

bq20z80EVM-001 SBS1.1 Impedance Track™ Technology Enabled Battery Management Solution Evaluation Module

This EVM is a complete evaluation system for the bq20z80/bq29312/bq29401 battery management system. The EVM includes one bq20z80/bq29312/bq29401 circuit module, a current sense resistor, two thermistors, an EV2300 PC interface board for gas gauge interface, a PC USB cable, and Windows™-based PC software. The circuit module includes one bq20z80 IC, one bq29312 IC, one bq29401 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 bq20z80 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq20z80/bq29312/bq29401 solution under different charge and discharge conditions.

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1 Features

- Complete evaluation system for the bq20z80 SBS 1.1-compliant advanced gas gauge with Impedance Track™ Technology, bq29312 analog front end (AFE) and protection IC, and bq29401 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

- bq20z80/bq29312/bq29401 circuit module
- EV2300 PC interface board
- Software CD with the evaluation software
- Connection cable to interface board
- Set of support documentation
- EV2300 USB interface board

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq20z80EVM-001	Li-ion	2, 3, or 4 cell	Any

2 bq20z80/bq29312-Based Circuit Module

The bq20z80/bq29312/bq29401-based circuit module is a complete and compact example solution of a bq20z80 and bq29312 circuit for battery management and protection of Li-ion or Li-polymer packs. The circuit module incorporates a bq20z80 battery monitor IC, bq29312 AFE and protection IC, bq29401 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)
- To the *sleep* pin (SLEEP)

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)
SLEEP	Sleep mode pin (if high, AFE enters sleep mode)
PACK-	Pack negative terminal
VSS	Pack negative terminal
PACK+	Pack positive terminal

3 bq20z80/bq29312 Circuit Module Schematic

This section contains information for modifying and choosing a precharge mode for bq20z80/bq29312/bq29401 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 bq29312 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) 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	FET	ZVCHG1	ZVCHG0
1 (default)	R19, R24	Q3, SI4435DY	0	0
2	R17	–	0	1
3	R19, R29	Q3, open-drain FET	1	0

For more details about precharge operation and mode choices, see the bq29312 data sheet at <http://www-s.ti.com/sc/ds/bq29312.pdf>.

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 TP4 low if a fuse-blow condition occurs; so, monitoring TP4 can be used to test this condition. Fuse placement on the application board is shown in the bq20z80 data sheet reference-board schematic.

4 Circuit Module Physical Layouts and Bill of Materials

This section contains the board layout, bill of materials, and assembly drawings for the bq20z80/ bq29312/ bq29401 circuit module.

4.1 Board Layout

This section shows the dimensions, PCB layers, and assembly drawing for the bq20z80/bq29312 module.

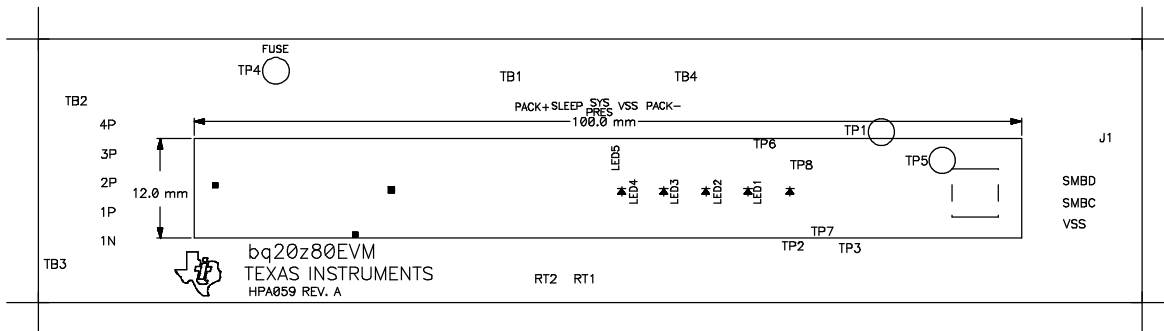


Figure 1. bq20z80EVM-001 Layout (Silk Screen)

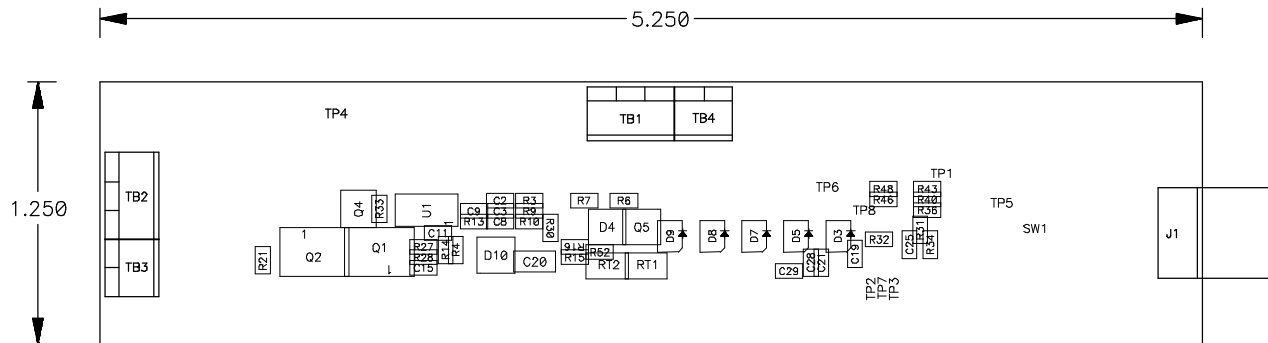


Figure 2. Top Assembly

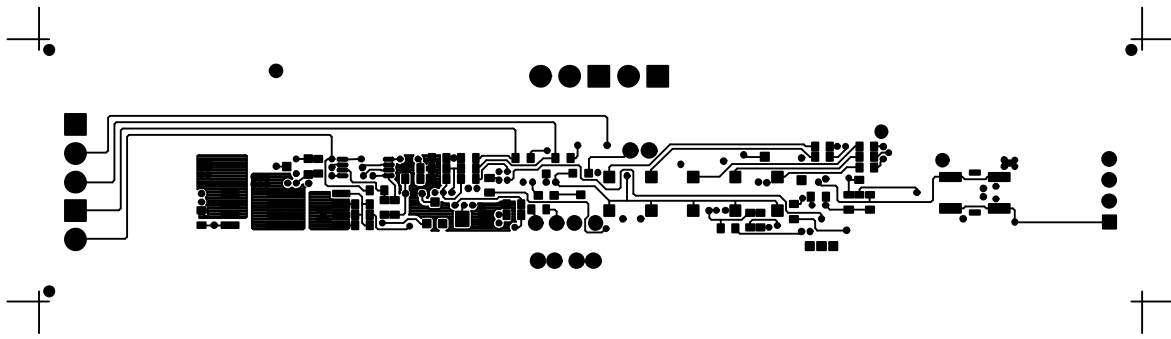


Figure 3. Layer 1

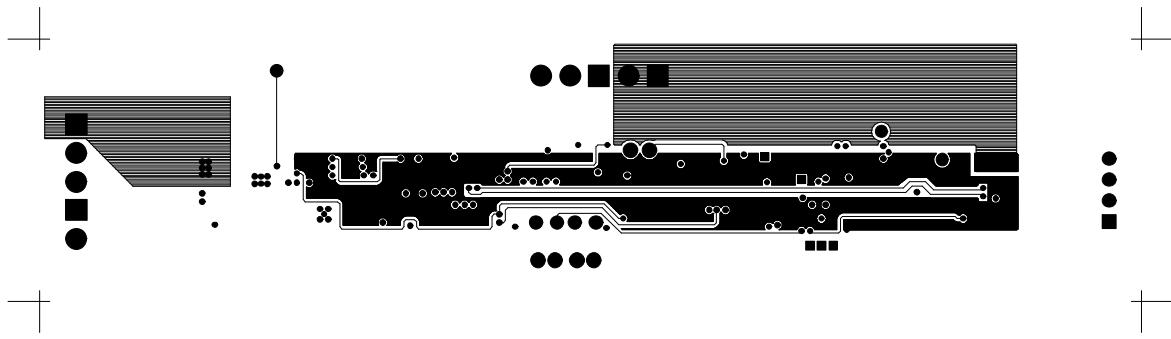


Figure 4. Layer 2 (Internal 1)

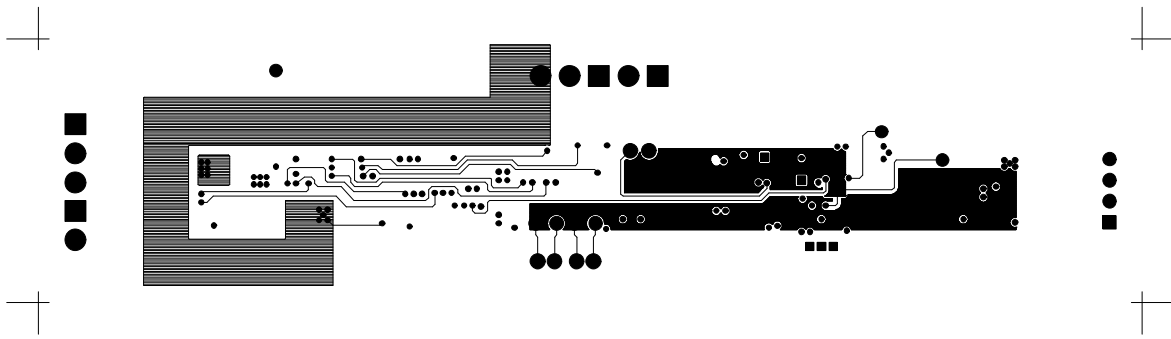


Figure 5. Layer 3 (Internal 2)

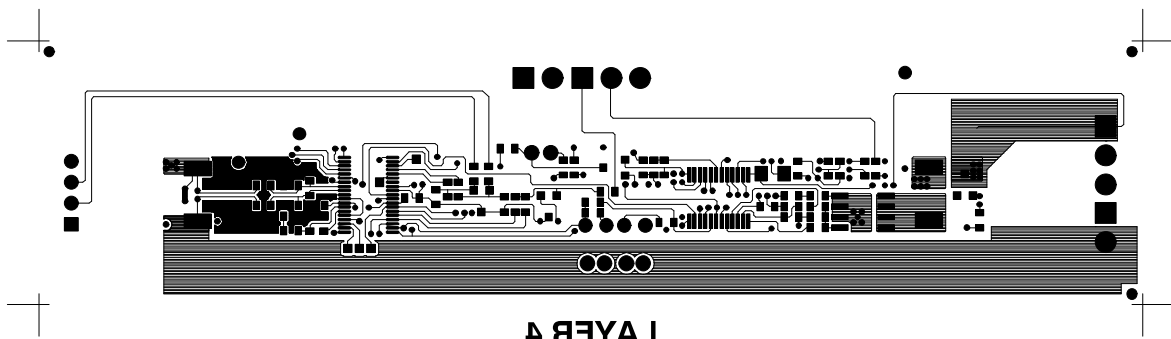


Figure 6. Layer 4

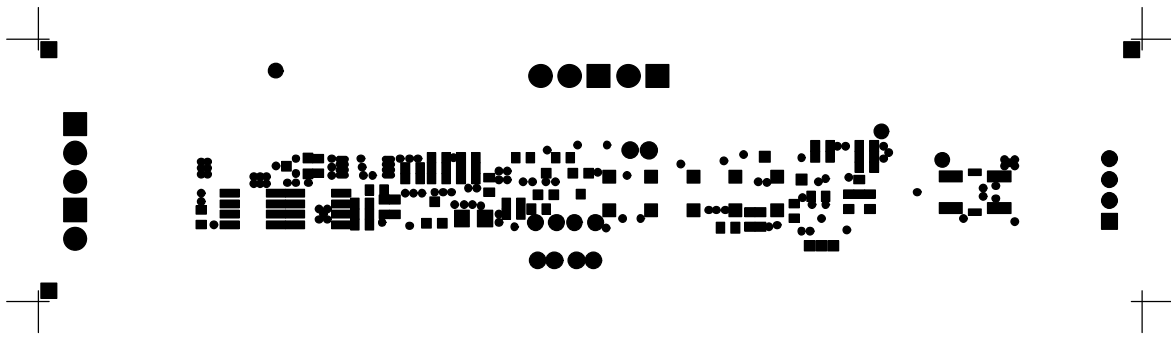


Figure 7. Mask (Layer 1)

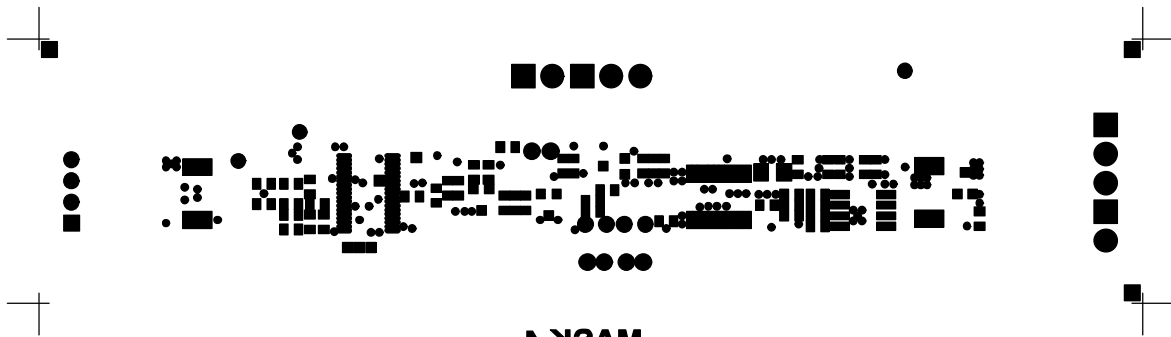


Figure 8. Mask (Layer 4)

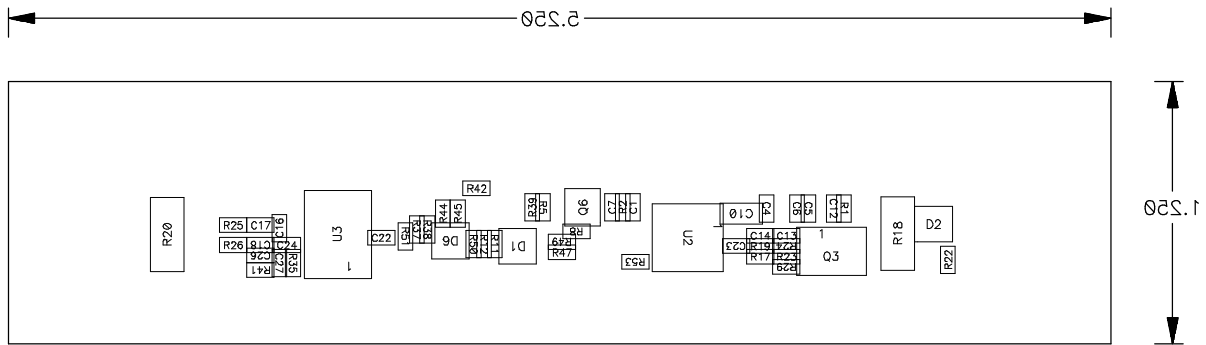


Figure 9. Bottom Assembly

4.2 Bill of Materials
Table 3. Bill of Materials

Count	Ref Des	Description	Size	MFG	Part No.
18	C1, C2, C3, C4, C5, C6, C7, C8, C9, C11, C12, C13, C14, C16, C17, C18, C19, C21	Capacitor, ceramic, 0.1 μ F 50 V, X7R, 20%	603	Any	STD
1	C10	Capacitor, ceramic, 1.0 μ F, 50 V, X7R, 20%	1206	Any	STD
0	C36	Capacitor, ceramic, 0.1 μ F, 16 V, X7R, 10%	603	Any	STD
1	C15	Capacitor, ceramic, 0.047 μ F, 50 V, X7R, 10%	603	Any	STD
1	C20	Capacitor, ceramic, 4.7 μ F, 16 V, X7R, 10%	1206	Any	STD
5	C19, C22, C24, C28, C29	Capacitor, ceramic, 0.47 μ F, 16 V, X7R, 10%	603	Any	STD
1	C26	Capacitor, ceramic, 2200 pF, 16 V, COG, 10%	603	Any	STD
1	C27	Capacitor, ceramic, 150 pF, 16 V, COG, 10%	603	Any	STD
2	D1, D6	Diode, dual, Zener, 5.6 V, 300 mW	SOT23	Vishay-Telefunken	AZ23C5V6
1	D2	Diode, dual ultra fast, series, 200 mA, 70 V	SOT23	Fairchild	BAV99
5	D3, D5, D7, D8, D9	Diode, LED, green, Gullwing, GW type, 20 mA, 7.5 mcd Typ	Gullwing	Panasonic	LN1361C
1	D4	Diode, dual Schottky, 200 mA, 30 V	SOT23	Vishay-Liteon	BAT54C
1	D10	Diode, Schottky	SOT23	Vishay-Liteon	BAT54C
1	J1	Header, friction lock assembly, 4-pin right angle	0.400 x 0.500	Molex	22-05-3041
3	Q1, Q2, Q3	MOSFET, P-ch, 30 V, 8.0 A, 20 m Ω	SO8	Vishay-Siliconix	Si4435DY
2	Q4, Q6	MOSFET, N-ch, 60 V, 115 mA, 1.2 Ω	SOT23	Vishay-Liteon	2N7002DICT
1	Q5	MOSFET, P-ch, 50 V, 130 mA, 10 Ω	SOT23	Vishay	BSS84
16	R1, R2, R3, R8, R9, R10, R13, R14, R15, R25, R26, R30, R37, R38, R44, R45	Resistor, chip, 100 Ω , 1/16 W, 5%	603	STD	STD
0	R29	Resistor, chip, 4.99 k Ω , 1/16 W, 1%	603	STD	STD
5	R11, R12, R22, R24, R28	Resistor, chip, 4.99 k Ω , 1/16 W, 1%	603	STD	STD
0	R17	Resistor, chip, 100 k Ω , 1/16 W, 5%	603	STD	STD
7	R16, R19, R31, R33, R34, R39, R42	Resistor, chip, 100 k Ω , 1/16 W, 5%	603	STD	STD
1	R18	Resistor, chip, 300 Ω , 1 W, 1%	2512		RCW-2512-301-F
1	R20	Resistor, chip, 0.020 Ω , 1 W, 1%	2512	Vishay	WSL-2512-0
5	R21, R23, R27, R50, R51	Resistor, chip, 1 M Ω , 1/16 W, 5%	603		
1	R32	Resistor, chip, 10 Ω , 1/16 W, 5%	603	STD	STD
1	R35 ⁽¹⁾	Resistor, chip, 100 k Ω , 1/16 W, 0.2%, 75 PPM	603	Vishay	TNPW06031003BT9RT1
5	R36, R40, R43, R46, R48	Resistor, chip, 470 Ω , 1/16 W, 5%	603	STD	STD
4	R4, R5, R6, R7	Resistor, chip, 1 k Ω , 1/16 W, 5%	603	STD	STD
2	R41, R47	Resistor, chip, 61.9 k Ω , 1/16 W, 1%	603	STD	STD
2	R49, R53	Resistor, chip, 8.45 k Ω , 1.16 W, 1%	603	STD	STD
2	RT1, RT2	Thermistor, 10 k Ω	0.095 x 0.150	Sematec	NTC103AT-2

(1) Reference designators marked with an asterisk (**) cannot be substituted. All other components can be substituted with equivalent MFG's components.

Table 3. Bill of Materials (continued)

Count	Ref Des	Description	Size	MFG	Part No.
1	SW1	Switch, push button, momentary, N.O. low profile	5 mm x 5 mm	Panasonic	EVQ-PLHA15
2	TB1, TB2	Terminal block, 3 pin, 6 A, 3.5 mm	0.41 x 0.25	OST	ED1515
2	TB3, TB4	Terminal block, 2 pin, 6 A, 3.5 mm	0.27 x 0.25	OST	ED1514
3	TP1, TP4, TP5	Test point, cir		Farnell	240-333
1	U1	IC, voltage protection for 2, 3, or 4 cell Li-Ion, 2nd protection, x.xx	TSSOP-08	TI	bq29400PW ⁽²⁾⁽³⁾⁽⁴⁾
1	U2	IC, 2, 3, or 4 cell series protection control AFE	TSSOP24	TI	bq29312PW ⁽²⁾⁽³⁾⁽⁴⁾
1	U3	IC, advanced gas gauge	TSSOP38	TI	bq20z80DBT ⁽²⁾⁽³⁾⁽⁴⁾⁽⁵⁾
1	—	PCB		Any	HPA059
Connector⁽⁶⁾					
2	J5 mate	Connector, Female, 0.100 centers		Molex	22-01-3407
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 inch		Any	Any

⁽²⁾ This assembly is ESD sensitive.

⁽³⁾ This assembly must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.

⁽⁴⁾ This assembly must comply with workmanship standards IPC-A-610 Class 2.

⁽⁵⁾ Ensure that the latest version of firmware available at <http://power.ti.com> is used. Refer to *Updating Firmware With the bq20z80 and EVM* (SLUA366) for further details.

⁽⁶⁾ Make one SMBus connector wire assembly for each assembly produced, from J5 mate, 4-24 awg wires, and crimp terminals. Wire colors for pin numbers are listed below. The wire assembly shall have a J5 mate on each end.

- Red - Pin #4 (Signal USB_5V)
- Brown - Pin #3 (Signal Data)
- White - Pin #2 (Signal Clock)
- Black - Pin #1 (GND)

4.3 bq20z80/bq29312/bq29401 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq20z80/ bq29312/bq29401 circuit module.

Table 4. Performance Specification Summary

Specification	Min	Typ	Max	Units
Input voltage Pack+ to Pack-	6		25	V
Charge and discharge current			See (1)	A

(1) Maximum currents are determined by the value of the sense resistor used and the short-circuit threshold setting of the bq29312. It is important to operate this EVM within the input voltage range of 6 V and 25 V, with a maximum voltage drop across the sense resistor of +2150 mV (1-W power dissipation).

5 EVM Hardware and Software Setup

This section describes how to install the bq20z80EVM-102 PC software, and how to connect the different components of the EVM.

5.1 System Requirements

The bq20z80EVSW 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 bq20z80 tool folder on power.ti.com. Use the following steps to install the bq20z80EVSW software:

1. Copy the files from the CD into the temporary directory you selected, open the archive TI USB DRVRS.zip, and extract its contents in a subdirectory/drivers. Choose preserve *directory structure* option when extracting. Alternatively, run SETUP.EXE from the same directory.
2. Plug the EV2300 into a USB port.
3. Wait until system prompt *new hardware found* appears. Choose *select location manually*, and use the *browse* button to point to subdirectory TIUSBWin2K-XP-1.
4. Answer *continue* to the warning that drivers are not certified with Microsoft.
5. After installation finishes, another system prompt *new hardware found* appears. Repeat procedure above, but point to subdirectory TIUSBWin2K-XP-2
6. Answer *continue* to the warning that drivers are not certified with Microsoft. Installation of drivers is now finished.
7. For Windows 98, point to directory TIUSBWin98.
8. Return to the temporary directory where you extracted files; double-click on the *Setup.exe* icon to install EV Software.

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 - 8.

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 bq20z80EVM-001 comprises three hardware components: the bq20z80/bq29312/bq29401 circuit module, the EV2300 PC interface board, and the PC.

7.1 Connecting the bq20z80/bq29312/bq29401 Circuit Module to a Battery Pack

Figure 10 shows how to connect the bq20z80/bq29312/bq29401 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 PRES pin to PACK- pin to set SYS PRES state. To test sleep mode, disconnect the PRES pin.

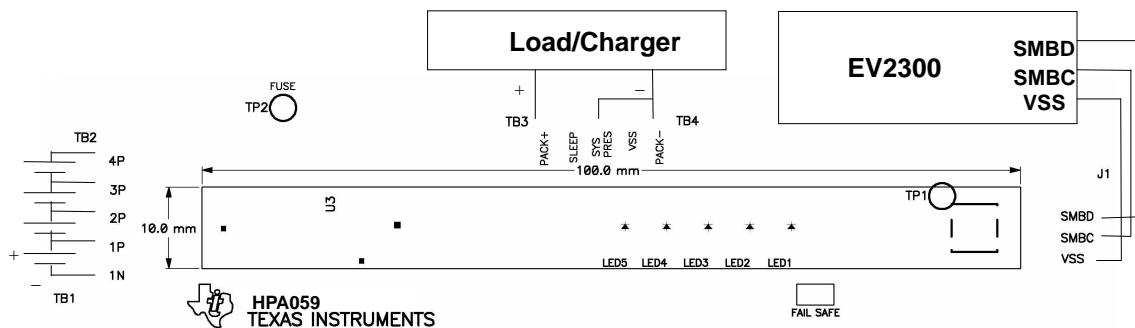


Figure 10. bq20z80/bq29312 Circuit Module Connection to Cells and System Load/Charger

7.2 PC Interface Connection

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

1. Connect the bq20z80/bq29312-based smart battery to the EV2300 using wire leads as shown in Table 5.

Table 5. Circuit Module to EV2300 Connections

bq20z80/bq29312-Based Battery	EV2300
SMBD	SMBD
SMBC	SMBC
VSS	GND

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

The bq20z80EVM-001 is now set up for operation.

8 Operation

This section details the operation of the bq20z80 EVSW software.

8.1 Starting the Program

Run bq20z80 EVSW from the Start | Programs | Texas Instruments | bq20z80 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 bq20z80 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 scan interval because this results in the same value being logged at least twice.



Figure 11. 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 bq20z80 and bq29312 Options

The bq20z80 data flash comes configured per the default settings detailed in the bq20z80 data sheet. Ensure that the settings are correctly changed to match the pack and application for the bq20z80/bq29312 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.

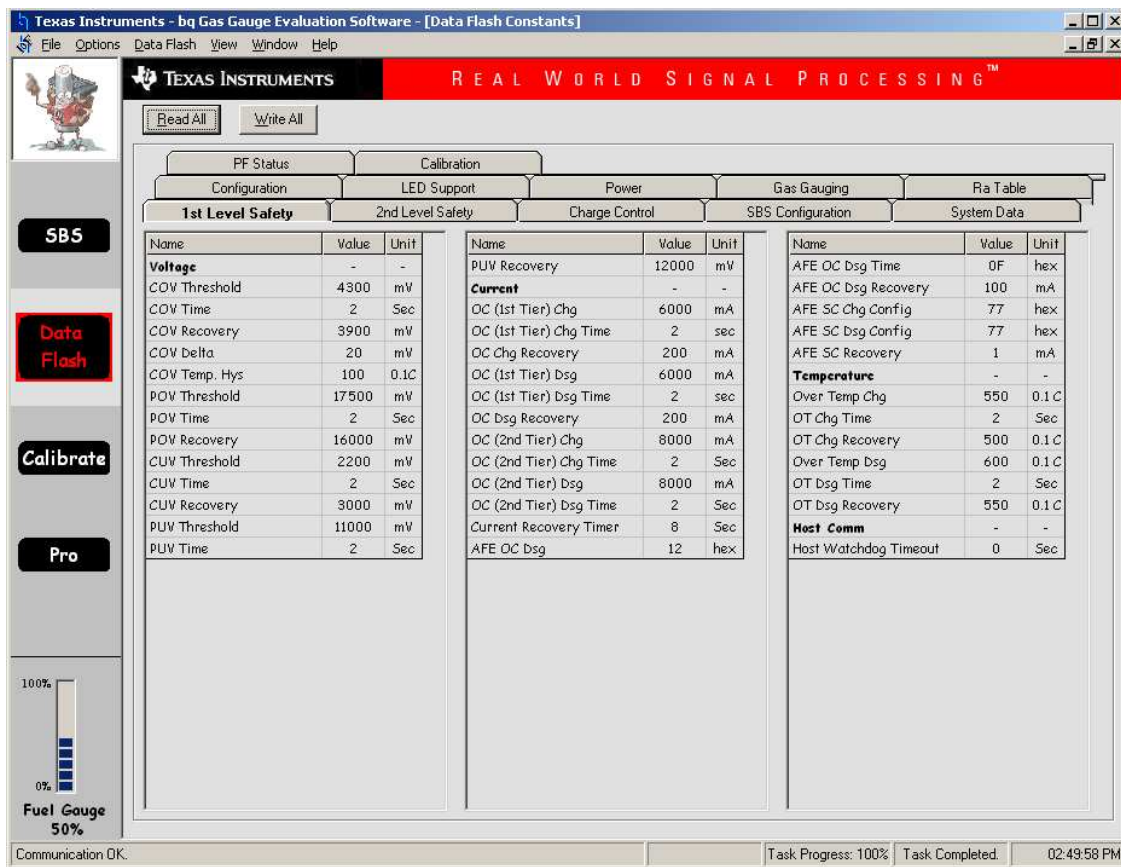


Figure 12. Data Flash Screen, 1st Level Safety Class

To read all the data from the bq20z80 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.

Operation

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 bq20z80 using the | Write All | button.

The configuration information of the bq29312 and module calibration data is also held in the bq20z80 data flash.

The bq20z80 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 bq20z80 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 bq20z80 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 bq20z80

Select the types of calibration to be performed.

Enter the measured values for the types selected.

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* checkbox.

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* 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.

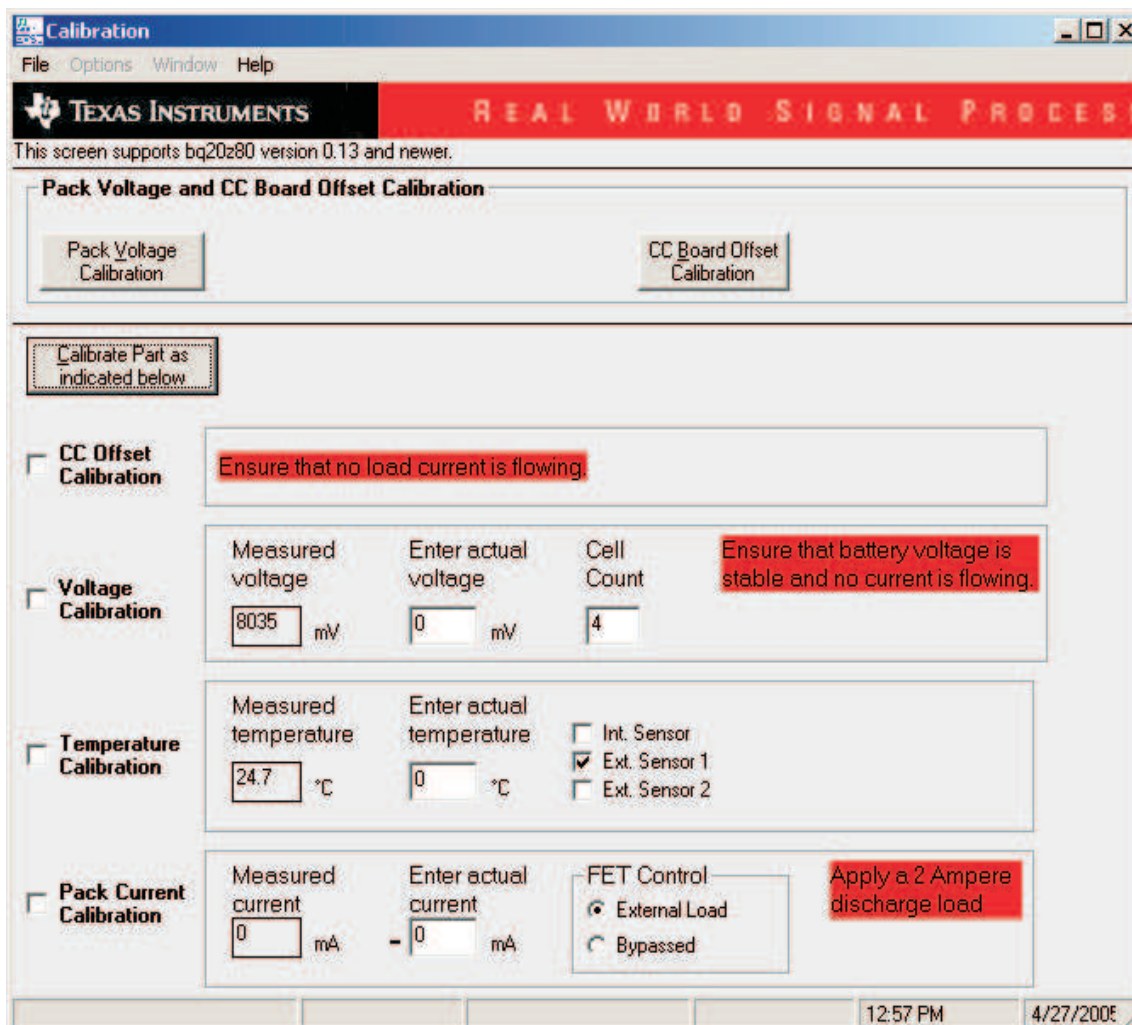


Figure 13. Calibration Screen

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 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.

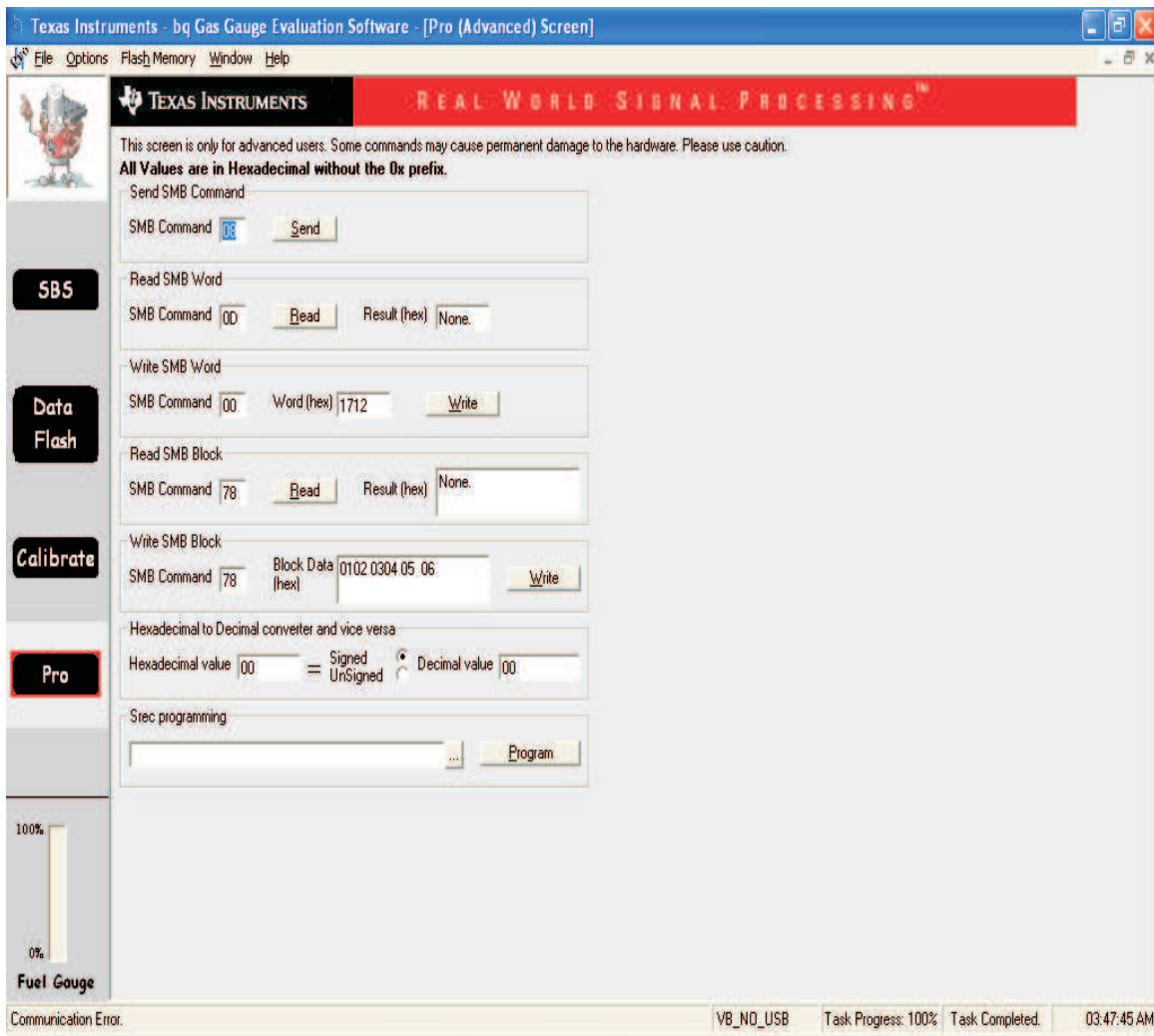


Figure 14. Pro (Advanced) Screen

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

Data Sheets:

bq20z80-V102

bq29312

Literature Number:[SLUS681](#)[SLUS546](#)

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FCC Warnings

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

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It is user's responsibility to ensure that persons handling the EVM and the product have electronics training and observe good laboratory practice standards.

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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.

EVM WARNINGS AND RESTRICTIONS (continued)

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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