bq27530EVM with bq27530 Battery Management Unit Impedance Track™ Fuel Gauge and bq24161 2.5-A, Dual-Input, 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 bq27530-G1 fuel gauge and bq24161 battery charger. The EVM includes one bq27530 circuit, including a current sense resistor one thermistor, and an EV2300 PC interface board for gas gauge interface and a PC USB cable. In addition, the fuel gauge controls the bq24161 battery charger's settings and monitors its status via I^2C communication lines. Together, the chipset provides all necessary components to monitor and predict capacity for a system-side fuel gauge solution as well asto charge the battery from either an adapter or USB input with up to 2.5-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 bq27530-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 Windows™-based PC software can be downloaded from the product folder on the Texas Instruments Web site.

Contents

List of Figures

List of Tables

1 Features

- Complete evaluation system for the Battery Management Unit chipset consisting of the bq27530-G1 Impedance Track fuel gauge and bq24161 2.5-A Dual Input Battery Charger.
- Populated circuit module for quick setup
- Personal computer (PC) software and interface board for easy evaluation
- Software that allows data logging for system analysis
- Ability to upgrade to the latest firmware version by flash reprogramming

1.1 Kit Contents

- bq27530-G1 and bq24161 chipset circuit module (HPA763)
- EV2300 PC interface board
- USB connection cable to interface board
- NTC103AT thermistor

This EVM is used for the evaluation of the bq27530-G1 and bq24161 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
bq27530EVM	Li-ion	1 cell	Any

2 bq27530-Based Circuit Module

The bq27530-based circuit module is a complete and compact example solution of a bq27530 circuit for battery management. The circuit module incorporates a bq27530 battery gas gauge integrated circuit (IC) and all other components necessary to accurately predict the capacity of 1-series Li-ion cell.

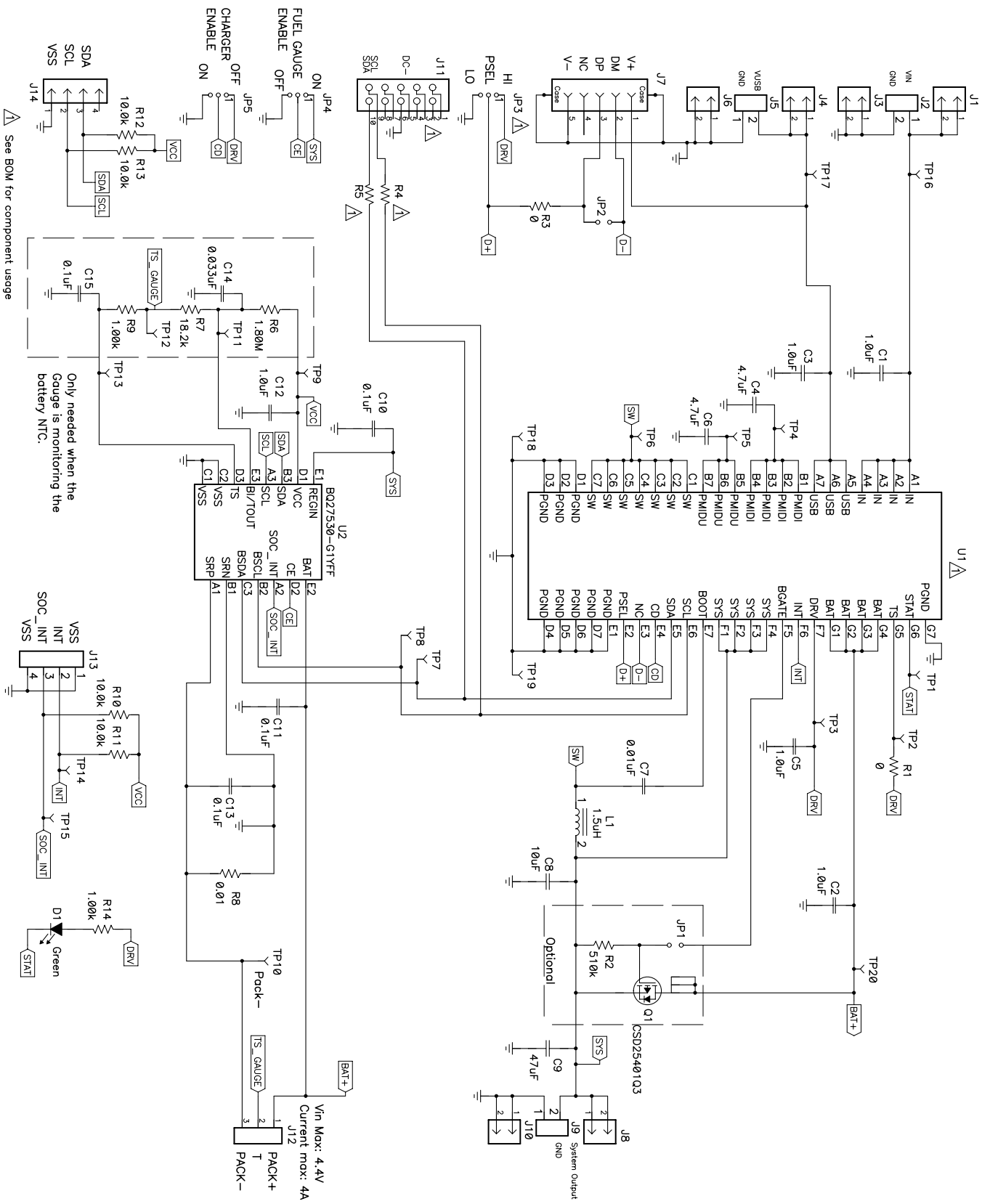

Figure 1. Schematic

2.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- Direct connection to the battery pack (J2 or J3): PACK+, PACK–, and TS
- To the serial communications port (J8): SDA, SCL, and VSS
- The system load and charger connect across charger and load (J6 and J7): CHARGER–/LOAD– and CHARGER+/LOAD+.
- Access to signal outputs (J5): SOC_INT, BAT_GD, and BAT_LOW

2.2 I/O Description

Header/Terminal Block	Description
J1–VIN	Apapter positive terminal
J2–VIN	Apapter positive terminal
J2–GND	Adapter negative terminal
J3-GND	Adapter negative header
J4-USB	USB positive header
J5-USB	USB positive terminal
J5-GND	USB negative terminal
J6-GND	USB negative header
J7	USB Miniconnector
J8-SYS	System positive header
J9-SYS	System positive terminal
J9-GND	System negative terminal
J10-GND	System ground header
J10-SYS	System output positive header
J11	USBTOGPIO 10-pin connector (not installed)
J12-PACK+	Battery positive terminal
J12-T	Pack thermistor input that leads to IC TS pin
J12-PACK-	Battery negative terminal
J13	I2C SDA/SCL/VSS - I2C communication header
J14	EV2300 connector for using bq27530 software to communicate with bq27530 IC

2.3 Test Points

Test Point	Description
TP1	bq24161 STAT pin
TP2	bq24161 TS pin
TP3	bq24161 DRV pin
TP4	bq24161 PMIDI pin
TP5	bq24161 PMIDU pin
TP6	bq24161 SW pin
TP7	bq24161 SDA = bq27530 BSDA - I2C communication data line
TP8	bq24161 SCL = bq27530 BSCL - I2C communication clock line
TP9	bq27530 VCC
TP10	bq27530 PACK-
TP11	bq27530 BI/TOUT
TP12	Battery pack NTC positive side
TP13	bq27530 TS pin
TP14	bq24161 INT pin

Test Point	Description
TP15	bq27530 SOC_INT pin - Access to open-drain output that signals interrupt for changes in SOC.
TP16	bq24161 IN voltage
TP17	bq24161 USB voltage

2.4 Control and Key Parameters Setting

Jumper	Description	Default Factory Setting
JP1 BGATE	When installed, connects the bq24161's BGATE output to the gate of Q1, thereby enabling the external battery FET.	INSTALLED
JP2 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.	NOT INSTALLED
JP3 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)
JP4 CHARGE ENABLE	2-3 ON: Charge disable (CD) pin low for normal operation 1-2 OFF: Charge disable (CD) pin high to disable charge and enter Hi-Z mode	1-2 OFF
JP5 FUEL GAUGE ENABLE	1-2 ON: Charge enable (CE) pin high for normal operation 2-3 OFF: Charge enable (CE) pin low to disable charge and gauging	2-3 OFF

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 bq27530 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 bq27530 module.

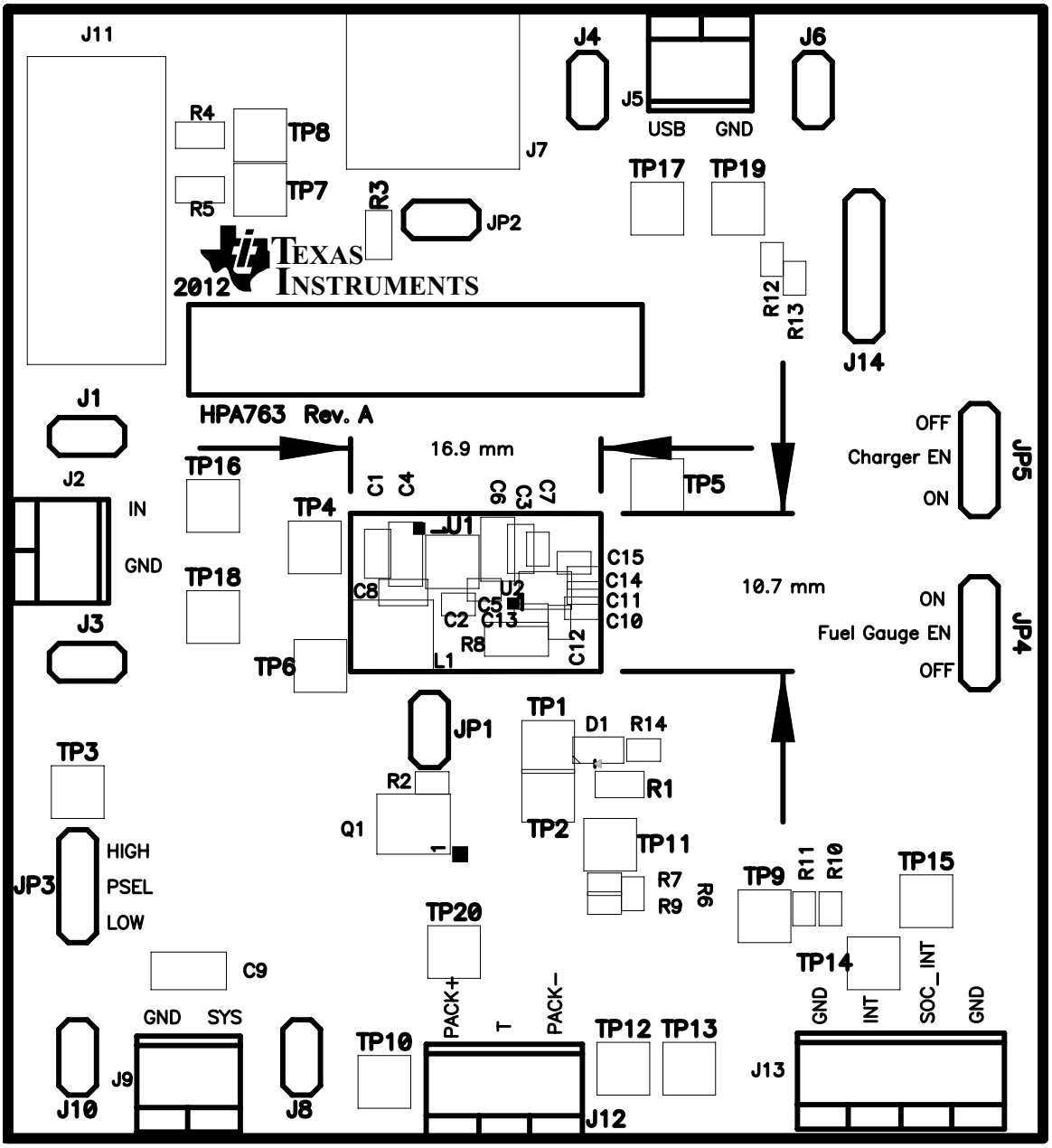

Figure 2. bq27530EVM-001 Layout – Layer 1 Silk Screen

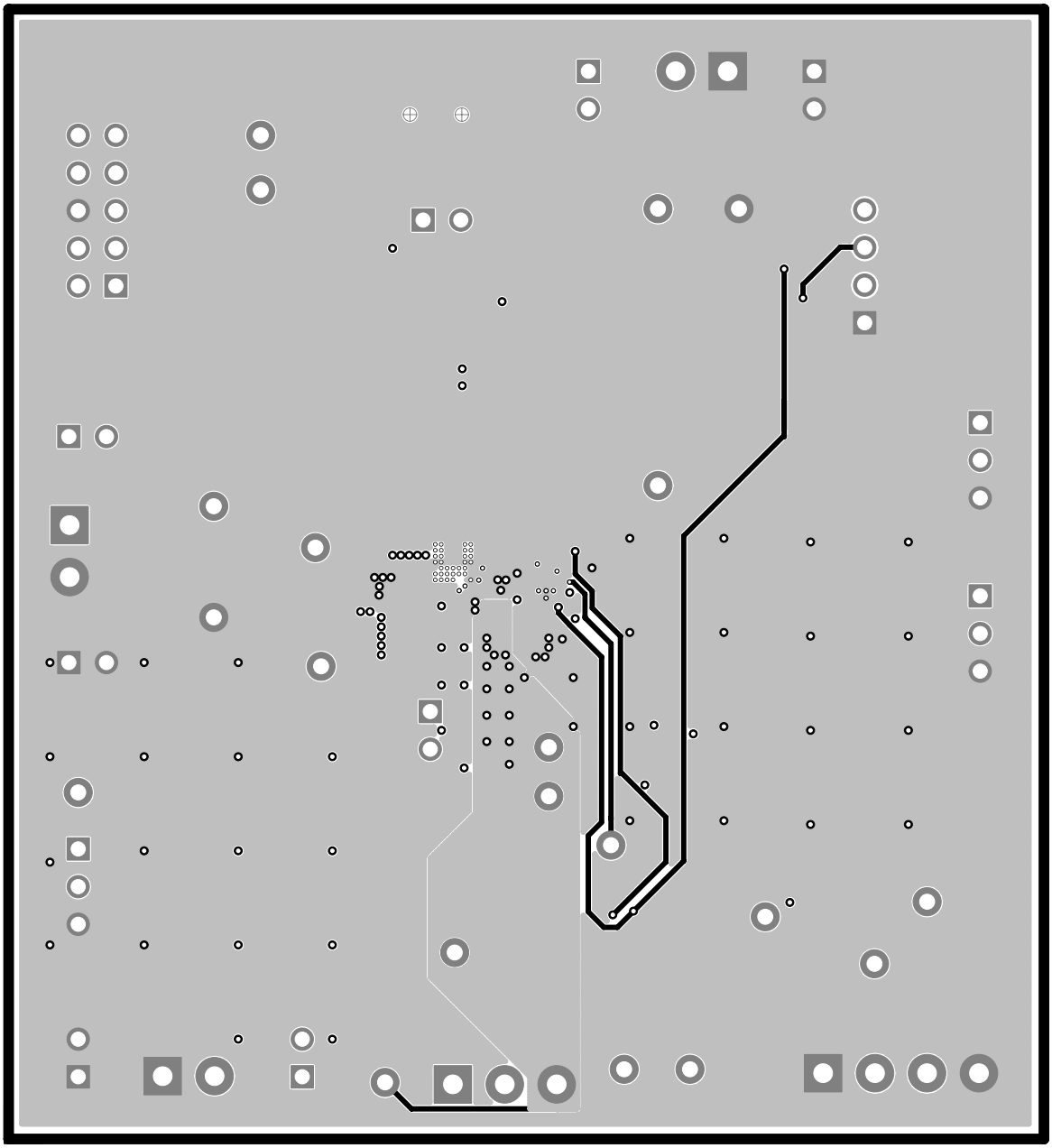

Figure 3. Layer 2

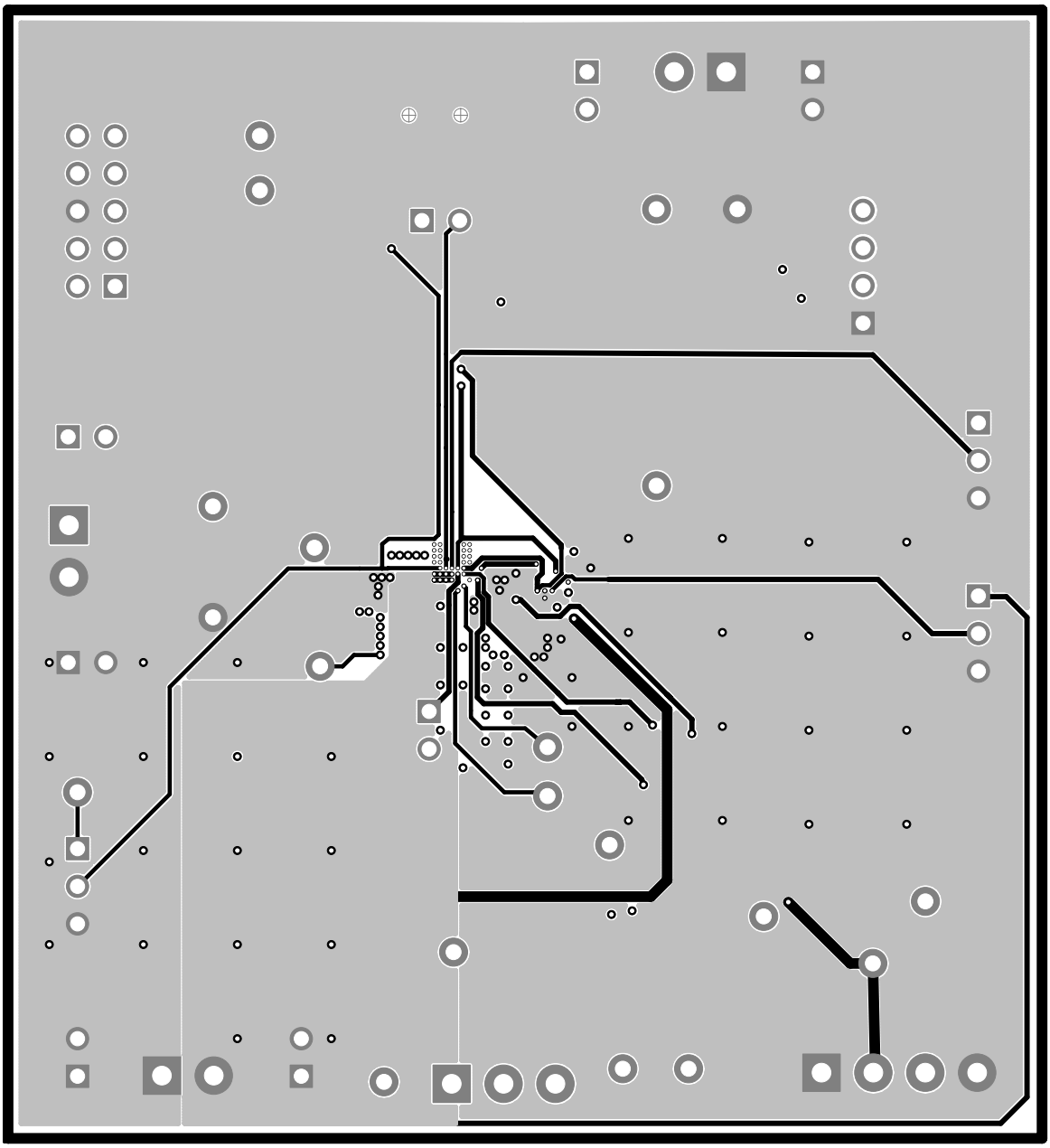

Figure 4. Layer 3

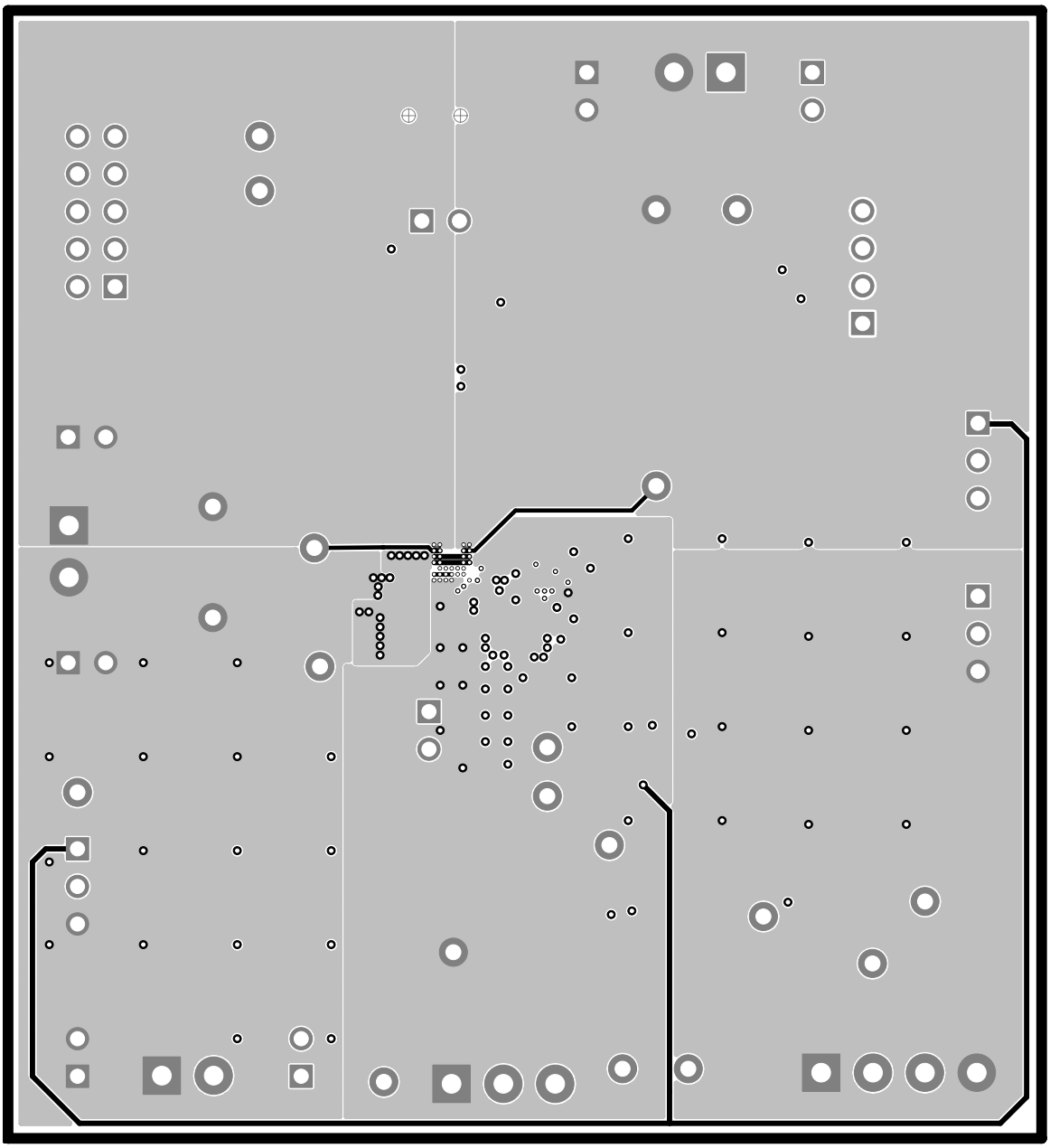

Figure 5. Layer 4

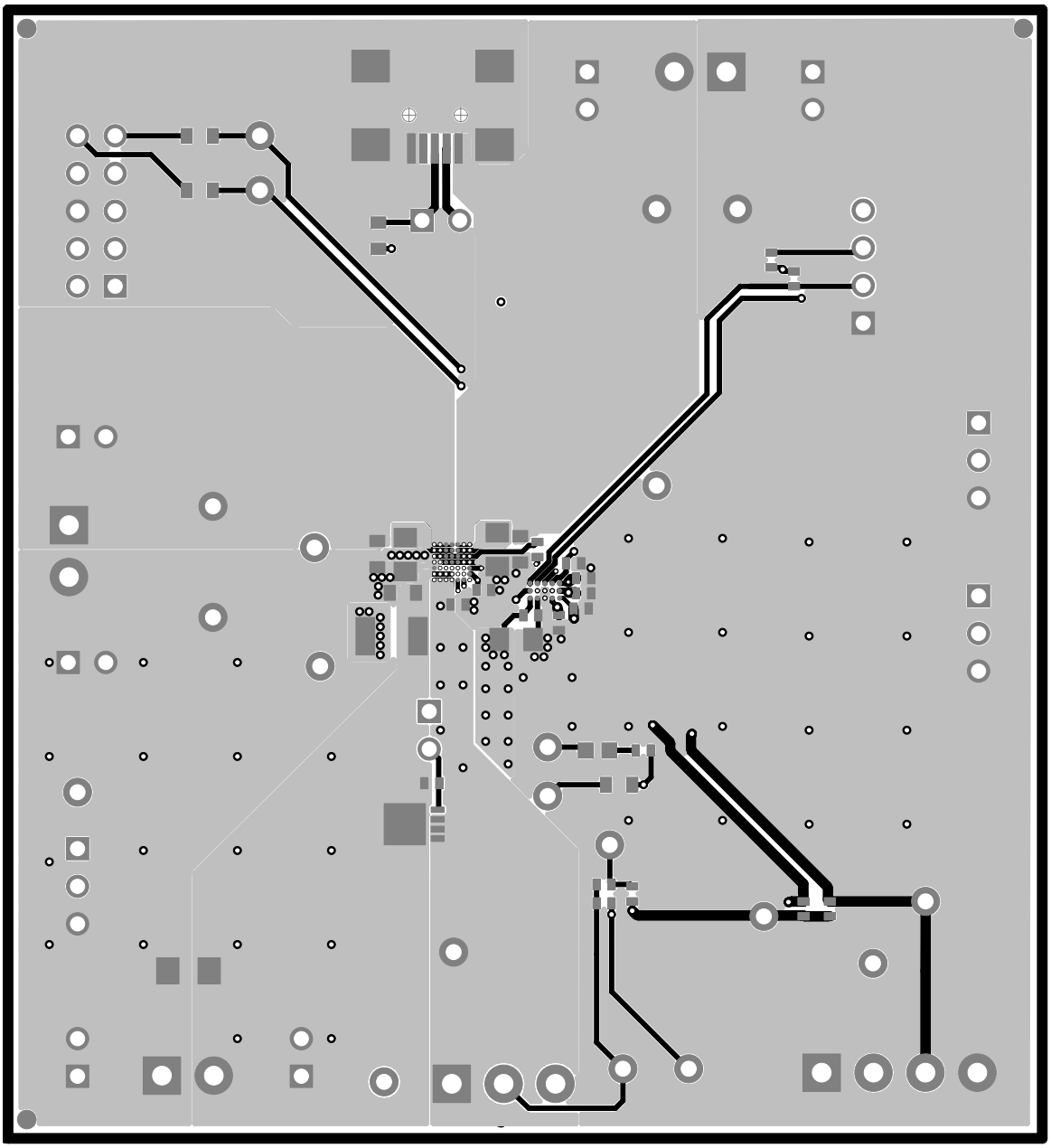

Figure 6. Layer 5

3.2 Bill of Materials and Schematic

Table 2. Bill of Materials

COUNT	RefDes	VALUE	Description	Size	Part Number	MFR
2	C1, C3	1.0uF	Capacitor, Ceramic, 25V, X5R, 10%	0603	Std	Std
3	C2, C5, C12	1.0uF	Capacitor, Ceramic, 6.3V, X5R, 10%	0402	Std	Std
2	C4, C6	4.7uF	Capacitor, Ceramic, 25V, X5R, 10%	0805	Std	Std
1	C7	0.01uF	Capacitor, Ceramic, 16V, X7R, 10%	0402	Std	Std
1	C8	10uF	Capacitor, Ceramic, 10V, X5R, 10%	0603	Std	Std
1	C9	47uF	Capacitor, Ceramic, 10V, X5R, 20%	1206	Std	Std
4	C10, C11, C13, C15	0.1uF	Capacitor, Ceramic, 6.3V, X5R, 10%	0402	Std	Std
1	C14	0.033uF	Capacitor, Ceramic, 16V, X7R, 10%	0402	Std	Std
1	D1	Green	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190GKT	Liteon
6	J1, J3, J4, J6, J8, J10	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
0	J11	Open	Connector, Male Straight 2x5 pin, 100mil spacing, 4 Wall	0.338 x 0.788 inch	N2510-6002-RB	3M
1	J12	ED555/3DS	Terminal Block, 3-pin, 6-A, 3.5mm	0.41 x 0.25 inch	ED555/3DS	OST
1	J13	ED555/4DS	Terminal Block, 4-pin, 6-A, 3.5mm	0.55 x 0.25 inch	ED555/4DS	OST
1	J14	22-05-3041	Header, Friction Lock Ass'y, 4-pin Right Angle	0.400 x 0.500	22-05-3041	Molex
3	J2, J5, J9	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25	ED555/2DS	OST
1	J7	UX60-MB-5ST	Connector, Recpt, USB-B, Mini, 5-pins, SMT	0.354 X 0.303 Inches	UX60-MB-5ST	Hiroise
2	JP1, JP2	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
2	JP4, JP5	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
1	JP3	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
1	L1	1.5uH	Inductor, SMT, 3.5A, 70 milliohm	4.1x4.4 mm	SPM4012T-1R5M Alternate: FDSD0415-H-1R5M	TDK Alternate: Toko
1	Q1	CSD25401Q3	MOSFET, PChan, -20V, 60A, 8.7 milliOhm	QFN3.3X3.3mm	CSD25401Q3	TI
1	R1	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R3	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R10, R11, R12, R13	10.0k	Resistor, Chip, 1/16W, 1%	0402	Std	Std
1	R2	510k	Resistor, Chip, 1/16W, 1%	0402	Std	Std
0	R4, R5	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R6	1.80M	Resistor, Chip, 1/16W, 1%	0402	Std	Std
1	R7	18.2k	Resistor, Chip, 1/16W, 1%	0402	Std	Std

Table 2. Bill of Materials (continued)

COUNT	RefDes	VALUE	Description	Size	Part Number	MFR
1	R8	0.01	Resistor, Chip, 1/4W, 1%	0805	WSL0805R0100FEA18	Vishay
2	R9, R14	1.00k	Resistor, Chip, 1/16W, 1%	0402	Std	Std
20	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20	5002	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	U1	BQ24161YFF	IC, 2.5A, Dual-Input, Single Cell SwitchmodeLi-Ion BATTERY CHARGER with Power Path Management	BGA	BQ24161YFF	TI
1	U2	BQ27530-G1YZF	IC, Battery Monitor and Data Logger	DSBGA	BQ27530-G1YZF	TI
4	--		Shunt, 100-mil, Black	0.100	929950-00	3M
1	--		PCB		HPA763	Any
1	--		Label (See note 5)	1.25 x 0.25 inch	THT-13-457-10	Brady
2	J5 mate		Connector, Female, 0.100 Centers		22-01-3047	Molex
8	N/A		Terminals, Crimp, Tin		08-50-0114	Molex
	N/A		Wire, Insulated 24 Awg, Red, 18 Inches (+/- 3 inches)(USB_5V)		1854-3	Alpha
	N/A		Wire, Insulated 24 Awg, White, 18 Inches (+/- 3 inches)(SCL)		1854-1	Alpha
	N/A		Wire, Insulated 24 Awg, Black, 18 Inches (+/- 3 inches)(GND)		1854-2	Alpha
	N/A		Wire, Insulated 24 Awg, Brown, 18 Inches (+/- 3 inches) (SDA)		1854-7	Alpha
1	N/A		Heatshrink 1" placed at middle of wire set		Any	Any

3.3 bq27530 Circuit Module Performance Specification Summary

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

3.4 Recommended Operating Conditions

		Min	Typ	Max	Unit
Supply voltage, V_{IN}	Input voltage from ac adapter	4.2		10	V
USB voltage, V_{USB}	Input voltage from USB or equivalent supply	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		VBATREG+4.17%	V
Battery voltage, V_{BAT}	Voltage output at VBAT terminal (registers set via bq27530 software)	3	4.2	4.44	V
Supply current, $I_{IN(MAX)}$	Maximum input current from ac adapter input (registers set via bq27530 software)	1.5		2.5	A
Supply current, $I_{USB(MAX)}$	Maximum input current from USB input (registers set via bq27530 software)	0.1	0.5	1.5	A
Fast charge current, $I_{CHRG(MAX)}$	Battery charge current (registers set via bq27530 software)	0.550		2.5	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 bq27530EVM 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 inFigure 7 can simulate a battery when connected to a power supply.

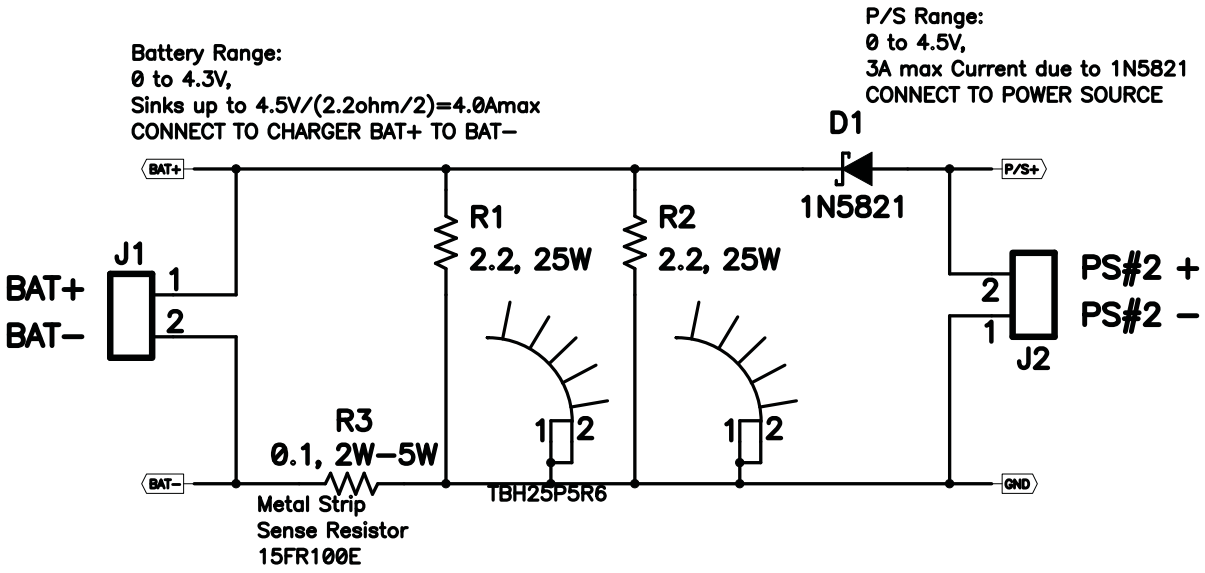

Figure 7. BAT_Load (PR1010) Schematic

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

Four 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 (multimeter) #2 (CM #2) to J2 and J6 or J3 (BAT, GND). Ensure that a voltage meter is connected across J2 or TP3 and J6 or TP9 (BAT, GND).
5. Connect VM #3 across J10 or TP7 and J14 or TP9 (SYS, GND).
6. Connect VM #4 across J15 or TP5 and J14 or TP9 (DRV, GND).
7. Ensure jumpers are at the default factory settings per Section 2.4
8. Connect I2C port of EV2300 with J14 board using the assembled 4 colored-wire connector included with EV2300 kit (GND / BLACK at the bottom).
9. After the preceding steps have been performed, the test setup for HPA721 is configured as is shown in Figure 8

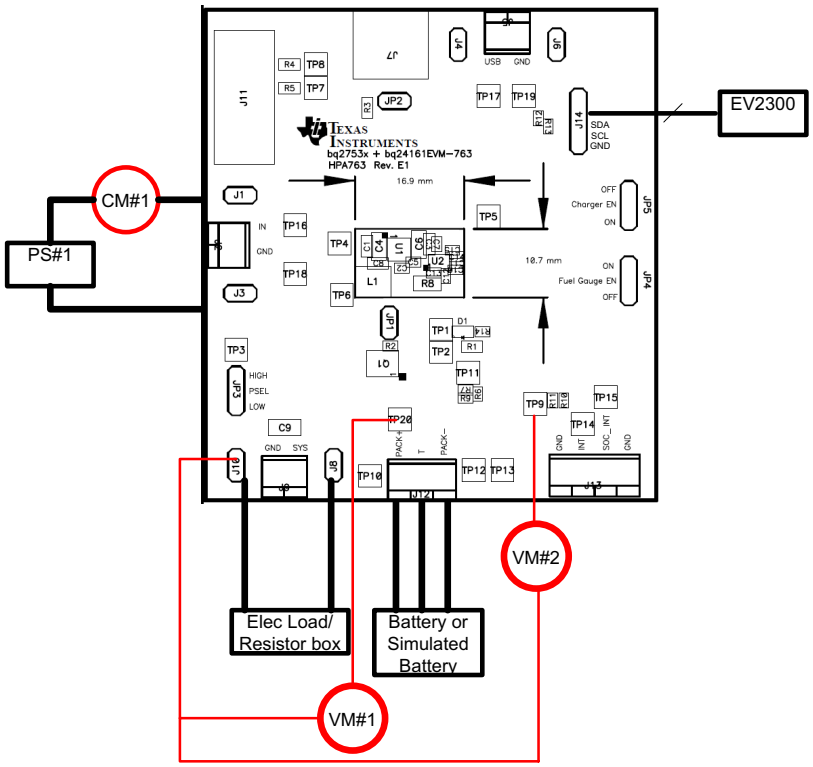

Figure 8. Original Test Setup for bq24160/161/163/168EVM (HPA721)

10. Turn on the computer. Open the bq27530 evaluation software. The main window of the software is shown in Figure 9 (DataRAM Screen)

4.2 Software System Requirements

The bq27530EVSW software requires 32-bit versions of Windows 2000 or Windows XP. Drivers for Windows 98SE are provided, but Microsoft™ no longer supports Windows 98; therefore, Windows 98 can have issues 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.

4.3 Software Installation

Find the latest software version in the bq27530 tool folder on power.ti.com. Make a search by part number for bq27530 to access the tool folder.

4.3.1 Using EV2300

Use the following steps to install the bq27530EVSW software when using EV2300:

1. Ensure that the EV2300 is not connected to the PC through a USB cable before starting this procedure.
2. Browse for the supported software link within the bq27530 TI web site product folder to find the downloadable evaluation software (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. Before starting the EVSW, connect the EV2300 to the computer using the USB cable.
6. Wait until the system prompt “new hardware found” appears. Choose “select location manually”, and use the “browse” button to point to subdirectory TIUSBWin2K-XP-1.
7. Answer “continue” to the warning that drivers are not certified with Microsoft™.
8. After installation finishes, another system prompt "new hardware found" appears. Repeat steps 6 and 7, but specify the directory as TIUSBWin2K-XP-2.
9. Answer "continue" to the warning that drivers are not certified with Microsoft. Driver installation is now finished.

4.3.2 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 bq27530 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 bq27530 EVSW software.

6.1 Starting the Program

Run bq27530 EVSW from the Start | Programs | Texas Instruments | bq Evaluation Software menu sequence. The DataRAM screen (Figure 9) 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 with the | Options | and | Set Scan Interval | menu selections. The range for this interval is 0 ms to 65,535 ms. Only items that are selected for scanning are scanned within this period.

The bq27530 EVSW provides a logging function which logs the values that were last scanned by EVSW. To enable this function, select the *Start Logging* button; this causes the *Keep Scanning* button to be selected. When logging is *Stopped*, the Keep Scanning button is still selected and has to be manually unchecked.

The logging intervals are specified under the | Options | menu with the maximum value of 65,535 ms. The *Log* interval cannot be smaller than the scan interval because this results in the same value being logged at least twice.

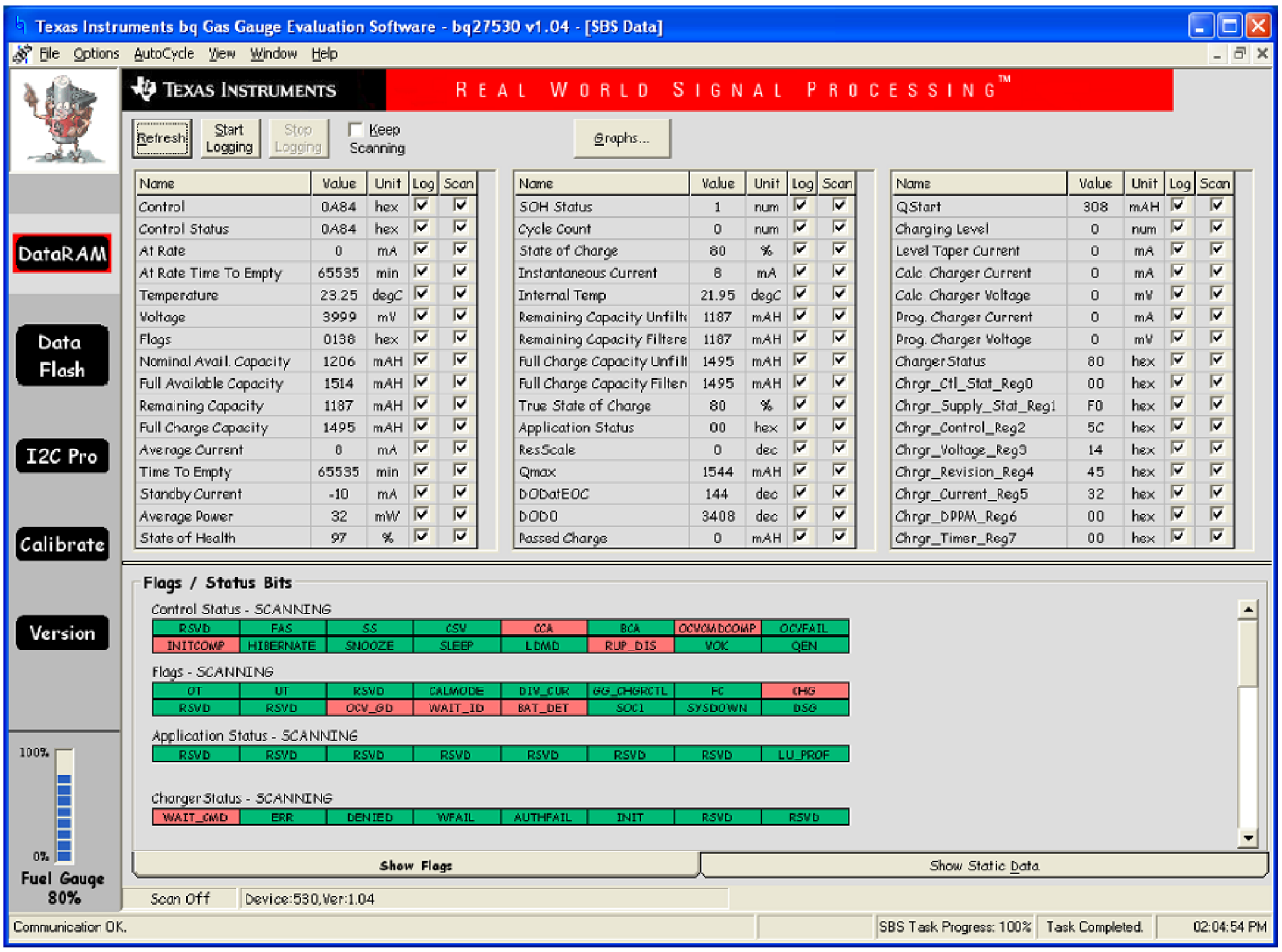

Figure 9. DataRAM Screen

This screen (Figure 9) shows the RAM data set. Additional Flag and Status data can be viewed at the bottom of the DataRAM screen.

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

6.2 Setting Programmable bq27530 Options

The bq27530 data flash comes configured per the default settings detailed in the bq27530 data sheet. Ensure that the settings are correctly changed to match the pack and application for the bq27530 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 10).

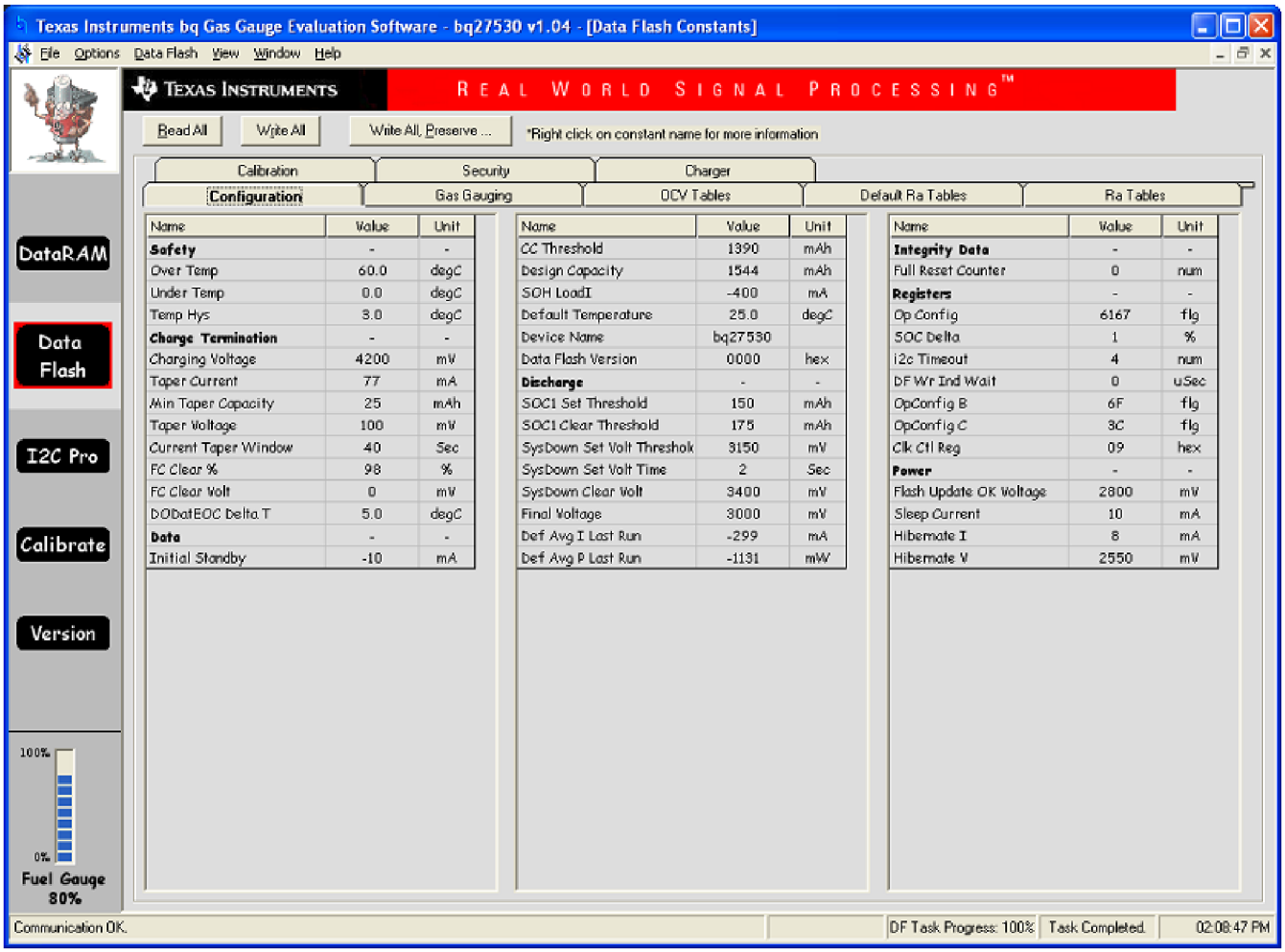

Figure 10. Data Flash Screen

To read all the data from the bq27530 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 bq27530 using the | Write All | button.

The module calibration data is also held in the bq27530 data flash.

The bq27530 allows for an automatic data-flash export function, similar to the DataRAM 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 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 bq27530 that is being used may not be supported by the bqEVSW version that is being used. An upgrade may be required. Most of the Data Flash also cannot be read if the bq27530 is in Sealed mode.

7 Calibrate Screen

To ensure proper calibration, perform the following steps. These steps may or may not be required, depending on the type of calibration being performed. Only one calibration item can be selected and calibrated at a time.

7.1 To Calibrate the bq27530

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 11).

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 Pack Current* button.

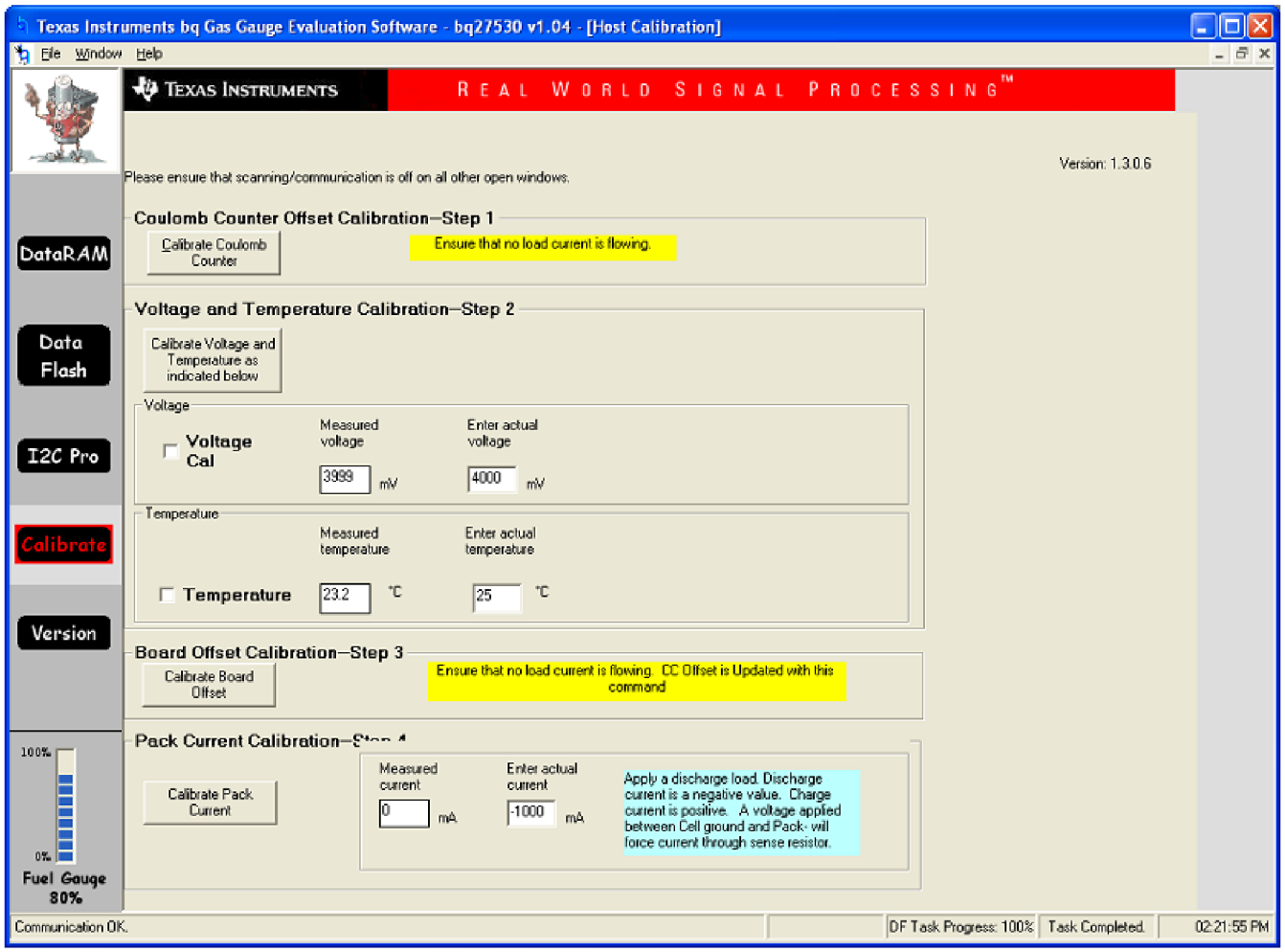

Figure 11. Calibration Screen

8 I2C Pro Screen

8.1 I²C Communication

The read/write operations of the I2C Pro function is not specific to any gas gauge. These operations serve as general-purpose communication tools (Figure 12).

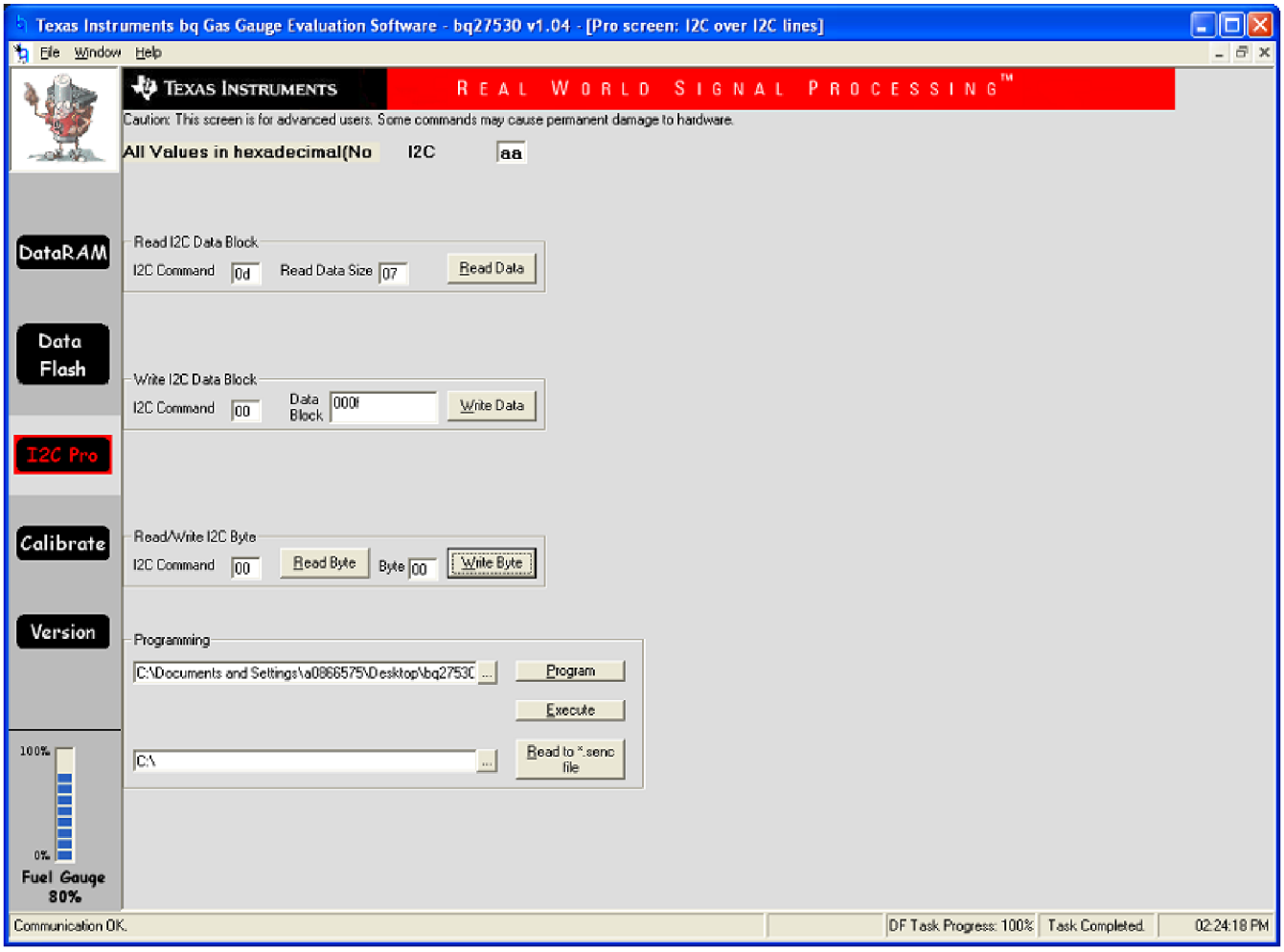

Figure 12. I2C Pro Screen

9 Related Documentation From Texas Instruments

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- *bq27530, System-Side Impedance Track™ Fuel Gauge With Integrated LDO* data sheet (SLUS955)

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