User's Guide
SLUU353–June 2009

bq20z65EVM-001 SBS 1.1 Impedance Track™ Technology Enabled Battery Management Solution Evaluation Module

This evaluation module (EVM) is a complete evaluation system for the bq20z65/bq29412 battery management system. The EVM includes one bq20z65/bq29412 circuit module and a link to Windows™-based PC software. The circuit module includes one bq20z65 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 bq20z65 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq20z65/bq29412 solution under different charge and discharge conditions.

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1 Features

- Complete evaluation system for the bq20z65 SBS 1.1-compliant advanced gas gauge with Impedance Track™ technology and bq29412 independent overvoltage protection IC
- Populated circuit module for quick setup
- Software that allows data logging for system analysis

1.1 Kit Contents

- bq20z65/bq29412 circuit module
- Set of support documentation

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq20z65EVM-001	Li-ion	2, 3, or 4 cell	Any

2 bq20z65-Based Circuit Module

The bq20z65/bq29412-based circuit module is a complete and compact example solution of a bq20z65 circuit for battery management and protection of Li-ion or Li-polymer packs. The circuit module incorporates a bq20z65 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 bq20z65 Circuit Module Schematic

This section contains information for modifying and choosing a precharge mode for bq20z65/bq29412 implementation.

3.1 Schematic

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

3.2 Modifications for Choosing Particular Precharge Mode

In order to charge, the charge FET (CHG-FET) must be turned on to create a current path. When the $V_{(BAT)}$ is 0 V and CHG-FET = ON, the $V_{(PACK)}$ is as low as the battery voltage. In this case, the supply voltage for the device is too low to operate. This function has three possible configurations, and the IC can be easily configured according to the application needs. The three modes are 0-V Charge FET mode, Common FET mode, and Precharge FET mode.

1. 0-V Charge FET mode - Dedicates a precharge current path using an additional FET (ZVCHG-FET) to sustain the PACK+ voltage level.
2. Common FET mode - Does not use a dedicated precharge FET. The charge FET (CHG-FET) is set to ON state as default.
3. Precharge FET mode - Dedicates a precharge current path using an additional open-drain (OD) pin drive FET (PCHG-FET) to sustain the PACK+ voltage level.

To use a particular mode of charging with the EVM, add or remove some elements shown in Table 2, and use the given settings of DF.Configuration, ZVCHG1, 0.

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

MODE	RESISTORS	PRECHG FET	ZVCHG1	ZVCHG0
1. 0-V Chg (default)	R21, R28	Q3	0	0
2. Common FET	R24	Q2	0	1
3. Precharge	R23, R28	Q3	1	0

For more details about precharge operation and mode choices, see the bq20z65 data sheet (SLUS878).

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; so, monitoring TP3 can be used to test this condition. Fuse placement on the application board is shown in the bq20z65 data sheet reference-board schematic.

4 Circuit Module Physical Layouts and Bill of Materials

This section contains the printed-circuit board (PCB) layout, bill of materials, and assembly drawings for the bq20z65/bq29412 circuit module.

4.1 Board Layout

This section shows the dimensions, PCB layers (Figure 1 through Figure 5), and assembly drawing for the bq20z65 module.

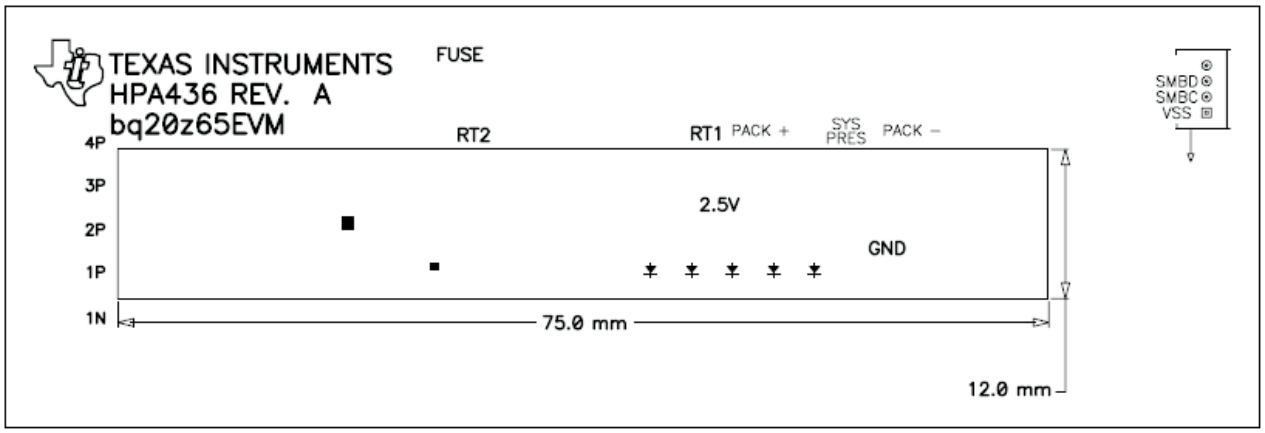

Figure 1. bq20z65EVM-001 Layout – Silk Screen

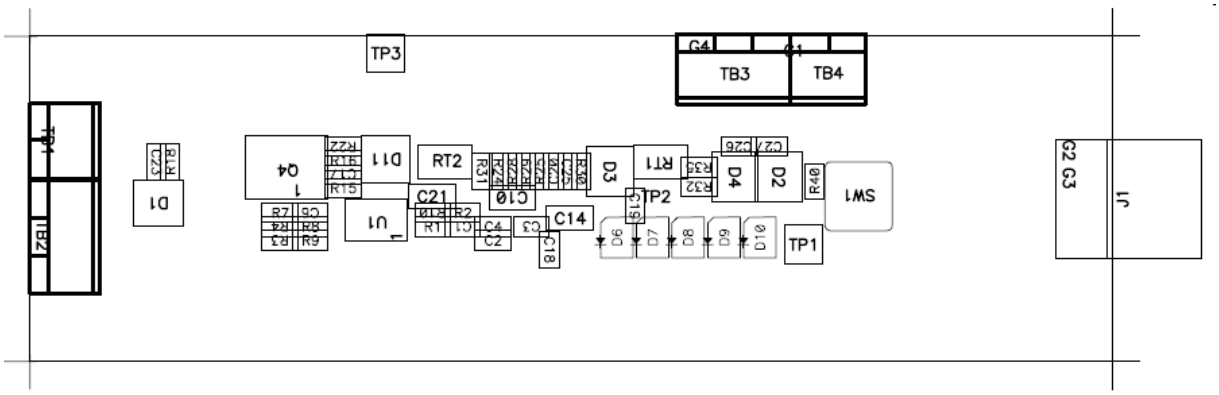

Figure 2. Top Assembly

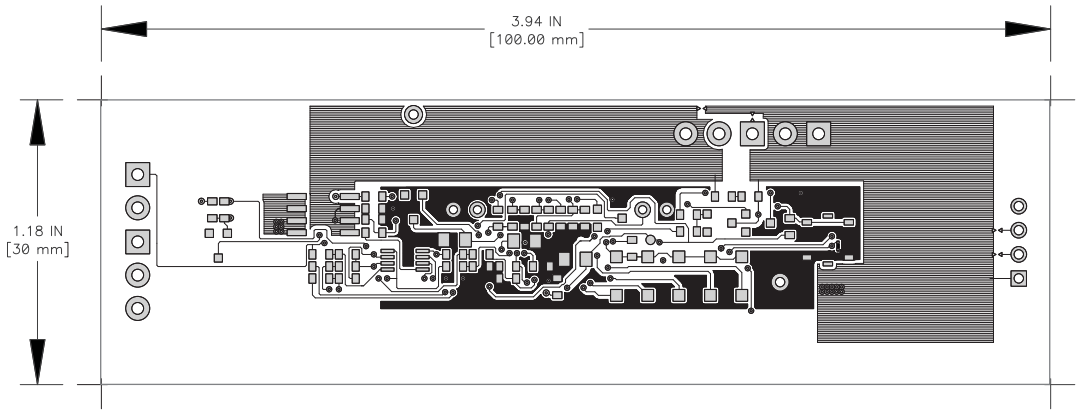

Figure 3. Top Layer

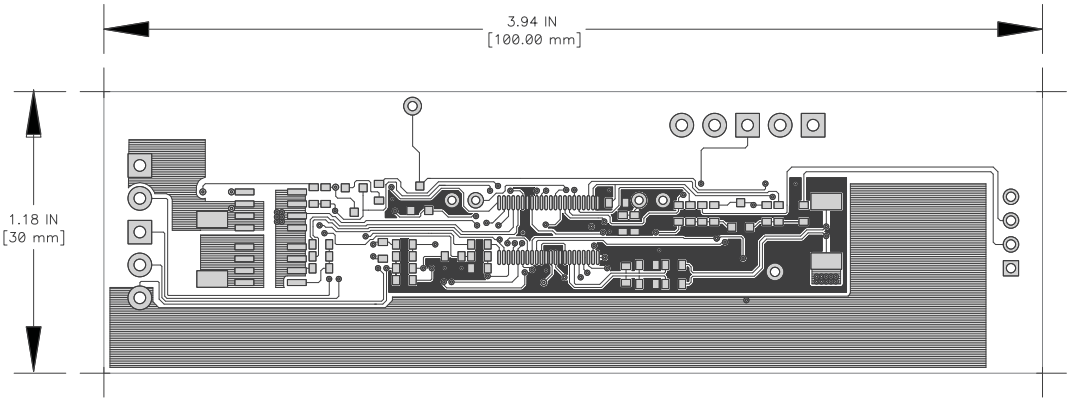

Figure 4. Bottom Layer

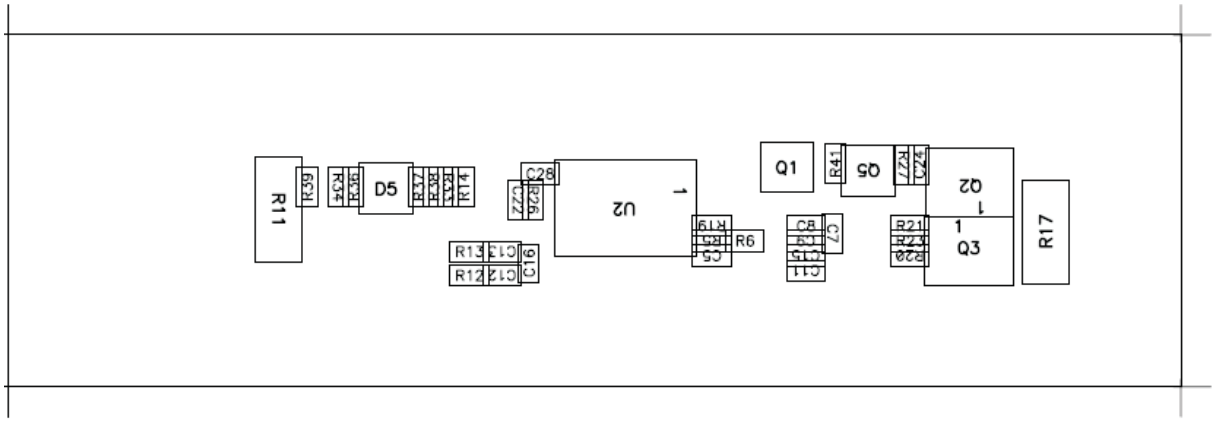

Figure 5. Bottom Assembly

4.2 Bill of Materials and Schematic

Table 3. Bill of Materials

Count	RefDes	Description	Size	Mfr	Part Number
21	C1–C9, C12, C13, C15–C18, C23, C24, C26–C28	Capacitor, Ceramic, 0.1µF, 50 V, X7R, 20%	0603	Any	STD
1	C11	Capacitor, Ceramic, 0.22µF, 50 V, X7R, 20%	0603	Any	STD
1	C19	Capacitor, Ceramic, 4.7µF, 10 V, X7R, 20%	0603	Any	STD
1	C20	Capacitor, Ceramic, 47nF, 50 V, X7R, 20%	0603	Any	STD
2	C22, C25	Capacitor, Ceramic, 0.47µF, 16 V, X7R, 20%	0603	Any	STD
3	C10, C14, C21	Capacitor, Ceramic, 1.0µF, 25 V, X7R, 20%	0805	Any	STD
4	D1–D3, D11	Diode, Switching, 150-mA, 75-V, 350mW	SOT23	Vishay-Liteon	BAS16
2	D4, D5	Diode, Dual, Zener, 5.6V, 300mW	SOT23	Vishay-Telefunken	AZ23C5V6
5	D6–D10	Diode, LED, Green, Gullwing, GW Type, 20ma, 7.5 mcd typ.	0.120 × 0.087 inches	Panasonic	LN1361C
1	J1	Header, Friction Lock Ass'y, 4-pin Right Angle,	0.400 × 0.500	Molex	22-05-3041
1	Q1	MOSFET, N-ch, 20-V, 1.3A, 0.16-Ω	SOT23	Fairchild	NDS331N
2	Q2, Q4	MOSFET, N-ch Logic Level, Power Trench, 30V, 11A, 12.5 mΩ	SO8	Fairchild	FDS6690A

Table 3. Bill of Materials (continued)

Count	RefDes	Description	Size	Mfr	Part Number
1	Q3	MOSFET, P-ch, 30-V, 8.0-A, 20-mΩ	SO8	Siliconix	Si4435DY
1	Q6	MOSFET, Nch, 50V, 0.22A, 6 Ω	SOT23	Fairchild	BSS138
12	R1–R5, R12, R13, R32–R34, R38, R39	Resistor, Chip, 100-Ω, 1/16-W, 5%	0603	Std	Std
1	R11	Resistor, Chip, 0.010 Ω, 1-W, xx%	2512	Vishay	WSL-2512-010 1% R86
3	R15, R16, R40	Resistor, Chip, 220 kΩ, 1/16-W, 5%	0603	Std	Std
1	R17	Resistor, Chip, 300-Ω, 1-W, 10%	2512		WSL-2512-300 1% R86
2	R18, R27	Resistor, Chip, 3.01MΩ, 1/16-W, 5%	0603	Std	Std
5	R14, R19, R21–R23	Resistor, Chip, 5.1kΩ, 1/16-W, 5%	0603	Std	Std
4	R20, R36, R37, R41	Resistor, Chip, 1MΩ, 1/16-W, 5%	0603	Std	Std
2	R24, R28	Resistor, Chip, 100kΩ, 1/16-W, 5%	0603	Std	Std
2	R25, R29	Resistor, Chip, 8.45kΩ, 1/16-W, 1%	0603	Std	Std
2	R26, R30	Resistor, Chip, 61.9kΩ, 1/16-W, 1%	0603	Std	Std
7	R6–R10, R31, R35	Resistor, Chip, 1kΩ, 1/16-W, 5%	0603	Std	Std
2	RT1, RT2	Thermistor, 10kΩ	0.095 × 0.150	Semitec	NTC103AT
1	SW1	Switch, Push button, Momentary, N.O. Low Profile	5 mm × 5 mm	Panasonic	EVQPLCxxxx
2	TB1, TB4	Terminal Block, 2-pin, 6-A, 3,5mm	0.27 × 0.25	OST	ED1514
2	TB2, TB3	Terminal Block, 3-pin, 6-A, 3,5mm	0.41 × 0.25	OST	ED1515
1	TP1	Test Point, Black, Thru Hole Color Keyed	0.100 × 0.100 inch	Keystone	5001
1	TP3	Test Point, White, Thru Hole Color Keyed	0.100 × 0.100 inch	Keystone	5002
1	U1	IC, Voltage Protection for 2, 3, 4 Cell Lion , 2nd Protection, 4.45 V OVP	SSOP-08	TI	BQ29412DCT
1	U2	IC, Cool-GG Programmable Battery Management	TSSOP30	TI	bq20z65DBT

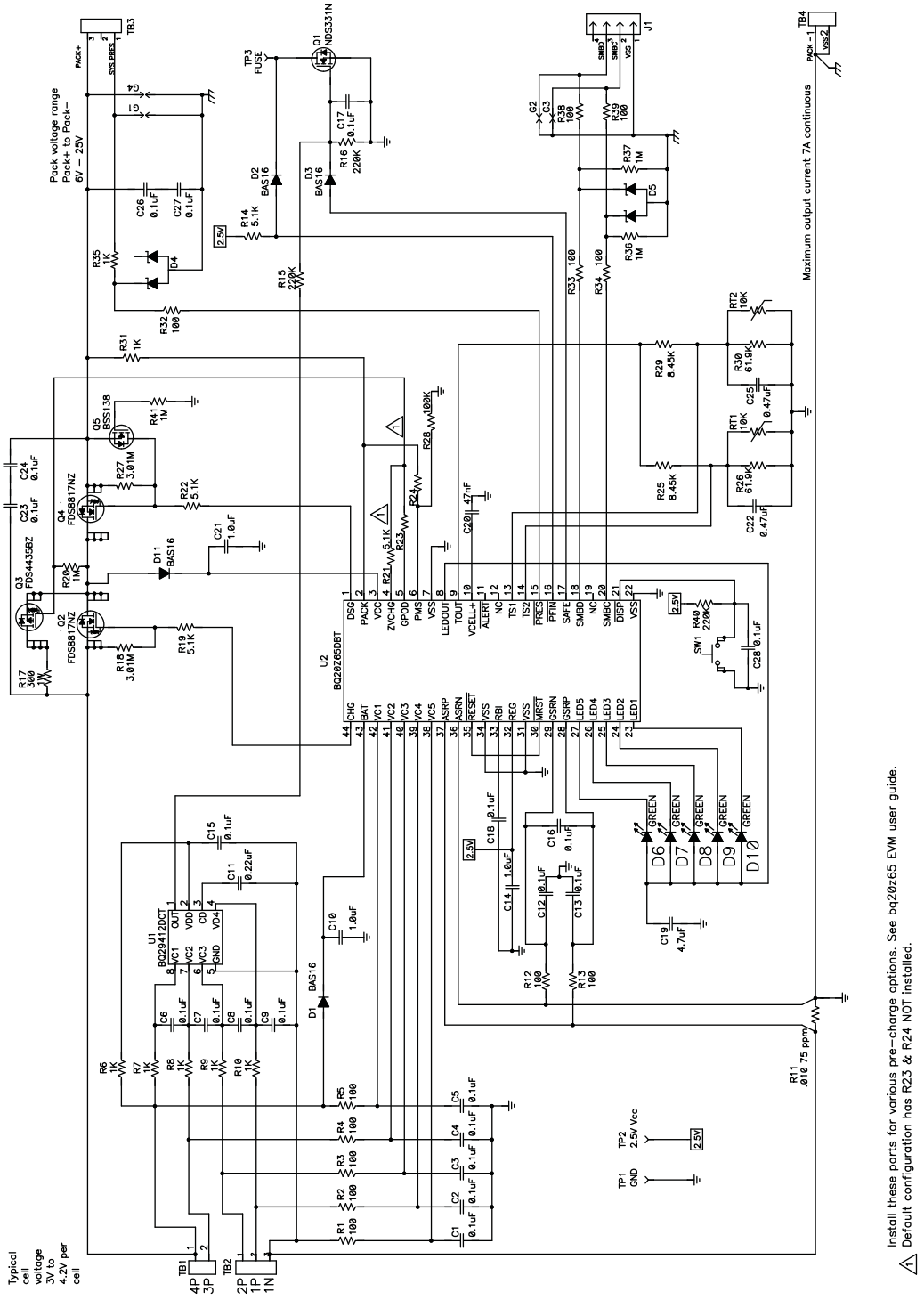

Figure 6. Schematic

4.3 bq20z65/bq29412 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq20z65/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 bq20z65 PC software and how to connect the different components of the EVM.

5.1 System Requirements

The bq20z65EVSW software requires Windows™ 2000 or Windows XP.

5.2 Software Installation

Find the latest software version in the bq20z65 tool folder on power.ti.com. Use the following steps to install the bq20z65EVSW software:

1. Copy the files from the Ti Web site into a temporary directory you select, double-click on *bqEV-EASYSetup00.09.xx.exe*, where xx indicates the version, and follow the installer instructions to complete the bq20z60 EVSW installation.
2. If the EV2300 was not previously installed, after bq20z60 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 instructions 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 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 was 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.

6 Troubleshooting Unexpected Dialog Boxes

The following actions can help the user to avoid 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 bq20z65EVM-001 comprises three hardware components: the bq20z65/bq29412 circuit module, the EV2300 PC interface board, and the PC.

7.1 Connecting bq20z65/bq29412 Circuit Module to Battery Pack

Figure 7 shows how to connect the bq20z65/bq29412 circuit module to the cells and system load/charger.

The cells must 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 SYS PRES pin.

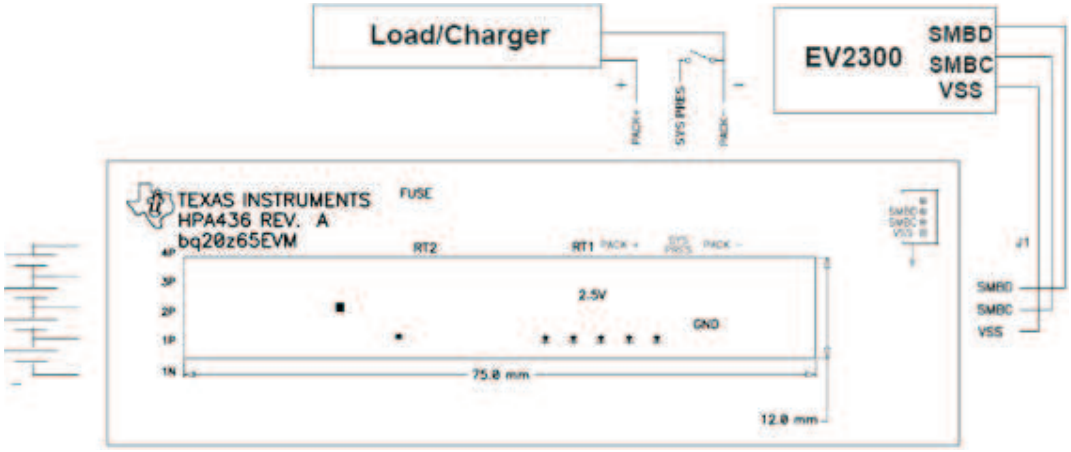

Figure 7. bq20z65 Circuit Module Connection to Cells and System Load/Charger

7.2 PC Interface Connection

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

1. Connect the bq20z65-based smart battery to the EV2300 using wire leads as shown in Table 5.

Table 5. Circuit Module to EV2300 Connections

bq20z65-Based Battery	EV2300
SMBD	SMBD
SMBC	SMBC
VSS	GND

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

The bq20z65EVM-001 is now set up for operation.

8 Operation

This section details the operation of the bq20z65 EVSW software.

8.1 Starting the Program

Run bq Evaluation Software from the Start | Programs | Texas Instruments | bq20z65 EVSW menu sequence. The SBS Data screen (Figure 8) 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 the scan interval because this results in the same value being logged at least twice.

Figure 8. SBS Data Screen

This screen (Figure 8) 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 bq20z65 Options

The bq20z65 data flash comes configured per the default settings detailed in the bq20z65 data sheet. Ensure that the settings are correctly changed to match the pack and application for the bq20z65 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).

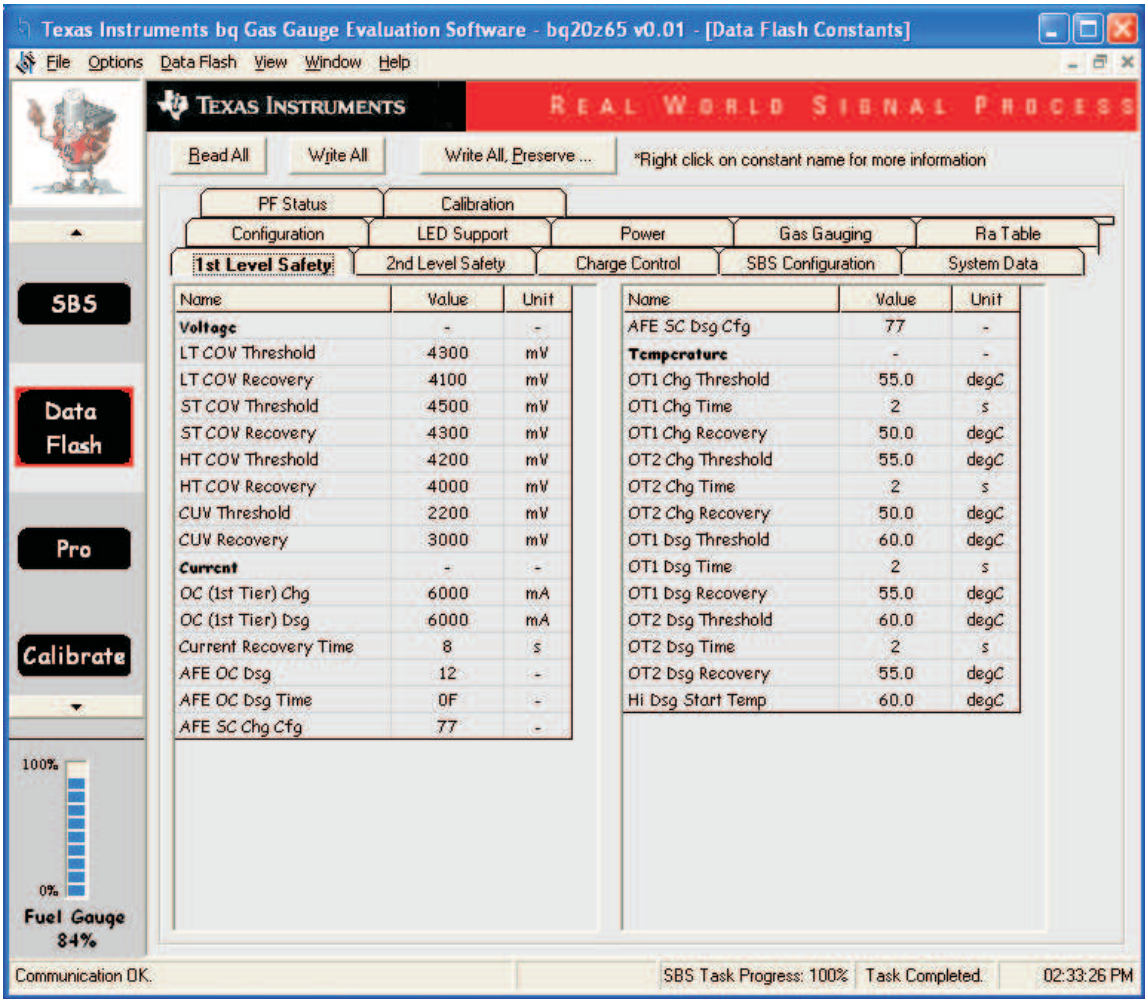

Figure 9. Data Flash Screen, 1st Level Safety Class

To read all the data from the bq20z65 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 option 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 bq20z65 using the | Write All | button.

The configuration information of the bq29z95 and module calibration data also is held in the bq20z65 data flash.

The bq20z65 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 bq20z65 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

The bq20z65 must be calibrated using power supplies or a power supply and cell simulation resistors (200 Ω to 1000 Ω each) before cells are attached. Before the bq20z65 is calibrated:

- Connect and measure a 2-A current source from 1N (-) and Pack- (+) to calibrate without using the FETs. (Calibration using the FETs is not recommended.)
- Measure the pack voltage from Batt+ to Batt- (total of cell voltages).
- Measure the temperature of the pack.
- These steps may not be required, depending on the type of calibration being performed.

9.2 To Calibrate the bq20z65

Perform the following steps.

1. Select the types of calibration to be performed (see Figure 10).
2. Enter the measured values for the types selected (except for CC Offset Calibration).
3. If *Voltage Calibration* is selected, then enter the number of cells on the pack.
4. If *Temperature Calibration* is selected, then select the sensor that is to be calibrated.
5. If the current source is connected between 1N and Pack-, then select the Off (bypassed) check box in the FET Control section.
6. Press the *Calibrate Part* button.

9.3 Board Offset Calibration

The following steps perform the offset calibration for the current offset of the board.

1. Remove load/external voltage and short Pack- to Batt-.
2. Press the *CC Board Offset Calibration* button.

9.4 Pack Voltage Calibration

The following steps calibrate the voltage at the AFE Pack pin.

1. Ensure that *Voltage Calibration* has been performed for the pack. Ensure that a stable charger voltage higher than 8-V is present at Pack+.
2. Press the *Pack Voltage* button to calibrate.

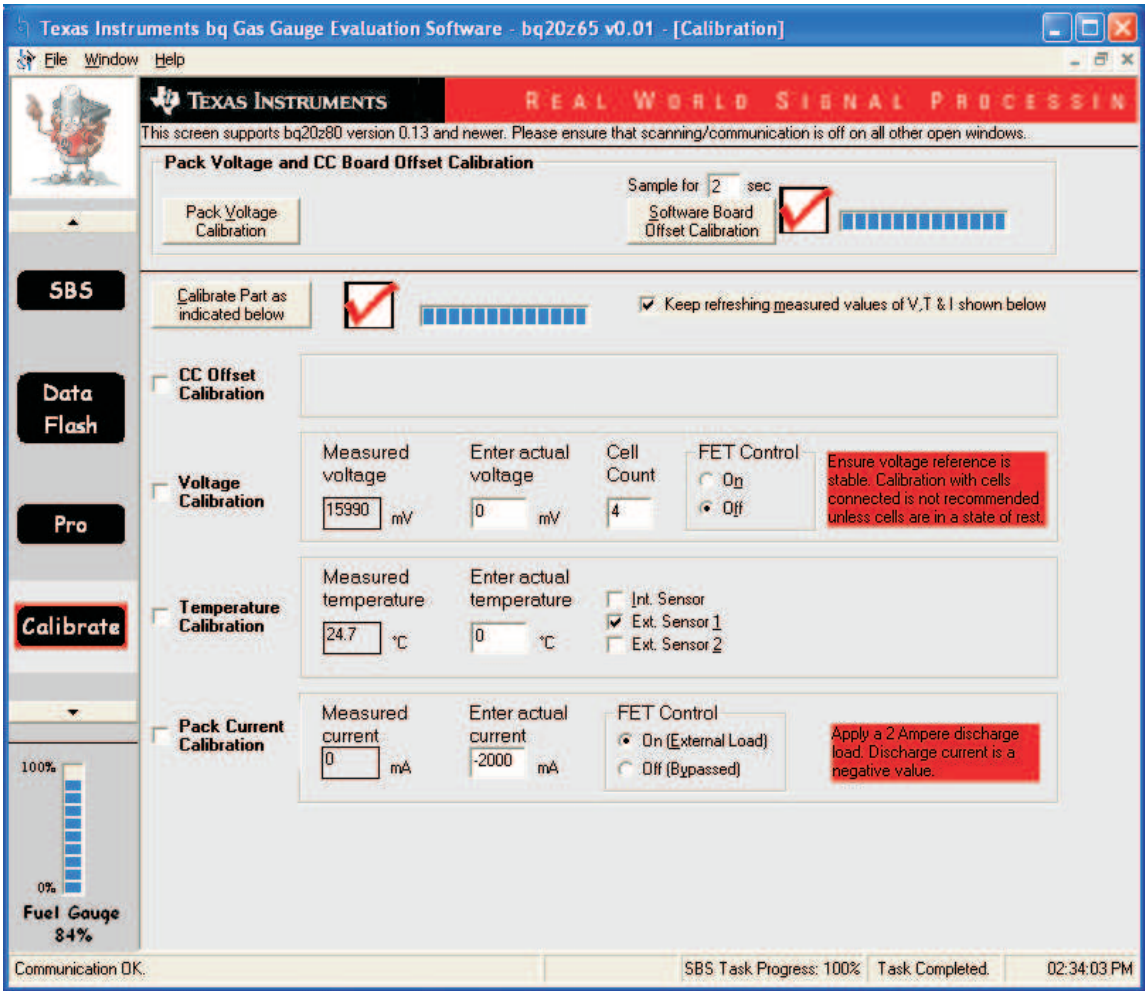

Figure 10. Calibration Screen

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 (Figure 11).

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.

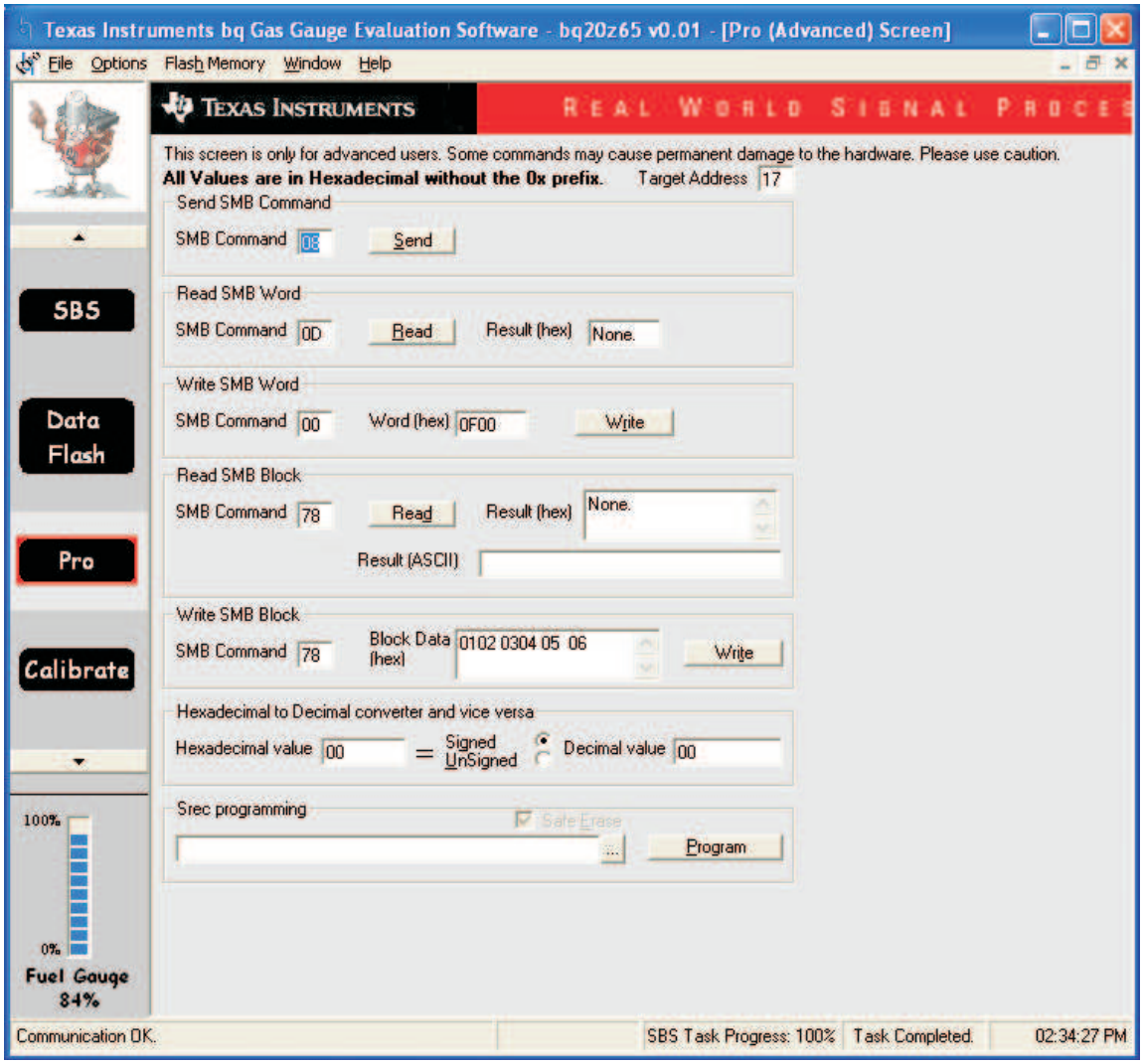

Figure 11. Pro (Advanced) Screen

11 Related Documentation from Texas Instruments

1. *bq20z95, SBS 1.1-Compliant Gas Gauge Enabled and Protection Enabled With Impedance Track™* data sheet (SLUS757)
2. *bq20z90-V1.50 + bq29330, bq20z95 Technical Reference* manual (SLUU264)
3. *bq20z70 and bq20z90 Application Book* (SLUA404)
4. *Quick-Start Guide for bq20zxx Family Gas Gauge* application report (SLUA421)
5. *bqEasy™ User's Guide* (SLUU278)

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 6 V to 25 V and the output voltage range of 0 V to 16.4 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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