# bq20z40EVM-001 SBS 1.1 Impedance Track™ Technology Enabled Battery Management Solution EVM

This EVM is a complete evaluation system for the bq20z40/bq29330/bq29412 battery management system. The EVM includes one bq20z40/bq29330/bq29412 circuit module, a current sense resistor, two thermistors, and a link to Windows™-based PC software. The circuit module includes one bq20z40 IC, one bq29330 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, overdischarge, 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 bq20z40 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq20z40/bq29330/bq29412 solution under different charge and discharge conditions.

## Contents

## List of Figures

## List of Tables

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

## 1   Features

- Complete evaluation system for the bq20z40 SBS 1.1-compliant advanced gas gauge with Impedance Track™ technology, bq29330 analog front end (AFE) and protection IC, and bq29412 independent overvoltage protection integrated circuit (IC)
- Populated circuit module for quick setup
- Link to software that allows data logging for system analysis

### 1.1   Kit Contents

- bq20z40/bq29330/bq29412 circuit module
- Set of support documentation

### 1.2   Ordering Information

**Table 1. Ordering Information**

| EVM PART NUMBER | CHEMISTRY | CONFIGURATION | CAPACITY |
|:---:|:---:|:---:|:---:|
| bq20z40EVM-001 | Li-ion | 2, 3, or 4 cell | Any |

## 2   bq20z40/bq29330-Based Circuit Module

The bq20z40/bq29330/bq29412-based circuit module is a complete and compact example solution of a bq20z40 and bq29330 circuit for battery management and protection of Li-ion or Li-polymer packs. The circuit module incorporates a bq20z40 battery monitor IC, bq29330 AFE and protection 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 bq20z40/bq29330 Circuit Module Schematic

This section contains information on the schematic for the bq20z40/bq29330/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 supports a charger that does not have a precharge mode by grounding the PMS pin with resistor R16. R12 and Q2 are used as the precharge current path in order to sustain sufficient Pack+ voltage when the battery voltage is too low to power up the bq29330 IC.

If the charger has a precharge function, R12 and FET Q2 are not used. The EVM does not have a provision to pull high the PMS pin 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 bq20z40 is up and running, the firmware may change the precharge settings. See the bq20z40 data sheet (SLUS801). for further information.

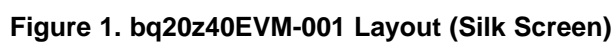### 3.3 Testing Fuse-Blowing Circuit

To prevent the loss of board functionality during the fuse-blowing test, the actual chemical fuse is not provided in the circuit. FET Q4 drives TP3 low if a fuse-blow condition occurs; so, 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 bq20z40/ bq29330/ bq29412 circuit module.

> **Note:** For the battery pack designer: D3 may have side effects. See the application report *bq29330 External Short-Circuit Protection* (SLUA436)

### 4.1 Board Layout

This section shows the dimensions, PCB layers, and assembly drawing for the bq20z40/bq29330 module.



**Figure 1. bq20z40EVM-001 Layout (Silk Screen)**



**Figure 2. Top Assembly**
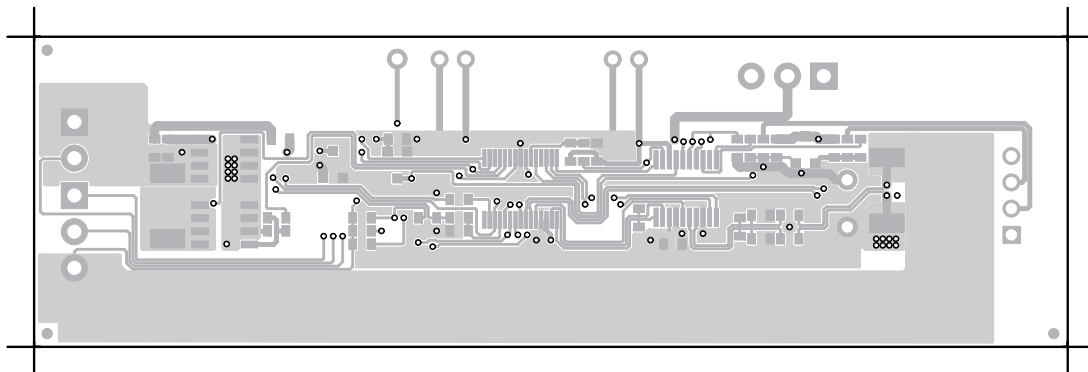


**Figure 3. Top Layer**

**Figure 4. Bottom Layer**
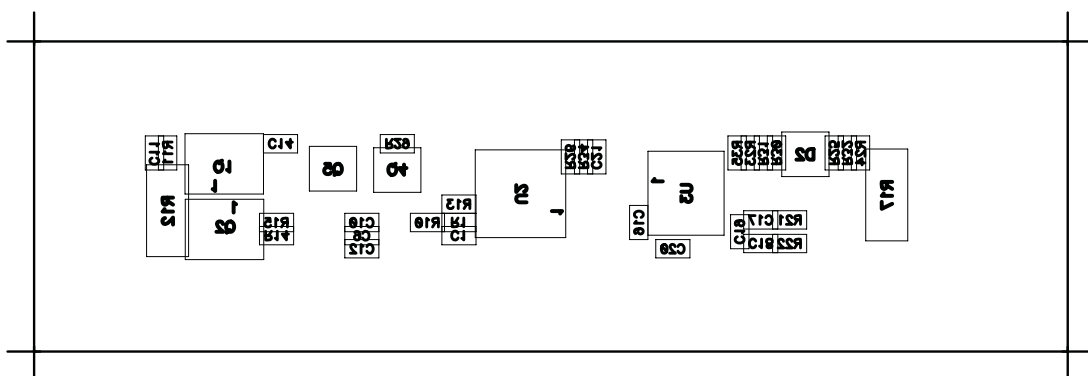


**Figure 5. Bottom Assembly**

## 4.2 Bill of Materials

**Table 2. Bill of Materials**

| Count | Ref Des | Value | Description | Size | Part No. | MFR |
|---|---|---|---|---|---|---|
| 20 | C1–C11, C14, C16–C20, C22–C24 | 0.1 µF | Capacitor, ceramic, 0.1 µF, 50 V, X7R, 20% | 0603 | STD | Any |
| 1 | C12 | 0.22 µF | Capacitor, ceramic, 0.22 µF, 25 V, X7R, 20% | 0603 | STD | Any |
| 3 | C13, C15, C27 | 1.0 µF | Capacitor, ceramic, 1.0 µF, 25 V, X7R, 20% | 0805 | STD | Any |
| 2 | C21, C26 | 0.47 µF | Capacitor, ceramic, 0.47 µF, 16 V, X7R, 20% | 0603 | STD | Any |
| 1 | C25 | 2.2 µF | Capacitor, ceramic, 2.2 µF, 10 V, X7R, 20% | 0805 | STD | Any |
| 4 | D1, D3, D4, D6 | BAS16 | Diode, Switching, 150-mA, 75-V, 350 mW | SOT23 | BAS16 | Vishay-Liteon |
| 2 | D2, D5 | AZ23C5V6 | Diode, dual, Zener, 5.6V, 300mW | SOT23 | AZ23C5V6 | Vishay-Telefunken |
| 1 | J1 | 22-05-3041 | Header, friction lock assembly, 4-pin right angle | 0.400 x 0.500 | 22-05-3041 | Molex |
| 2 | Q1, Q3 | FDS8817NZ | MOSFET, N-ch, 30 V, 15 A, 7 mΩ | SO8 | FDS8817NZ | Fairchild |
| 1 | Q2 | FDS4435BZ | MOSFET, P-ch, –30 V, –8.8 A, 20 mΩ | SO8 | FDS4435BZ | Fairchild |
| 1 | Q4 | NDS331N | MOSFET, N-ch, 20 V, 1.3 A, 0.16 Ω | SOT23 | NDS331N | Fairchild |
| 1 | Q5 | BSS138 | MOSFET, N-ch, 50 V, 0.22 A, 6 Ω | SOT23 | BSS138 | Fairchild |
| 12 | R1–R5, R21–R24, R31, R32, R36 | 100 | Resistor, chip, 100 Ω, 1/16 W, 5% | 0603 | STD | STD |
| 2 | R11, R19 | 3M | Resistor, chip, 3 MΩ, 1/16 W, 5% | 0603 | STD | STD |
| 1 | R12 | 301 | Resistor, chip, 301 Ω, 1 W, 1% | 2512 | WSL-2512-301 1% R86 | Vishay |
| 3 | R13, R15, R18 | 5.1K | Resistor, chip, 5.1 kΩ, 1/16 W, 5% | 0603 | STD | STD |
| 3 | R14, R25, R30 | 1M | Resistor, chip, 1 MΩ, 1/16 W, 5% | 0603 | STD | STD |
| 1 | R16 | 100K | Resistor, chip, 100 kΩ, 1/16 W, 5% | 0603 | STD | STD |
| 1 | R17 | 0.010 75ppm | Resistor, chip, 0.010 Ω, 1 W, 1% | 2512 | WSL-2512-010 1% R86 | Vishay |
| 1 | R20 | 10K | Resistor, chip, 10 kΩ, 1/16 W, 5% | 0603 | STD | STD |
| 2 | R26, R34 | 8.45K | Resistor, chip, 8.45 kΩ, 1/16 W, 1% | 0603 | STD | STD |
| 2 | R27, R33 | 61.9K | Resistor, chip, 61.9 kΩ, 1/16 W, 1% | 0603 | STD | STD |
| 3 | R28, R29, R35 | 220K | Resistor, chip, 220 kΩ, 1/16 W, 5% | 0603 | STD | STD |
| 6 | R6–R10, R37 | 1K | Resistor, Chip 1 kΩ, 1/16W, 5% | 0603 | STD | STD |
| 2 | RT1, RT2*** | 10K | Thermistor, 10 kΩ | 0.095 x 0.150 | 103AT-2 | Sematec |
| 2 | TB1, TB3 | ED1515 | Terminal block, 3 pin, 6 A, 3,5 mm | 0.41 x 0.25 | ED555/3DS | OST |
| 1 | TB2 | ED1514 | Terminal block, 2 pin, 6 A, 3,5 mm | 0.27 x 0.25 | ED555/2DS | OST |
| 1 | TP1 | GND | Test point, Black, Thru Hole Color Keyed | 0.100 × 0.100 in | 5000 | Keystone |
| 1 | TP2 | VCC | Test point, Red, Thru Hole Color Keyed | 0.100 × 0.100 in | 5001 | Keystone |
| 1 | TP3 | ~FUSE | Test point, White, Thru Hole Color Keyed | 0.100 × 0.100 in | 5002 | Keystone |
| 1 | U1 | bq29412DCT3R | IC, voltage protection for 2, 3, or 4 cell Li-Ion, 2nd protection, 4.45 OVP ±25 mV | MSOP-08 (DCT3) | bq29412DCT3R | TI |
| 1 | U2 | bq29330DBT | IC, 2, 3, or 4 cell series protection control AFE | TSSOP-30 | bq29330DBT | TI |
| 1 | U3 | bq20z40PW | IC, Impedance Track Gas Gauge | TSSOP-20 | bq20z40PW | TI |
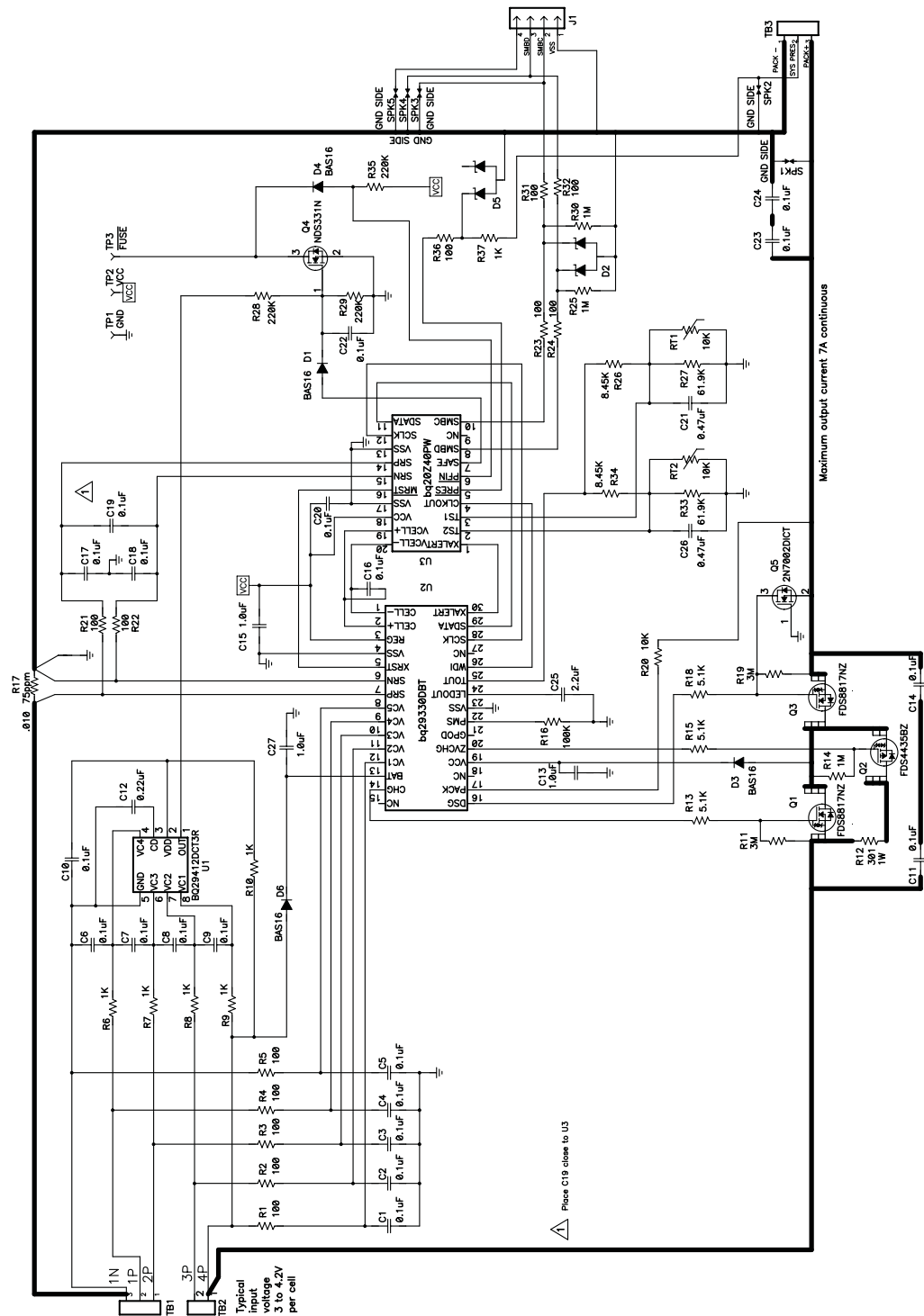
**Figure 6. Schematic**

## 4.3 *bq20z40/bq29330/bq29412 Circuit Module Performance Specification Summary*

This section summarizes the performance specifications of the bq20z40/ bq29330/bq29412 circuit module.

**Table 3. Performance Specification Summary**

| Specification | Min | Typ | Max | 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 bq20z40EVM-001 PC software, and how to connect the different components of the EVM.

### 5.1 *System Requirements*

The bq20z40EVSW requires Windows 2000 or Windows XP.

### 5.2 *Software Installation*

Obtain the latest software archive from the Support software section of the EVM product folder at **xxx**, or search for the latest software version from power.ti.com. Use the following steps to install the bq20z40EVSW 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 bq20z40 EVSW installation.
2. If the EV2300 was not previously installed, after bq20z40 EVSW 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 bq20z40EVM-001 comprises two hardware components: the bq20z40/bq29330/bq29412 circuit module and the EV2300 PC interface board.
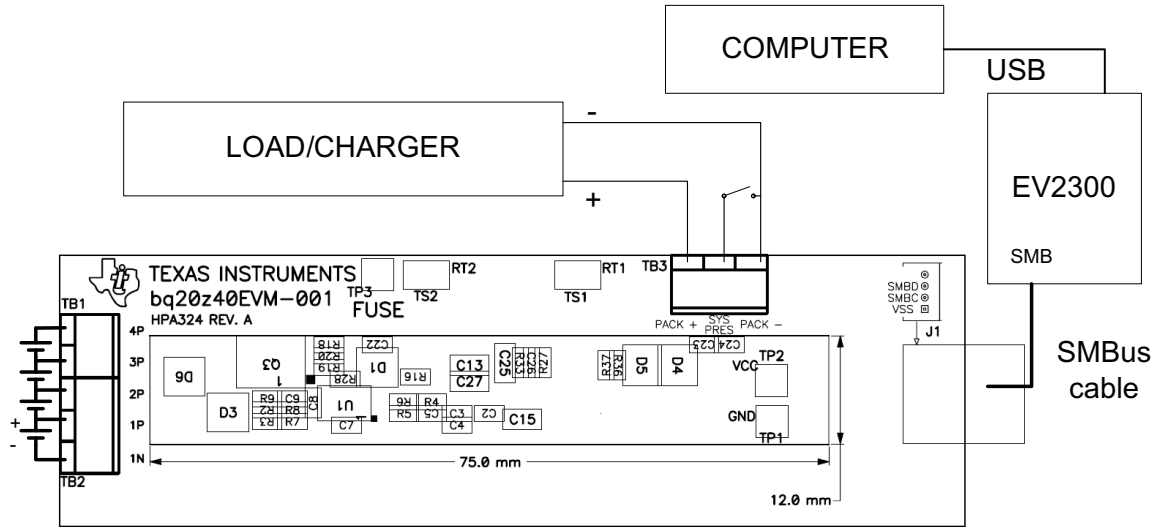
## 7.1  Connecting the bq20z40/bq29330/bq29412 Circuit Module to a Battery Pack

Figure 7 shows how to connect the bq20z40/bq29330/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, then 4P (see Section 2.2 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. bq20z40/bq29330 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 bq20z40/bq29330-based smart battery to the EV2300 using the provided cable or the connections shown in Table 4.

**Table 4. Circuit Module to EV2300 Connections**

| bq20z40/bq29330-Based Battery | EV2300 |
|---|---|
| SMBD | SMBD |
| SMBC | SMBC |
| VSS | GND |

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

The bq20z40EVM-001 is now set up for operation.

## 8 Operation

This section details the operation of the bq20z40 EVSW software. Note: the EV2300 driver does not support Windows Sleep or Hibernate. If communicating with the EV2300 or the EVM is a problem, first unplug the USB cable, then plug it back in. If the problem persists, check to determine if the EVM is in Shutdown mode. The bq20z40 can be awakened by momentarily applying a voltage higher than 5.5 V (but less than 25 V) at Pack+ pin of the EVM.

### 8.1 *Starting the Program*

With the EV2300 and the bq20z40EVM connected to the computer, run bq20z40 EVSW from the Start | All Programs | Texas Instruments | bq Evaluation Software 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 bq20z40 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 ms. The *Log* interval cannot be smaller than the scan interval because this results in the same value being logged at least twice.
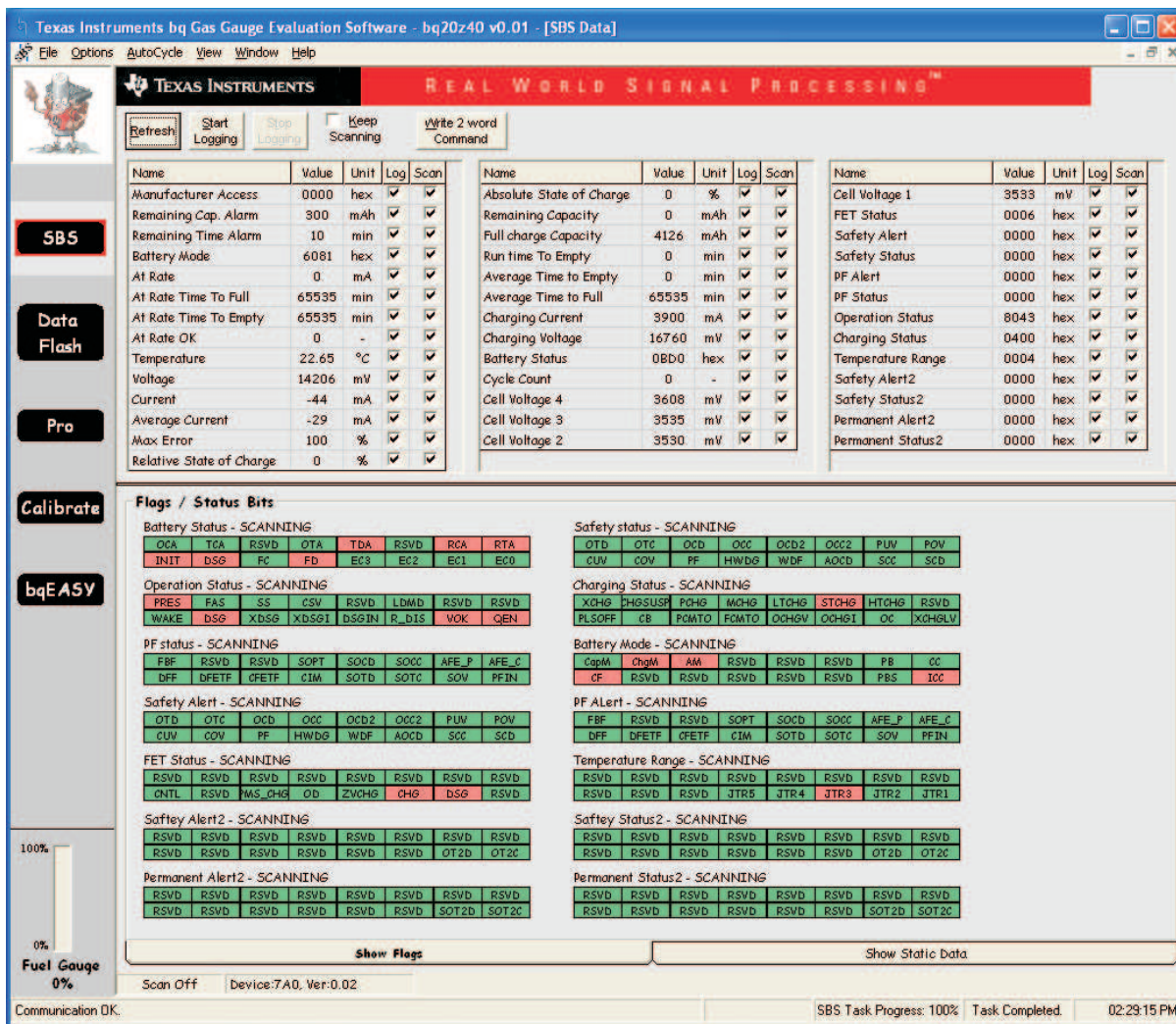
**Figure 8. SBS Data Screen**

This screen 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 bq20z40 and bq29330 Options

The bq20z40 data flash comes configured per the default settings detailed in the bq20z40 data sheet (SLUS801). Ensure that the settings are correctly changed to match the pack and application for the bq20z40/bq29330 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 bq20z40 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 bq20z40 using the | Write All | button.

The configuration information of the bq29330 and module calibration data is held in the bq20z40 data flash.

The bq20z40 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 set under the | Options menu |.

When a check 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 bq20z40 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 bq20z40 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 bq20z40 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.
- Whether the foregoing steps are necessary depends on the type of calibration being performed.

### 9.2    *To Calibrate the bq20z40*

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, enter the number of cells on the pack.

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

If the current source is connected between 1N and Pack-, then select the *Off (Bypassed)* check box in the *FET Control* section.

Press the *Calibrate Part* button.

### 9.3    *Board Offset Calibration*

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

Remove any current source, load, or external voltage from the PACK terminals.

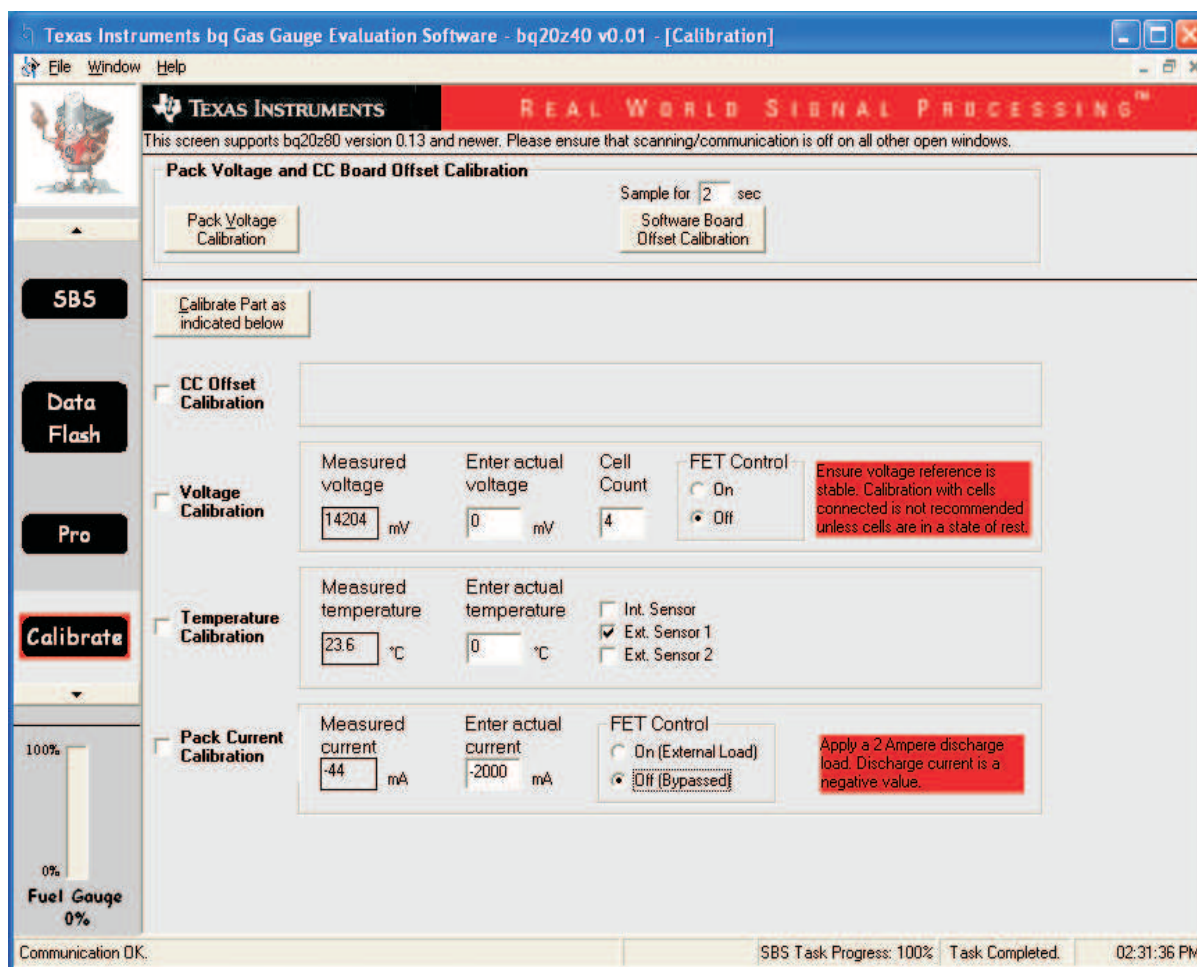Press the *Software Board Offset Calibration* button.

### 9.4    *Pack Voltage Calibration*

This calibrates the voltage at the AFE Pack pin.

Ensure that *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 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 can 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    Related Documentation from Texas Instruments

To obtain a copy of any of the following TI documents, 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: |
|---|---|
| bq20z40, SBS 1.1-Compliant Gas Gauge With Impedance Track data sheet | SLUS801 |
| bq20z40 and bq20z45 Technical Reference Manual | SLUU313 |
| bq29330, 2-, 3-, and 4-Cell Li-Ion or Li-Polymer Battery Protective AFE data sheet | SLUS673 |

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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.

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