

bq27531EVM With bq27531 Battery Management Unit Impedance Track™ Fuel Gauge and bq24192 4.5-A, Switch-Mode Battery Charger for Single-Cell Applications

This evaluation module (EVM) is a complete evaluation system for the Battery Management Unit (BMU) chipset consisting of the bq27531-G1 fuel gauge and bq24192 battery charger. The EVM includes one bq27531 circuit, including a current sense resistor and one thermistor. In addition, the fuel gauge controls the bq24192 battery charger's settings and monitors its status via I²C communication lines. Together, the chipset provides all necessary components to monitor and predict capacity for a system-side fuel gauge solution as well as to charge the battery from either an adapter or USB input with up to 4.5-A of charge current. The circuit module connects directly across the battery pack. With the EV2300 interface board and software, the user can read the bq27531-G1 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the battery management unit solution under different charge and discharge conditions. The latest Microsoft® Windows® based PC software can be downloaded from the product folder on the Texas Instruments Web site.

Contents

1	Features.....	2
2	bq27531-Based Circuit Module	2
3	Circuit Module Physical Layouts, Bill of Materials, and Schematic	6
4	EVM Hardware and Software Setup	13
5	Troubleshooting Unexpected Dialog Boxes	16
6	Operation	17
7	Calibration	19
8	Advanced Communication I ² C	21
9	Related Documentation From Texas Instruments	22

List of Figures

1	Schematic.....	3
2	bq27531EVM-001 Layout – Silk Screen.....	6
3	Layer 1	7
4	Layer 2	8
5	Layer 3	9
6	Layer 4.....	10
7	BAT_Load (PR1010) Schematic	13
8	Test Setup for bq27531EVM (PWR216)	15
9	Registers Screen	17
10	bqStudio Default Page.....	18
11	Data Memory Screen	19
12	Calibration Screen	20
13	Advanced Communication I ² C.....	21
14	Golden Image Output Screen	21
15	Perform Programming Screen.....	21

Impedance Track is a trademark of Texas Instruments.
Microsoft, Windows are registered trademarks of Microsoft Corporation.
All other trademarks are the property of their respective owners.

List of Tables

1	Ordering Information	2
2	Bill of Materials	11

1 Features

- Complete evaluation system for the Battery Management Unit chipset consisting of the bq27531-G1 Impedance Track fuel gauge and bq24192 4.5-A Battery Charger.
- Populated circuit module for quick setup
- Personal computer (PC) software and interface board (orderable on TI website) for easy evaluation
- Software that allows data logging for system analysis (available in product folder on TI website)
- Ability to upgrade to the latest firmware version by flash reprogramming

1.1 Kit Contents

- bq27531-G1 and bq24192 chipset circuit module (PWR216)
- NTC103AT thermistor

This EVM is used for the evaluation of the bq27531-G1 and bq24192 BMU chipset. Ensure that you visit the product Web folder at www.ti.com to download the latest firmware version, evaluation software, and documentation for the associated product to be evaluated.

1.2 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq27531EVM	Li-ion	1 cell	Any

2 bq27531-Based Circuit Module

The bq27531-based circuit module is a complete and compact example solution of a bq27531 circuit for battery management. The circuit module incorporates a bq27531 battery gas gauge integrated circuit (IC) and all other components necessary to accurately predict the capacity of 1-series Li-ion cell.

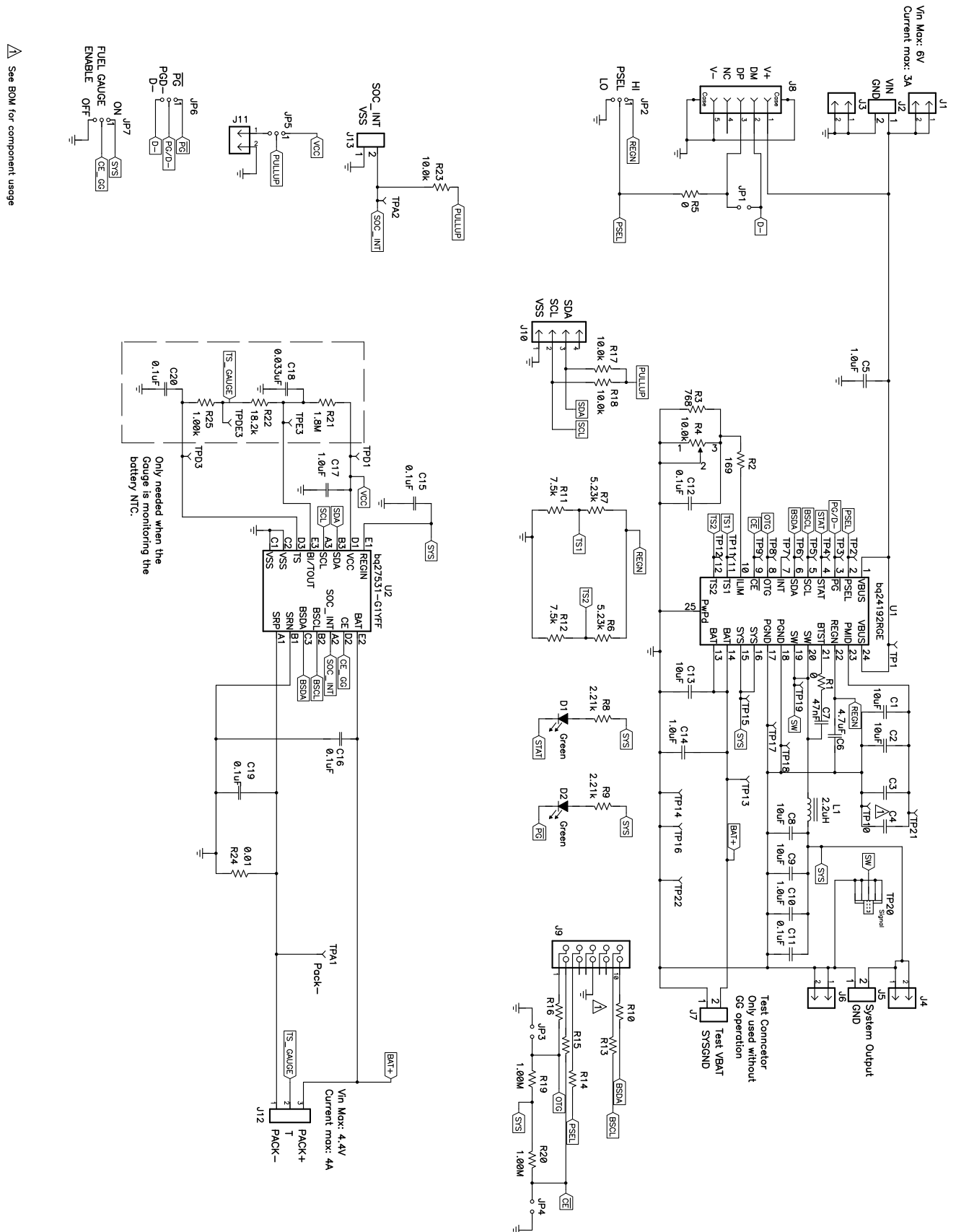


Figure 1. Schematic

2.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- Direct connection to the battery pack (J12): PACK+, PACK–, and TS
- To the serial communications port (J10): SDA, SCL, and VSS
- Connection to system load (J5)
- Connection to charger (J2)
- Access to signal output (J13): SOC_INT

2.2 I/O Description

Header/Terminal Block	Description
J1-VIN	Adapter positive terminal
J2-VIN	Adapter positive terminal
J2-GND	Adapter negative terminal
J3-GND	Adapter negative terminal
J4-SYS	System positive terminal
J5-SYS	System positive terminal
J5-GND	System negative terminal
J6-GND	System negative terminal
J7-TEST	Test terminal
J8	USB Miniconnector
J9	USBTOGPIO 10-pin connector (not installed)
J10	EV2300 connector for using bq27531 software to communicate with bq27531 IC
J11	Allows SOC_INT to be tied to external pullup rather than VCC
J12-PACK+	Battery positive terminal
J12-T	Pack thermistor input that leads to IC TS pin
J12-PACK-	Battery negative terminal
J12-SOC_INT	SOC_INT output from gauge

2.3 Test Points

Test Point	Description
TP1	bq24192 IN voltage
TP2	bq24192 PSEL pin
TP3	bq24192 PG/D- pin
TP4	bq24192 STAT pin
TP5	bq24192 SCL = bq27531 BSCL - I2C communication clock line
TP6	bq24192 SDA = bq27531 BSDA - I2C communication data line
TP7	bq24192 INT pin
TP8	bq24192 OTG pin
TP9	bq24192 CE pin
TP10	PGND
TP11	bq24192 TS1 pin
TP12	bq24192 TS2 pin
TP13	bq24192 BAT pin
TP14	PGND
TP15	bq24192 SYS pin
TP16	PGND
TP17	PGND

Test Point	Description
TP18	PGND
TP19	bq24192 SW pin
TP20	bq24192 SW signal
TP21	bq24192 PMID pin
TP22	PGND
TPA1	PACK-
TPA2	bq27531 SOC_INT pin
TPD1	bq27531 VCC pin
TPD3	bq27531 TS pin
TDPE3	External thermistor output
TPE3	bq27531 BI/TOUT pin

2.4 Control and Key Parameters Setting

Jumper	Description	Default Factory Setting
JP1 USB D+/D-	Shorting jumper for USB data lines DM (D-) and DP (D+). When shorted, USB input current limit defaults to 1.5 A. Otherwise, USB100 mode is selected.	INSTALLED
JP2 PSEL	2-3 (PSEL = LO): Indicates that an ac adapter is connected to the USB input and sets the USB input current limit to 1.5 A. 1-2 (PSEL = HI): Indicates that a USB source is connected to the USB input and sets the input current limit to 500 mA. (DEFAULT)	1-2 (PSEL = HI)
JP3 OTG	When installed, OTG feature will be disabled.	NOT INSTALLED
JP4 CHARGE ENABLE	When installed, charging is enabled.	INSTALLED
JP5 SOC_INT	2-3: SOC_INT is tied to external pull-up 1-2: SOC_INT is tied to onboard VCC through pull-up (DEFAULT)	1-2 VCC
JP6 D-/PG	2-3: Connect D-/PG to D- 1-2: Connect D-/PG to PG (DEFAULT)	1-2 PG
JP7 FUEL GAUGE ENABLE	1-2 ON: Fuel gauge enable (CE) pin high for normal operation (DEFAULT) 2-3 OFF: Fuel gauge enable (CE) pin low to disable gauging	1-2 ON

3 Circuit Module Physical Layouts, Bill of Materials, and Schematic

This section contains the board layout, bill of materials, assembly drawings, and schematic for the bq27531 circuit module.

3.1 Board Layout

This section shows the printed-circuit board (PCB) layers (Figure 2 through Figure 5), assembly drawing, and schematic for the bq27531 module.

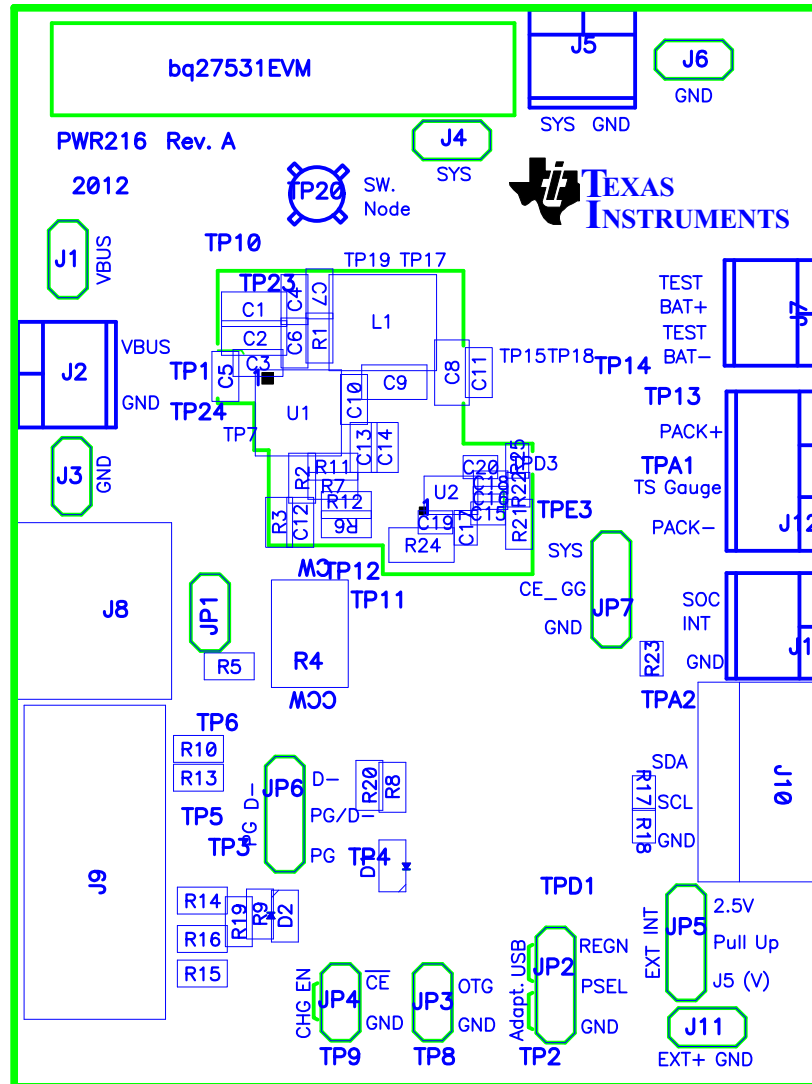


Figure 2. bq27531EVM-001 Layout – Silk Screen

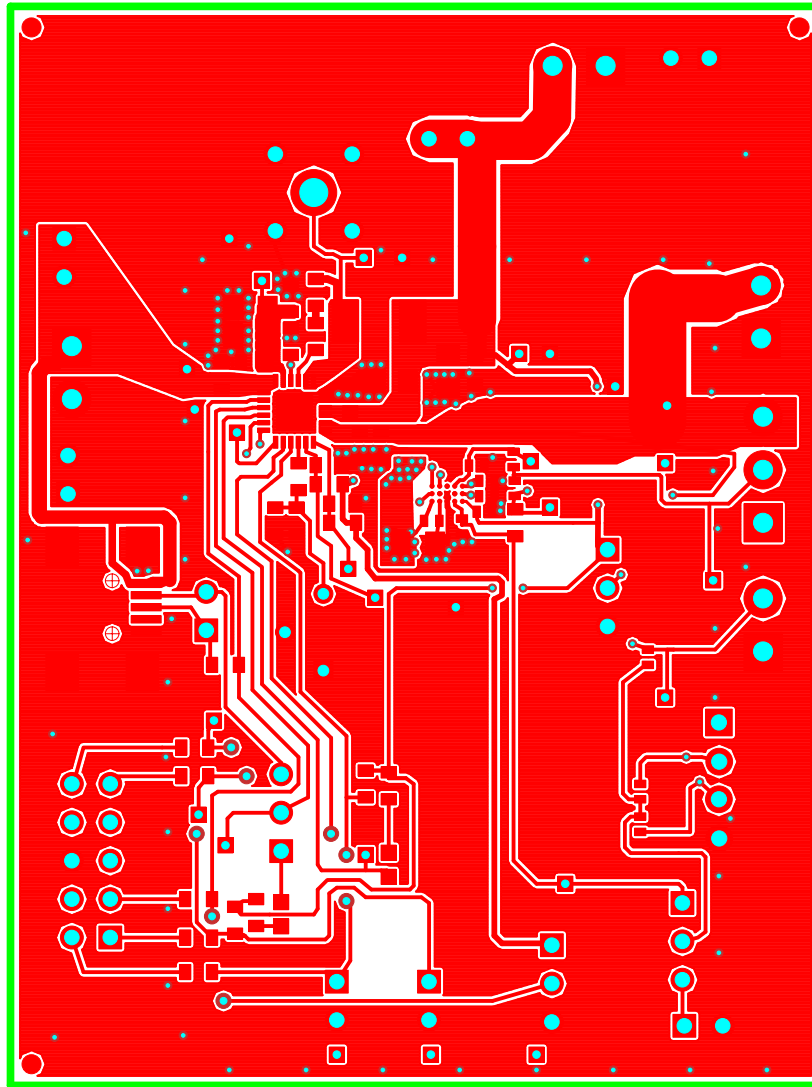


Figure 3. Layer 1

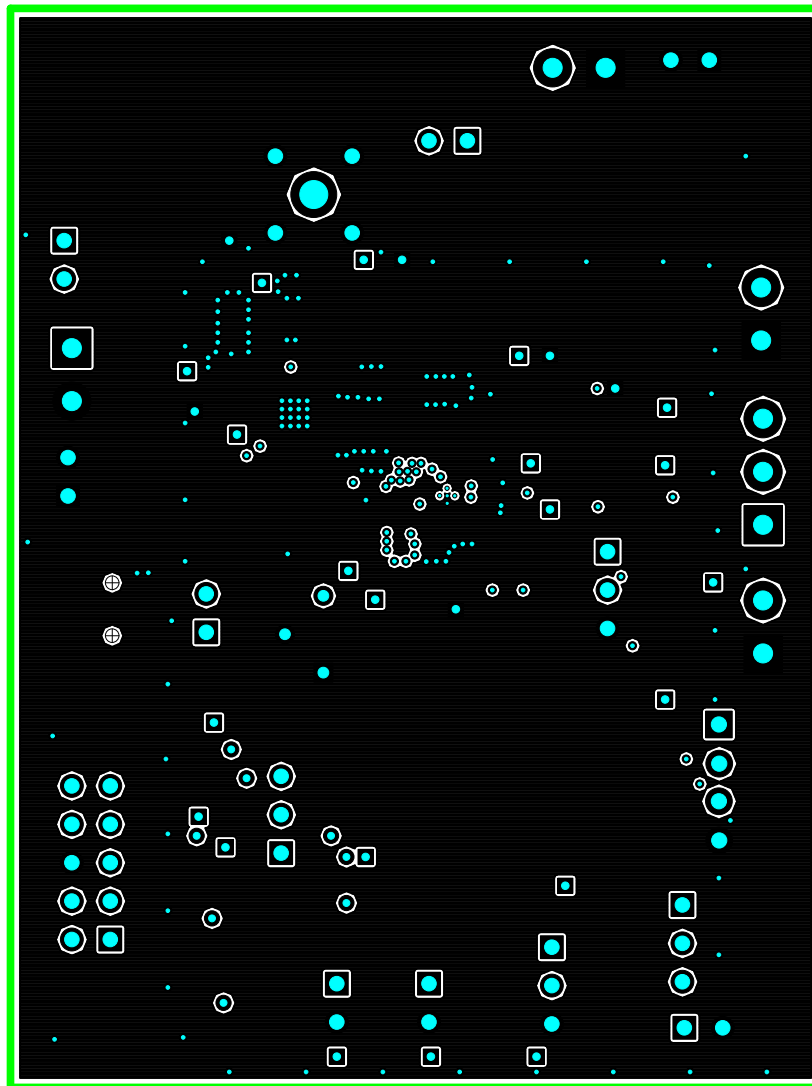


Figure 4. Layer 2

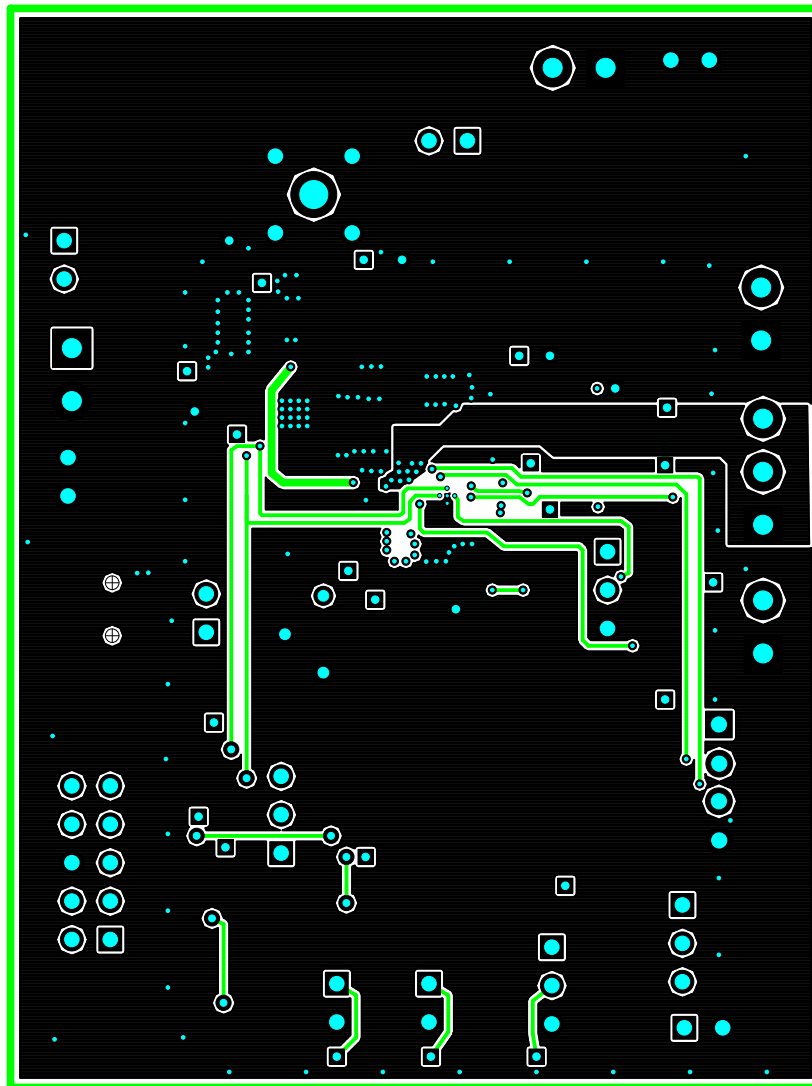


Figure 5. Layer 3

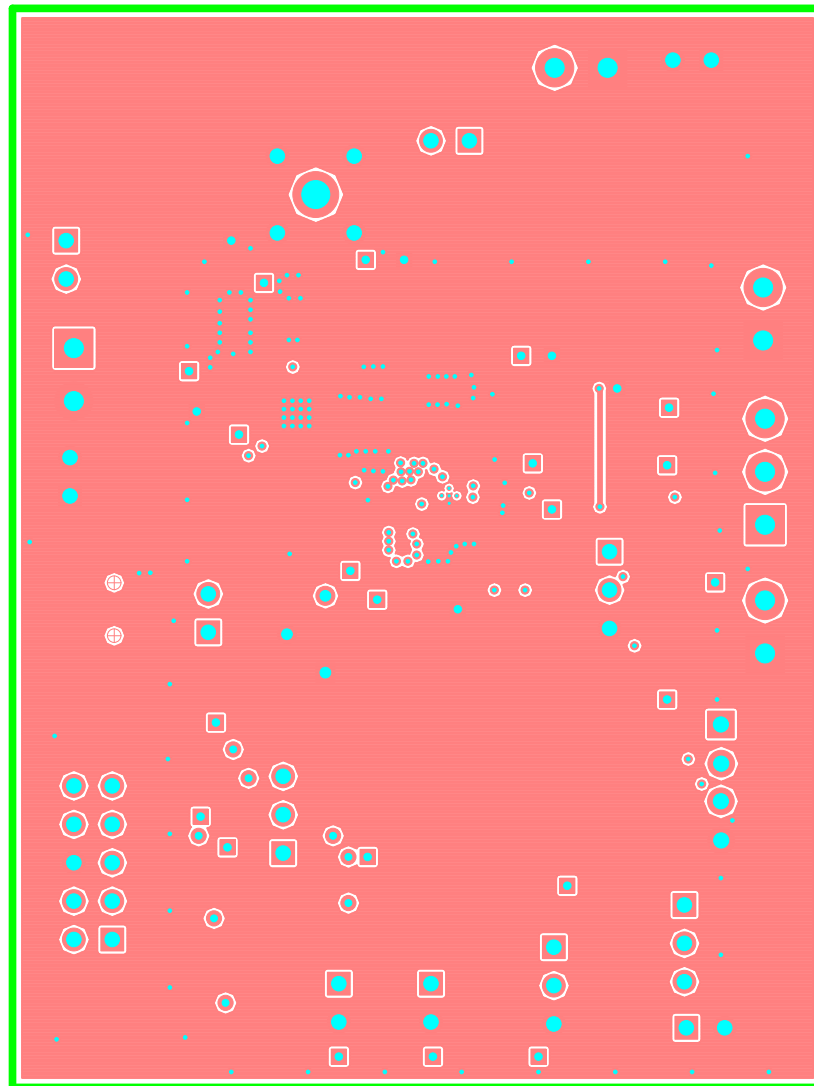


Figure 6. Layer 4

3.2 Bill of Materials and Schematic

Table 2. Bill of Materials

COUNT	RefDes	Value	Description	Size	Part Number	MFR
1	C18	0.033uF	Capacitor, Ceramic, 16V, X7R, 10%	402	C1005X7R1C333K	TDK
4	C15, C16, C19, C20	0.1uF	Capacitor, Ceramic, 6.3V, X5R, 10%	402	C1005X5R0J104K050BA	TDK
1	C17	1.0uF	Capacitor, Ceramic, 6.3V, X5R, 10%	402	C1005X5R0J105K050BB	TDK
2	C11, C12	0.1uF	Capacitor, Ceramic, 25V, X5R, 10%	603	C1608X5R1E104K	TDK
2	C10, C14	1.0uF	Capacitor, Ceramic, 10V, X5R, 10%	603	C1608X5R1A105K080AC	TDK
1	C5	1.0uF	Capacitor, Ceramic, 25V, X5R, 10%	603	C1608X5R1E105K080AC	TDK
1	C6	4.7uF	Capacitor, Ceramic, 10V, X5R, 10%	603	CGB3B1X5R1A475K055AC	TDK
1	C13	10uF	Capacitor, Ceramic, 10V, X5R, 10%	603	C1608X5R1A106K080AC	TDK
1	C7	47nF	Capacitor, Ceramic, 10V, X5R, 10%	603	06033D473KAT2A	AVX
0	C3, C4	DNP	Capacitor, Ceramic, 10V, X5R, 10%	603		
4	C1, C2, C8, C9	10uF	Capacitor, Ceramic, 25V, X5R, 10%	805	C2012X5R1E106K125AB	TDK
0	J9	DNP	Connector, Male Straight 2x5 pin, 100mil spacing, 4 Wall	0.338 x 0.788 inch	N2510-6002-RB	3M
1	J8	UX60-MB-5ST	Connector, Recpt, USB-B, Mini, 5-pins, SMT	0.354 X 0.303 Inches	UX60-MB-5ST	Hirose Electric Co
2	D1, D2	Green	Diode, LED, Green, 2.1-V, 10-mA, 6-mcd	603	LTST-C190GKT	Liteon
5	J1, J3, J4, J6, J11	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
1	J10	22-05-3041	Header, Friction Lock Ass'y, 4-pin Right Angle	0.400 x 0.500	22-05-3041	Molex
1	L1	2.2uH	Inductor, SMT, 4.2A, 50.1milliohm	0.204 x 0.216 inch	IHLP2020BZER2R2M01	Vishay
3	JP1, JP3, JP4	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
4	JP2, JP5, JP6, JP7	PEC03SAAN	Header, Male 3-pin, 100mil spacing	0.100 inch x 3	PEC03SAAN	Sullins
1	R4	10.0k	Potentiometer, 3/8 Cermet, Single-Turn	0.25x0.17 inch	3266W-1-103LF	Bourns
1	R25	1.00k	Resistor, Chip, 1/16W, 1%	402	CRCW04021K00FKED	Vishay
3	R17, R18, R23	10.0k	Resistor, Chip, 1/16W, 1%	402	CRCW040210K0FKED	Vishay
1	R22	18.2k	Resistor, Chip, 1/16W, 1%	402	CRCW040218K2FKED	Vishay
2	R1, R5	0	Resistor, Chip, 1/10W	603	CRCW06030000Z0EA	Vishay
2	R6, R7	5.23k	Resistor, Chip, 1/10W, 1%	603	CRCW06035K23FKEA	Vishay
2	R19, R20	1.00M	Resistor, Chip, 1/10W, 1%	603	ERJ-3EKF1004V	Panasonic
2	R11, R12	7.5k	Resistor, Chip, 1/10W, 1%	603	CRCW06037K50FKEA	Vishay
1	R2	169	Resistor, Chip, 1/10W, 1%	603	ERJ-3EKF1690V	Panasonic
0	R10, R13, R14, R15, R16	DNP	Resistor, Chip, 1/10W, 1%	603		
1	R3	768	Resistor, Chip, 1/10W, 1%	603	ERJ-3EKF7680V	Panasonic

Table 2. Bill of Materials (continued)

1	R21	1.8M	Resistor, Chip, 1/10W, 1%	603	ERJ-3EKF1804V	Panasonic
2	R8, R9	2.21k	Resistor, Chip, 1/10W, 1%	603	ERJ-3EKF2211V	Panasonic
1	R24	0.01	Resistor, Chip, 1/4W, 1%	805	WSL0805R0100FEA18	Vishay
4	J2, J5, J7, J13	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25	ED555/2DS	OST
1	J12	ED555/3DS	Terminal Block, 3-pin, 6-A, 3.5mm	0.41 x 0.25 inch	ED555/3DS	OST
0	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TPA1, TPA2, TPD1, TPD3, TPDE3, TPE3	DNP	Test Point, 0.020 Hole	0.100 x 0.100 inch		
1	TP20	131-4244-00	Adaptor, 3.5-mm probe clip (or 131-5031-00)	0.200 inch	131-4244-00	Tektronix
1	U1	bq24192RGET	IC, I2C Controlled 4.5A Single Cell USB/Adapter Charger	QFN-24	bq24192RGET	TI
1	U2	bq27531-G1YZFT	IC, Battery Management Unit Impedance Track Fuel Gauge With bq24192 Charger Controller	BGA	bq27531-G1YZFT	TI
1	RT1	10K	Thermistor, NTC, 3-A	0.095 X 0.150 inch	103AT-2	Semitec
5			Shunt, 100-mil, Black	0.100	929950-00	3M
1			PCB		PWR216	Any

3.3 bq27531 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq27531 circuit module.

3.4 Recommended Operating Conditions

		Min	Typ	Max	Unit
Supply voltage, V_{IN}	Input voltage from ac adapter	4.2		6	V
System voltage, V_{SYS}	Voltage output at SYS terminal (depends on VBAT voltage and status of V_{INDPM} and input current limit circuits)	3.3		VBATR EG+4.17 %	V
Battery voltage, V_{BAT}	Voltage output at VBAT terminal (registers set via bq27531 software)	3	4.2	4.44	V
Supply current, $I_{IN(MAX)}$	Maximum input current from ac adapter input (registers set via bq27531 software)	1.5		3	A
Fast charge current, $I_{CHRG(MAX)}$	Battery charge current (registers set via bq27531 software)	0.550		3	A
Operating junction temperature range, T_J		-40		125	°C

4 EVM Hardware and Software Setup

This section describes how to connect the different components of the EVM how to install the bq27531EVM PC software and.

4.1 Recommended Test Equipment

4.1.1 Power Supplies

1. Power Supply #1 (PS #1) capable of supplying 6 V at 3 A is required.
2. If not using a battery as the load, then power supply #2 (PS #2) capable of supplying up to 5 V at 5 A is required to power the circuit shown in Figure 7.

4.1.2 Load #1 Between BAT and GND

Testing with an actual battery is the best way to verify operation in the system. If a battery is not available, then a circuit similar to the one shown in Figure 7 can simulate a battery when connected to a power supply.

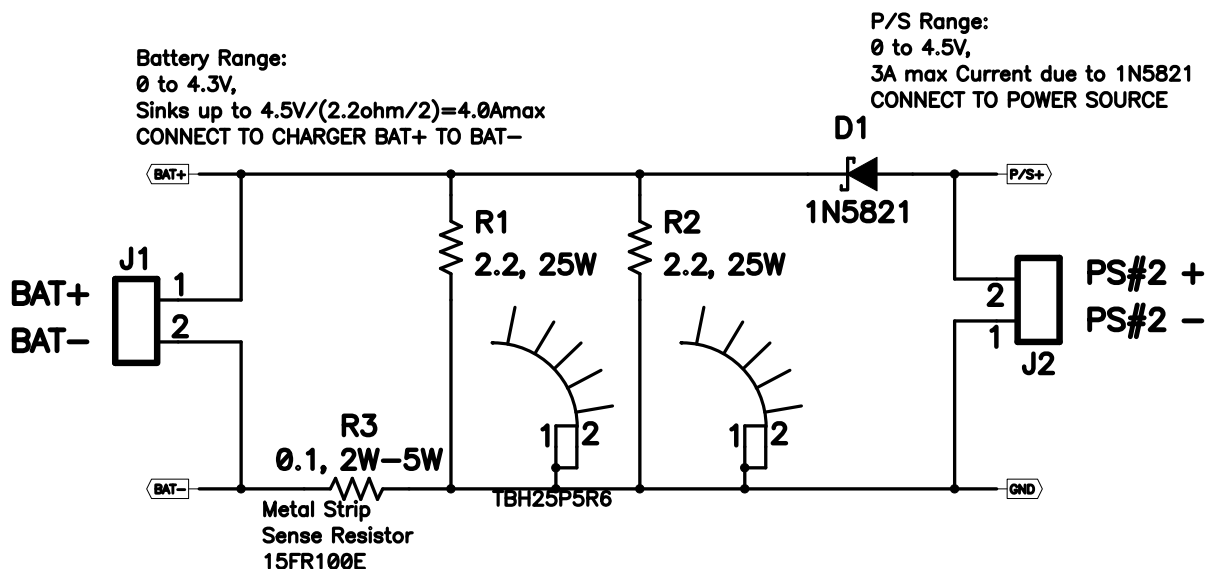


Figure 7. BAT_Load (PR1010) Schematic

4.1.3 Load #2 Between SYS and GND

Although not required, a resistive load capable of sinking up to 3 A can be used.

4.1.4 Meters

Three equivalent voltage meters (VM #) and two equivalent current meters (CM #) are required. The current meters must be able to measure 3-A current.

4.1.5 Test Equipment Setup

1. For all power connections, use short, twisted-pair wires of appropriate gauge wire for the amount of the current.
2. Set Power Supply #1 (PS #1) for 6-V, 3-A current limit and then turn off supply.
3. If BAT_Load as shown in [Figure 8](#) is used, connect Power Supply #2 (PS #2) set to approximately 3.6 V to the input side (PS #2+/-) of BAT_Load, then turn off PS #2.
4. Connect the output side of the battery or BAT_Load in series with current meter to J12 (PACK+, PACK-). Ensure that a voltage meter is connected across J12 (PACK+,PACK-).
5. Connect VM #3 across J5 (SYS, GND).
6. Ensure jumpers are at the default factory settings per [Section 2.4](#)
7. Connect I2C port of EV2300 with J10 board using the assembled 4 colored-wire connector included with EV2300 kit (GND / BLACK at the bottom).
8. After the preceding steps have been performed, the test setup for PWR216 is configured as is shown in [Figure 8](#)

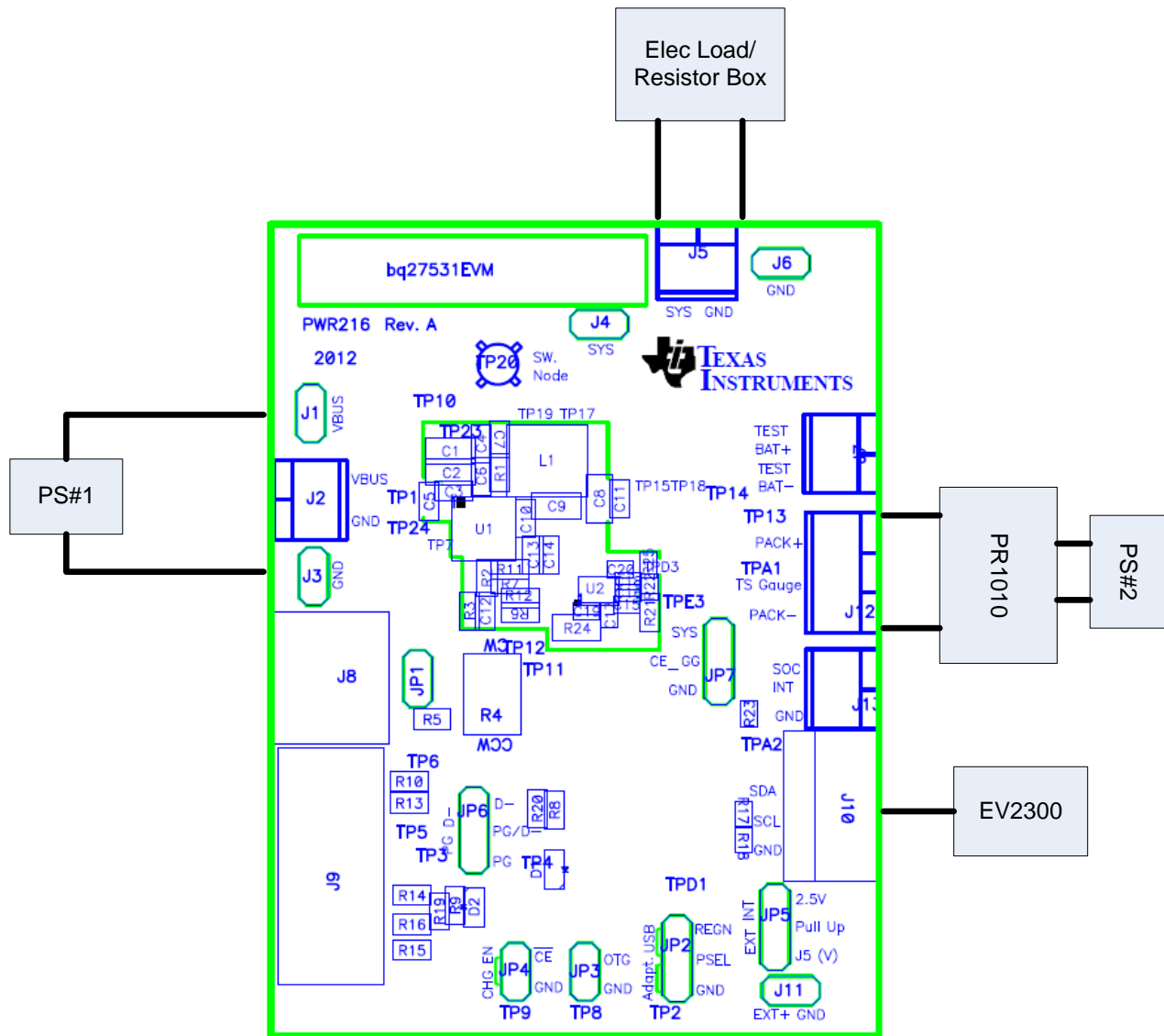


Figure 8. Test Setup for bq27531EVM (PWR216)

- Turn on the computer. Open the bq27531 evaluation software. The main window of the software is shown in Figure 9 (DataRAM Screen).

4.2 Software Installation

Find the latest software version at <http://www.ti.com/tool/bqStudio>. Use the following steps to install Battery Management Studio:

4.2.1 Using EV2300

- Ensure that the EV2300 is not connected to the PC through a USB cable before starting this procedure.
- Select the *Tool and Software* tab in the product folder.
- Under the *Software* section, click on *Battery Management Studio (bqStudio) Software Suite*.
- Click the **Download** button to download the software.
- Download software to hard drive.
- Double-click the software executable and follow all instructions and prompts.

4.2.2 Using EV2400:

1. Ensure that the EV2400 is not connected to the PC through a USB cable before starting this procedure.
2. Browse for the supported software link within the bq27531 TI web site product folder to find the downloadable EVSW installation files.
3. Open the software file that was downloaded from the TI web site.
4. Follow the instructions on screen until the software installation is completed.

5 Troubleshooting Unexpected Dialog Boxes

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.

6 Operation

This section details the operation of the bqStudio software.

6.1 Starting the Program

Run bqStudio from the Start | All Programs | Texas Instruments | Battery Management Studio. The main screen (Figure 9) appears. If instead of Figure 9 appearing, Figure 10 appears, it may mean that the EVM is not connected to the computer correctly. Make sure that the USB interface (EV2300 or EV2400 or GDK) and the bq27531 are connected and restart bqStudio. If this still does not resolve the issue, check if the I2C pullup resistors are connected. Data begins to appear once the <Refresh> (single-time scan) button is clicked, or when the Scan button is clicked. To disable the scan feature, simply click the **Scan** button again.

The continuous scanning period can be set by opening Window | Preferences → Registers section. The range for this interval is 0 ms to 65,535 ms. Only items that are selected for scanning are scanned within this period.

Battery Management Studio provides a logging function which logs the values that were last scanned. To enable this function, select the Start Log button; this causes the Scan button to be pressed. When logging is Stopped, the Scan button will still be selected and has to be manually clicked again.

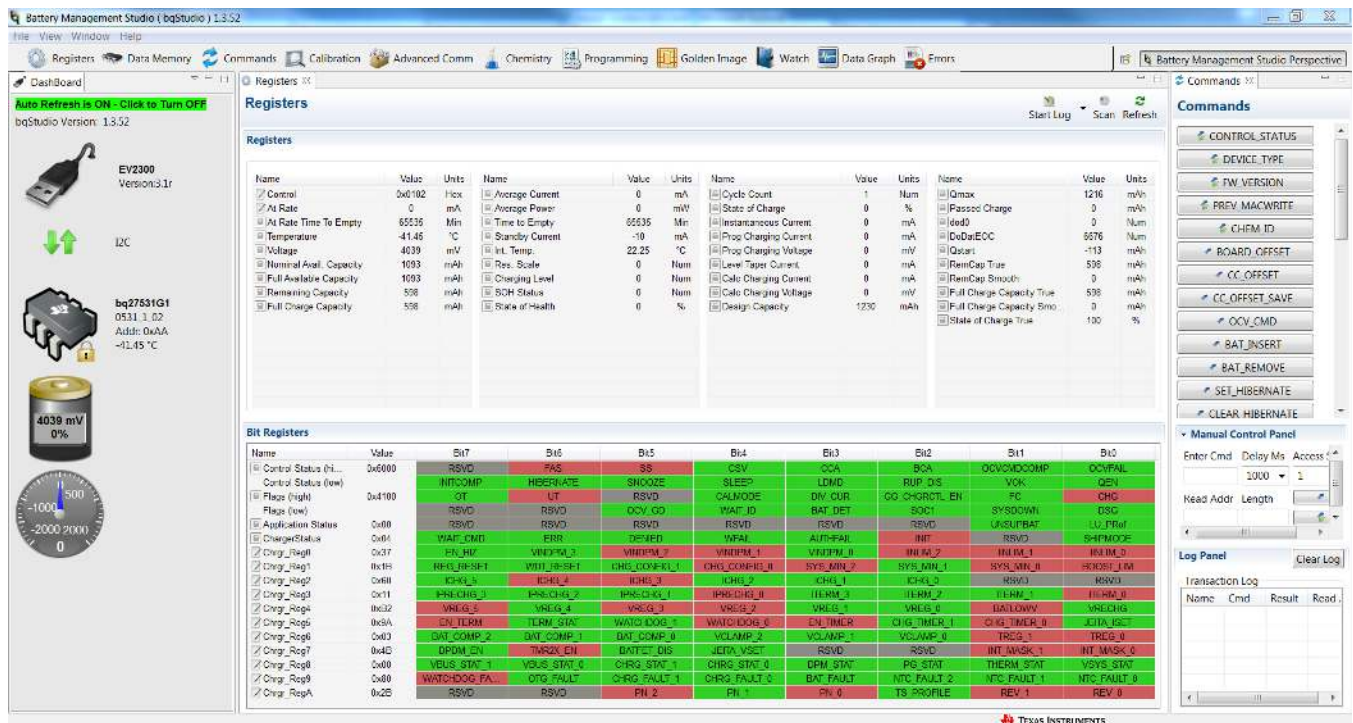


Figure 9. Registers Screen

This screen (Figure 9) shows the RAM data in the bq27531 device. Additional Flags and Status data can be viewed at the bottom of the Registers screen.

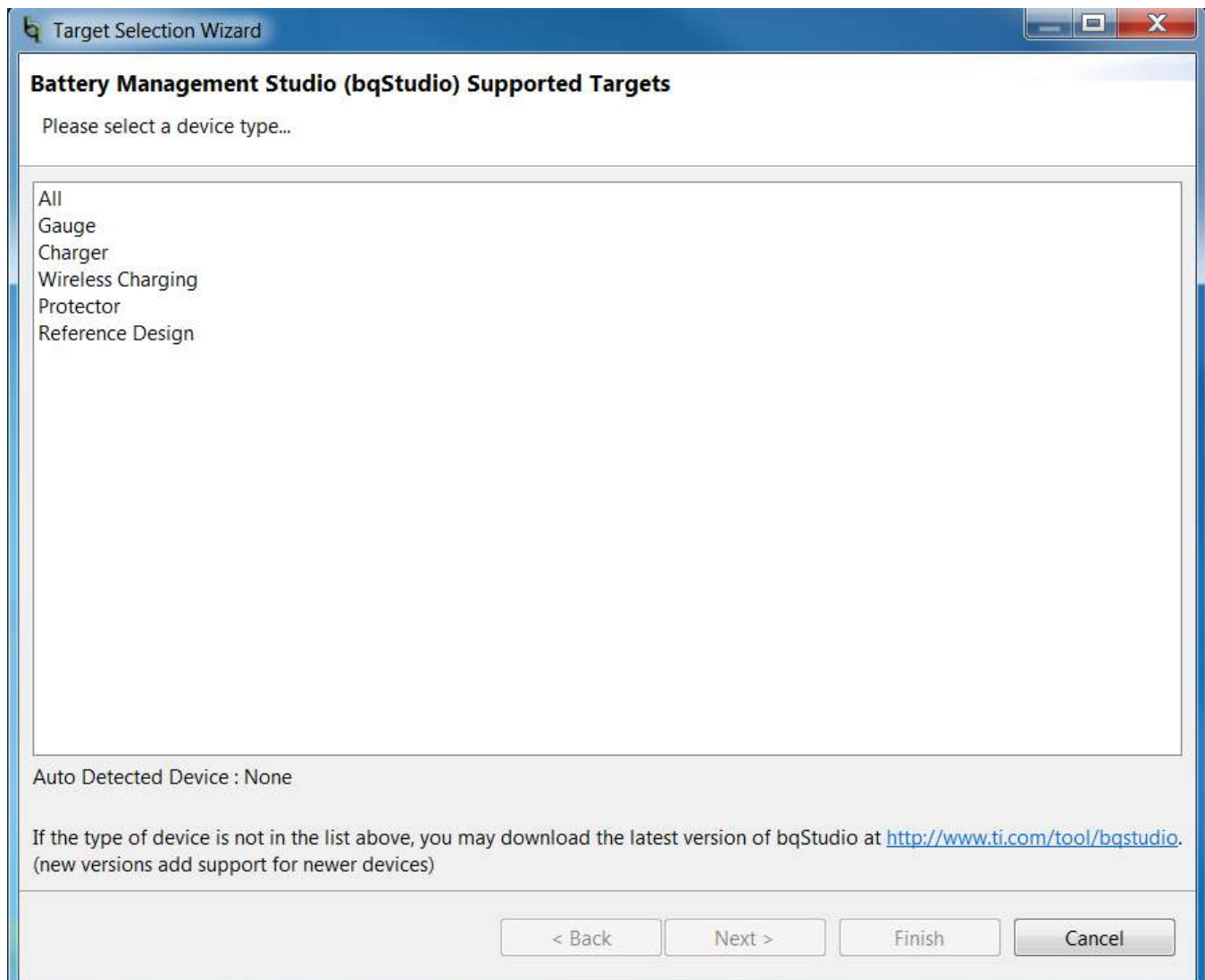


Figure 10. bqStudio Default Page

6.2 Setting Programmable bq27531 Options

The bq27531 data memory comes configured per the default settings detailed in the bq27531 technical reference manual (SLUUA96). Ensure that the settings are correctly changed to match the pack and application for the bq27531 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 Memory screen (Figure 11).

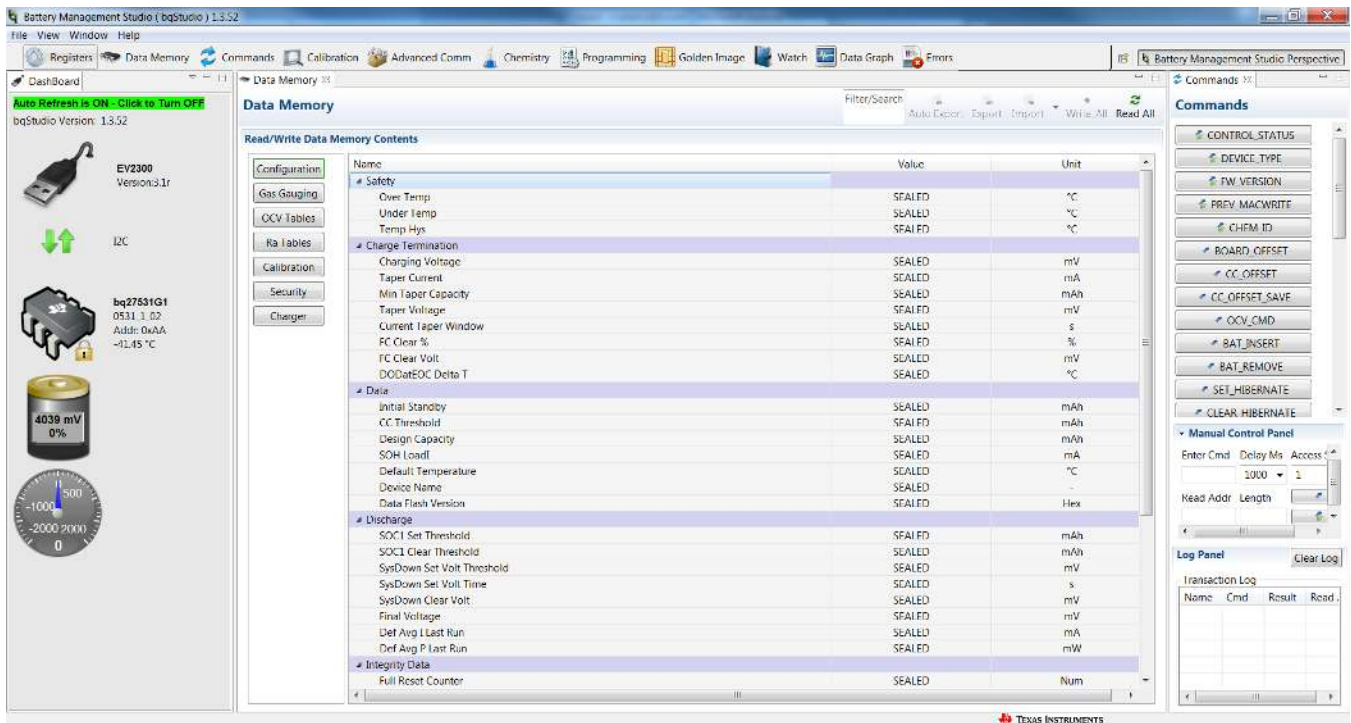


Figure 11. Data Memory Screen

To read all the data from the bq27531 non-volatile flash memory, click on the **Read All** button on the *Data Memory* window. Make sure the device is not sealed and in full access to read or write to the data memory. To update a parameter, click on the desired parameter and a window pops-up that provides details on the selected parameter. Next, enter the value in the value textbox and press **Enter**. After pressing **Enter**, bqStudio updates the selected parameter. The **Import** button in the *Data Memory* window can be clicked in order to import an entire configuration from a specified *.gg.csv file.

Save the configuration to a file by clicking the **Export** button in the *Data Memory* window and entering a file name. The configuration is saved to a *.gg.csv file. The module calibration data is also held in the bq27531 data memory. If the Gauge Dashboard is not displaying any information, then the bq27531 may not be supported by the bqStudio version being used, a bqStudio upgrade may be required.

7 Calibration

The bq27530EVM must be calibrated to ensure accurate value reporting. This can be done by going to the *Calibration* window in bqStudio (Figure 12).

7.1 Calibrating the bq27531

Calibrate each item one at a time in the order presented in this document. Select the types of calibration to be performed by selecting the corresponding checkbox (see Figure 12).

Enter the measured values for the types selected, if necessary.

Then press the *Calibrate Part as indicated below* button. After all calibration is complete, close the Calibrate subwindow. While the Calibrate subwindow is open, even in the background, the calibration routines are running in firmware. Close the subwindow to ensure that they are stopped before proceeding with configuration or testing.

7.2 CC Offset Calibration

This performs the internal calibration of the coulomb counter input offset. Press the *Calibrate Coulomb Counter* button.

7.3 Voltage Calibration

- Measure the voltage across Pack+ and Pack- with a calibrated meter.
- Type the voltage value in mV into *Enter Actual Voltage* .
- Measure the temperature for PACK.
- Type the temperature value into Enter Actual Temperature.
- Press the *Calibrate Voltage and Temperature* as indicated below button.

7.4 Board Offset Calibration

This performs the offset calibration for the current offset of the board. It takes approximately 35 seconds to complete.

It is expected that no current is flowing through the sense resistor while performing this calibration step. Remove load and short PACK- to GND.

Press the *Calibration Board Offset* button.

7.5 Pack Current Calibration

- Connect a load to GND and SYS that draws approximately 1 A, or connect a current source to GND and Pack-. Ensure that the Measured Current reported is negative, or else reverse the connections.
- Measure the current with a calibrated meter, and type the value into Enter Actual Current using (-) for current in discharge direction.
- Press the *Calibrate Gas Gauge* button.

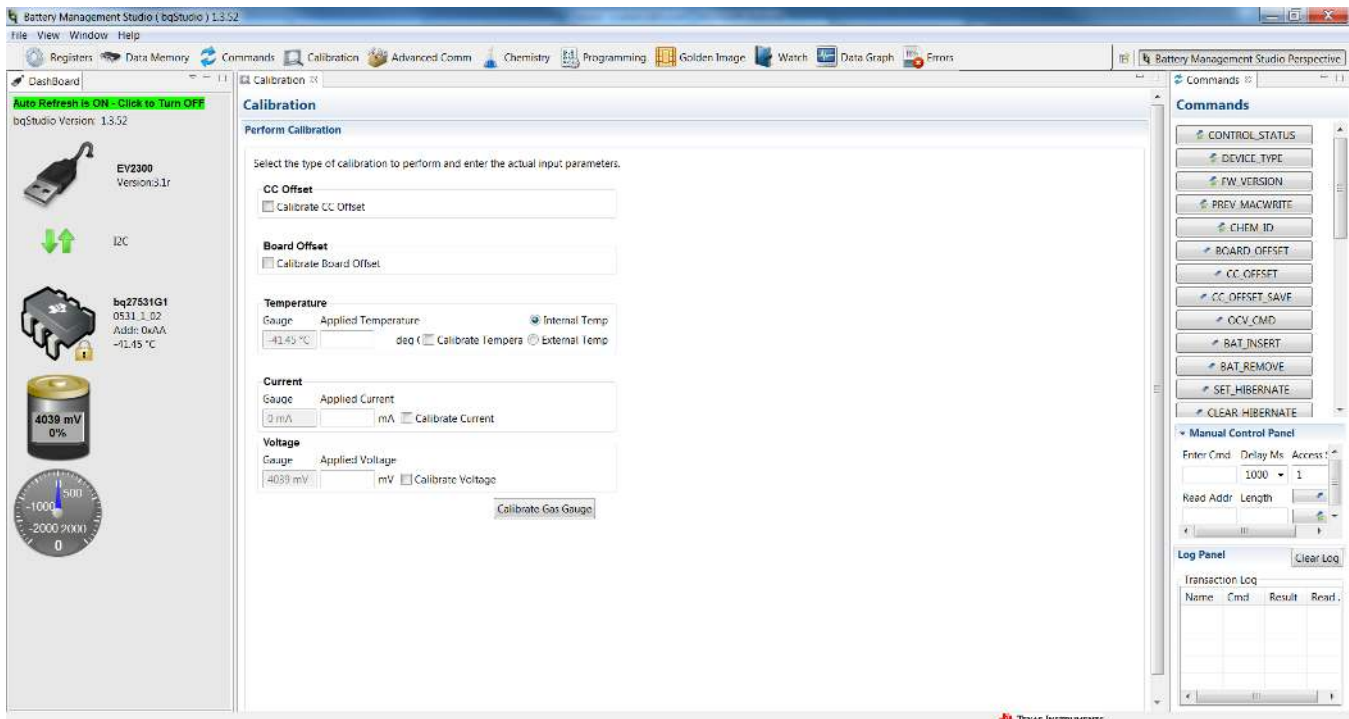


Figure 12. Calibration Screen

8 Advanced Communication I²C

8.1 I²C Communication

I²C read/write operations are not specific to any gas gauge. These operations serve as general-purpose communication tools (Figure 13).

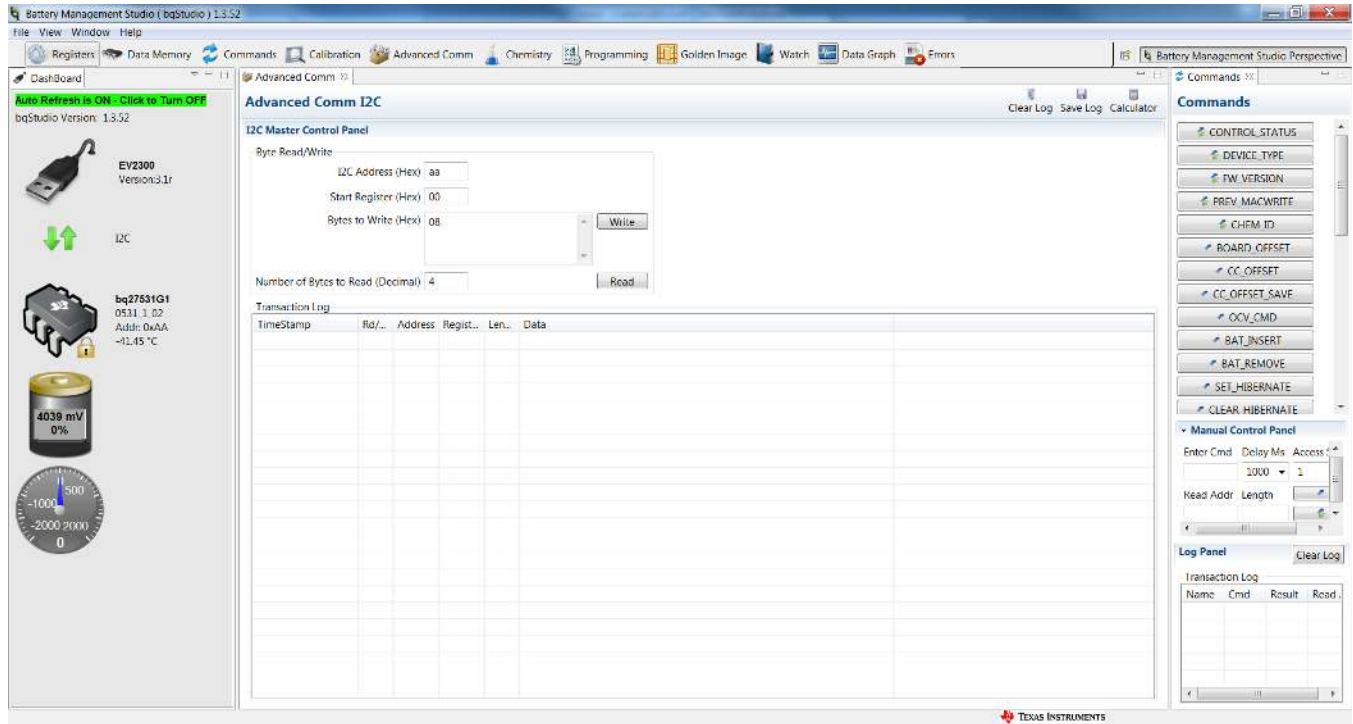


Figure 13. Advanced Communication I²C

Golden Image

Golden Image Export

This plug-in will allow you to export image files. It will read the data memory contents of the connected gauge and save it to your hard drive in various formats.

Output Location

Output Directory

Base File Name

Output Formats

SREC File (.srec)

BQFS File (.fs)

DFFS File (.fs)

Figure 14. Golden Image Output Screen

Programming

Perform Programming

This plug-in will allow you to program image files to a device.

Select Programmable File

Figure 15. Perform Programming Screen

9 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 also can be obtained through the TI Web site at www.ti.com.

- *bq27531, System-Side Impedance Track™ Fuel Gauge With Integrated LDO* data sheet ([SLUSBE7](#))

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (April 2013) to A Revision	Page
• Deleted <i>System Requirements</i> and rewrote <i>Software Installation</i> sections in <i>EVM Hardware and Software Setup</i>	15
• Changed the entire <i>Operation</i> section, text and images.	17
• Changed <i>Calibrate Screen</i> section to <i>Calibration</i> section, and changed much of the text in the section.	19
• Changed <i>I2C Pro Screen</i> section to <i>Advanced Communication I2C</i> , changed some text and the images in this section.	21

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
 - 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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
 - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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.
3. *Regulatory Notices:*
 - 3.1 *United States*
 - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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/lstds/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。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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 2 4 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/llds/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。http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page

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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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 AND CONDITIONS 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 MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.
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 AND CONDITIONS. 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 AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, 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 ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.
- 8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2015, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com