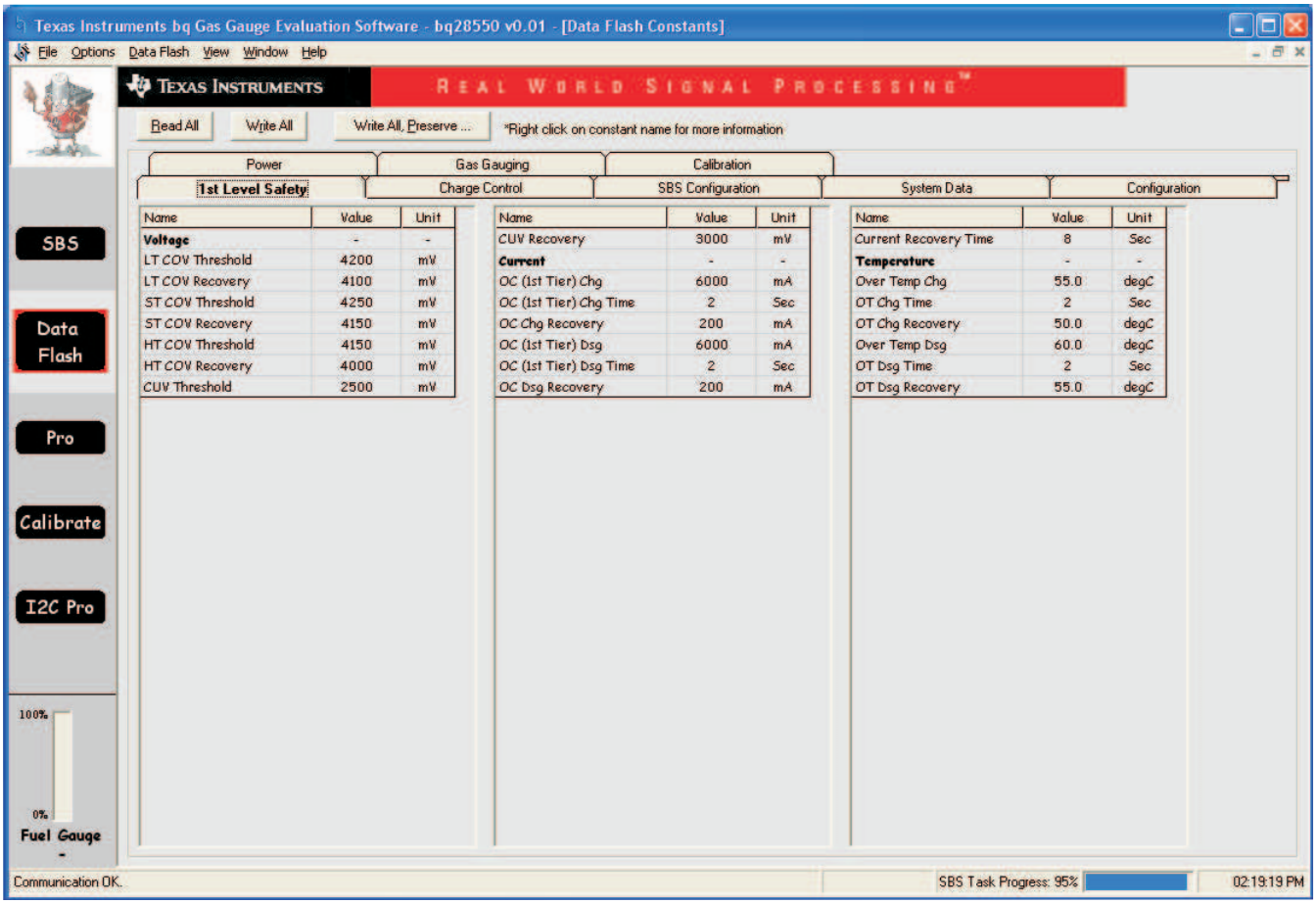


Figure 8. Data Flash Screen, Safety Class

To read all the data from the bq28550 data flash, click on the menu option | **Data Flash** | **Read All** |.

To write to a data flash location, click on the desired location, enter the data, and click **Enter**, which writes the entire tab of flash data, or select the 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 bq28550 using the | **Write All** | button.

The configuration information of the bq28550 and module calibration data are also held in the bq28550 data flash.

The bq28550 allows for an automatic data flash export function, similar to the *SBS Data 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 mark 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 bq28550 in use may not be supported by the bqEVSW version in use. An upgrade may be required.

8 Calibration Screen

To ensure proper calibration, proceed in the order that follows. These steps may or may not be required, depending on the type of calibration being performed.

8.1 To Calibrate the bq28550

1. Select the types of calibration to be performed (see Figure 9 and Figure 10).
2. Enter the measured values for the types selected.

   The calibration routine consists of two tabs. The first tab is for **Voltage and Temperature**. The second tab is for **CC Offset, Board Offset, and Current** calibration.
3. Ensure that the **Keep Scanning** checkbox in the SBS screen is unchecked.
4. If **Temperature Calibration** is selected, then select the sensor that is to be calibrated.

8.2 Voltage and Temperature Calibration

1. Select the **Voltage and Temperature** tab.
2. Remove the load applied between Pack+/Load+ and Pack–/Load–.
3. Ensure that voltage is stable before performing voltage calibration. Measure the voltage across Cell+ and Cell–. Type the voltage value in mV into **Enter Actual Voltage**.
4. Measure the temperature near the sensor to be calibrated. Type the temperature value into **Enter Actual Temperature**. Select if the temperature sensor to calibrate is the internal or the external sensor.
5. Click the **Calibrate Voltage and Temperature as indicated below** button.

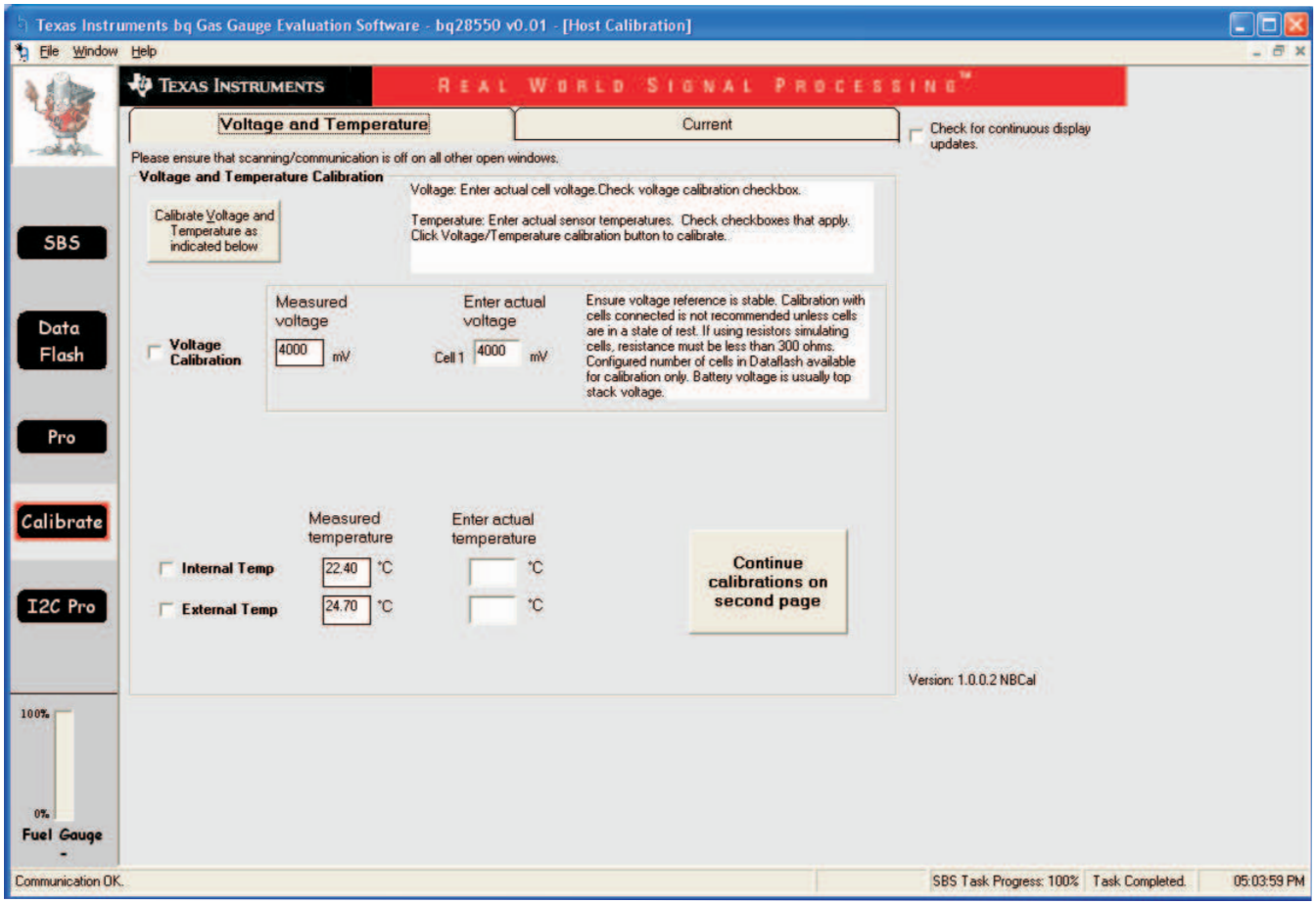


Figure 9. Voltage and Temperature Calibration Screen

8.3 CC Offset Calibration

Select the **Current** tab. **CC Offset Calibration** performs the internal calibration of the coulomb counter input offset.

8.4 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/external voltage and short Pack– to Batt–.

Click the **Calibrate Board Offset** button.

8.5 Pack Current Calibration

Connect a load to Pack+/Load+ and Pack–/Load– that draws approximately 2 A. Measure the current and type the value into Enter Actual Current using (–) for current in discharge direction.

Click the **Calibrate Pack Current** button.

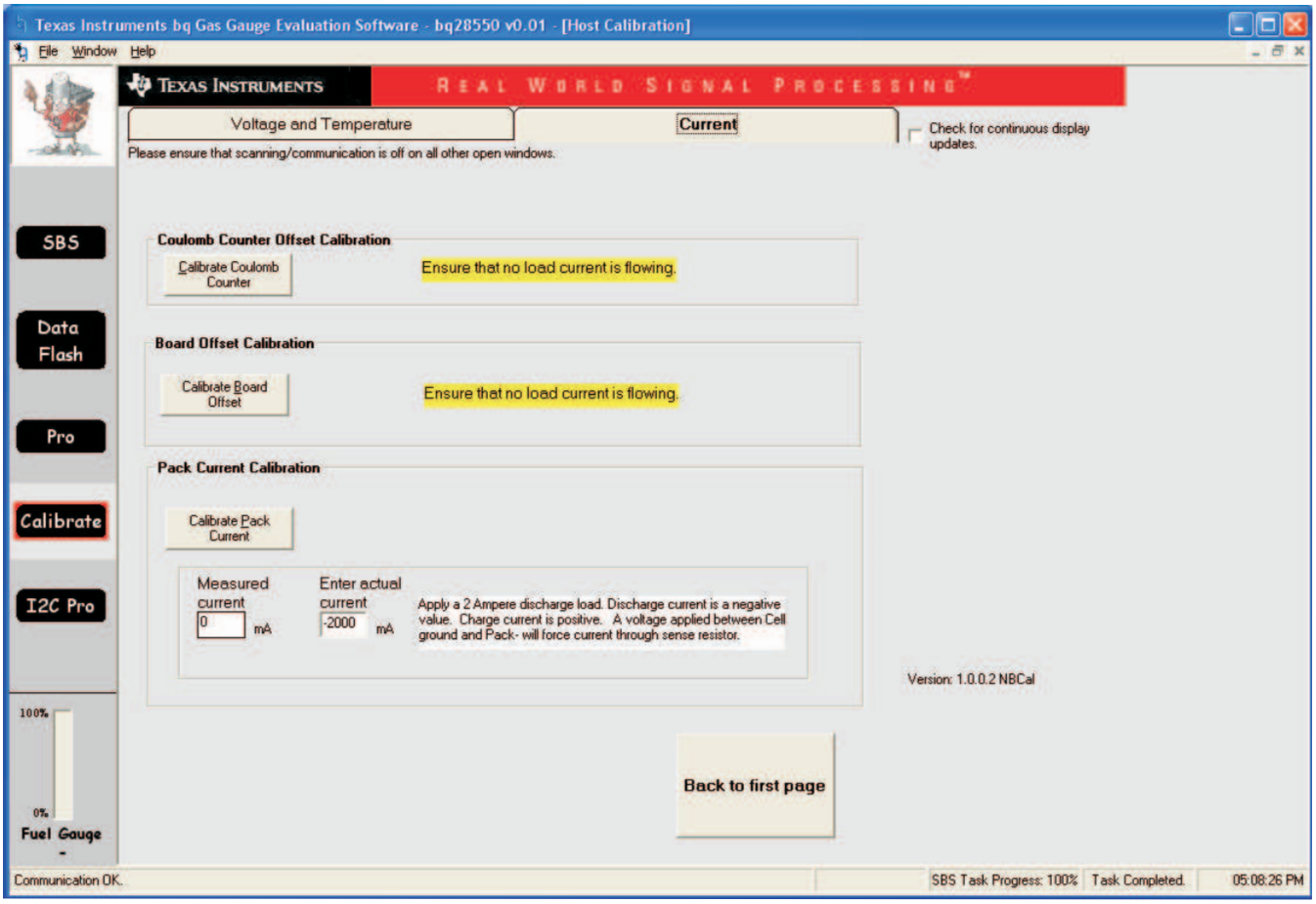


Figure 10. Current Calibration Screen

9 Pro (Advanced) Screen

9.1 SMB Communication

The set of read/write operations over the SMBus are not specific to any gas gauge. These are provided as general-purpose communication tools (Figure 12).

9.2 Hexadecimal/Decimal Converter

These two boxes convert between hexadecimal and decimal as soon as values are typed into the boxes. Invalid values may cause erroneous results.

When scaling converted hexadecimal values to a higher number of bytes, follow these rules:

- When **Unsigned** is selected, the left pad contains zeroes.
- When **Signed** is selected, the left pad contains zeroes for a positive number, or the left pad contains *F* for negative numbers.

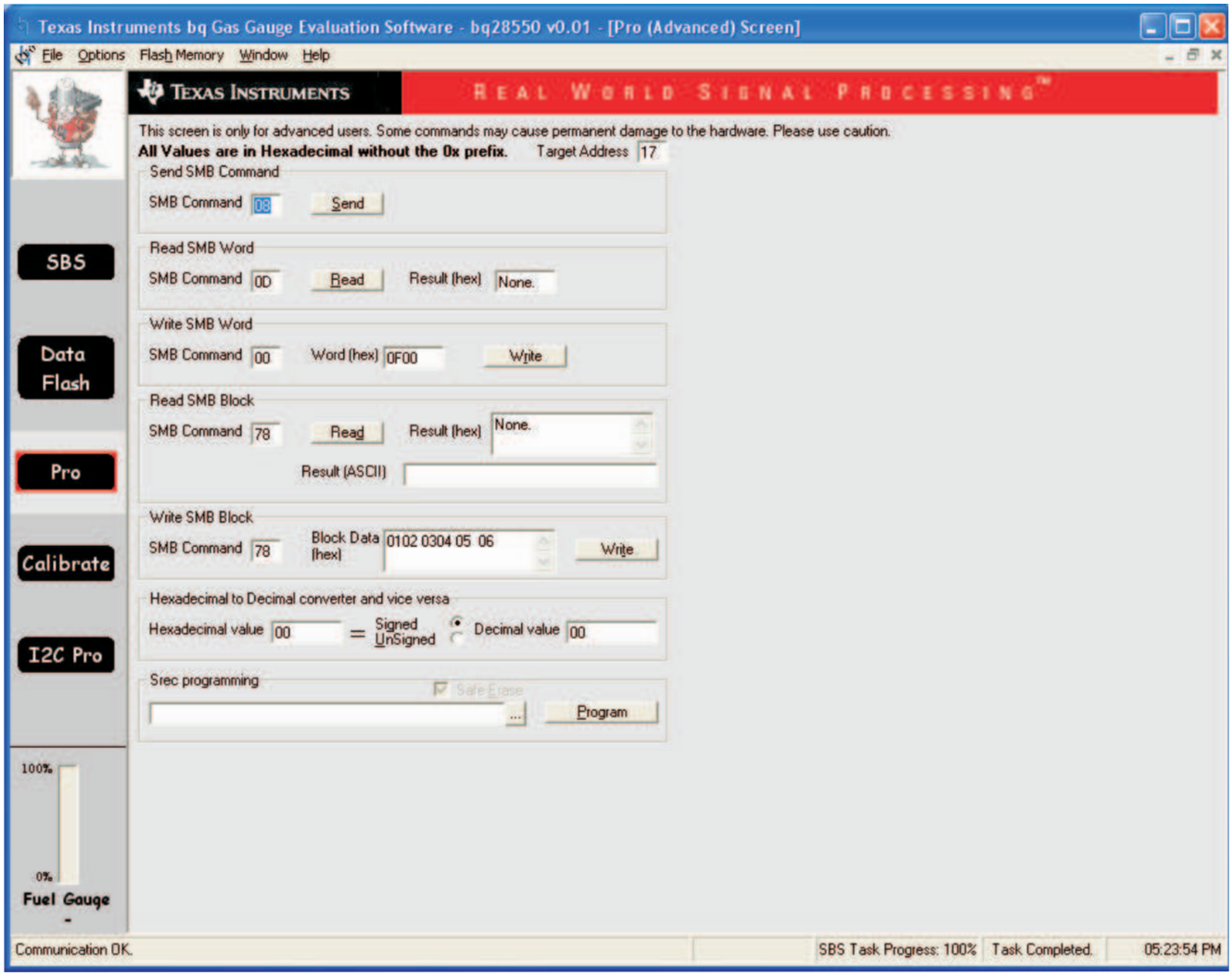


Figure 11. Pro (Advanced) Screen

10 I²C Pro (Advanced) 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 12).

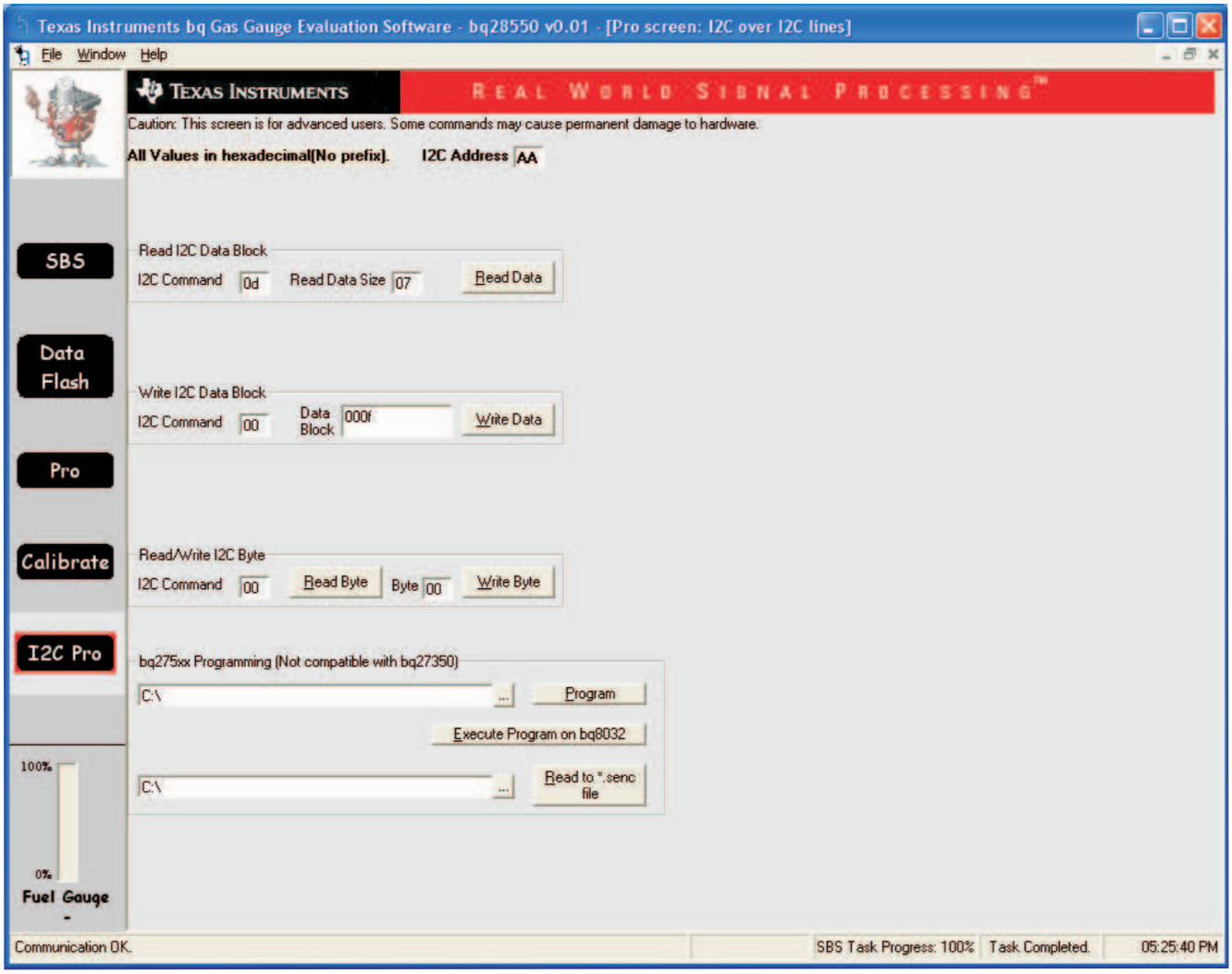


Figure 12. I²C Pro (Advanced) Screen

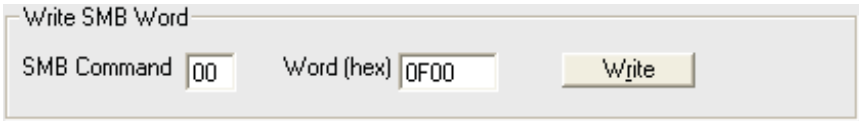
10.2 bq275xx Programming

This screen allows device reprogramming from unencrypted and encrypted files.

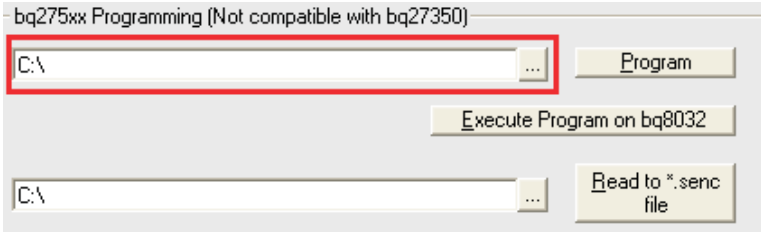
10.3 Firmware Programming Procedure

1. Ensure that jumpers J2 and J3 are shunted.
2. Connect J1 (EVM bus communication) to the SMBus connector of the EV2300 or EV2400.

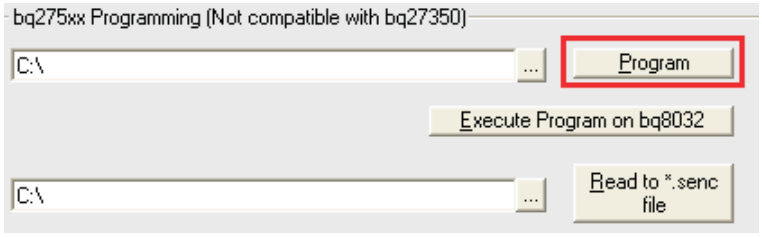
3. Send command 0x0f00 to MAC (0x00) using **SMBus Pro** screen on EVSW.



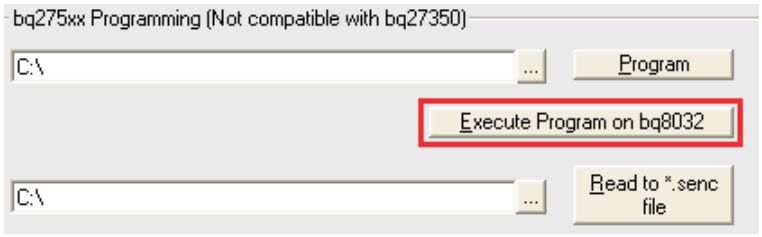
4. Disconnect J1 from the SMBus connector of the EV2300/EV2400, and connect to the I²C connector of EV2300/EV2400.
5. Click on the **I²C Pro** button on the EVSW to change to the **I²C Pro** screen.
6. Using the browse function, select the firmware for programming.



7. Click on the **Program** button to program the firmware.



8. Click **Execute Program on 8032** on **I²C Pro** to bring the gauge to firmware mode.



9. Disconnect J1 from the I²C connector of the EV2300/EV2400 interface board, and connect to the SMBus connector of the EV2300/EV2400.
10. Click on the **SBS** tab to monitor the device. The device is now running in firmware mode.

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 2.5 V to 5.5 V and the output voltage range of 0 V to 5.5 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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

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