User's Guide

SLUU277A – October 2007 – Revised October 2013

bq20z75EVM-001 SBS 1.1 Impedance Track™ Technology-Enabled Battery Management Solution EVM

This EVM is a complete evaluation system for the bq20z75/bq29412 battery management system. The EVM includes one bq20z75/bq29412 circuit module, a current sense resistor, two thermistors and Windows®- based PC software. The circuit module includes one bq20z75 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. An EV2300 board for gas gauge interface is required to interface this EVM with the PC and can be purchased separately. With the EV2300 interface board and software, the user can read the bq20z75 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq20z75/bq29412 solution under different charge and discharge conditions.

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Impedance Track is a trademark of Texas Instruments.
Windows is a registered trademark of Microsoft Corporation.

1 Features

- Complete evaluation system for the bq20z75 SBS 1.1-compliant advanced gas gauge with Impedance Track technology 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

- bq20z75/bq29412 circuit module
- Software CD with the evaluation software
- Set of support documentation

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq20z75EVM-001	Li-ion	2, 3, or 4 cell	Any

2 bq20z75-Based Circuit Module

The bq20z75/bq29412-based circuit module is a complete and compact example solution of a bq20z75 circuit for battery management and protection of Li-ion or Li-polymer packs. The circuit module incorporates a bq20z75 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, VSS)
- 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
VSS	Pack negative terminal
PACK–	Pack negative terminal
SYS PRES	System present pin (if low, system is present)
PACK+	Pack positive terminal

3 bq20z75 Circuit Module Schematic

This section contains information for modifying and choosing a precharge mode for bq20z75/bq29412 implementation.

3.1 Schematic

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

3.2 Choosing Particular Precharge Mode

The chipset supports both a charger that has a precharge mode and one that does not. The EVM by default supports a charger that does not have a precharge mode. This is configured by grounding the PMS pin with a resistor. R17 and Q3 are used as the precharge current path in order to sustain sufficient Pack+ voltage when the battery voltage is too low.

If the charger has a precharge function, R17 and FET Q3 are not used. The PMS pin must be pulled high to disable ZVCHG output. The charge FET Q1 is used as the precharge FET, and the charger must control the precharge current and voltage.

Note: The configuration at PMS pin is a hardware-level control. Once the bq20z75 is up and running, the firmware may change the precharge settings. See the bq20z75 data sheet for further information.

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 Q1 drives TP3 low if a fuse-blow condition occurs; therefore, monitoring TP3 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 bq20z75/bq29412 circuit module.

4.1 Board Layout

This section shows the dimensions, PCB layers, and assembly drawing for the bq20z75 module.

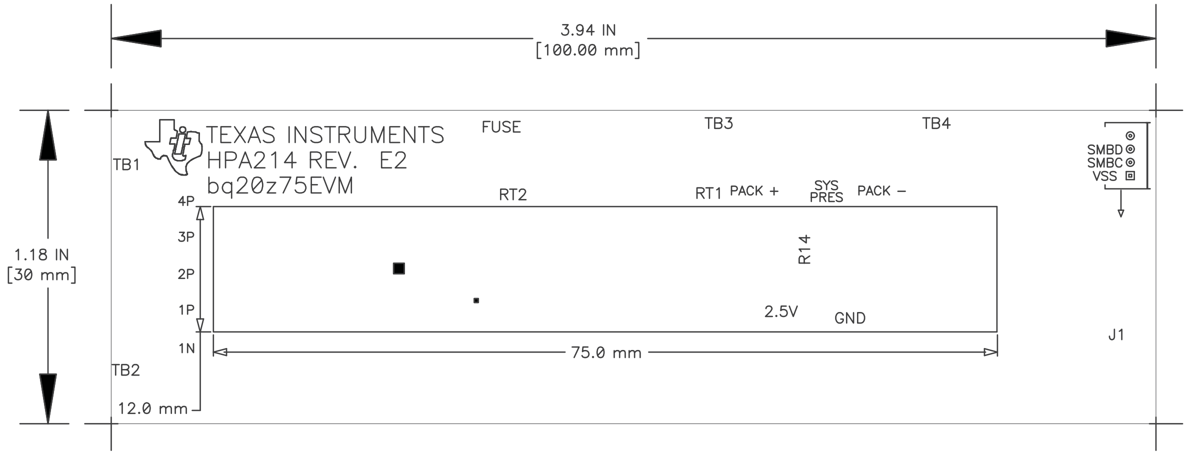

Figure 1. Layout (Silk Screen)

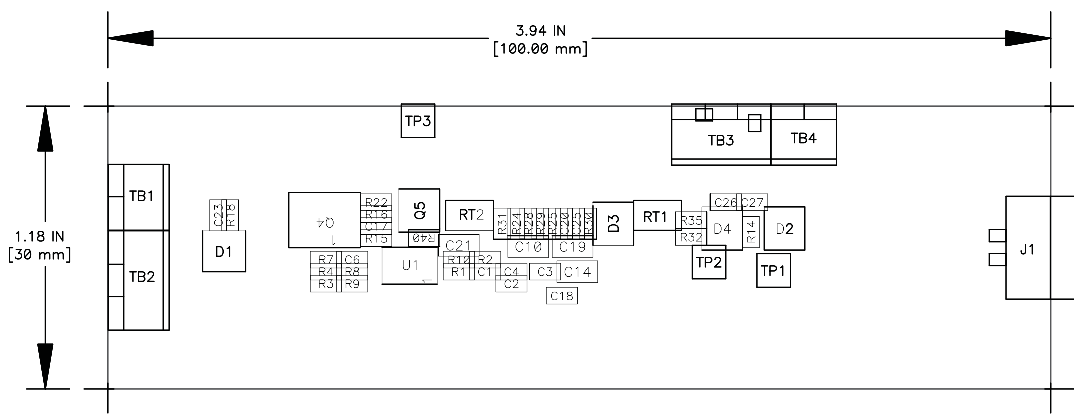

Figure 2. Top Assembly

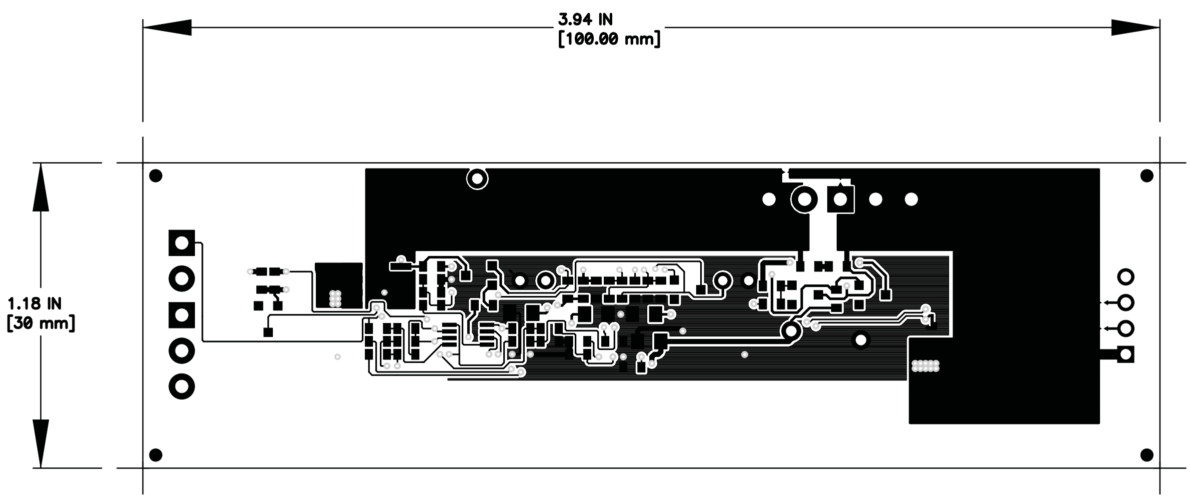

Figure 3. Top Layer

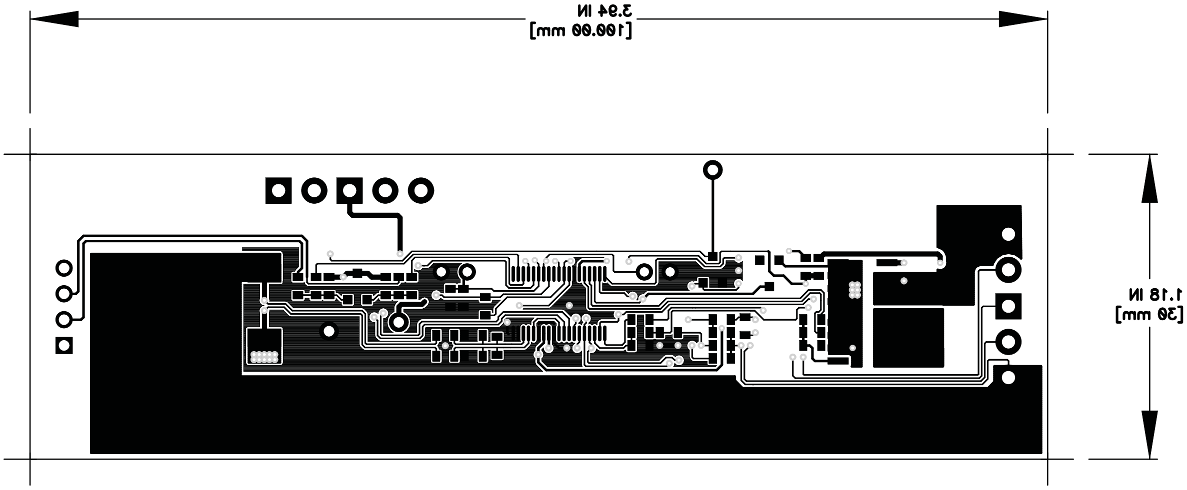

Figure 4. Bottom Layer

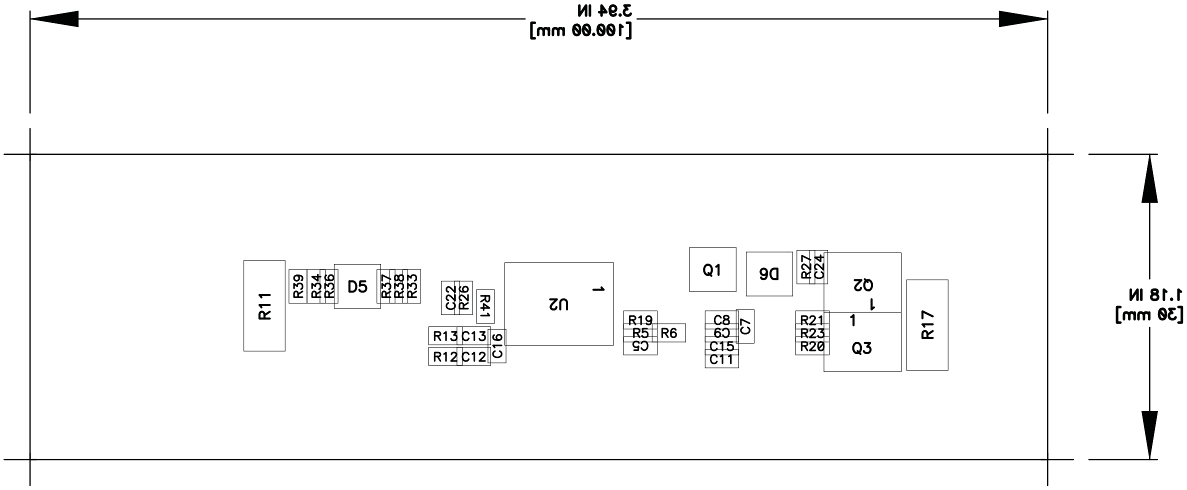

Figure 5. Bottom Assembly

4.2 Bill of Materials

Table 2. Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	Mfr
20	C1– C9, C12, C13, C15–C18, C20, C23, C24, C26, C27	0.1µF	Capacitor, Ceramic, 0.1-µF, 50 V, X7R, 20%	0603	STD	Any
1	C11	0.22µF	Capacitor, Ceramic, 0.22-µF, 50-V, X7R, 20%	0603	STD	Any
1	C19	2.2µF	Capacitor, Ceramic, 2.2-µF, 10-V, X7R, 20%	0805	Std	Any
2	C22, C25	0.47µF	Capacitor, Ceramic, 0.47-µF, 16-V, X7R, 20%	0603	STD	Any
3	C10, C14, C21	1.0µF	Capacitor, Ceramic, 1.0-µF, 25-V, X7R, 20%	0805	STD	Any
4	D1, D2, D3, D6	BAS16	Diode, Switching, 150-mA, 75-V, 350-mW	SOT23	BAS16	Vishay
2	D4, D5	AZ23C5V6	Diode, Dual, Zener, 5.6-V, 300-mW	SOT23	AZ23C5V6	Vishay
1	J1	22-05-3041	Header, Friction Lock Ass'y, 4-pin Right Angle,	0.400 × 0.500	22-05-3041	Molex
1	Q1	NDS331N	MOSFET, N-ch, 20-V, 1.3-A, 0.16-Ω	SOT23	NDS331N	Fairchild
2	Q2, Q4	FDS6690A	MOSFET, N-ch Logic Level, Power Trench, 30-V, 11-A, 12.5-mΩ	SO8	FDS6690A	Fairchild
1	Q3	Si4435DY	MOSFET, P-ch, 30-V, 8.0-A, 20-mΩ	SO8	Si4435DY	Siliconix
1	Q5	2N7002DICT	MOSFET, N-ch, 60-V, 115-mA, 1.2-Ω	SOT23	2N7002DICT	Vishay-Liteon
12	R1– R5, R12, R13, R32–R34, R38, R39	100	Resistor, Chip, 100-Ω, 1/16-W, 5%	0603	Std	Std
1	R11	0.010 75ppm	Resistor, Chip, 0.010-Ω, 1-W, xx%	2512	WSL-2512-010 1% R86	Vishay
2	R15, R16	220K	Resistor, Chip, 220-kΩ, 1/16-W, 5%	0603	Std	Std
1	R17	300	Resistor, Chip, 300-Ω, 1-W, 10%	2512	WSL-2512-300 1% R86	
2	R18, R27	3.01M	Resistor, Chip, 3.01-MΩ, 1/16-W, 5%	0603	Std	Std
5	R14, R19, R21–R23	5.1K	Resistor, Chip, 5.1-kΩ, 1/16-W, 5%	0603	Std	Std
4	R20, R36, R37, R40	1M	Resistor, Chip, 1-MΩ, 1/16-W, 5%	0603	Std	Std
3	R24, R28, R41	100K	Resistor, Chip, 100-kΩ, 1/16-W, 5%	0603	Std	Std
2	R25, R29	8.45K	Resistor, Chip, 8.45-kΩ, 1/16-W, 1%	0603	Std	Std
2	R26, R30	61.9K	Resistor, Chip, 61.9-kΩ, 1/16-W, 1%	0603	Std	Std
1	R35	1.00K	Resistor, Chip, 1-kΩ, 1/16-W, 5%	0603	Std	Std
6	R6– R10, R31	1K	Resistor, Chip, 1-kΩ, 1/16-W, 5%	0603	Std	Std
2	RT1, RT2	10K	Thermistor, 10-kΩ	0.095 × 0.150	NTC103AT	Semitec
2	TB1, TB4	ED1514	Terminal Block, 2-pin, 6-A, 3,5mm	0.27 × 0.25	ED1514	OST
2	TB2, TB3	ED1515	Terminal Block, 3-pin, 6-A, 3,5mm	0.41 × 0.25	ED1515	OST
1	TP1	GND	Test Point, Black, Thru Hole Color Keyed	0.100 × 0.100 inch	5001	Keystone
1	TP2	2.5V	Test Point, Red, Thru Hole Color Keyed	0.100 x 0.100 inch	5000	Keystone
1	TP3	FUSE	Test Point, White, Thru Hole Color Keyed	0.100 × 0.100 inch	5002	Keystone
1	U1	BQ29412DCT	IC, Voltage Protection for 2, 3, 4 Cell Lion , 2nd Protection, 4.45 v OVP	SSOP-08	BQ29412DCT	TI
1	U2	BQ20Z75DBT	IC	TSSOP-38 (DBT)	BQ20Z75DBT	TI
Connector						
2	J5 mate	Connector, Female, 0.100 Centers			22-01-3047	Molex
8	N/A	Terminals, Crimp, Tin			08-50-0114	Molex
	N/A	Wire, Insulated 24 Awg, Red, 18 inches (±3 inches) (USB_5V)			1854-3	Alpha
	N/A	Wire, Insulated 24 Awg, White, 18 inches (±3 inches) (SCL)			1854-1	Alpha
	N/A	Wire, Insulated 24 Awg, Black, 18 inches (±3 inches) (GND)			1854-2	Alpha
	N/A	Wire, Insulated 24 Awg, Brown, 18 inches (±3 inches) (SDA)			1854-7	Alpha

Table 2. Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	Mfr
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 MFG's components.

5. Make one SMBus connector wire assembly for each assembly produced, from J5 male, 4–24 Awg wires and
Red – Pin #4 — (Signal USB_5V)
Brown – Pin #3 — (Signal SDA)
White – Pin #2 — (Signal SCL)
Black – Pin #1 — (GND)

6. RT1 and RT2 should be assembled horizontally laying flat against the board Edge.

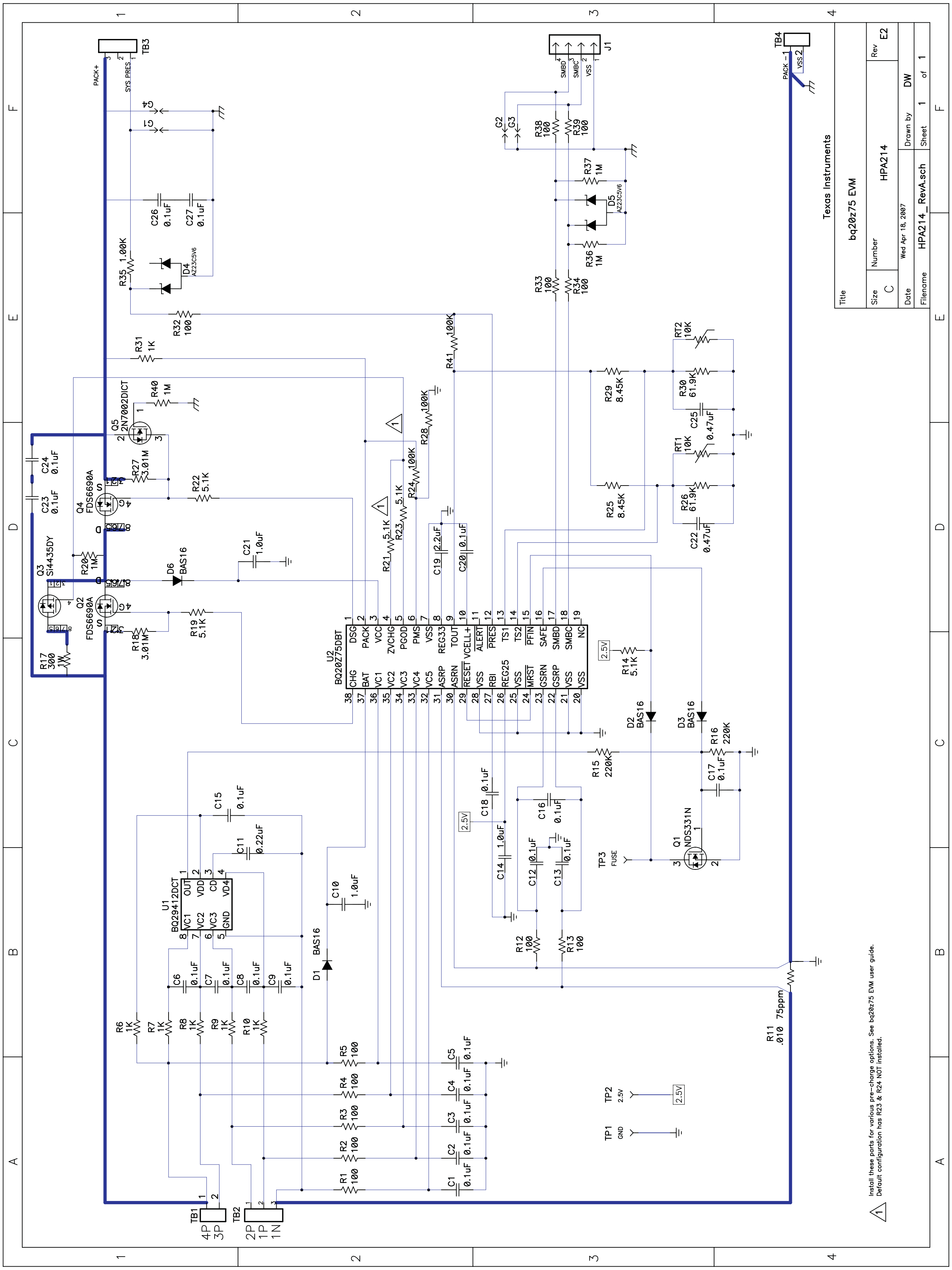

Figure 6. Schematic

4.3 bq20z75/bq29412 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq20z75/bq29412 circuit module.

Table 3. Performance Specification Summary

Specification	Min	Typ	Max	Unit
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 bq20z75EVM-001 PC software, and how to connect the different components of the EVM.

5.1 System Requirements

The bq20z75 evaluation software requires Windows 2000 or Windows XP. Drivers for Windows 98SE are provided, but Microsoft no longer supports Windows 98; Windows 98 may have issues 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 bq20z75 tool folder on power.ti.com. Use the following steps to install the bq20z75 evaluation software from the compact disk (CD):

1. Copy the files from the CD into a temporary directory you selected; double-click on *bqEV-EASY Setup00.09.36.exe*, and follow the installer instructions to complete the bq20z75 EVSW installation.
2. If the EV2300 was not previously installed, after bq20z75 EVSW installation, a TI USB DRIVER INSTALLER pops up. Click "Yes" for the agreement message and follow its instructions. Two drivers are associated with the EV2300. Follow the instruction to install both. Do not reboot the computer even if asked to do so.
3. Plug the EV2300 into a USB port. The Windows system may show a prompt saying that new hardware has been found. When asked "Can Windows connect to Windows Update to search for software?", select "No, not this time," and click on "NEXT". In the next dialog window, it indicates "This wizard helps you install software for: TI USB Firmware Updater." Select "Install the software automatically (Recommended)," and click "NEXT". It is common for the next screen to be the Confirm File Replace screen. Click "No" to continue. If this screen does not appear, then go to the next step. After Windows indicates that the installation has finished, a similar dialog window pops up to install the second driver. Proceed with the same installation preference as the first one. The second driver is "TI USB bq80xx Driver".
4. The Win98 Driver can be found in the archive Win98EV2300Drivers-DocUpdateDec1703.zip under the "EV2300 Drivers" folder.

If files were downloaded from the Web:

1. Open the archive containing the installation package, and copy its contents in a temporary directory.
2. Follow the preceding steps 1 - 4.

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 bq20z75EVM-001 comprises three hardware components: the bq20z75/bq29412 circuit module, the EV2300 PC interface board (purchased separately), and the PC.

7.1 Connecting the bq20z75/bq29412 Circuit Module to a Battery Pack

Figure 7 shows how to connect the bq20z75/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, and 2P (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 SYS PRES pin to PACK- pin to set SYS PRES state. To test sleep mode, disconnect the SYS PRES pin.

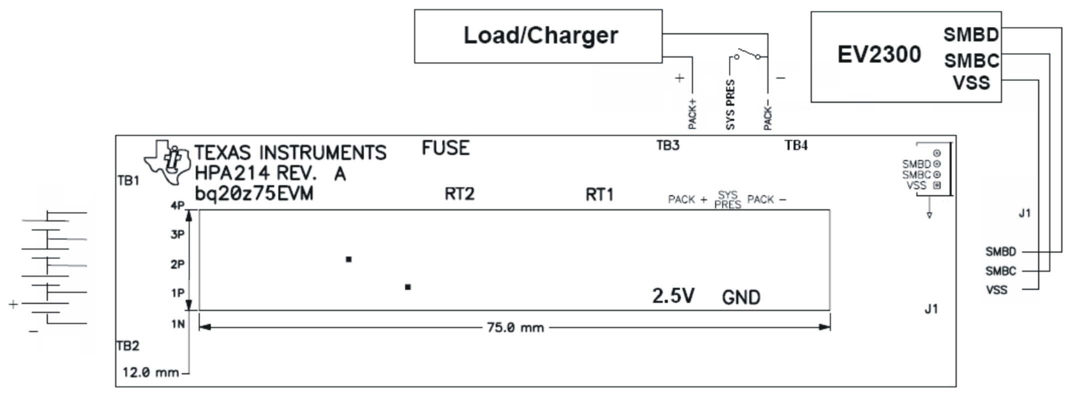

Figure 7. bq20z75 Circuit Module Connection to Cells and System Load/Charger

7.2 PC Interface Connection

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

1. Connect the bq20z75-based smart battery to the EV2300 using wire leads as shown in Table 4.

Table 4. Circuit Module to EV2300 Connections

bq20z75-Based Battery	EV2300
SMBD	SMBD
SMBC	SMBC
VSS	GND

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

The bq20z75EVM-001 is now set up for operation.

8 Operation

This section details the operation of the bq20z75 EVSW software. Note: the EV2300 driver does not support Windows Sleep or Hibernate. In case there is a problem communicating with the EV2300 or the EVM, first unplug the USB cable then plug it back in. If the problem persists, check whether the EVM is in Shutdown mode. The bq20z75 can be waken up by momentarily applying a voltage higher than 5.5V (but less than 25V) at Pack+ pin of the EVM.

8.1 Starting the Program

With the EV2300 and the bq20z75 EVM connected to the computer, run bq20z75 EVSW from the Start | Programs | Texas Instruments | bq20z75 EVSW menu sequence. The SBS Data screen 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 bq20z75 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 interval are specified under the |Options| menu with the maximum value of 65535 milliseconds. The *Log* interval cannot be smaller than the scan interval because this results in the same value being logged at least twice.

Figure 8. SBS Data Screen

This screen 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 bq20z75 Options

The bq20z75 data flash comes configured per the default settings detailed in the bq20z75 data sheet (SLUS723) and bq20z75 Technical Reference literature (SLUU262). Ensure that the settings are correctly changed to match the pack and application for the bq20z75 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.

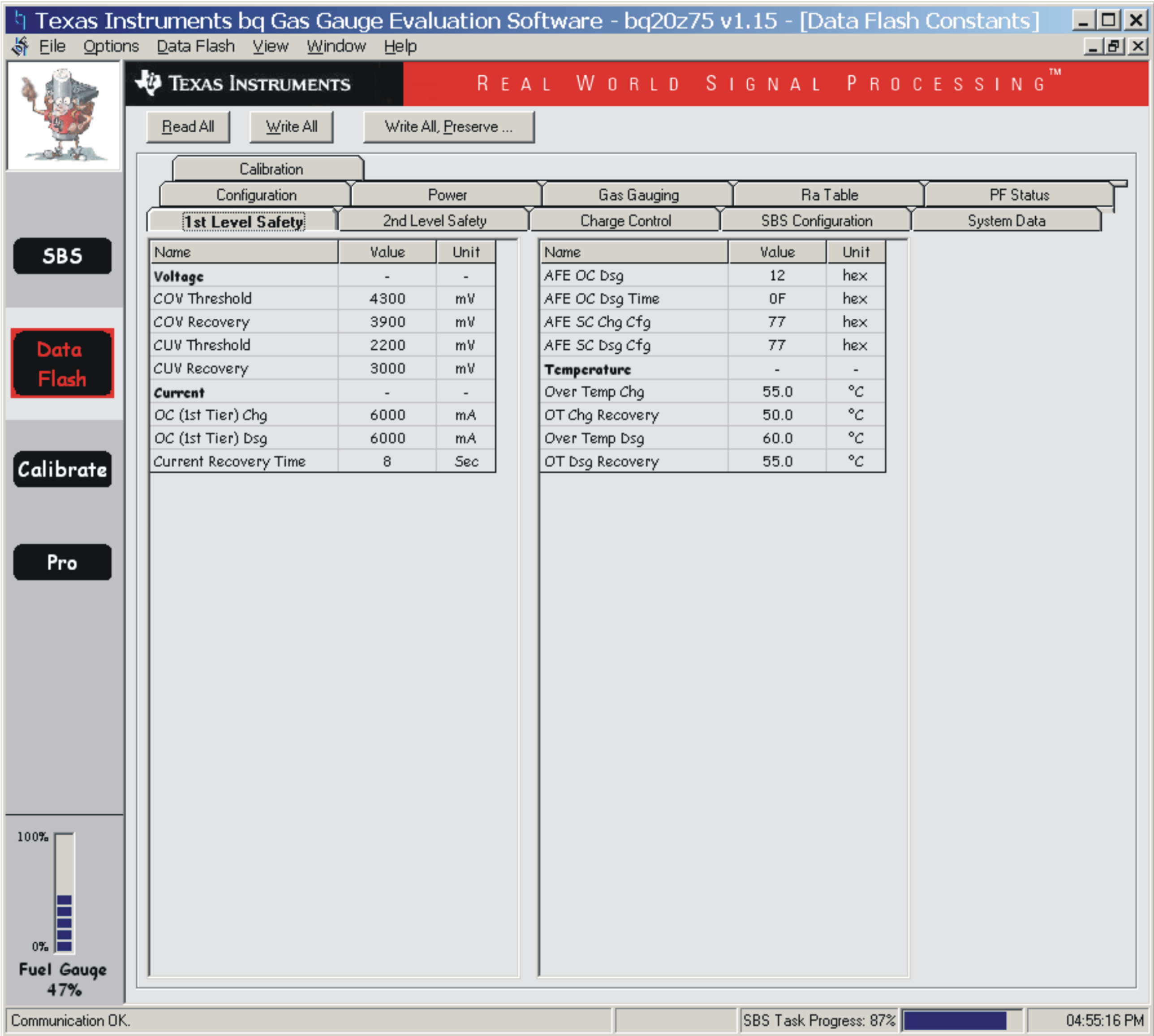

Figure 9. Data Flash Screen, 1st Level Safety Class

To read all the data from the bq20z75 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 can also be retrieved in this way, imported, and written to the bq20z75 using the | Write All | button.

The configuration information and module calibration data is held in the bq20z75 data flash.

The bq20z75 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 seconds. The AutoExport filename is also set under the | Options menu |.

When there is a check 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 bq20z75 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 bq20z75 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- and Pack- to calibrate without using the FETs.
- Measure the pack voltage from Batt+ to Batt- (Total of Cell voltages).
- Measure the temperature of the pack.
- These steps may or may not be required, depending on the type of calibration being performed.

9.2 To Calibrate the bq20z75

Select the types of calibration to be performed.

Enter the measured values for the types selected (Except for *CC Offset Calibration*).

If *Voltage Calibration* is selected, then enter the number of cells on the pack.

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.

Press the *Software 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. Make sure to have a stable charger voltage higher than 8V present at Pack+.

Press the *Pack Voltage* button to calibrate.

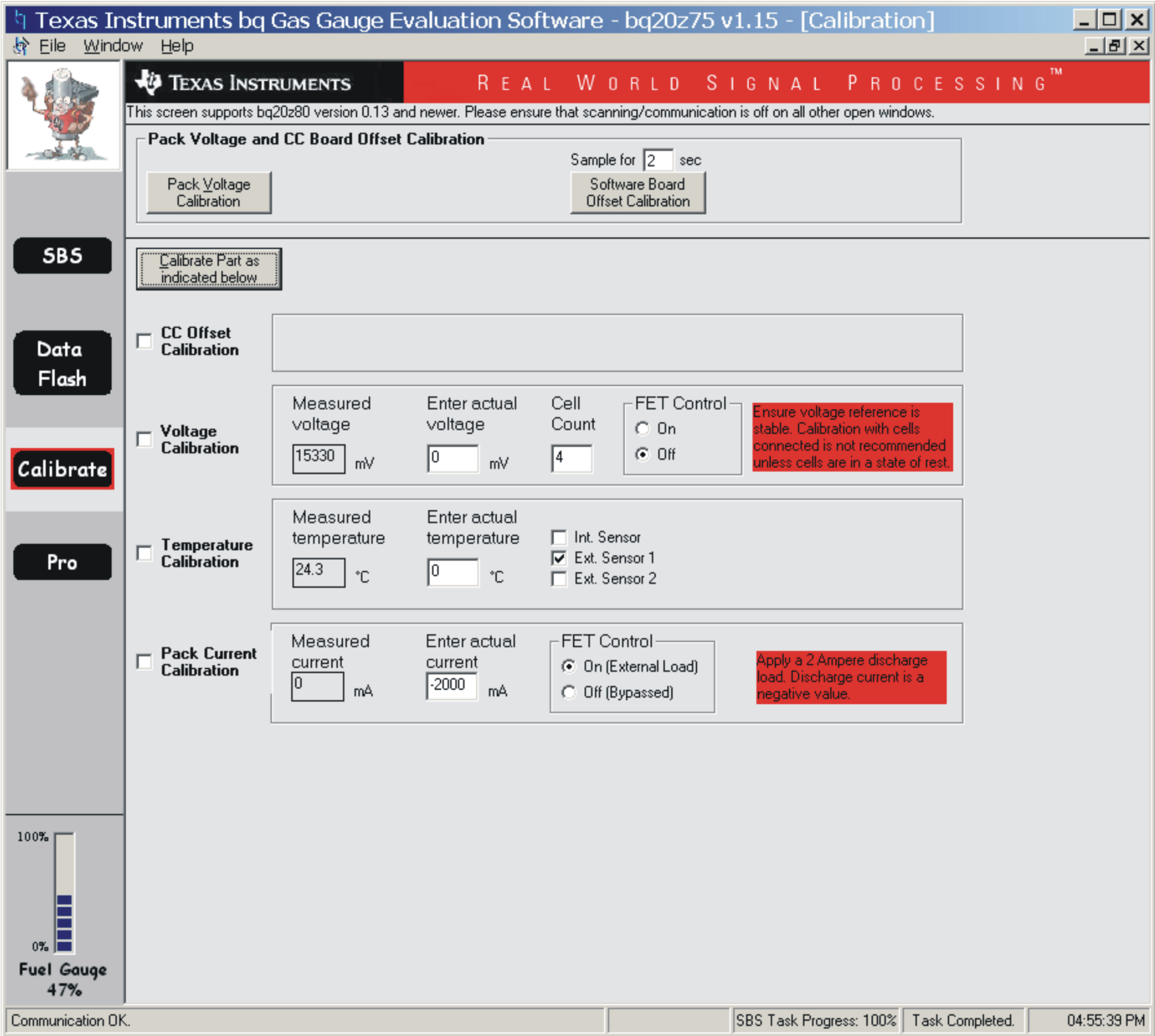

Figure 10. Calibration Screen

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.

10.2 Hex/Decimal Converter

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

When scaling converted hex 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

Allows for device reprogramming from unencrypted and encrypted files.

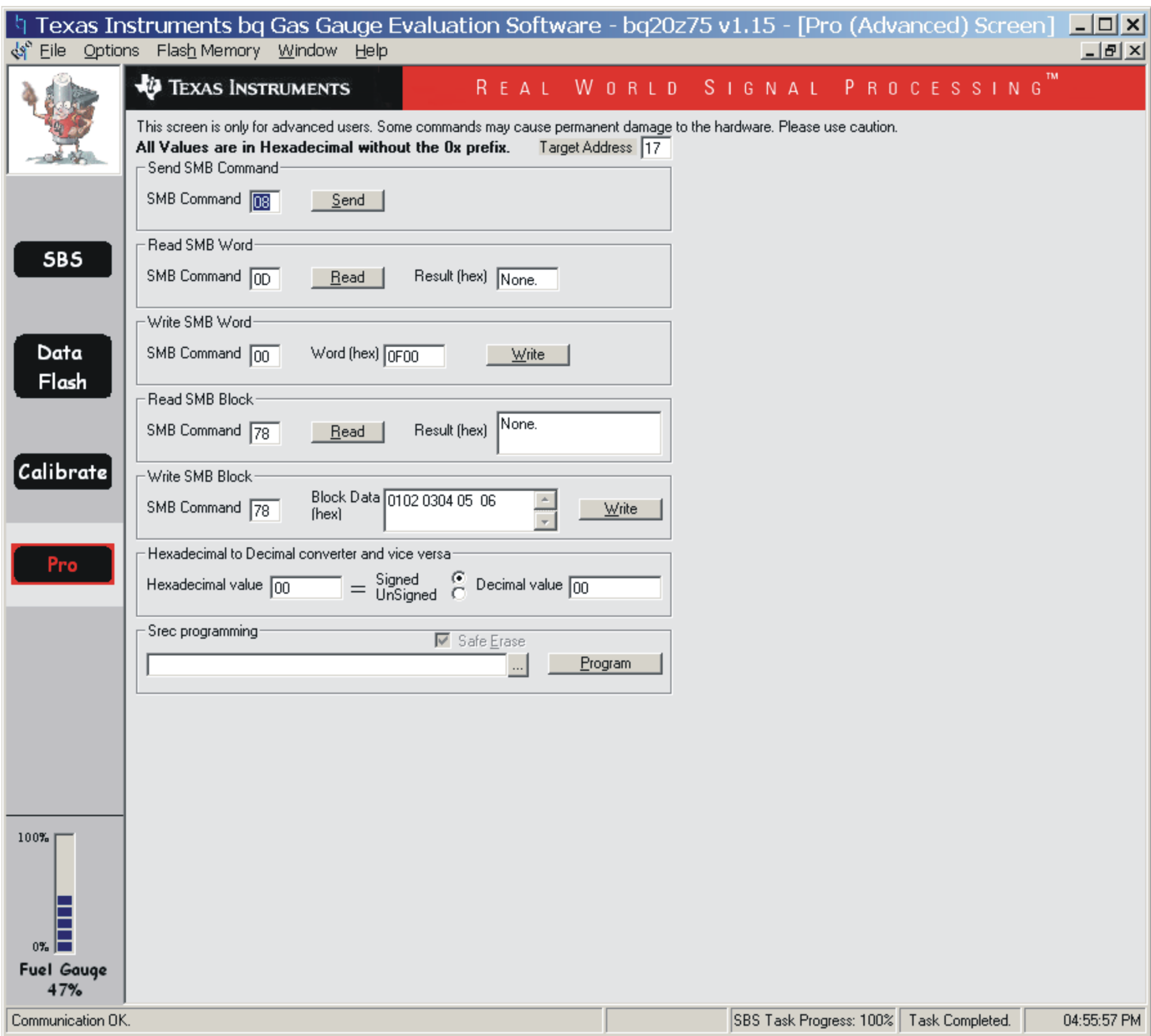

Figure 11. Pro (Advanced) Screen

11 Pack Assembly and the bq20zxx

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 bq20z75EVM 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.

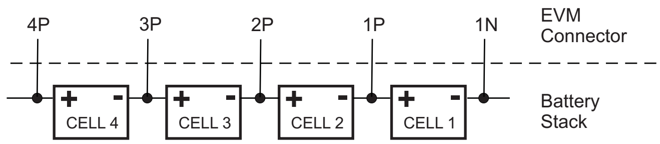

Figure 12. Connection Sequence

1. Connect the most negative terminal (– terminal of cell 1) of the serially-connected, 4-cell battery stack to the 1N PIN of the TB3–TB2 connector as shown in Figure 12.
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 bq20zxx 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 voltage near *Measured voltage* field. Measure the actual pack voltage between pins 1N and 4P, and enter the value into the *Enter actual voltage* field. Click the *calibrate part* button.
11. To start fuel-gauging, 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 13, and click the *Write* button.

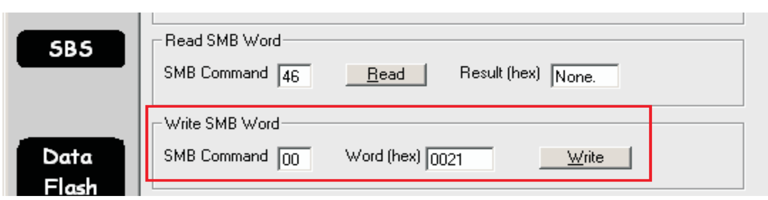

Figure 13. Fuel Gauging Command

12. Navigate to the SMB Screen and be sure that the QEN bit in Operation Status is set (red). The *Relative State of Charge* value is now updated to the correct value that corresponding to the state of charge of the attached cells.
13. 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

Documents:	Literature Number:
bq20z75 Data Sheet	SLUS686
bq20z75 Technical Reference	SLUU250
bq29330 Data Sheet	SLUS673
bq20z70-V110 Technical Reference	SLUU265
bqEASY User's Guide	SLUU278
Quick-Start Guide for bq20zxx Family Gas Gauges Application Report	SLUA421
bq20z70 and bq20z90 Application Book	SLUA404

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