bq33100 Super Capacitor Pack Manager EVM

> **NOTE:** BEFORE YOU START: Download the latest revision of the device firmware and the evaluation software from the TI bq33100 product page at www.ti.com. Go to the *Tools and Software* section. For step-by-step instructions on reprogramming the device firmware, refer to the application report SLUA336B.

This evaluation module (EVM) is a complete evaluation system for the bq33100 super capacitor manager. The EVM includes one bq33100 circuit module. An EV2300 PC interface board for gas gauge interface and a PC USB cable are required for communication with a PC and can be ordered online. Windows™-based PC software is available online as well. The circuit module includes one bq33100 integrated circuit (IC), charging circuitry, and all other onboard components necessary to monitor and predict state of health, perform charging, perform cell balancing, monitor critical parameters, and protect the super capacitors from overvoltage, short-circuit, and overtemperature in 2-, 3-, 4-, or 5-series super capacitor stacks. The circuit module connects directly across the super capacitor stack. With the EV2300 interface board and software, the user can read the bq33100 data registers, program the chipset for different stack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the bq33100 under different conditions.

Contents

List of Figures

Windows is a trademark of Microsoft.
All other trademarks are the property of their respective owners.

1 Features

- Complete evaluation system for the bq33100 SBS 1.1-compliant super capacitor management 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

- bq33100 circuit module
- Set of support documentation

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq33100EVM-001	Super Capacitor	2, 3, 4, or 5 cell	Any

2 bq33100-Based Circuit Module

The bq33100-based circuit module is a complete and compact example solution of a bq33100 circuit for super capacitor management and protection. The circuit module incorporates a bq33100 battery monitor IC, charging circuitry and all other components necessary to accurately predict the capacity of 2-, 3-, 4-, or 5-series cells.

2.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- Direct connection to the cells: 1N, 1P, 2P, 3P, 4P, 5P
- To the serial communications port (SMBC, SMBD)
- The system load across CAPOUT and VSS
- The system power across System PWR and System GND
- To the fault pin (FAULT)

PIN NAME	DESCRIPTION
1N	-ve connection of first (bottom) cap
1P	+ve connection of first (bottom) cap
2P	+ve connection of second cap
3P	+ve connection of third cap
4P	+ve connection of fourth cap
5P	+ve connection of fifth (top) cap
SMBC	Serial communication clock port
SMBD	Serial communication data port

PIN NAME	DESCRIPTION
CAPOUT	System load positive terminal
VSS	System load negative terminal
System PWR	System power positive terminal
System GND	System power negative terminal
FAULT	Fault indicator pin

3   bq33100 Circuit Module Schematic

This section contains information to consider when changing the cell configuration.

3.1   Schematic

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

3.1.1   Modifications for Changing the Cell Configuration

The bq33100 charger provides the option for changing the 4 voltage levels for various cell configurations. The default configuration assumes a 5-cell configuration. An adjustment to these voltages will need to be made for 2-, 3-, or 4- cell configurations. Adjusting the charging levels requires changing out R5, R6, and R7. See Table 2 for common 2-, 3-, 4-, and 5- cell configurations.

Table 2. Common Charging Voltage Configurations for 2-, 3-, 4-, and 5- Cell Monitors

	2-Cell	3-Cell	4-Cell	5-Cell
R4	30kΩ	30kΩ	30kΩ	30kΩ
R5	137kΩ	93.1kΩ	68.1kΩ	57.6kΩ
R6	300kΩ	187kΩ	150kΩ	125kΩ
R7	44.2kΩ	19.6kΩ	12.7kΩ	9.31kΩ

Another modification to consider is to R26. This resistor is used to dissipate extra power in the learn load circuit. For 4- and 5-cell configurations the resistor should be 7.5 Ω, 2 W. For 2- and 3-cell configurations, R26 should be removed.

4   Circuit Module Physical Layouts and Bill of Materials

This section contains the board layout, bill of materials, and assembly drawings for the bq33100 circuit module.

4.1   Board Layout

This section shows the dimensions, PCB layers (Figure 1 through Figure 7), and assembly drawing for the bq33100 module.
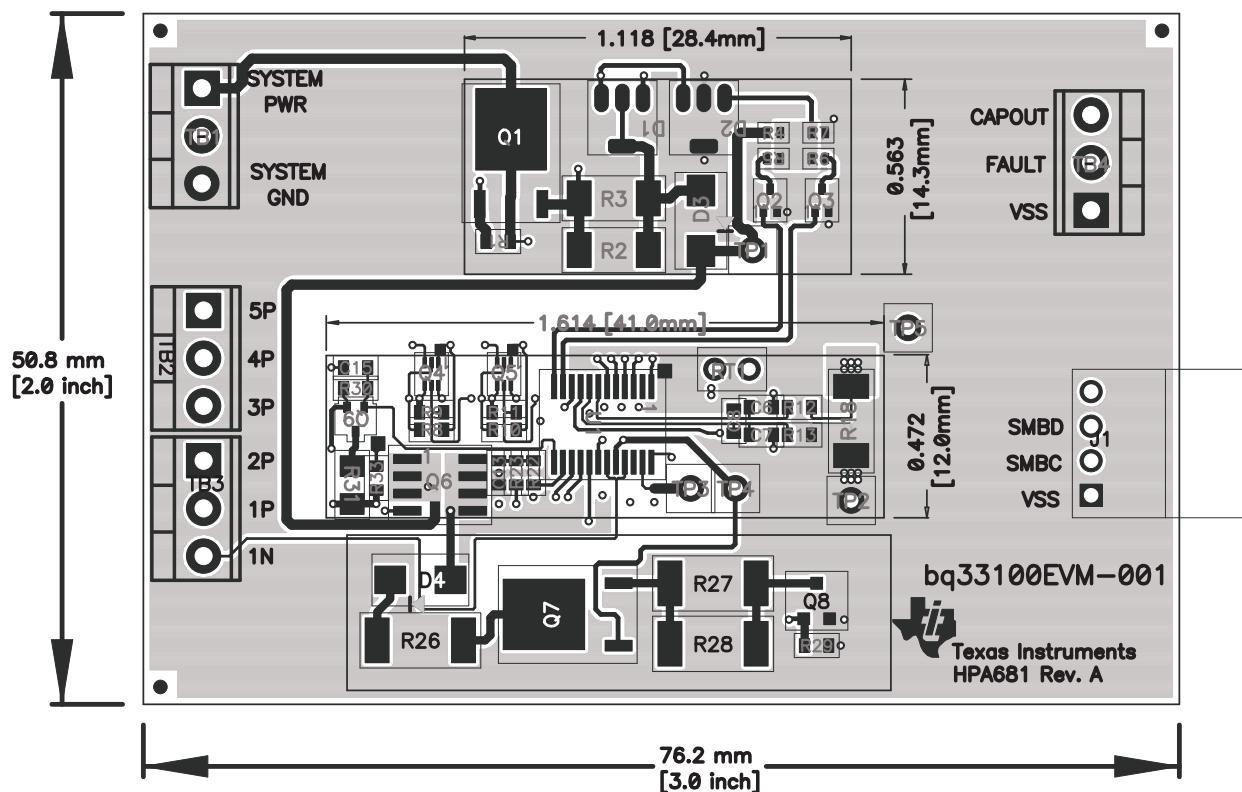
**Figure 1. bq33100EVM-001 Layout (Silk Screen)**
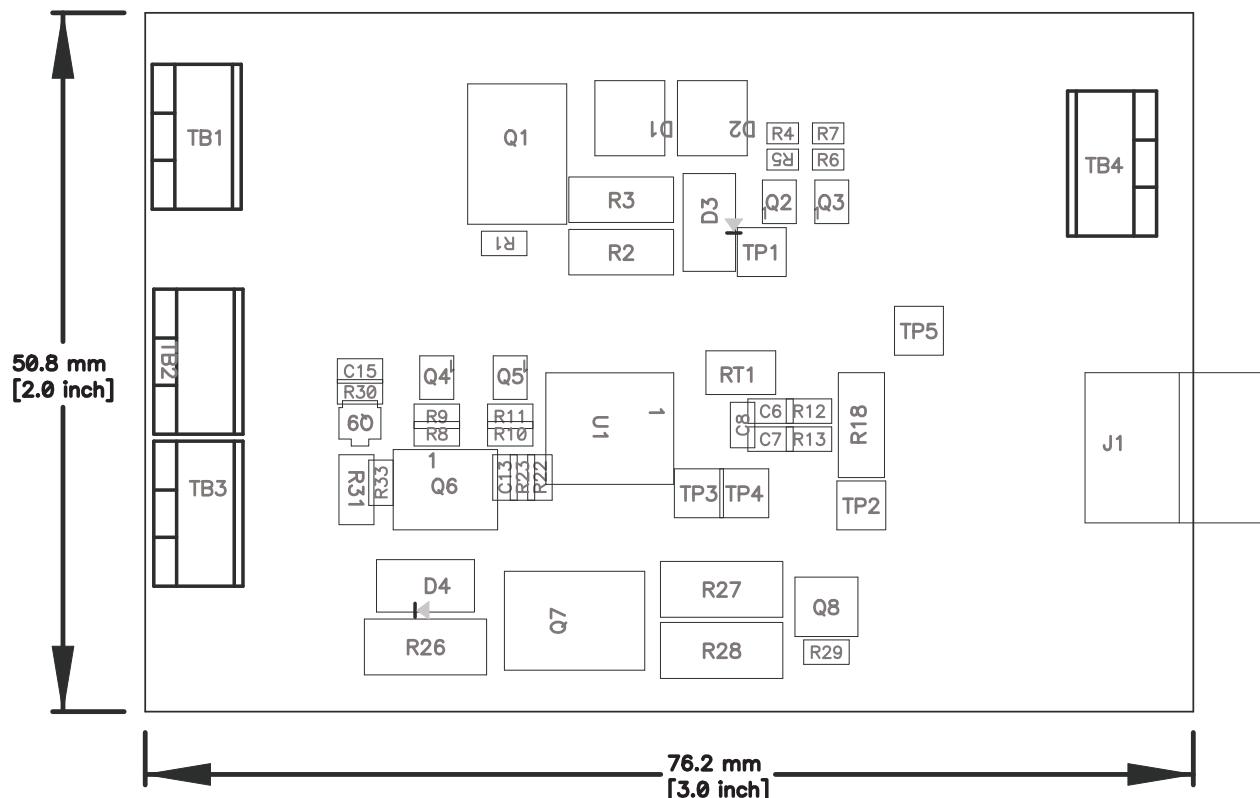
Figure 2. Top Assembly
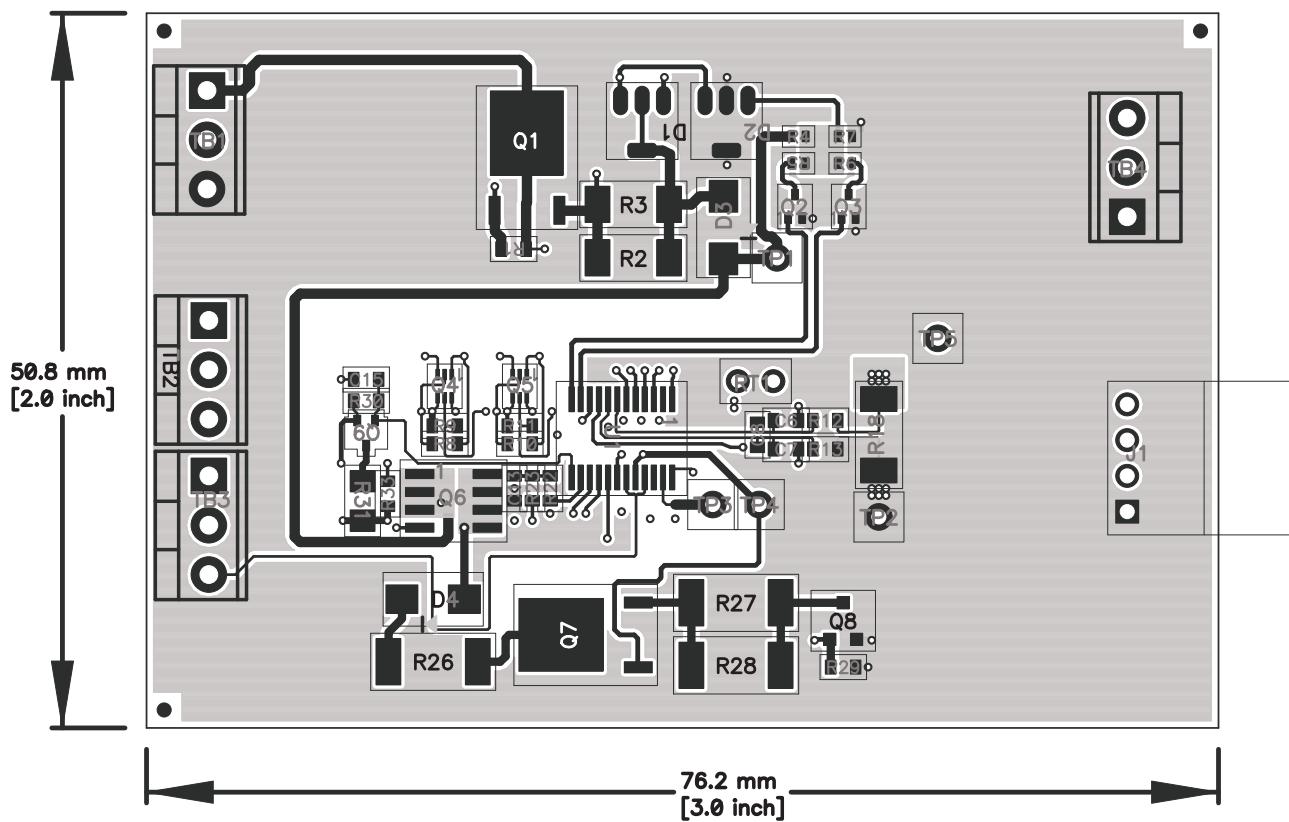
Figure 3. Top Layer
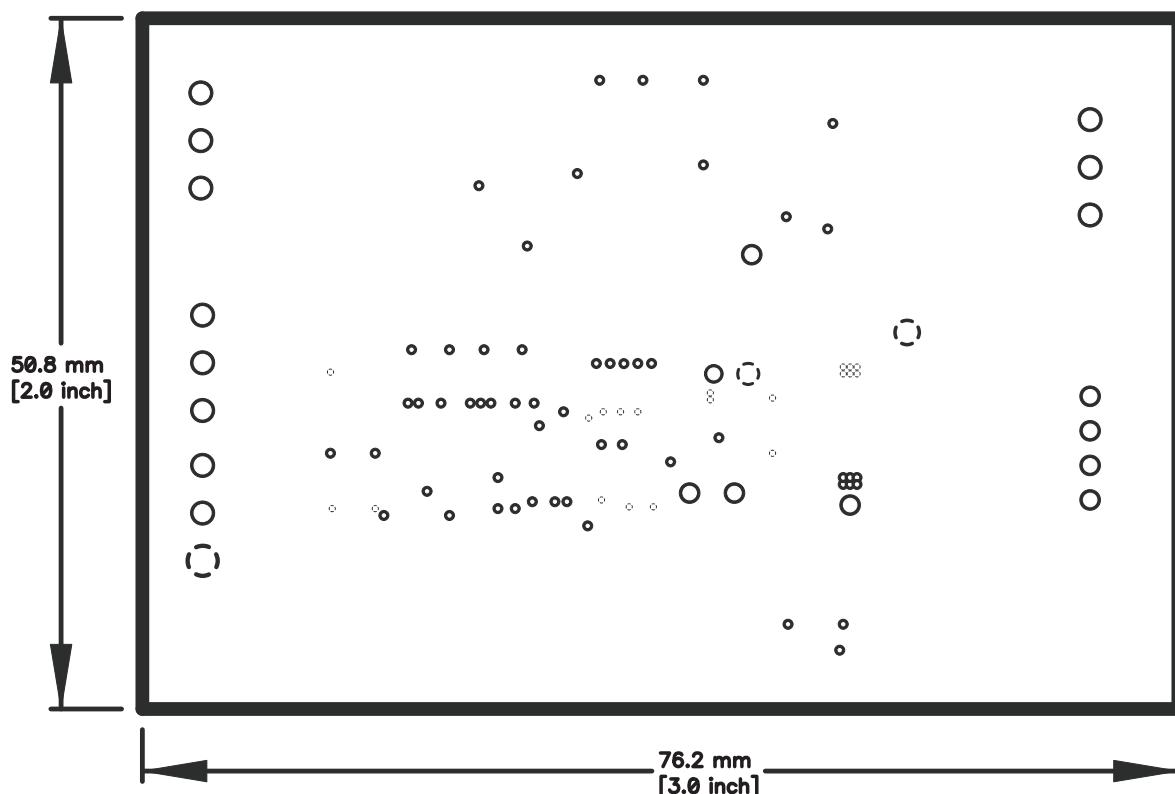
Figure 4. Internal Layer 1
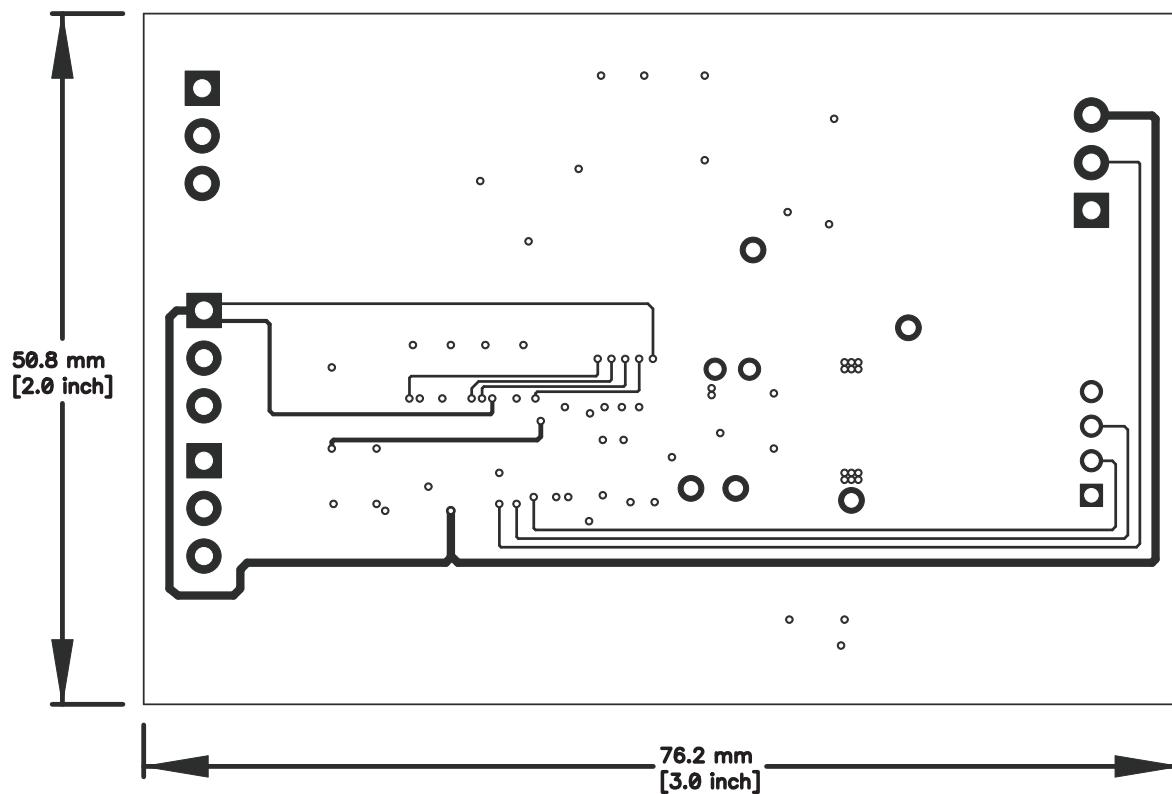
Figure 5. Internal Layer 2
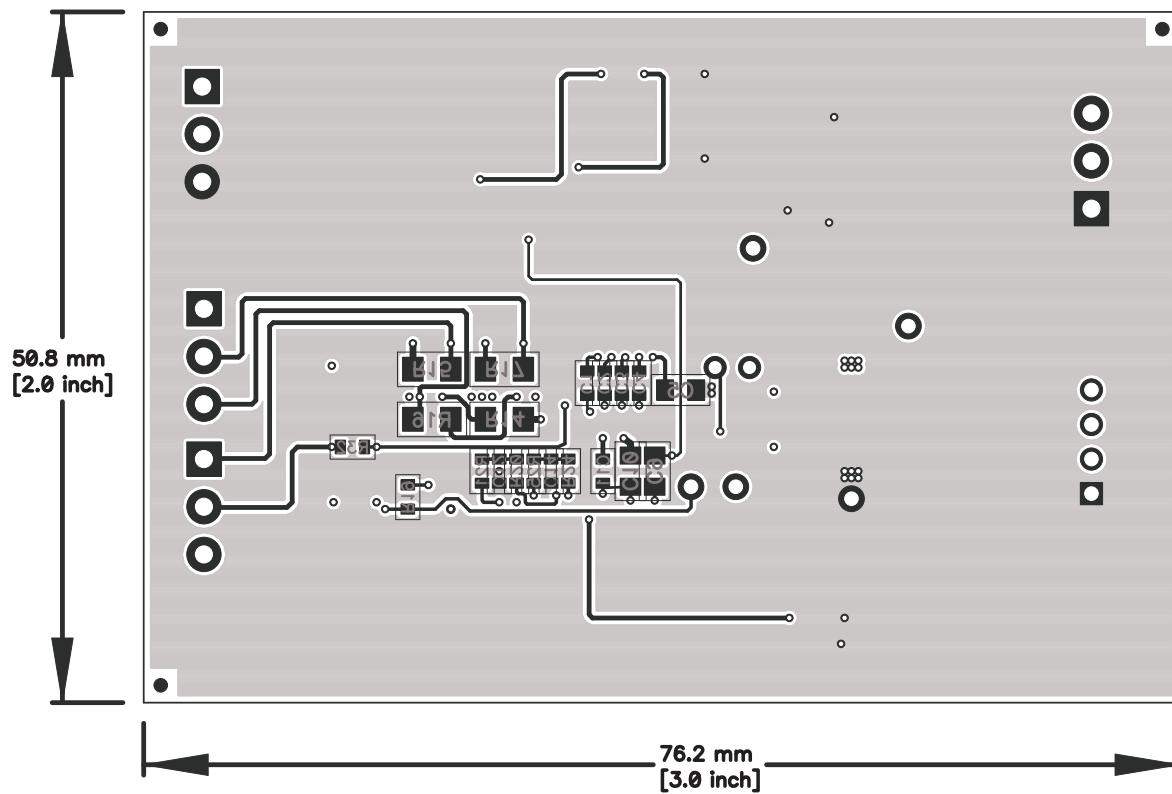
Figure 6. Bottom Layer
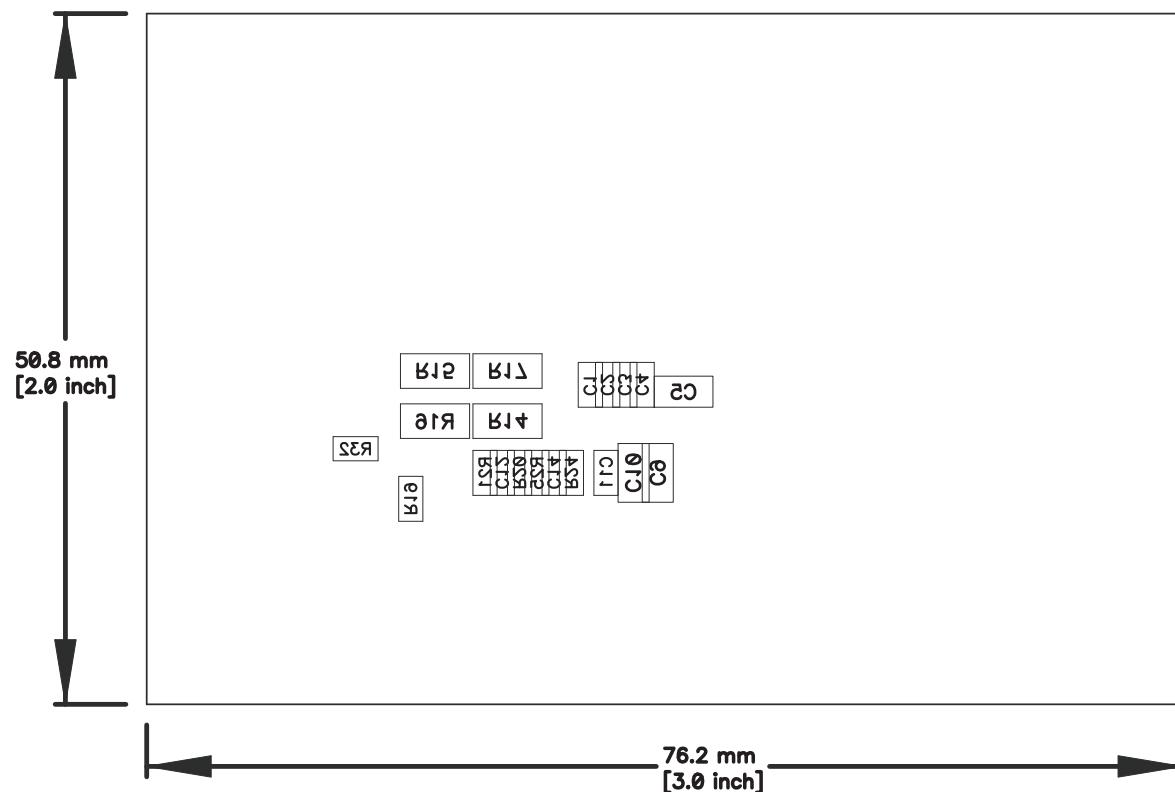
Figure 7. Bottom Assembly

4.2 Bill of Materials and Schematic

Table 3. Bill of Materials

COUNT	RefDes	Value	Description	SIZE	Part Number	Mfr
9	C1, C2, C3, C4, C6, C7, C8, C11, C15	0.1 µF	Capacitor, Ceramic, 50V, X7R, 20%	0603	STD	Any
3	C12, C13, C14	100 pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	Any
3	C5, C9, C10	1.0 µF	Capacitor, Ceramic, 25V, X7R, 20%	0805	STD	Any
2	D1, D2	TL431CPK	IC, Adjustable precision shunt regulator	SOT-89	TL431CPK	TI
2	D3, D4	S1A-13-F	Diode, Glass Passivated Rect. 1A, 50V	SMA	S1A-13-F	Diodes
1	J1	22-05-3041	Header, Friction Lock Ass'y, 4-pin Right Angle	0.400 x 0.500	22-05-3041	Molex
2	Q1, Q7	2SD1758TLR	Transistor, NPN Medium Power, 32V, 2A	SC-63	2SD1758TLR	Rohm
2	Q2, Q3	2SK3019	MOSFET, Nch, 30V, 100mA, 8 Ohm	SC-75A	2SK3019	Rohm
2	Q4, Q5	Si1023X	MOSFET, Pch, -20V, 350mA, 1.2 Ohm	SC-89	Si1023X-T1-E3	Vishay
1	Q6	Si4435DDY	MOSFET, Pch, 30V, 8.0A, 20 milliohm	SOT23	Si4435DDY-T1-E3	Vishay
1	Q8	ZXMN3A14FTA	MOSFET, Nch, 30V, 3.2A, 65 milliOhm	SOT23	ZXMN3A14FTA	Diodes/Zetex
1	Q9	BSS223PW	MOSFET, Pch, -20V, -0.39A, 1.2 Ohm	SOT323	BSS223PW	Infineon
5	R1, R8, R9, R10, R11	1K	Resistor, Chip, 1/16W, 5%	0603	STD	Any
5	R12, R13, R21, R23, R25	100	Resistor, Chip, 1/16W, 5%	0603	STD	Any
5	R14, R15, R16, R17, R31	100	Resistor, Chip, 1/4W, 5%	1206	CRCW1206100RJNEA	Vishay
1	R18	.020 75ppm	Resistor, Chip, 1/2W, 1%, 75ppm	2010	WSL2010R0200FEA	Dale
1	R19	3M	Resistor, Chip, 1/16W, 5%	0603	STD	Any
2	R2, R3	10	Resistor, Chip, 1W, 1%	2010	CRCW201010R0FKEFHP	Vishay/Dale
3	R20, R22, R24	200	Resistor, Chip, 1/16W, 5%	0603	STD	Any
1	R26	7.5	Resistor, Chip, 2W, 1%	2512	RHC2512FT7R50	Stackpole
2	R27, R28	8.2	Resistor, Chip, 1W, 1%	2512	ERJ-1TRQF8R2U	Panasonic - ECG
0	R29	DNP	Resistor, Chip, 1/16W, 5%	0603	STD	Any
1	R30	20K	Resistor, Chip, 1/16W, 5%	0603	STD	Any
1	R32	20K	Resistor, Chip, 1/16W, 1%	0603	STD	Any
1	R33	10K	Resistor, Chip, 1/16W, 1%	0603	STD	Any
1	R4	30.0K	Resistor, Chip, 1/16W, 1%	0402	STD	Any
1	R5	57.6K	Resistor, Chip, 1/16W, 1%	0402	STD	Any
1	R6	124K	Resistor, Chip, 1/16W, 1%	0402	STD	Any
1	R7	9.31K	Resistor, Chip, 1/16W, 1%	0402	STD	Any

Table 3. Bill of Materials (continued)

COUNT	RefDes	Value	Description	SIZE	Part Number	Mfr
1	RT1	10K	Thermistor, 10K Ohm	0.095 x 0.150 inches	103AT-2	Semitec
4	TB1, TB2, TB3, TB4	ED555/3DS	Terminal Block, 3-pin, 6A, 3.5mm	0.41 x 0.25 inch	ED555/3DS	OST
1	TP1	CHG+	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	TP2	CHG-	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	TP3	CHGFET	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	TP4	2.7V	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	TP5	GND	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	U1	BQ33100PW	IC, SUPERCAP PACKMANAGER and PROTECTION	TSSOP-24	BQ33100PW	TI
1	–		PCB	2 x 3 inches	HPA681	Any
Connector						
2		J1 mate	Connector, Female, 0.100 Centers		Molex	22-01-3047
8		N/A	Terminals, Crimp, Tin		Molex	08-50-0114
1		N/A	Wire, Insulated 24 Awg, Red, 18 Inches (+/- 3 inches)(USB_5V)		Alpha	1854-3
1		N/A	Wire, Insulated 24 Awg, White, 18 Inches (+/- 3 inches)(SCL)		Alpha	1854-1
1		N/A	Wire, Insulated 24 Awg, Black, 18 Inches (+/- 3 inches)(GND)		Alpha	1854-2
1		N/A	Wire, Insulated 24 Awg, Brown, 18 Inches (+/- 3 inches) (SDA)		Alpha	1854-7
1		N/A	Heatshrink 1"		Any	Any

Table 3. Bill of Materials (continued)

COUNT	RefDes	Value	Description	SIZE	Part Number	Mfr

| 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 J1 mate, 4 - 24 Awg wires and Crimp terminals. Wire colors for Pin numbers are listed below. The wire assembly shall have a J1 mate on each end.
	Red - Pin # 4 (Signal USB_5V)
	Brown - Pin # 3 (Signal SDA)
	White - Pin # 2 (Signal SCL)
	Black - Pin # 1 (GND)
	6. RT1 should be assembled horizontally laying flat against the board Edge.

Figure 8. Schematic

© 2011, Texas Instruments Incorporated

4.3   bq33100 Circuit Module Performance Specification Summary

Table 4. Performance Specification Summary

Specification	Minimum	Typical	Maximum	Units
Input Voltage System PWR to System GND	6	12	15	V
Discharge current	0	2	7	A

5   EVM Hardware and Software Setup

This section describes how to install the bq33100EVM-001 PC software, and how to connect the different components of the EVM.

5.1   System Requirements

The bq33100EVSW software requires Windows™ 2000 or Windows XP™. Drivers for Windows 98SE are provided, but Microsoft™ no longer supports Windows 98 and there may be issues in Windows 98 with USB driver support. The EV2300 USB drivers have been tested for Windows 98SE, but no assurance is made for problem-free operation with specific system configurations.

5.2   Software Installation

Get the latest software version in the bq33100 tool folder on www.ti.com, and follow these steps to install the bq33100 EVSW software:

1. Save the archive to a temporary directory. Open the archive containing the installation package, and copy its contents to 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 bq33100 EVM installation.
2. If the EV2300 was not previously installed, after bq33100 EVM installation, a TI USB DRIVER INSTALLER pops up. Click "Yes" for the agreement message and follow its instructions.
3. Plug the EV2300 into a USB port.

6   Troubleshooting Unexpected Dialog Boxes

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

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

The user that is downloading the files must be logged in as the administrator.

The driver is not signed, so the administrator must allow installation of unsigned drivers in the operating system policy.

7   Hardware Connection

The bq33100EVM-001 comprises three hardware components: the bq33100 circuit module, the EV2300 PC interface board, and the PC.

7.1   Connecting bq33100 Circuit Module to Super Capacitor Stack

Figure 9 shows how to connect the bq33100 circuit module to the super capacitors, system load, and system power.

The super capacitors should be connected in the following order:

1. 5-Cell Pack: 1N, 1P, 2P, 3P, 4P, and 5P (see Section 2.1 for definitions).
2. 4-Cell Pack: 1N and 1P are connected together, 2P, 3P, 4P, and 5P.
3. 3-Cell Pack: 1N and 1P are connected together, 2P, 3P, and then connect 4P and 5P together.
4. 2-Cell Pack: 1N and 1P are connected together, 2P, and then connect 3P, 4P and 5P together.

Connect the system load between the CAPOUT and VSS terminals. Connect the system power between the System PWR and System GND terminals.
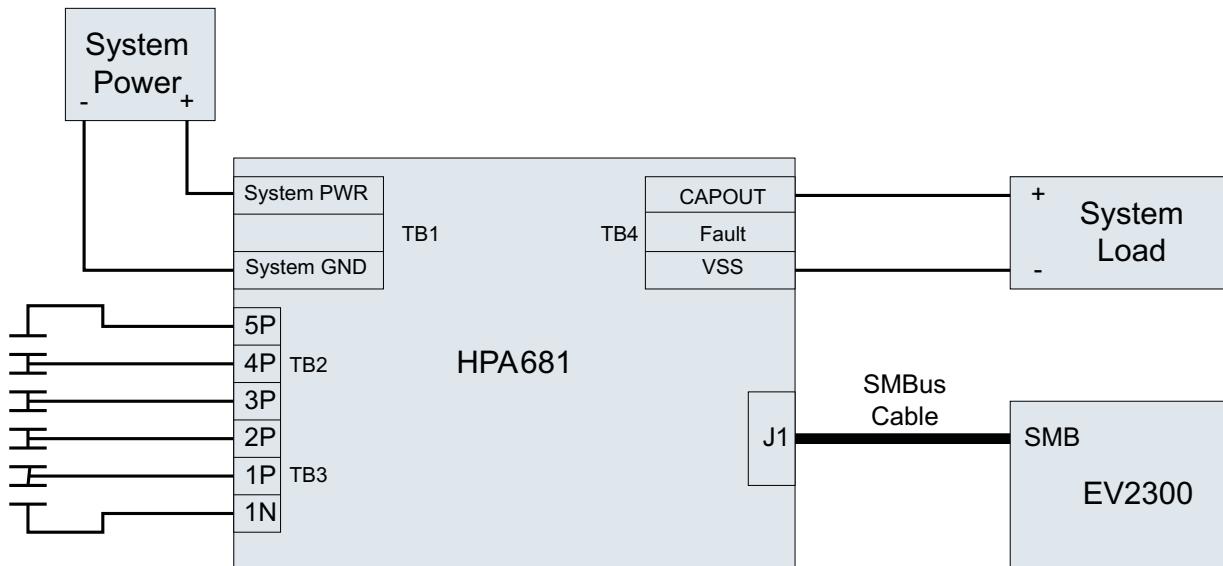

Figure 9. bq33100 Circuit Module Connection to Cells, System Load, and System Power

7.2 PC Interface Connection

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

1. Connect the bq33100 circuit module to the EV2300 using wire leads as shown in Table 5.

Table 5. Circuit Module to EV2300 Connections

bq33100 Circuit Module	EV2300
SMBD	SMBD
SMBC	SMBC
VSS	GND

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

The bq33100EVM-001 is now set up for operation.

8 Operation

This section details the operation of the bq33100 EVSW software.

8.1 Starting the Program

Run bq Evaluation Software from the Start | Programs | Texas Instruments | bq33100 EVSW menu sequence. The SBS Data screen (Figure 10) appears. Data begins to appear once the <Refresh> (single time scan) button is clicked, or when the <Keep Scanning> check box is checked. To disable the scan feature, deselect <Keep Scanning>.

The continuous scanning period can be set via the | Options | and | Set Scan Interval | menu selections. The range for this interval is 0 ms to 65535 ms. Only items that are selected for scanning are scanned within this period.

The bq Evaluation Software provides a logging function which logs the values that were last scanned by EVSW. To enable this function, select the *Start Logging* button, this causes the *Keep Scanning* button to be selected. When logging is *Stopped*, the keep scanning button is still selected and has to be manually unchecked.

The logging intervals are specified under the | Options | menu with the maximum value of 65535 ms. The *Log* interval cannot be smaller than the *Scan* interval because this results in the same value being logged at least twice.
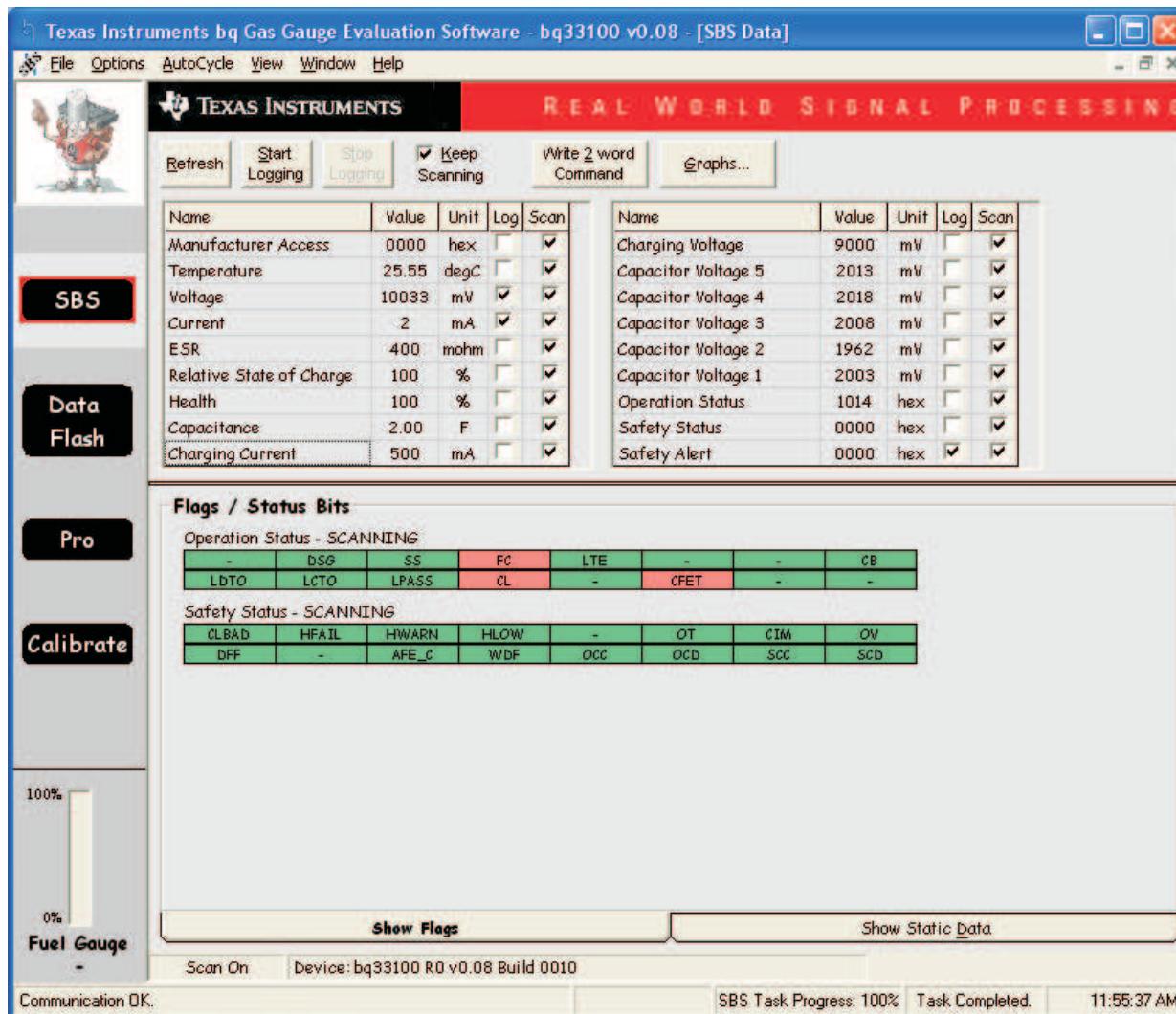

Figure 10. SBS Data Screen

This screen (Figure 10) shows the SBS data set along with additional ManufacturersAccess() command information such as individual cell measurements. Additional Flag and Static data can be viewed by selecting the appropriate tab at the bottom of the SBS screen.

Data such as SBS.ManufacturerName( ) is static and does not change. This data is viewed separately using the *Static Data* tab available at the bottom of the screen.

Dragging the splitter bar (line that separates the Flags/Static data from SBS values) changes the height of the Flags/Static Data display. Selecting | View |, then | Auto Arrange | returns the splitter bar to its original location.

8.2 Setting Programmable bq33100 Options

The bq33100 data flash comes configured per the default settings detailed in the bq33100 data sheet. Ensure that the settings are correctly changed to match the capacitor stack and application for the bq33100 solution being evaluated.

IMPORTANT: The correct setting of these options is essential to get the best performance.

The settings can be configured using the Data Flash screen (Figure 11).
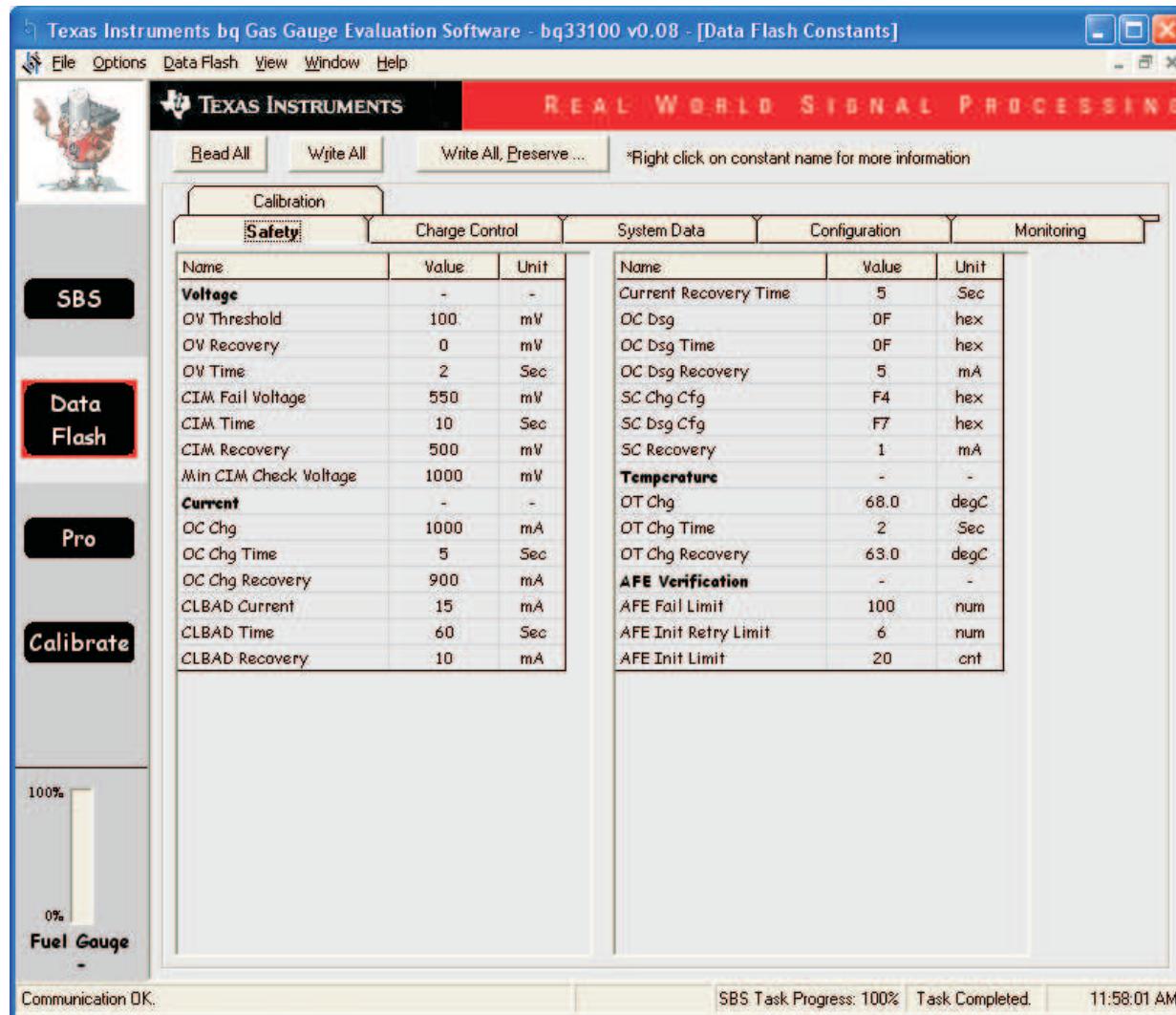
Figure 11. Data Flash Screen, Safety Class

To read all the data from the bq33100 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 bq33100 using the | Write All | button.

The configuration information of the bq33100 and module calibration data also is held in the bq33100 data flash.

The bq33100 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 bq33100 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 bq33100 is calibrated:

- Connect 12V to System PWR and System GND inputs
- Connect a load to CAPOUT and VSS that draws approximately 0.5 A and measures discharge current to use the FET, or
- Connect a current source to 1N and VSS to calibrate without using the FET.
- Measure individual cell stack voltage from 1N, to Cap1(1P), Cap1 + 2(2P), Cap1 + 2 + 3(3P), Cap1 + 2 + 3 + 4(4P), Cap1 + 2 + 3 + 4 + 5(5P).
- Measure the voltage from the System PWR to System GND inputs
- Measure the temperature of the pack.

These steps may not be required, depending on the type of calibration being performed.

Note that voltage calibration with capacitors attached requires special consideration. Capacitors must be in a resting state.

9.2 To Calibrate the bq33100

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

Enter the measured values for the types selected.

If *Capacitor Stack Voltage Calibration* is selected, then enter the capacitor voltages.

If the load is connected between CAPOUT and VSS-, then select the *On (External Load)* radio button.

Press the *Calibrate Part* button.

9.3 System Voltage Calibration

This calibrates the voltage at the VCC pin.

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

Remove load/external voltage applied between CAPOUT and VSS.

Check the *System Voltage Calibration* box, and enter the measured System PWR voltage

Press the *Calibrate device as indicated below* button to calibrate.
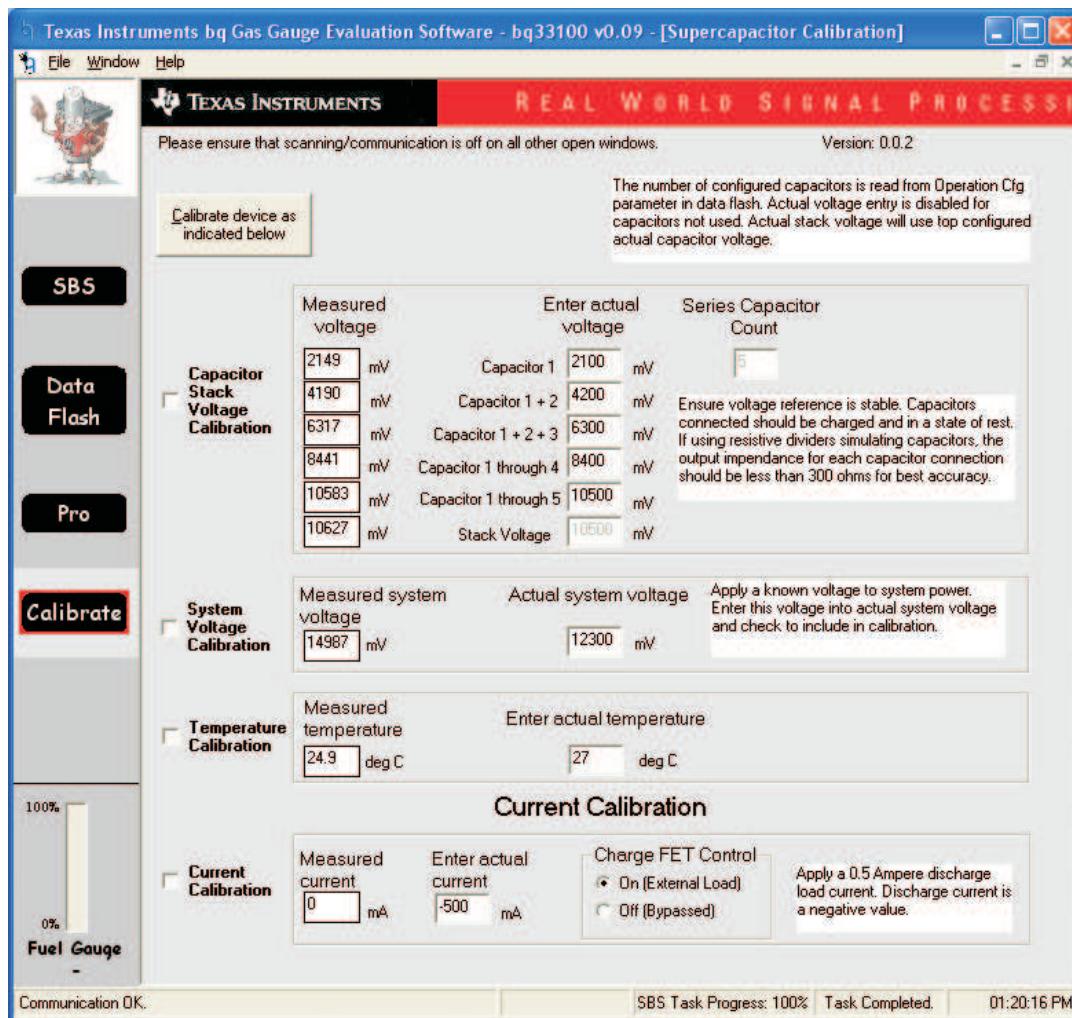
Figure 12. Calibration Screen

10 Pro (Advanced) Screen

10.1 SMB Communication

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

10.2 Hexadecimal/Decimal Converter

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

When scaling converted hexadecimal values to a higher number of bytes, follow these rules:

• When unsigned is selected, the left pad contains zeroes.

• When signed is selected, the left pad contains zeroes for a positive number, or the left pad contains *F* for negative numbers.

10.3 Programming

This screen allows device reprogramming from unencrypted and encrypted files.
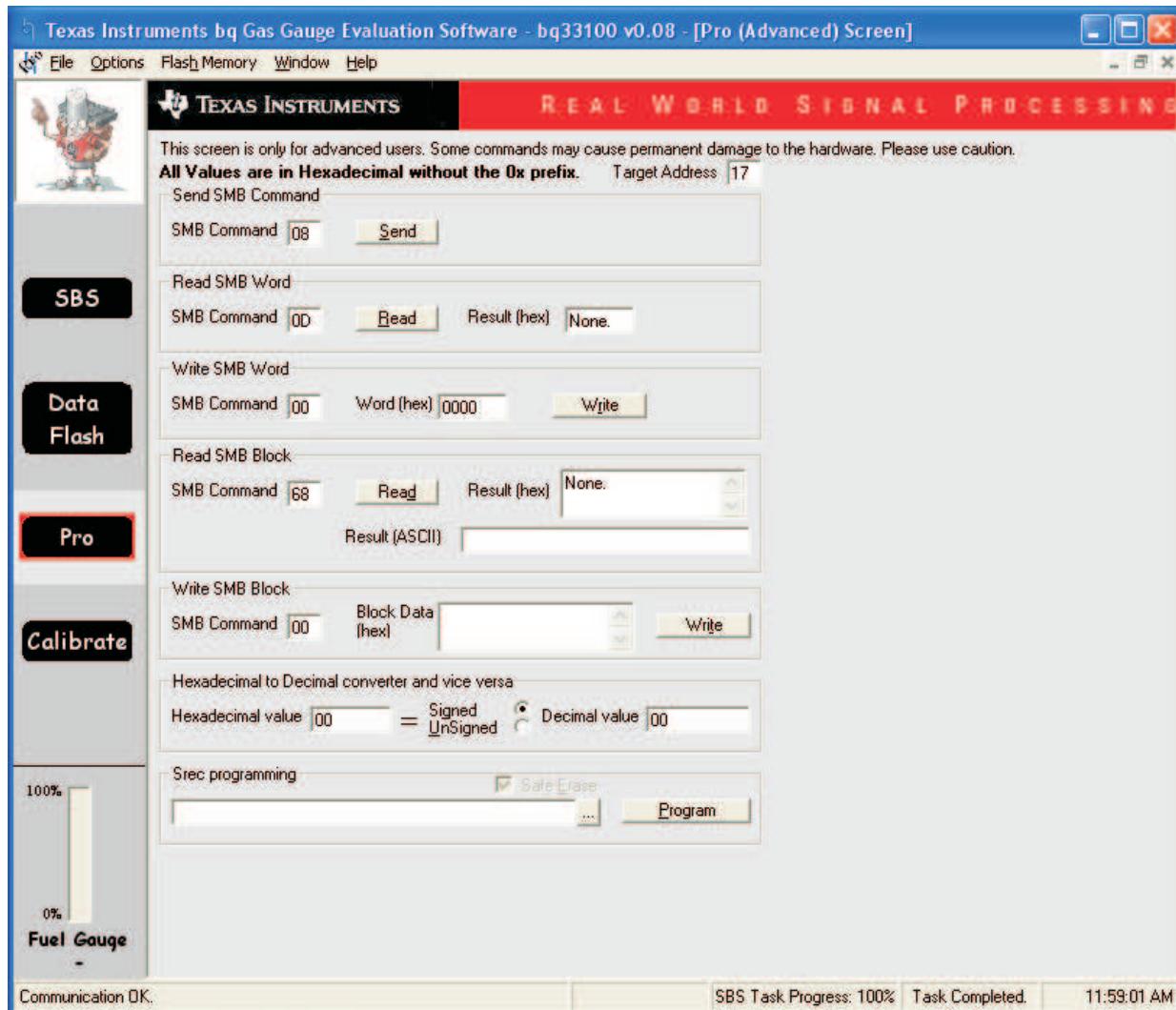
Figure 13. Pro (Advanced) Screen

11   Stack Assembly and the bq33100

This section describes a recommended assembly sequence for a bq33100-based super capacitor stack. This procedure results in the most time-efficient setup of the super capacitor stack. Following are the steps for connecting a 5-series capacitor stack to the bq33100EVM board.
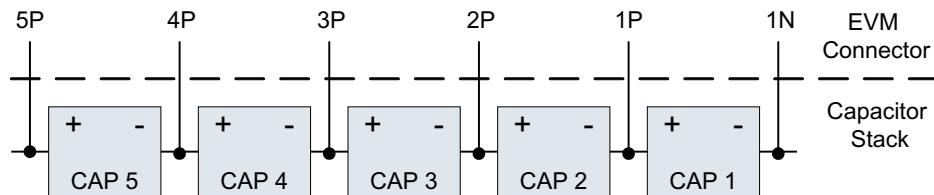
Figure 14. Connection Sequence

1. Connect the most negative terminal (– terminal of cap 1) of the serially-connected, 5-capacitor stack to the 1N PIN of the TB2–TB3 connector as shown in Figure 14. (See also Figure 9 for TB2–TB3 location).
2. Connect the positive terminal of cell 1 to 1P.
3. Connect the positive terminal of cell 2 to 2P.
4. Connect the positive terminal of cell 3 to 3P.
5. Connect the positive terminal of cell 4 to 4P.
6. Connect the positive terminal of the capacitor stack (+) to 5P.
7. Connect external power (from 6 V to 15 V) to the System PWR and System GND terminals to wake up the EVM from shutdown mode.
8. Connect the SMBus connector (J1) to the EV2300 adapter and start the EV software.
9. Navigate to the *Flash Screen.* Change the flash constants that correspond to the specific parameters of your application (see the data sheet). For the first evaluation, the default values may be used.
10. Navigate to the *Calibration screen*. Select the check-box for software voltage calibration near *Measured voltage* field. Measure between 1P and 1N for capacitor 1, 2P and 1N for capacitors 1 + 2, 3P and 1N for capacitors 1 + 2 + 3, 4P and 1N for capacitors 1 + 2 + 3 + 4, 5P and 1N for capacitors 1 + 2 + 3 + 4 + 5 and enter the values into the *Enter actual voltage* field. Click the *calibrate part* button.
11. Now the pack is ready and charge/discharge tests can be conducted.

Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive.**

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to 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.

EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 6 V to 15 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.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

    1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

    1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2. *Limited Warranty and Related Remedies/Disclaimers*:

    2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

    2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

    2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

<u>WARNING</u>

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,

2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or

3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。

2. 実験局の免許を取得後ご使用いただく。

3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。 上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4   *EVM Use Restrictions and Warnings:*

  4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

  4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

  4.3 *Safety-Related Warnings and Restrictions:*

    4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

    4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

  4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

  6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

  6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale, TI's General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025