bq3060EVM-001 SBS 1.1 Compliant Advanced Gas Gauge Battery Management Solution EVM

This evaluation module (EVM) is a complete evaluation system for the bq3060/bq29412 battery management system. The EVM includes one bq3060/bq29412 circuit module, an EV2300 PC interface board for gas gauge interface, a PC USB cable, and Windows™-based PC software. The circuit module includes one bq3060 integrated circuit (IC), one bq29412 IC, and all other onboard components necessary to monitor and predict capacity, perform cell balancing, monitor critical parameters, protect the cells from overcharge, over-discharge, short-circuit, and overcurrent in 2-, 3- or 4-series cell Li-ion or Li-polymer battery packs. The circuit module connects directly across the cells in a battery. With the EV2300 interface board and software, the user can read the bq3060 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq3060/bq29412 solution under different charge and discharge conditions.

Contents

List of Figures

List of Tables

1 Features

- Complete evaluation system for the bq3060 SBS 1.1-compliant advanced gas gauge and bq29412 independent overvoltage protection IC
- 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

- bq3060/bq29412 circuit module
- Set of support documentation

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq3060EVM-001	Li-ion	2, 3, or 4 cell	Any

2 bq3060-Based Circuit Module

The bq3060/bq29412-based circuit module is a complete and compact example solution of a bq3060 circuit for battery management and protection of Li-ion or Li-polymer packs. The circuit module incorporates a bq3060 battery monitor IC, bq29412 independent overvoltage protection IC, and all other components necessary to accurately predict the capacity of 2-, 3-, or 4-series cells.

2.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- Direct connection to the cells: 1N (BAT–), 1P, 2P, 3P, 4P (BAT+)
- To the serial communications port (SMBC, SMBD)
- The system load and charger connect across PACK+ and PACK–
- To the system-present pin (SYS PRES)

2.2 Pin Descriptions

PIN NAME	DESCRIPTION
1N	–ve connection of first (bottom) cell
1P	+ve connection of first (bottom) cell
2P	+ve connection of second cell
3P	+ve connection of third cell
4P	+ve connection of fourth (top) cell
SMBC	Serial communication port clock
SMBD	Serial communication data port
SYS PRES	System present pin (if low, system is present)
PACK–	Pack negative terminal
VSS	Pack negative terminal
PACK+	Pack positive terminal

3 bq3060 Circuit Module Schematic

This section contains information for modifying and choosing a pre-charge mode for bq3060/bq29412 implementation.

3.1 Schematic

The schematic follows the bill of materials in this user's guide. To target a low cost solution, the external cell balance circuit is not part of the reference schematic in the datasheet. However, this circuit is included in the EVM for customers who would like to evaluate external cell balancing feature of the device.

NOTE: The optional Zener diode (D4) and resistor (R32) on the SYS PRES pin, which are only required if SYS PRES has a chance to short to PACK+, are not available on REV. A EVM.

3.2 Modifications for Choosing Particular Pre-charge Mode

The bq3060 provides a current-limited charging path typically used for low battery voltage or low temperature charging. The external zero voltage or pre-charge (ZVCHG) FET connects to an external pre-charge load resistor bypassing the CHGFET path, and can be controlled via the setting of the DF.Configuration, ZVCHG1, 0.

Table 2. Components and Flash-Memory Settings for Different Pre-charge Modes

MODE	RESISTORS	PRECHG FET	ZVCHG1	ZVCHG0
1. ZVCHG FET	R23	Q4	0	0
2. Not defined	N/A	N/A	0	1
3. Not defined	N/A	N/A	1	0
4. No action	N/A	N/A	1	1

For more details about pre-charge operation and mode choices, see the bq3060 data sheet (SLUS928).

3.3 Testing Fuse-Blowing Circuit

To prevent the loss of board functionality during the fuse-blowing test, the actual chemical fuse is not provided in the circuit. FET Q3 drives TP5 low if a fuse-blow condition occurs (a pull-up at TP5 is required); so, monitoring TP5 can be used to test this condition.

4 Circuit Module Physical Layouts and Bill of Materials

This section contains the board layout, bill of materials, and assembly drawings for the bq3060/bq29412 circuit module.

NOTE: The optional zener diode (D4) and resistor (R32) on the SYS PRES pin, which are only required if SYS PRES has a chance to short to PACK+, are not available on REV. A EVM.

4.1 Board Layout

This section shows the dimensions, PCB layers (Figure 1 through Figure 7), and assembly drawing for the bq3060 module.

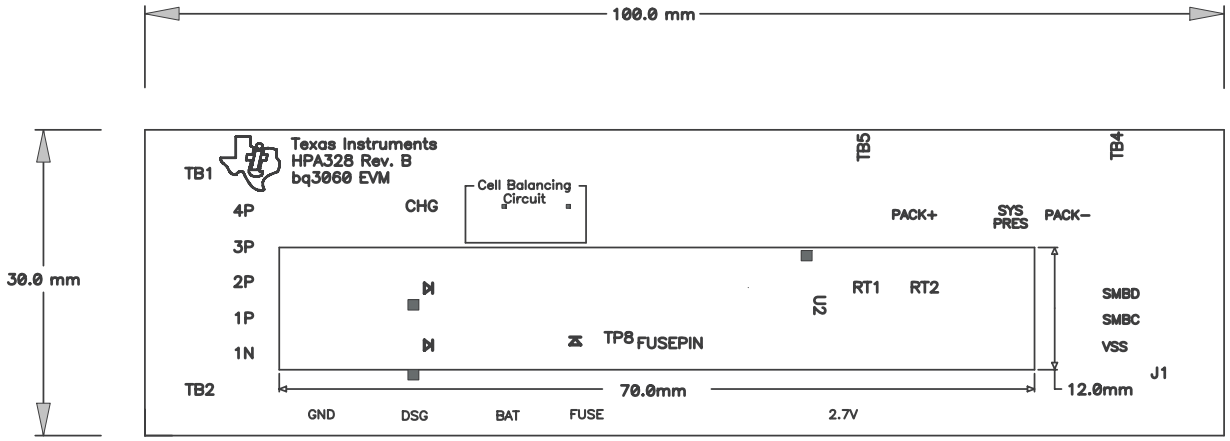

Figure 1. bq3060EVM-001 Layout (Silk Screen)

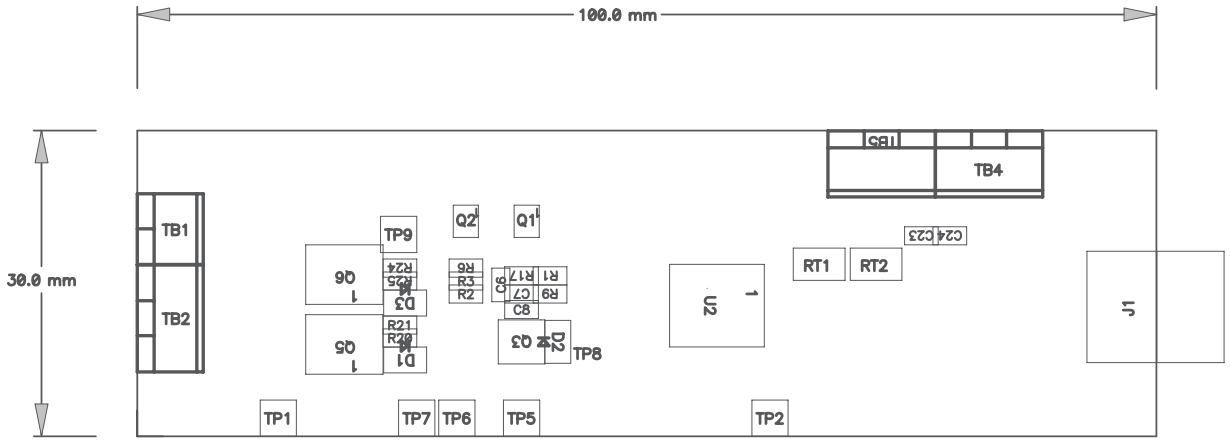

Figure 2. Top Assembly

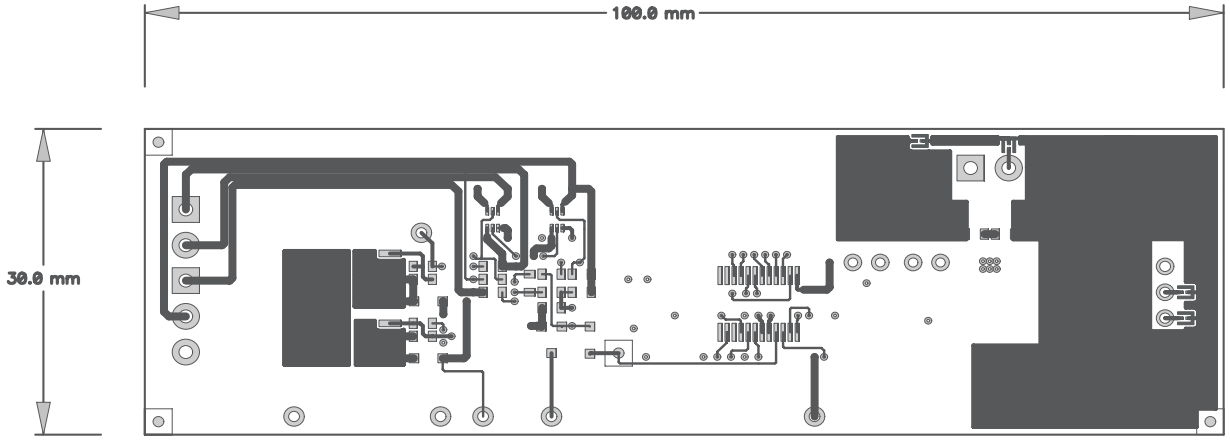

Figure 3. Top Layer

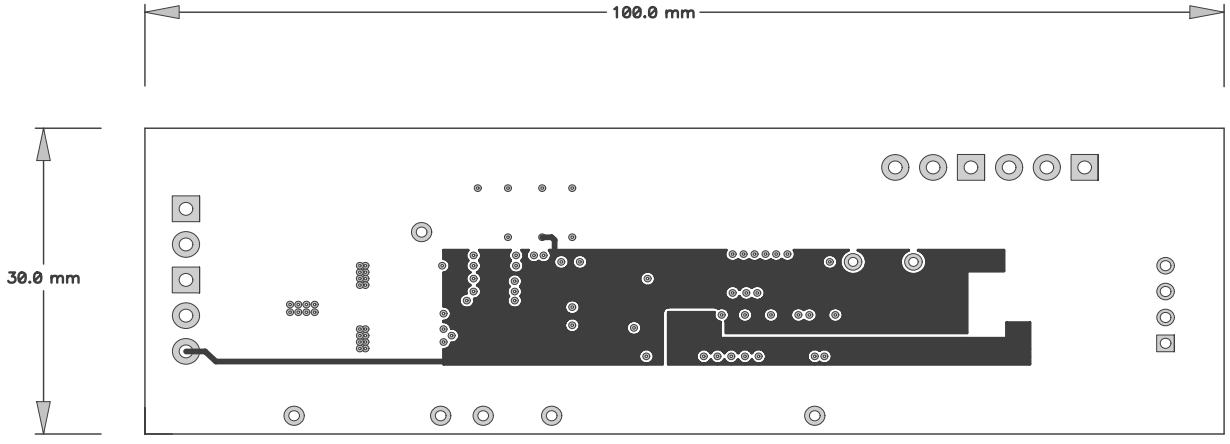

Figure 4. Internal Layer 1

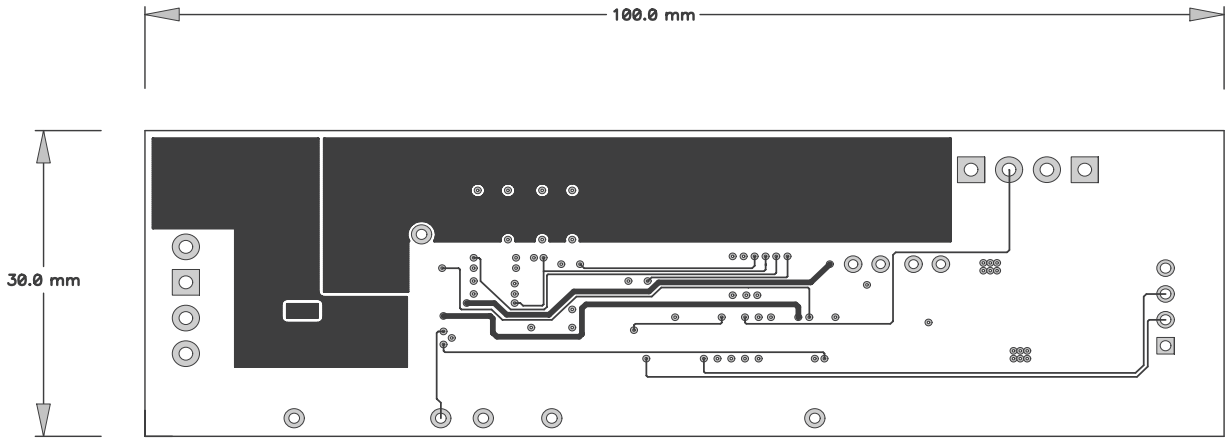

Figure 5. Internal Layer 2

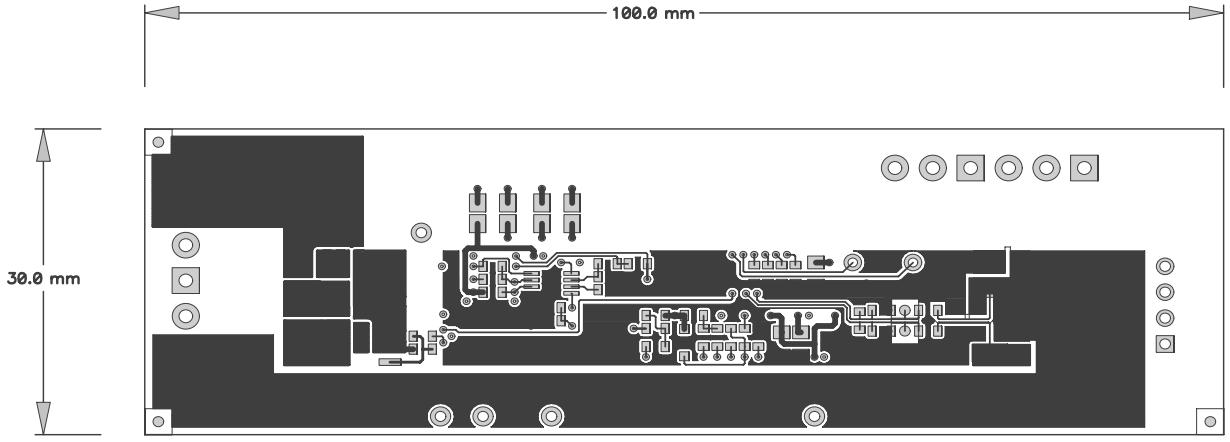

Figure 6. Bottom Layer

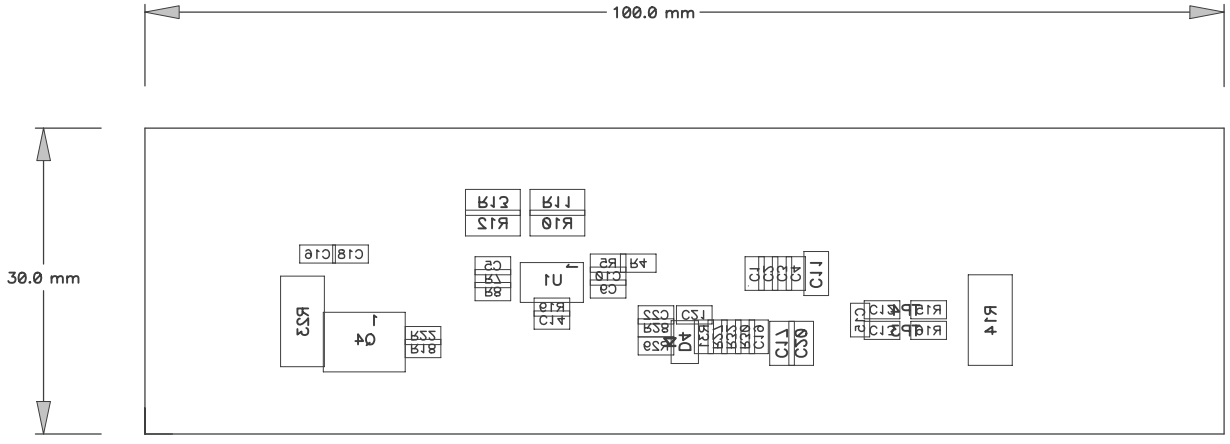

Figure 7. Bottom Assembly

4.2 Bill of Materials and Schematic

Table 3. Bill of Materials

RefDes	Value	Description	Size	Part Number	MFR
C1–C8, C10, C12–16, C18, C19, C23, C24	0.1µF	Capacitor, Ceramic, 0.1µF, 50 V, X7R, 20%	0603	STD	Any
C11, C17, C20	1.0µF	Capacitor, Ceramic, 1.0 µF, 25 V, X7R, 20%	0805	STD	Any
C21, C22	100pF	Capacitor, Ceramic, 100pF, 50 V, X7R, 10%	0603	STD	Any
C9	0.22µF	Capacitor, Ceramic, 0.22µF, 25 V, X7R, 20%	0603	STD	Any
D1–D3	MBRX02560	Diode, Schottky, 250mA, 60V	SOD-323	MBRX02560	Micro Commercial
D4	MM3Z5V6C	Diode, Zener, 5.6V, 200mw	SOD323	MM3Z5V6C	Fairchild
J1	22-05-3041	Header, Friction Lock Assy., 4-pin right angle	0.400 × 0.500	22-05-3041	Molex
Q1, Q2	Si1023X	MOSFET, P-ch, –20V, –350mA, 1.2Ω	SC-89	Si1023x	Vishay
Q3	NDS351AN	MOSFET, N-ch, 30-V, 1.4A, 0.16-Ω	SOT23	NDS351AN	Fairchild
Q4, Q5, Q6	Si4435DY	MOSFET, P-ch, 30-V, 8.0-A, 20-mΩ	SO8	Si4435DY	Siliconix
R1–R9, R30	1K	Resistor, Chip, 1kΩ, 1/16-W, 5%	0603	Std	Std
R10–R13	100	Resistor, Chip, 100 Ω, 1/4-W, 5%	1206	CRCW1206100RJNEA	Vishay
R14	.010 75ppm	Resistor, Chip, 0.010 Ω, 1-W, 1%	2512	WSL-2512-010 1% R86	Vishay
R15, R16, R29, R31, R32	100	Resistor, Chip, 100 Ω, 1/16-W, 5%	0603	Std	Std
R17, R19	220K	Resistor, Chip, 220 kΩ, 1/16-W, 5%	0603	Std	Std
R18	1M	Resistor, Chip, 1MΩ, 1/16-W, 5%	0603	Std	Std
R20, R25	3M	Resistor, Chip, 3 MΩ, 1/16-W, 5%	0603	Std	Std
R21, R22, R24	5.1K	Resistor, Chip, 5.1kΩ, 1/16-W, 5%	0603	Std	Std
R23	301	Resistor, Chip, 301-Ω, 1-W, 10%	2512	CRCW2512301RFKEG	Vishay
R27, R28	200	Resistor, Chip, 200-Ω, 1/16-W, 5%	0603	Std	Std
RT1, RT2	10K	Thermistor, 10 kΩ	0.095 × 0.150	BN35-3H103FB-50 or 103AT-2	Mitsubishi Material or Semitec
TB1	ED1514	Terminal Block, 2-pin, 6-A, 3,5 mm	0.27 × 0.25	ED555/2DS	OST
TB2, TB4, TB5	ED1515	Terminal Block, 3-pin, 6-A, 3,5 mm	0.41 × 0.25	ED555/3DS	OST
TP1, TP2, TP5–TP7, TP9		Test Point, White, Thru Hole Color Keyed	0.100 × 0.100 inch	5002	Keystone
U1	BQ29412DCT	IC, Voltage Protection for 2, 3, 4 Cell Lion , 2nd Protection, 4.45 v OVP	SSOP-08	BQ29412DCT	TI
U2	BQ3060PW	IC, SBS 1.1-Compliant gas gauge and protection	TSSOP-24	BQ3060PW	TI
--		PCB		HPA328	Any
QTY		**Connector**			
2	J1 mate	Connector, Female, 0.100-inch Centers		Molex	22-01-3047
8	N/A	Terminals, Crimp, Tin		Molex	08-50-0114
N/A	Wire, Insulated 24 AWG, Red, 18 Inches (±3 inches)(USB_5V)			Alpha	1854-3
N/A	Wire, Insulated 24 AWG, White, 18 Inches (±3 inches)(SCL)			Alpha	1854-1
N/A	Wire, Insulated 24 AWG, Black, 18 Inches (±3 inches)(GND)			Alpha	1854-2
N/A	Wire, Insulated 24 AWG, Brown, 18 Inches (±3 inches) (SDA)			Alpha	1854-7
1	N/A	Heatshrink 1"		Any	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 MFR's components.

5. Make one SMBus 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 assembly shall have a J1 mate on each end.

   Red - Pin # 4 (Signal USB_5V)

   Brown - Pin # 3 (Signal SDA)

   White - Pin # 2 (Signal SCL)

   Black - Pin # 1 (GND)

Table 3. Bill of Materials (continued)

RefDes	Value	Description	Size	Part Number	MFR
6. The generic part number for Mitsubishi Material is BN35-3H103XX-XX for RT1 and RT2. If they are not available use 103AT-2					

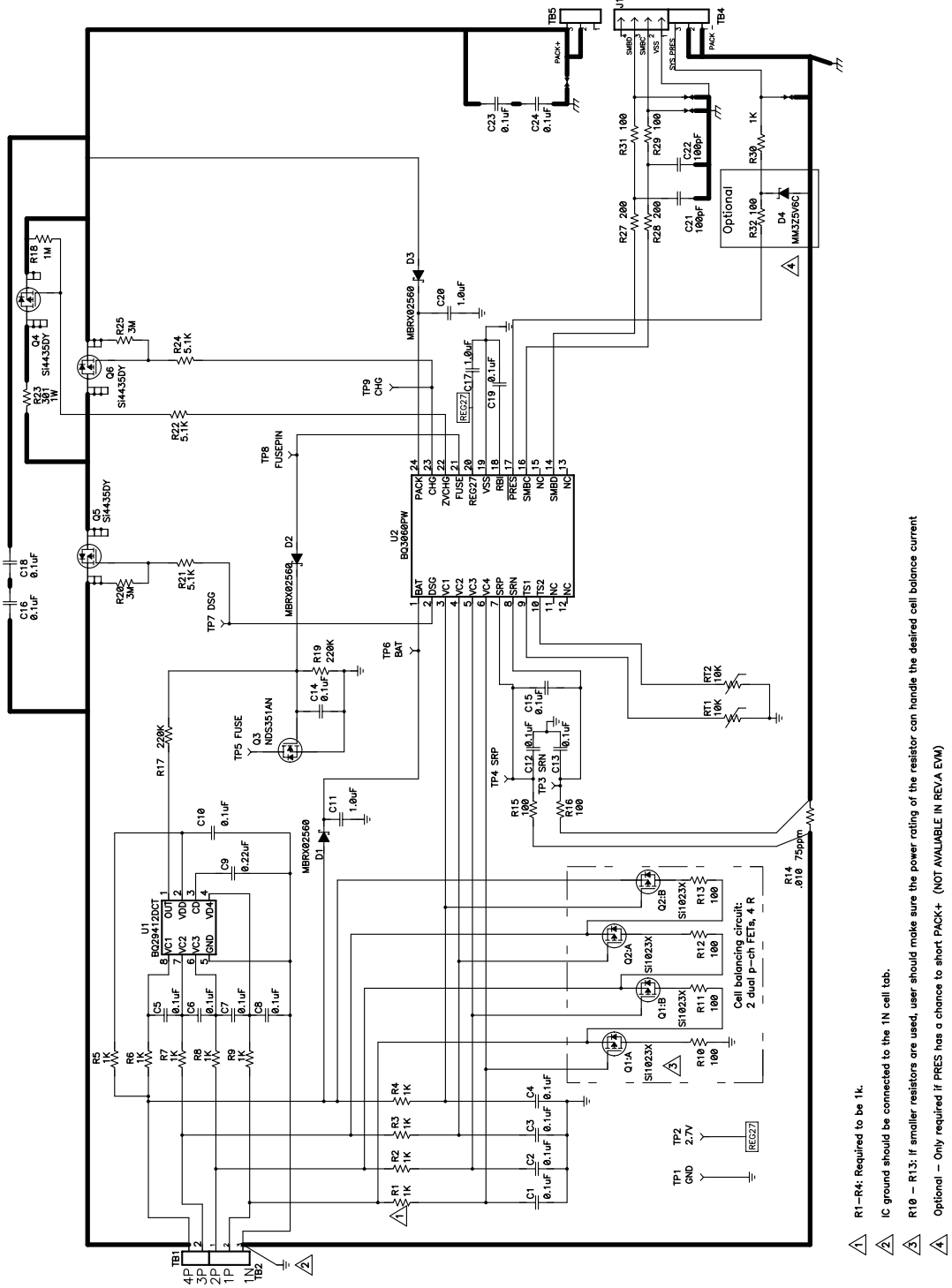

Figure 8. Schematic

4.3 bq3060/bq29412 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq3060/bq29412 circuit module.

Table 4. Performance Specification Summary

Specification	Minimum	Typical	Maximum	Units
Input voltage Pack+ to Pack–	6	15	25	V
Charge and discharge current	0	2	7	A

5 EVM Hardware and Software Setup

This section describes how to install the bq3060EVM-001 PC software, and how to connect the different components of the EVM.

5.1 System Requirements

The bq3060EVSW software requires Windows™ 2000 or Windows XP. Drivers for Windows 98SE are provided, but Microsoft™ no longer supports Windows 98; and 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 bq3060 tool folder on power.ti.com. Use the following steps to install the bq3060EVSW software:

1. Save the archive to a temporary directory. Open the archive containing the installation package, and copy its contents in 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 bq3060 EVM installation.
2. If the EV2300 was not previously installed, after bq3060 EVM installation, a TI USB DRIVER INSTALLER pops up. Click "Yes" for the agreement message and follow its instructions.
3. Plug the EV2300 into a USB port.

6 Troubleshooting Unexpected Dialog Boxes

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

Ensure that all the files were extracted from the zip file.

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 bq3060EVM-001 comprises three hardware components: the bq3060/bq29412 circuit module, the EV2300 PC interface board, and the PC.

7.1 Connecting bq3060/bq29412 Circuit Module to Battery Pack

Figure 9 shows how to connect the bq3060/bq29412 circuit module to the cells and system load/charger.

The cells should be connected in the following order:

1. 4-Cell Pack: 1N (BAT–), 1P, 2P, 3P, and 4P (see Section 2.1 for definitions).
2. 3-Cell Pack: 1N (BAT–), 1P, 2P, and then connect 4P and 3P together.
3. 2-Cell Pack: 1N (BAT–), 1P, and then connect 4P, 3P, and 2P together

To start charge or discharge test, connect PRES pin to PACK- pin to set SYS PRES state. To test sleep mode, disconnect the PRES pin.

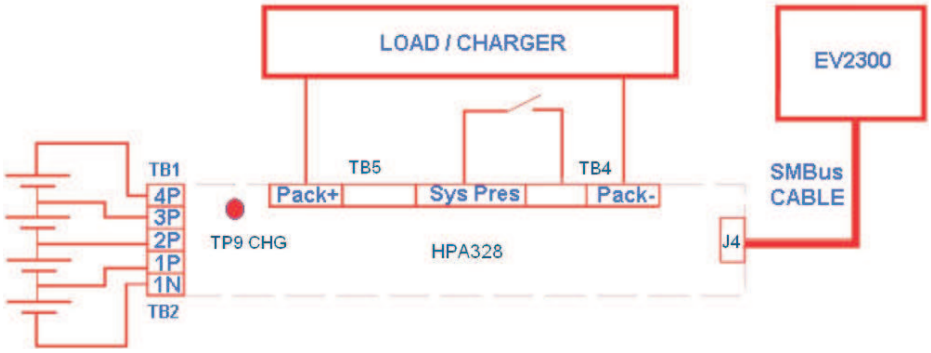

Figure 9. bq3060 Circuit Module Connection to Cells and System Load/Charger

7.2 PC Interface Connection

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

1. Connect the bq3060-based smart battery to the EV2300 using wire leads as shown in Table 5.

Table 5. Circuit Module to EV2300 Connections

bq3060-Based Battery	EV2300
SMBD	SMBD
SMBC	SMBC
VSS	GND

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

The bq3060EVM-001 is now set up for operation.

8 Operation

This section details the operation of the bq3060 EVSW software.

8.1 Starting the Program

Run bq Evaluation Software from the Start | Programs | Texas Instruments | bq3060 EVSW menu sequence. The SBS Data screen (Figure 10) 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 65535 ms. Only items that are selected for scanning are scanned within this period.

The bq Evaluation Software 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 65535 ms. The *Log* interval cannot be smaller than scan interval because this results in the same value being logged at least twice.

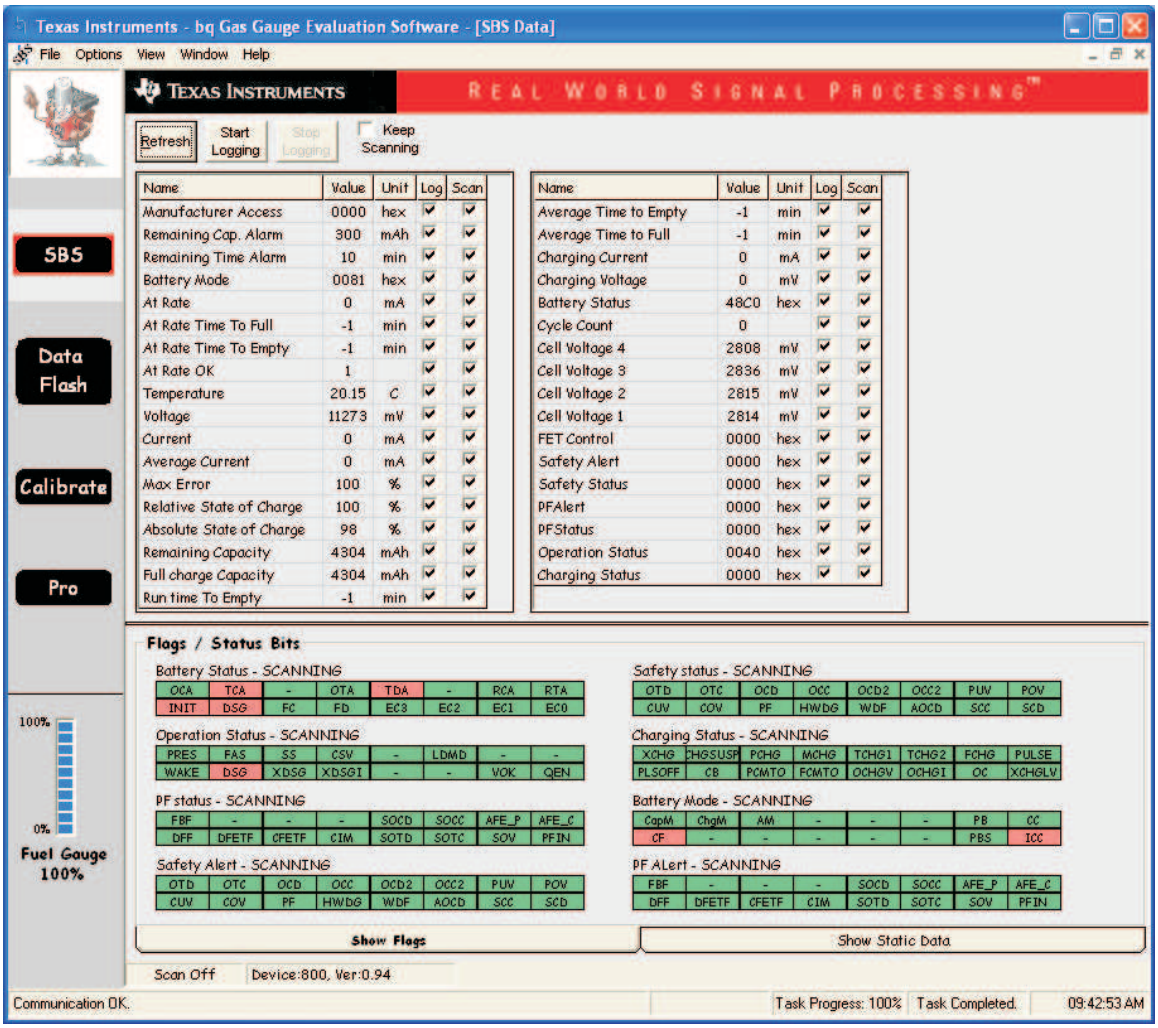

Figure 10. SBS Data Screen

This screen (Figure 10) 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 (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 bq3060 Options

The bq3060 data flash comes configured per the default settings detailed in the bq3060 data sheet. Ensure that the settings are correctly changed to match the pack and application for the bq3060 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 11).

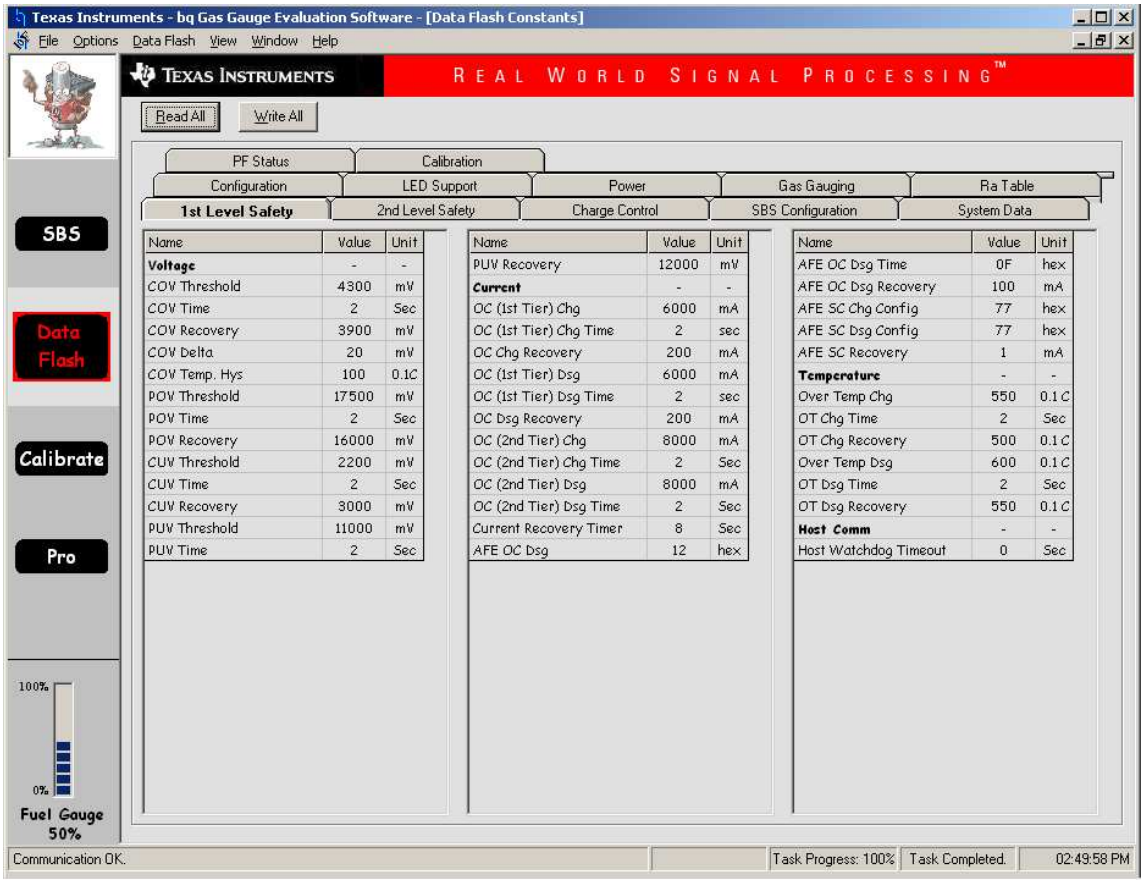

Figure 11. Data Flash Screen, 1st Level Safety Class

To read all the data from the bq3060 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 bq3060 using the | Write All | button.

The configuration information of the bq3060 and module calibration data also is held in the bq3060 data flash.

The bq3060 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 bq3060 that is being used may not be supported by the bqEVSW version that is being used. An upgrade may be required.

9 Calibration Screen

9.1 How to Calibrate

Before the bq3060 is calibrated:

- Connect a load to Pack- and Pack+ that draws approximately 2 A and measures discharge current to use the FETs.
- Connect a current source to Batt–(1N) and Pack- to calibrate without using the FETs.
- Measure individual cell stack voltage from Batt–(1N), to Cell1(1P), Cell1+2(2P), Cell1+2+3(3P), and Cell1+2+3+4(4P).
- Measure the temperature of the pack.
- These steps may not be required, depending on the type of calibration being performed.

Note that voltage calibration with cells attached requires special consideration. Cells must be in a resting state. For additional information, go to the TI Web site (www.ti.com) and search for *bq3060 Calibration Using EV Software*.

9.2 To Calibrate the bq3060

Select the types of calibration to be performed (see Figure 12).

Enter the measured values for the types selected.

If *Software Voltage Calibration* is selected, then enter the number of cells on the pack and individual cell voltage.

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

If the load is connected between Pack+ and Pack-, then select the *Use FETs* check box.

Press the *Calibrate Part* button.

9.3 Board Offset Calibration

This performs the offset calibration for the current offset of the board.

Remove load/external voltage and short Pack– to Batt–.

Press the *CC Board Offset Calibration* button.

9.4 Pack Voltage Calibration

This calibrates the voltage at the AFE Pack pin.

Make sure *Voltage Calibration* has been performed for the pack. If *Voltage Calibration* is not performed, then *Pack Voltage Calibration* calibrates incorrectly.

Remove load/external voltage applied between Pack+ and Pack-.

Press the *Pack Voltage* button to calibrate.

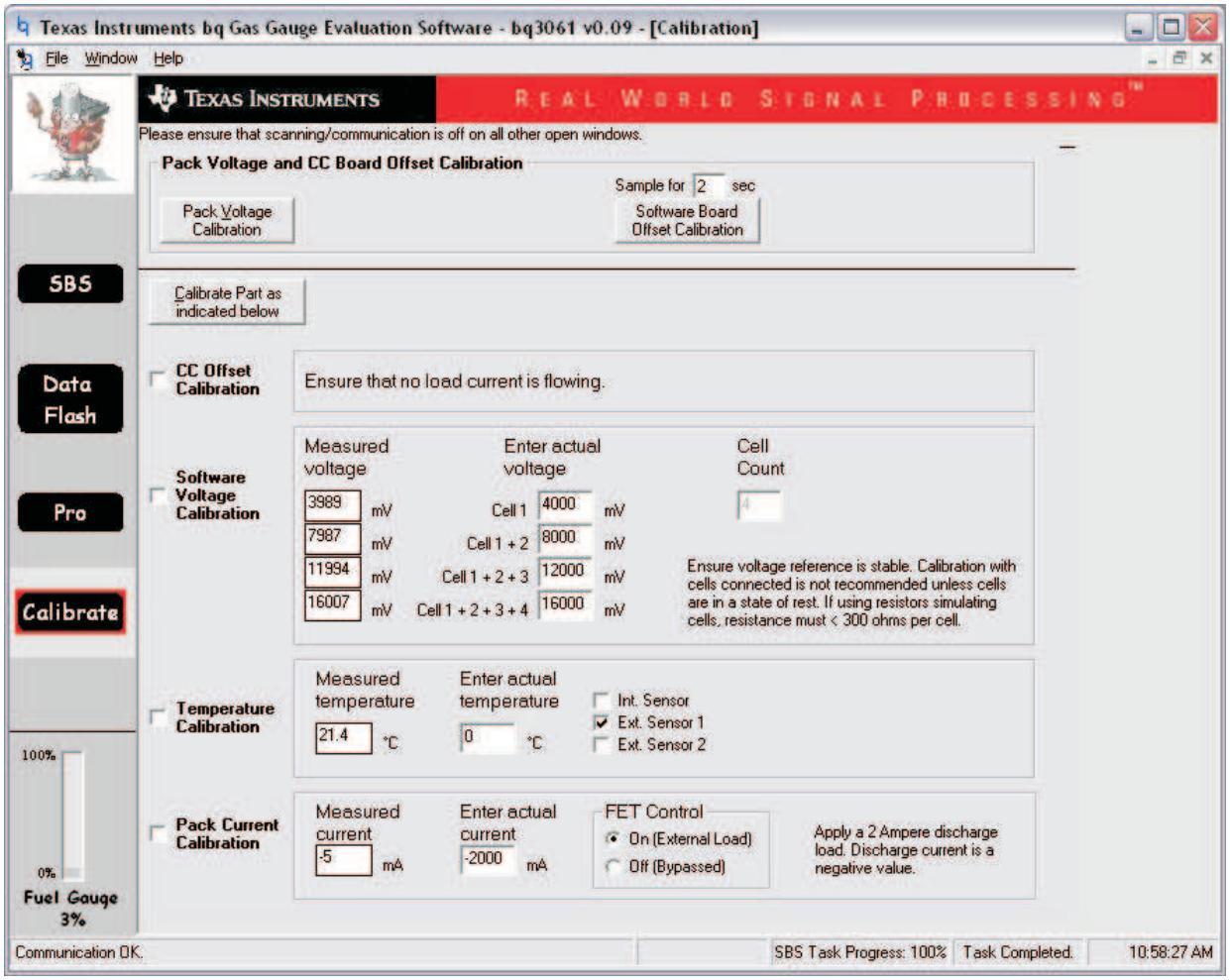

Figure 12. Calibration Screen

10 Pro (Advanced) Screen

10.1 SMB Communication

The set of read/write operations over SMBus are not specific to any gas gauge. These are provided as general-purpose communication tools (Figure 13).

10.2 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.

10.3 Programming

This screen allows device reprogramming from unencrypted and encrypted files.

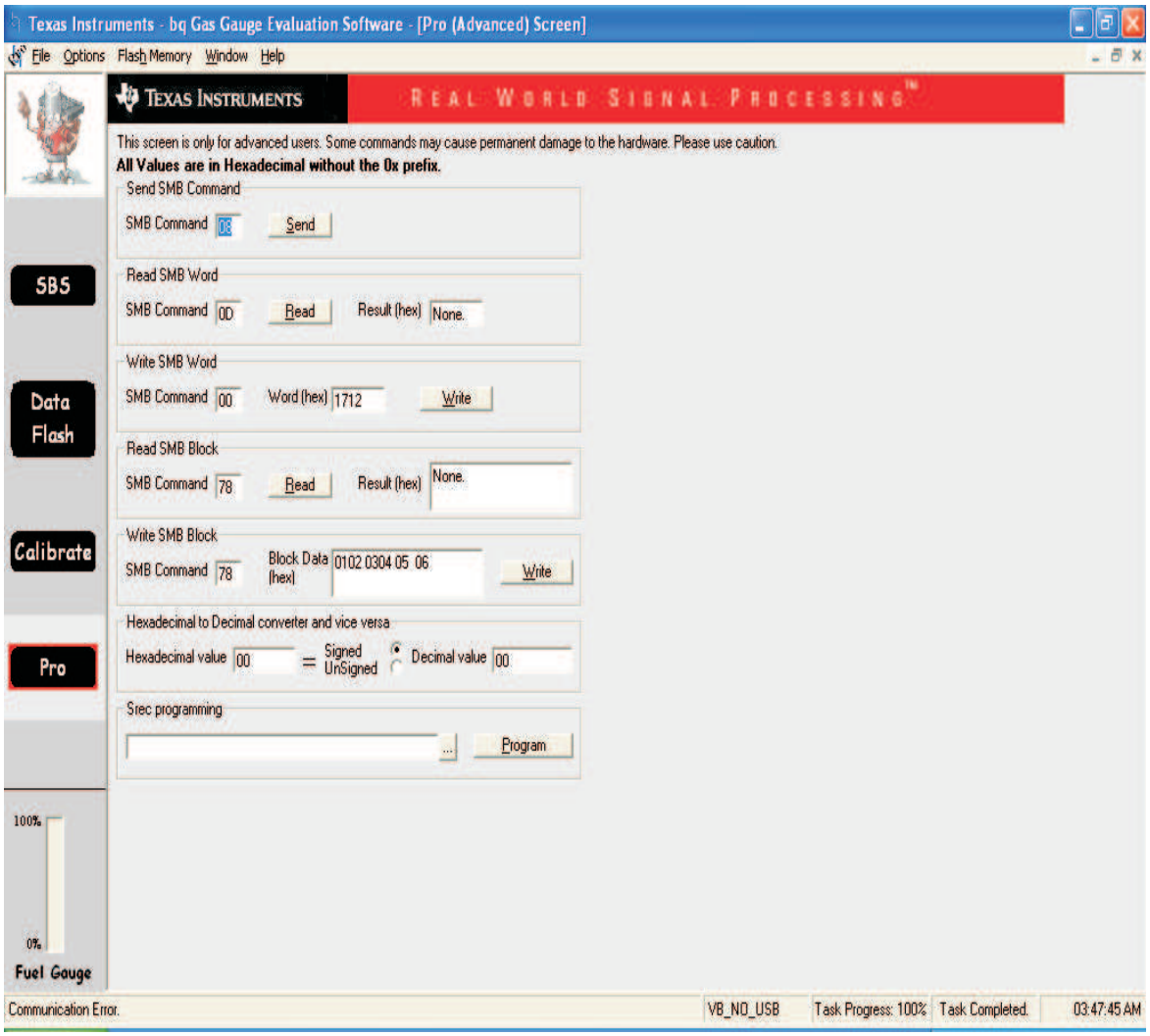

Figure 13. Pro (Advanced) Screen

11 Pack Assembly and The bq3060

This section describes a recommended assembly sequence for a bq3060-based battery pack. This procedure results in the most time-efficient setup of the battery pack. Following are the steps for connecting a 4-series cell battery to the bq3060EVM board. Review the application report *bq20zxx EVM Data Flash Settings for Number of Serial Cells and Pack Capacity*, SLVA208, for further details on 2- and 3-series cell arrangements.

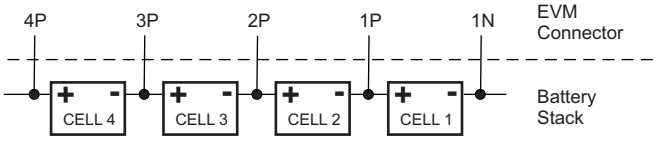

Figure 14. Connection Sequence

1. Connect the most negative terminal (– terminal of cell 1) of the serially-connected, 4-cell battery stack to the 1N PIN of the TB1–TB2 connector as shown in Figure 14. (See also Figure 9 for TB1–TB2 location).
2. Connect the positive terminal of cell 1 to 1P.
3. Connect the positive terminal of cell 2 to 2P.
4. Connect the positive terminal of cell 3 to 3P.
5. Connect the positive terminal of the battery stack (+) to 4P.
6. Connect external power (from 6 to 16.8V) to the Pack+ and Pack– terminals to wake up the EVM from shutdown mode. External power does not need to remain connected once the bq3060 has exited Shutdown Mode.
7. Connect the SMBus connector (J1) to the EV2300 adapter and start the EV software.
8. Navigate to the *Flash Screen*. Change the flash constants that correspond to the specific parameters of your application (refer to the data sheet or other application reports). For the first evaluation, the default values may be used.
9. Navigate to the *Calibration screen*. Select the check-box for *CC Offset Calibration*. Click the *calibrate part* button. It should show OK.
10. Uncheck previously-selected boxes. Select the check-box for software voltage calibration near *Measured voltage* field. Measure the actual cell 1N and 1P for cell 1, 1N and 2P for cell 1 + 2, 1N and 3P for cell 1 + 2 + 3, 1N and 4P for cell 1 + 2 + 3 + 4, and enter the values into the *Enter actual voltage* field. Click the *calibrate part* button.
11. To enter Lifetime Data and PF, navigate to the *Pro screen* in the EV software. Make sure that the *Write SMB Word* section reads: "SMB Command: 00 Word (hex): 0021" as shown in Figure 15, and click the *Write* button.

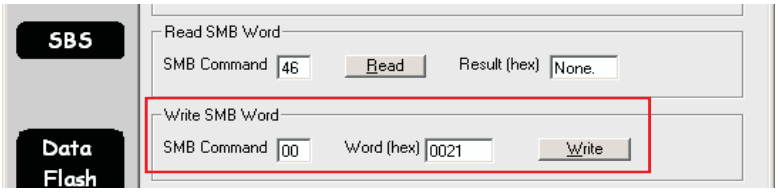

Figure 15. Fuel Gauging Command

12. Now the pack is ready. Simulate insertion into a system by shorting between the *Sys Pres* (System Present) and the *VSS* pins on the connector. At this point, the discharge and charge FETs are ON (as indicated by value of 0006 in the *FET Status* field in the SMB Screen of the EV software), and charge/discharge tests can be conducted. This step in not needed if the NR bit (nonremovable pack) is enabled in Operation Cfg B register.

12 Related Documentation from Texas Instruments

To obtain a copy of any of the following TI document, 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

Document:	Literature Number:
bqEasy user's guide	SLUU278
bq3060 Gas Gauge Circuit Design	SLUA507
bq3060 data sheet	SLUS928

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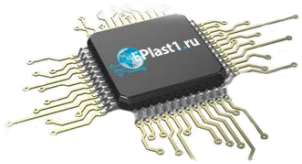

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Телефон: 8 (812) 309 58 32 (многоканальный)
Факс: 8 (812) 320-02-42
Электронная почта: org@eplast1.ru
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.