User's Guide
SLUUBD6–September 2015

bq78z100EVM 1- to 2-Series Li-Ion Battery Pack Manager Evaluation Module

This evaluation module (EVM) is a complete evaluation system for the bq78z100 or bq294502 battery management system. The EVM includes one bq78z100 and bq294502 circuit module and a link to Windows® based PC software. The circuit module includes one bq78z100 integrated circuit (IC), one bq294502 IC, and all other onboard components necessary to monitor and predict capacity, perform cell balancing, monitor critical parameters, protect the cells from overcharge, over-discharge, short-circuit, and over-current in 1- or 2-series cell Li-Ion or Li-Polymer battery packs. The circuit module connects directly across the cells in a battery. With the EV2300 or EV2400 interface board and software, the user can read the bq78z100 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the solution under different charge and discharge conditions using HDQ communication protocol.

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1 Features

- Complete evaluation system for the bq78z100EVM 1- to 2-Series Battery Pack Manager Evaluation Module and bq294502 independent overvoltage protection IC
- Populated circuit module for quick setup
- Software that allows data logging for system analysis

1.1 Kit Contents

- bq78z100 and bq294502 circuit module
- Cable to connect the EVM to an EV2300 or EV2400 Communications Interface adapter

1.2 Ordering Information

For complete ordering information, see the product page at www.ti.com.

Table 1. Ordering Information

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	CAPACITY
bq78z100EVM	Li-Ion	1-, 2-cell	Any

1.3 Documentation

For information on the bq78z100 and bq294502 device firmware and hardware, see the following documentation:

- *bq78z100 Impedance Track™ Gas Gauge for 1-Series to 2-Series Li-Ion/Li-Polymer Battery Packs* (SLUSC23)
- *bq78z100 Technical Reference Manual* (SLUUB63)
- *bq2945xx Overvoltage Protection For 2-Series and 3-Series Cell Li-Ion Batteries* (SLUSAJ3)
- *bq294502 EVM User's Guide* (SLUU659)

1.4 bq78z100 and bq294502 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq78z100 and bq294502 EVM.

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Table 2. Performance Specification Summary

SPECIFICATION	MINIMUM	TYPICAL	MAXIMUM	UNITS
Input voltage Pack+ to Pack–	3	7	25	V
Charge and discharge current	0	2	7	A

2 bq78z100EVM Quick Start Guide

This section provides the step-by-step procedures required to use a new EVM and configure it for operation in a laboratory environment.

2.1 Items Needed for EVM Setup and Evaluation

- bq78z100 and bq294502 circuit module
- EV2300 or EV2400 communications interface adapter
- Cable to connect the EVM to an EV2300 or EV2400 communications interface adapter
- USB cable to connect the communications interface adapter to the computer
- Computer setup with Windows® XP, or higher, operating system
- Access to the Internet to download the Battery Management Studio software setup program
- One or two battery cells or 1-kΩ resistors to configure a cell simulator
- A DC power supply that can supply 8.4 V and 2 A (constant current and constant voltage capability is desirable)

2.2 Software Installation

Find the latest software version in the bq78z100 tool folder on www.ti.com. Use the following steps to install the bq78z100 Battery Management Studio software:

1. Download and run the Battery Management Studio setup program from the Development Tools section of the bq78z100EVM product folder on www.ti.com. See Section 3 for detailed information on using the tools in the Battery Management Studio.
2. If the Communications Interface Adapter was not previously installed, after the bqStudio installation, a TI USB DRIVER INSTALLER pops up. Click **Yes** for the agreement message and follow its instructions. Two drivers are associated with the EV2300 and an additional file may be required for the EV2400. Follow the instructions to install both. Do not reboot the computer, even if asked to do so.
3. Plug the communications interface adapter into a USB port using the USB cable. The Windows® system may show a prompt that new hardware has been found. When asked, "Can Windows connect to Windows Update to search for software?", select "No, not this time", and click **Next**. In the next dialog window, it indicates "This wizard helps you install software for: TI USB Firmware Updater". Select "Install the software automatically (Recommended)" and click **Next**. It is common for the next screen to be the Confirm File Replace screen. Click **No** to continue. If this screen does not appear, then go to the next step. After Windows® indicates that the installation was finished, a similar dialog window pops up to install the second driver. Proceed with the same installation preference as the first one. The second driver is TI USB bq80xx Driver.

2.3 EVM Connections Module Connections

This section covers the hardware connections for the EVM. See Figure 1.

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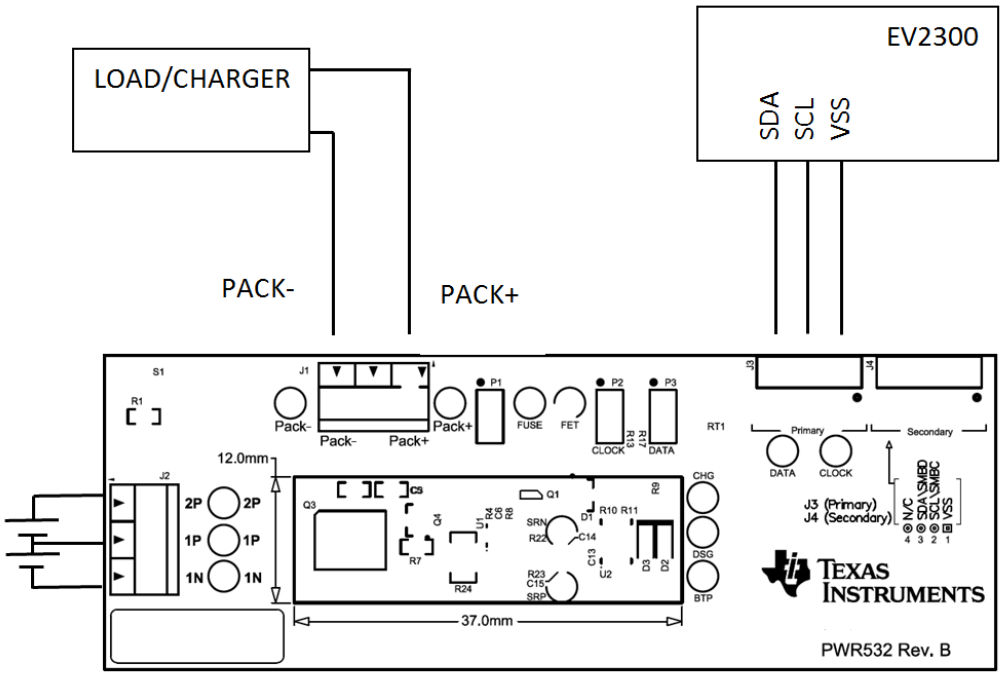

Figure 1. bq78z100 Circuit Module Connection to Cells and System Load or Charger

- Direct connection to the cells: 1N (BAT–), 1P, 2P (BAT+)

  Attach the cells to the J2 terminal block. A specific cell connection sequence is not required, although it is a good practice to start with lowest cell in the stack (cell1) and then add cell 2. The U1 and U2 devices should not get damaged by other cell connection sequences, but there is a possibility that the bq294502 could blow the fuse in a module that has one. Attaching cells starting with cell 1 should eliminate this risk.

Number of Cells	J2 Terminal Block Connections				
	1N		1P		2P
1	⊖	–cell1+	⊖	short	⊖
2	⊖	–cell1+	⊖	–cell2+	⊖

Figure 2. Cell Connection Configuration

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A resistor cell simulator can be used instead of battery cells. Connect a resistor between each of the contacts on the J2 connector; that is, from 1N to 1P and from 1P to 2P. If being used for a 1-series configuration no resistor is needed, simply short 1P and 2P. A power supply can provide power to the cell simulator. Set the power supply to the desired cell voltage x the number of cells and attach the ground wire to 1N and the positive wire to 2P. For example, for a 2-series configuration with a 3.6-V cell voltage, set the power supply to 2 × 3.6 = 7.2 V.

- I^2C™ (SDA, SCL) and HDQ port

  Attach the communications interface adapter cable to J3 and to the I^2C™ port on the EV2300.

NOTE: The bq78z100 ships with the firmware in I^2C mode for faster programming of the data flash. When programming is done, the device can be switched to HDQ mode using the GO_TO HDQ command. After the device is switched to HDQ, the connecting cable on the EV2300 should be switched to the HDQ port; otherwise, the user will not be able to communicate with the device. The user can also switch back from HDQ to I^2C using the GO_TO I^2C command.

- System load and charger connections across PACK+ and PACK–

  Attach the load or power supply to the J1 terminal block. The positive terminal of the load or power supply wire should be connected to the terminal block position labeled PACK+. The ground wire for the load or power supply should be connected to the other terminal block position labeled PACK–.

- Wake-up the device up from SHUTDOWN (WAKE)

  Press the **Wake** pushbutton switch S1 to temporarily connect BAT+ to PACK+. This applies voltage to the PACK pin on the bq78z100 to power-up the regulators and start the initialization sequence.

- Parameter setup

  The default data flash default settings is configured for 2-series Li-Ion cells. The user should change the | Data Memory | Settings | DA Configuration register to set up the number of series cells to match the physical pack configuration. This provides basic functionality to the setup. Other data flash parameters should also be updated to fine tune the gauge to the pack. See the *bq78z100 Technical Reference Manual* (SLUUB63) for help with setting the parameters.

NOTE: If using a 1-series configuration: To avoid an undervoltage safety condition, the device should be initially powered up with a 2-series configuration to allow the user to go into the | Data Memory | Settings | DA Configuration and modify the CC0 bit for 1-series configuration.

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3 Battery Management Studio

3.1 Starting the Program

Run Battery Management Studio from the Start | Programs | Texas Instruments | Battery Management Studio sequence or the Battery Management Studio shortcut. As long as the device has been woken up from shutdown mode by momentarily pressing button **S1** or applying a charger voltage, the gauge will be automatically detected and the register screen will appear as seen in Figure 3. If your device contains an earlier firmware version, then auto detection of the device may not occur. If that happens, on the window that pops up as shown in Figure 4, select any bq78z100 .bqz file. This action will enable the program to get started and the user can update the firmware using the latest .srec file for the device downloadable from the product folder of the gauge at www.ti.com.

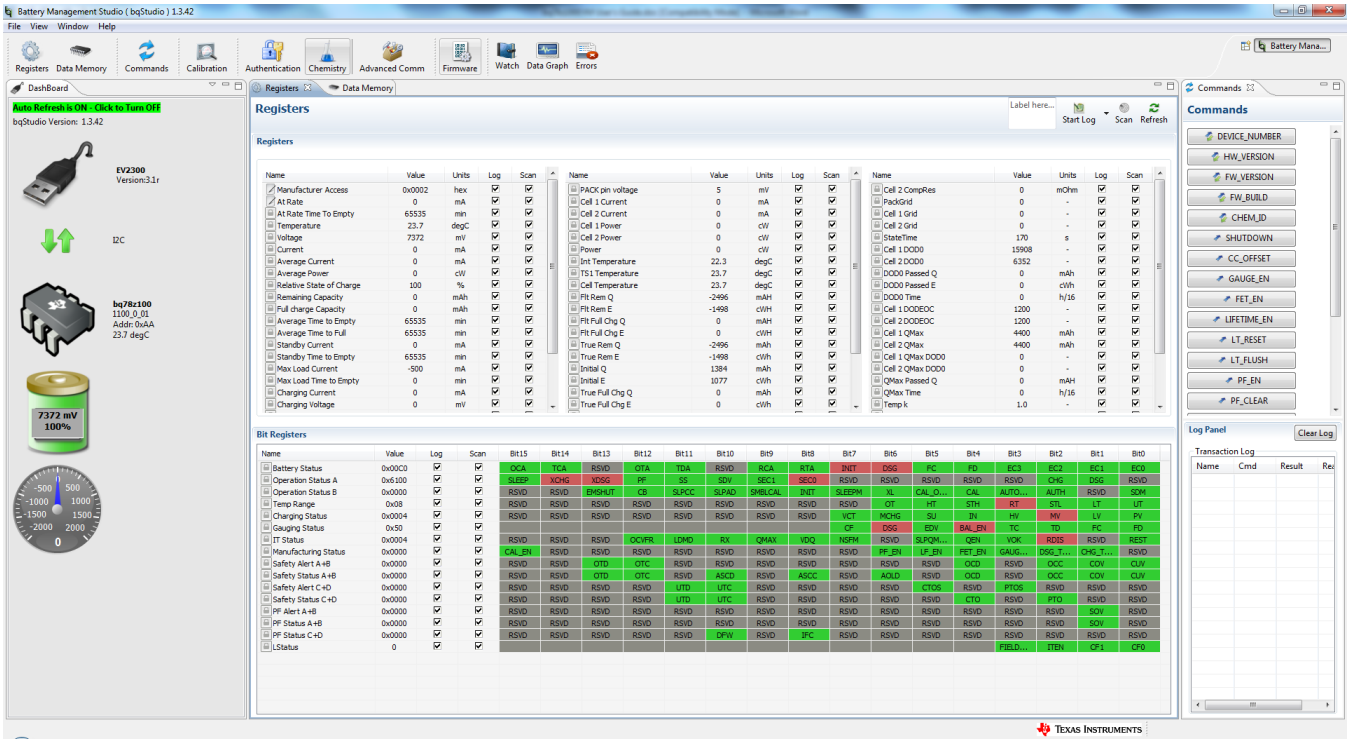

Figure 3. Registers Screen

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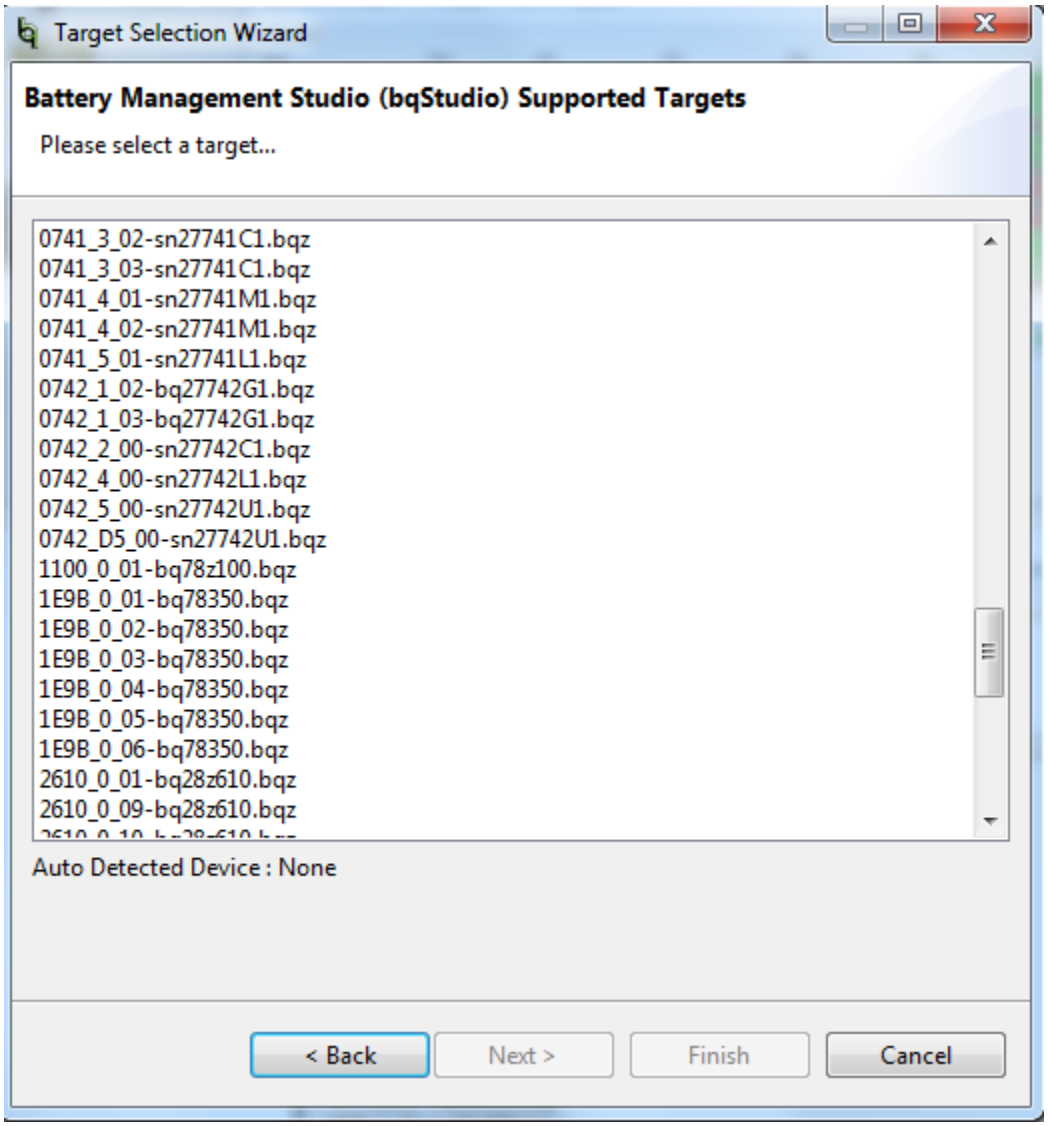

Figure 4. Battery Management Studio Supported Targets

3.2 Registers Screen

The Registers section contains parameters used to monitor gauging. The Bit Registers section provides bit level picture of status and fault registers. A green flag indicates that the bit is 0 (low state) and a red flag indicates that the bit is 1 (high state). A greyed out bit indicated that bit is reserved. Data begins to appear once the **Refresh** (single-time scan) button is selected, or it scans continuously if the **Scan** button is selected. The continuous scanning period can be set via the | Windows |preferences| register selections.

The battery management Studio program provides a logging function which logs all the values of the parameters in the Register section if running the program in “Show basic view mode”. In order to selectively choose the parameters of Register section that are scanned and logged, the user needs to set Battery Management Studio to “Show Advanced view mode”. This mode can be set via | Windows |preferences| All Global Settings| Show Advanced Views. Uncheck the fields that are not needed to be scanned or logged. To enable logging, select the **Log** button; this causes the **Scan** button to be selected. When logging is stopped, the **Scan** button is still selected and has to be manually deselected.

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3.3 Data Memory Screen

The bq78z100 data flash comes configured per the default settings detailed in the bq78z100 TRM. Ensure that the settings are correctly changed to match the pack and application for the solution being evaluated. For ease of configuration, a text file with a gg.csv extension can be extracted, modified and imported back on the device. Use the export and import buttons as seen in Figure 5 to export and import gg.csv files. The auto export button enables gg files to be exported periodically at intervals. This is useful when debugging issues with the gauge. A write all command is necessary if a gg.csv file is imported to ensure that all the changes made on the gg.csv file are effected on the gauge. The read all command is used to read back all of the data written to the gauge so that the changes made can be verified. The filter/search field enables the user to search for a particular parameter in the data memory content.

NOTE: Do not make modifications to the gg.csv file using Microsoft Excel® as it makes changes to file, which bqStudio rejects. Make sure to use a text editor like notepad or similar to edit a gg.csv file.

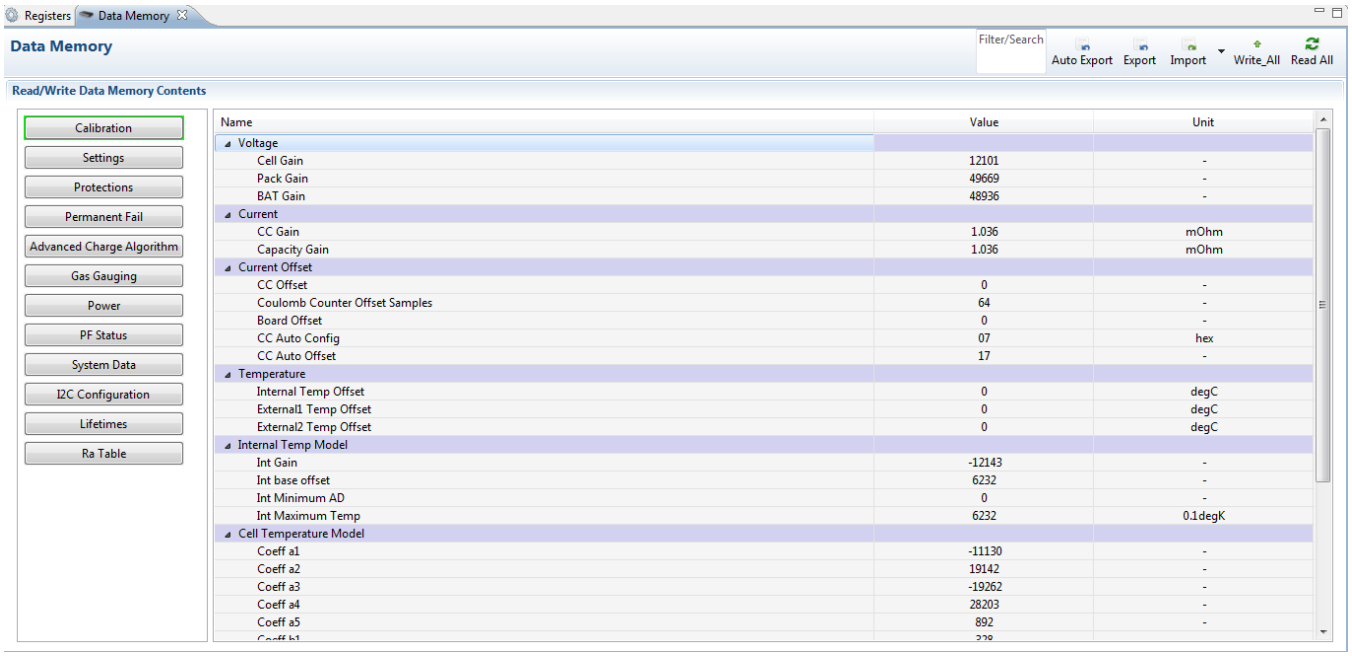

Figure 5. Data Memory Screen

3.4 Calibration Screen

The voltages, temperatures, and currents should be calibrated to provide good gauging performance. Press the **Calibration** button while in the “Show Advanced view mode” to select the **Advanced Calibration** window. See Figure 6. If in the “Show basic view mode”, the basic calibration window shows when the **Calibration** button is clicked. The **Advanced Calibration** window enables the internal temperature sensor as well as the external thermistor to be calibrated.

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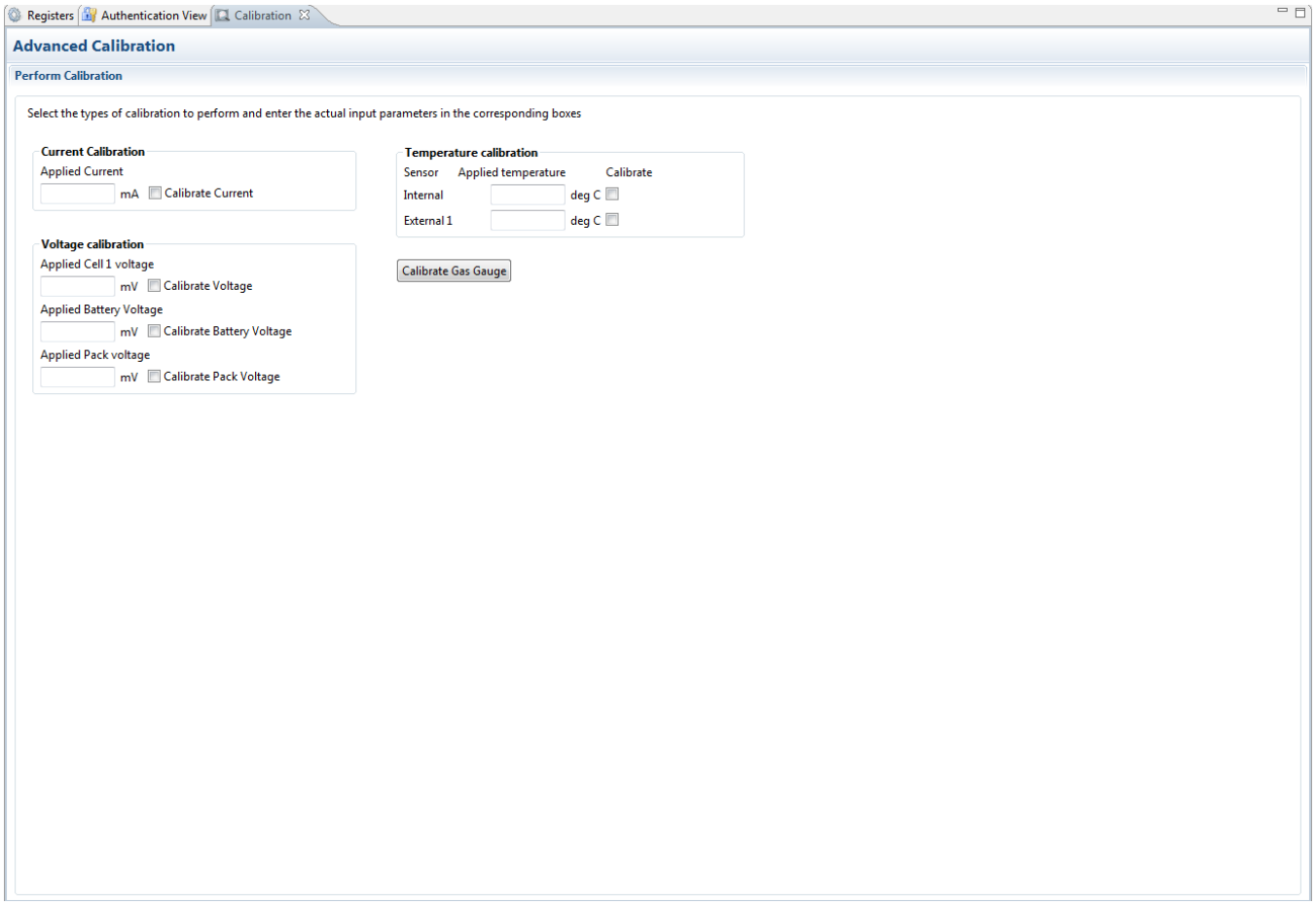

Figure 6. Calibration Screen

3.4.1 Voltage Calibration

- Measure the voltage from Cell 1 to 1N and enter this value in the *Applied Cell 1 Voltage* field and select the **Calibrate Voltage** box.
- Measure the voltage from Bat+ (2P) to Bat– (2N) and enter this value in the *Applied Battery Voltage* field and select the **Calibrate Battery Voltage** box.
- Measure the voltage from Pack+ to Pack– and enter this value in the *Applied Pack Voltage* field and select the **Calibrate Pack Voltage** box. If the voltage is not present, then turn the charge and discharge FETs on by entering a 0x22 command in the Manufacturer Access register on the **Register** screen.
- Press the **Calibrate Gas Gauge** button to calibrate the voltage measurement system.
- Deselect the **Calibrate Voltage** boxes after voltage calibration has completed.

3.4.2 Temperature Calibration

- Enter the room temperature in each of the *Applied Temperature* fields and select the **Calibrate** box for each thermistor to be calibrated. The temperature values must be entered in degrees Celsius.
- Press the **Calibrate Gas Gauge** button to calibrate the temperature measurement system.
- Deselect the **Calibrate** boxes after temperature calibration has completed.

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3.4.3 Current Calibration

The Board Offset calibration option is not offered in Battery Management Studio, because it is not required when using the bq78z100EVM. The Board Offset calibration option is available in bqProduction.

- Connect and measure a 2-A current source from 1N (–) and Pack– to calibrate without using the FETs. (TI does not recommend calibration using the FETs.)
- Enter –2000 in the *Applied Current* field and select the **Calibrate Current** box.
- Press the **Calibrate Gas Gauge** button to calibrate.
- Deselect the **Calibrate Current** box after current calibration has completed.

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3.5 Authentication Screen

The bq78z100 supports SHA-1 HMAC authentication with the host system. The authentication screen of bqStudio allows for the SHA-1 calculator to be tested, perform gauge authentication by the host and change the gauge authentication key.

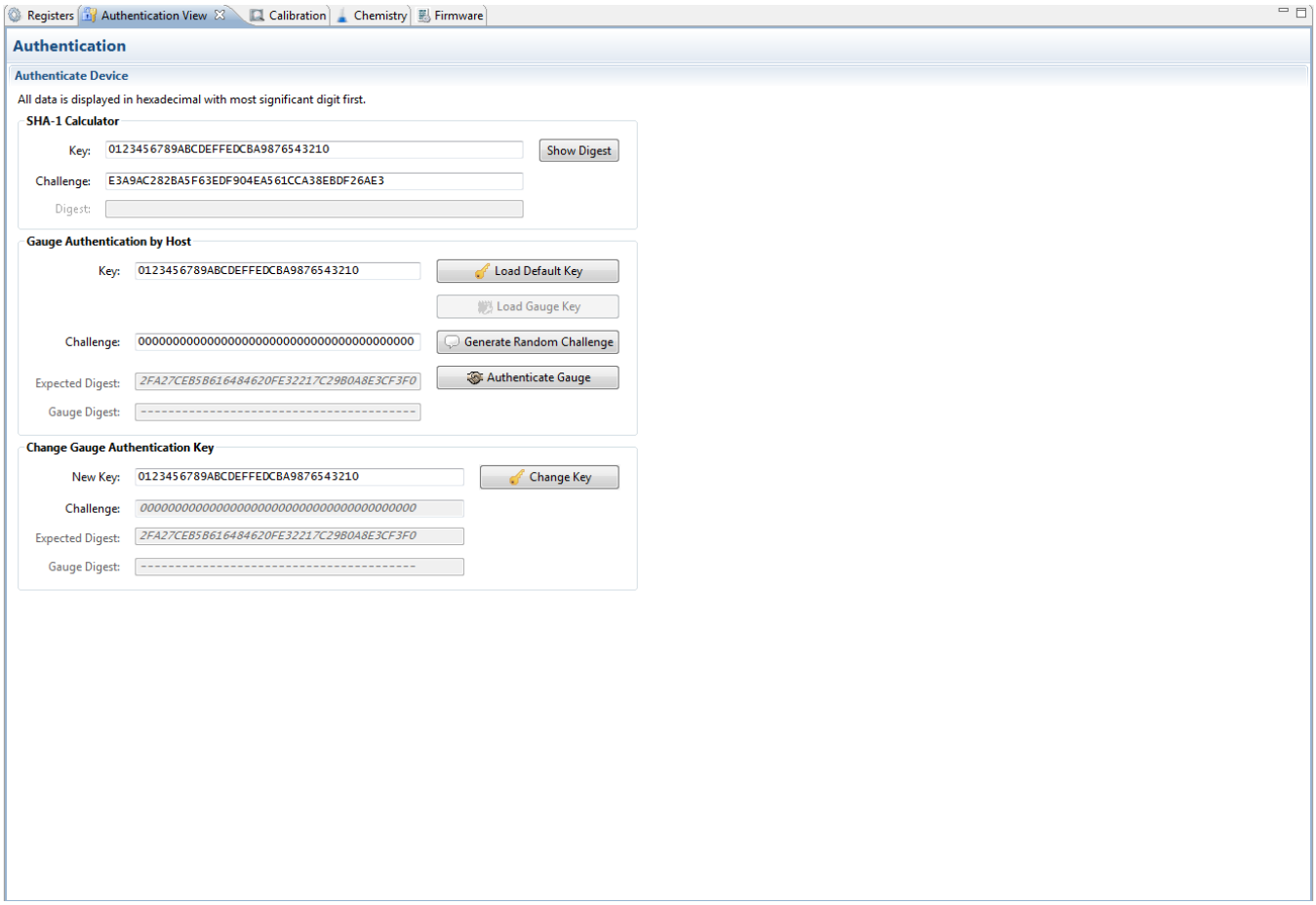

Figure 7. Authentication Screen

3.6 Chemistry Selection

The chemistry file contains parameters that the simulations use to model the cell and its operating profile. It is critical to program a Chemistry ID that matches the cell into the device. Some of these parameters can be viewed in the Data Flash section of the Battery Management Studio.

Press the **Chemistry** button to select the **Chemistry** window.

- The table can be sorted by clicking the desired column. For example: Click the *Chemistry ID* column header.
- Select the ChemID that matches your cell from the table (see Figure 8).
- Press **Update Chemistry from Database** to update the chemistry in the device.

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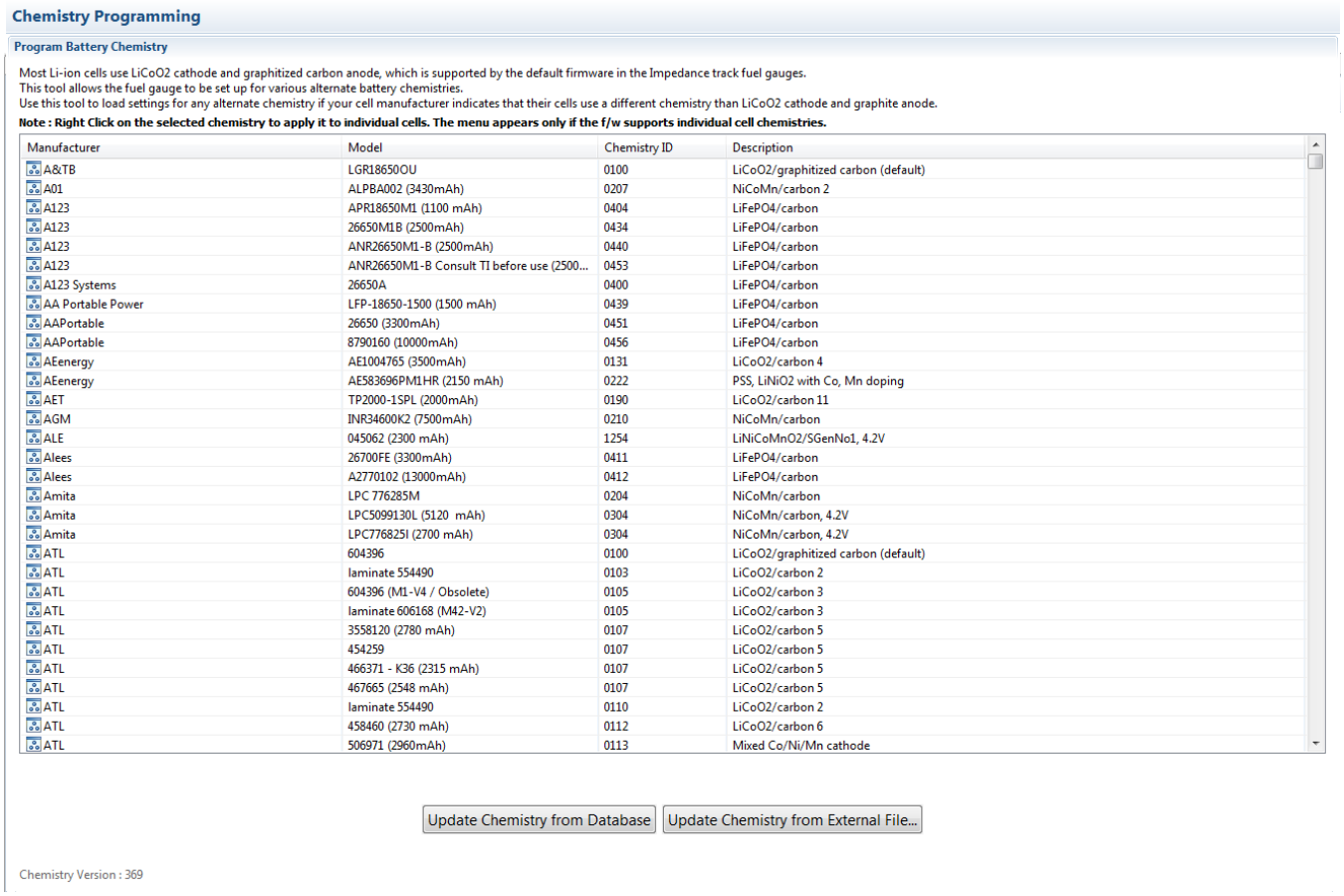

Figure 8. Chemistry Screen

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3.7 Firmware Screen

Press the **Firmware** button to select the **Firmware Update** window. This window allows the user to export and import the device firmware.

3.7.1 Programming the Flash Memory

The upper section of the Firmware screen is used to initialize the device by loading the default .srec into the flash memory (see Figure 9).

- Search for the .srec file using the **Browse** button.
- Select the **Execute after programming** box to automatically return the device to NORMAL mode after programming has completed.
- Press the **Program** button and wait for the download to complete.

3.7.2 Exporting the Flash Memory

The lower section of the Firmware screen is used to export all of the flash memory from the device (see Figure 9).

- Press the **Browse** button and enter an .srec filename.
- Press the *Read Srec* to save the flash memory contents to the file. Wait for the download to complete.

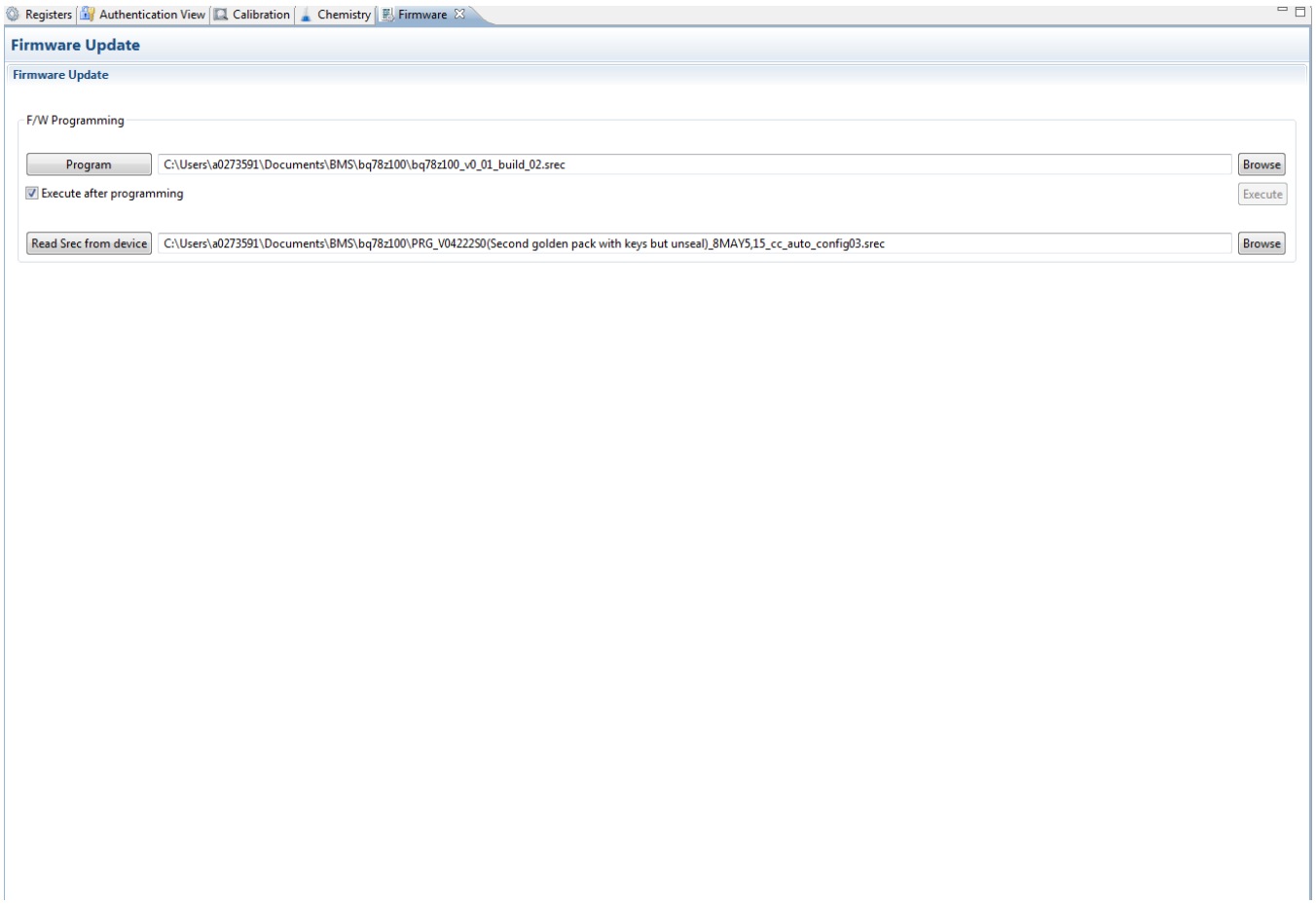

Figure 9. Firmware Screen

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3.8 Advanced Comm I²C Screen

Press the **Advanced Comm I2C** button to select the **Advanced Comm I2C** window. This tool provides access to parameters using I²C and Manufacturing Access commands. See Figure 10. The transaction log screen shows the history of sent commands.

NOTE: I²C commands are sent in Little Endian format.

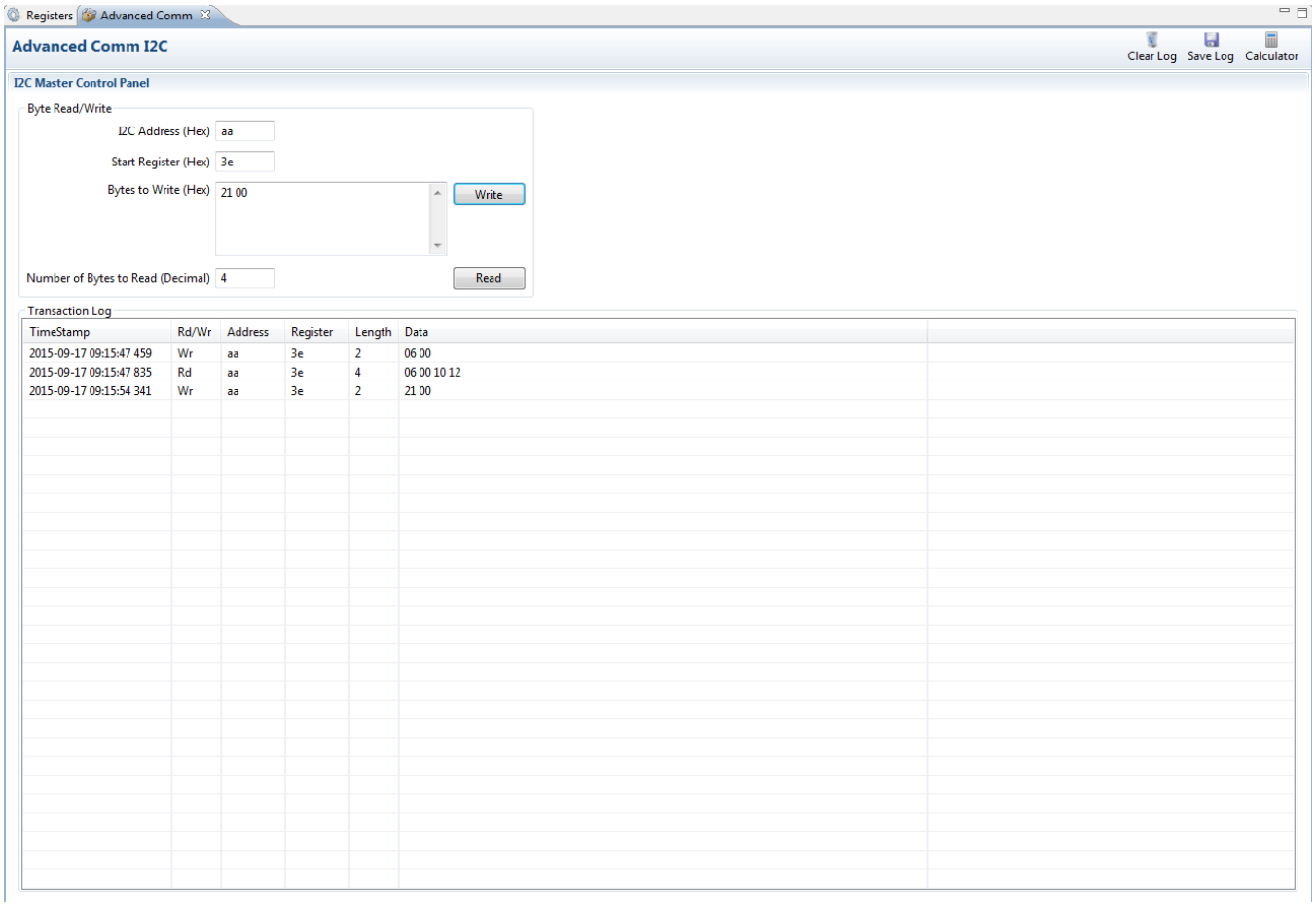

Figure 10. Advanced Comm I²C Screen

Examples:

Reading an I²C Command.

- Read chemical ID (0x 0006).
  - Write to mac address 3e Command 06 00 (see Figure 10).
  - Read 4 bytes.
  - The result returned is 10 12, which is little endian for chem id 1210.

Sending a MAC *Gauging()* to enable IT via *ManufacturerAccess()*.

- With Impedance Track™ disabled, send *Gauging()* (0x0021) to *ManufacturerAccess()*.
  - Write to mac address 3e command 21 00 (see Figure 10).

3.9 Watch Screen

This enables monitoring of specific registers and data memory items at user specified time intervals. By clicking the add register or add data memory item, these will be added to the table of values to be tracked.

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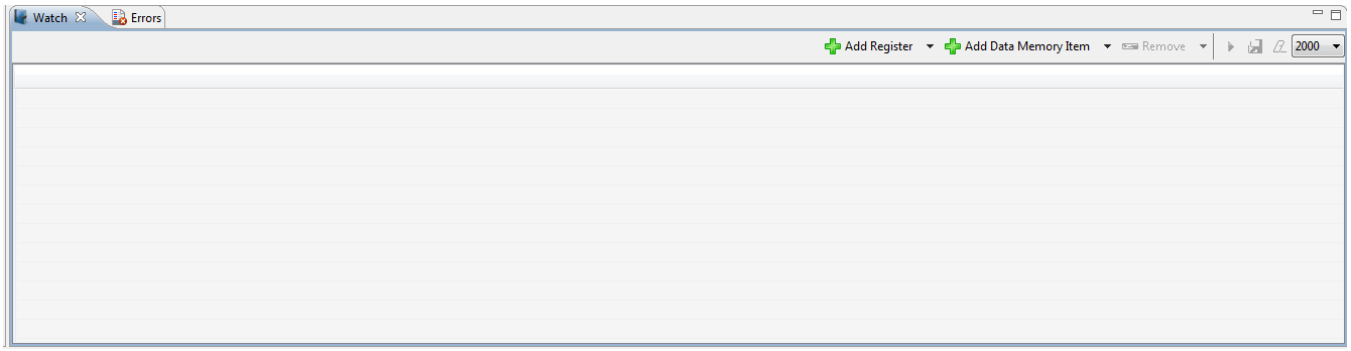

Figure 11. Watch Screen

3.10 Data Graph Screen

This enables specified registers and data memory items to be plotted in a graph real time based on a specific time interval chosen as shown in Figure 12.

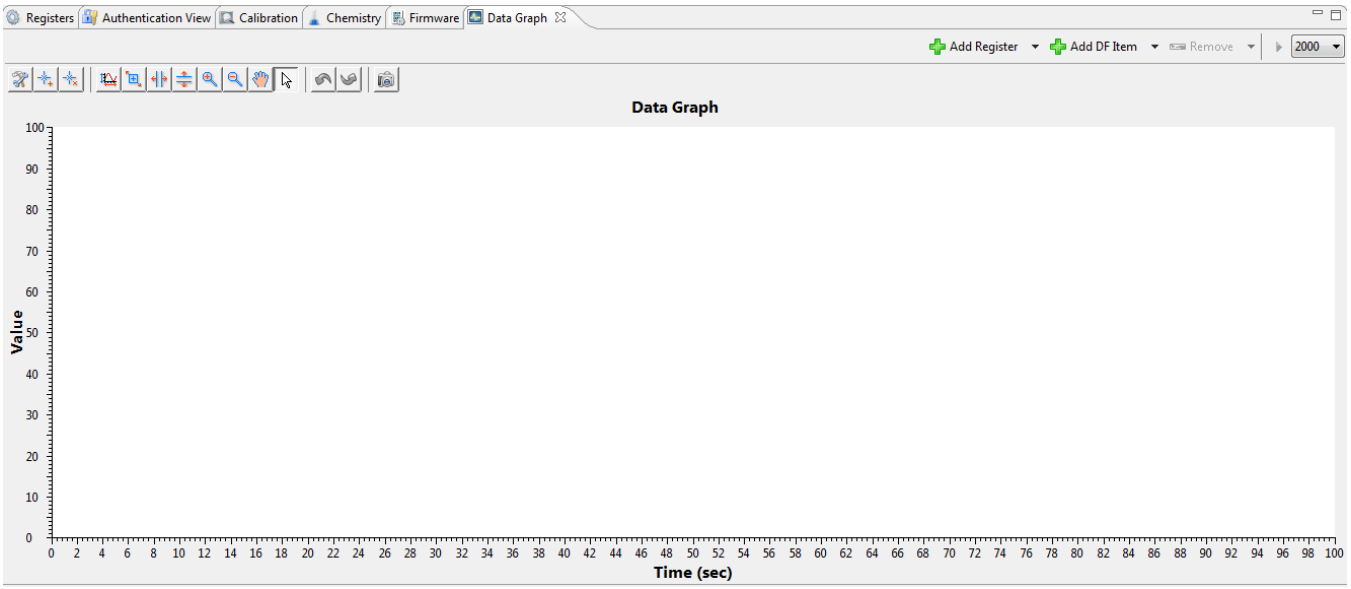

Figure 12. Data Graph Screen

3.11 Error Screen

This keeps track of any error that may occur with bqStudio during usage.

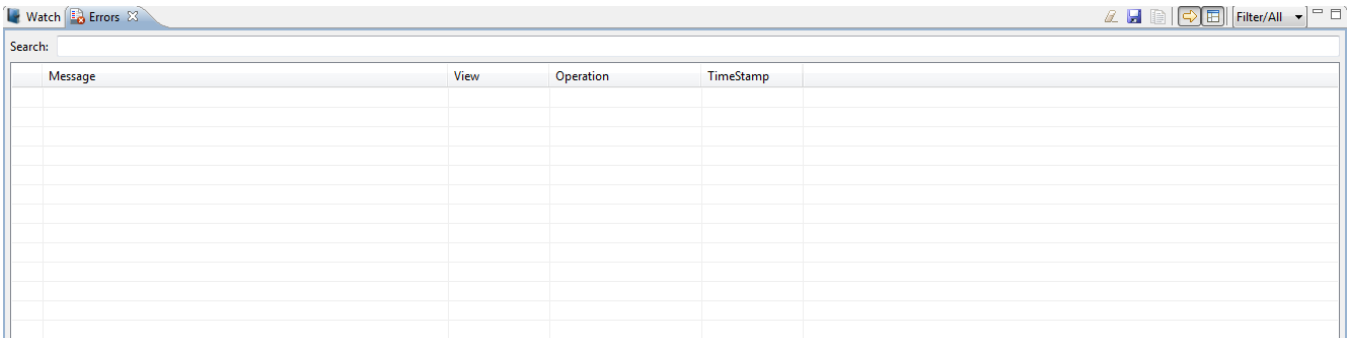

Figure 13. Error Screen

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4 Circuit Module Physical Layouts and Bill of Materials

This section contains the printed-circuit board (PCB) layout, bill of materials, and assembly drawings for the bq78z100/bq294502 circuit modules.

4.1 Board Layout

This section shows the dimensions, PCB layers (see Figure 14 through Figure 19), and assembly drawing for the bq78z100 modules.

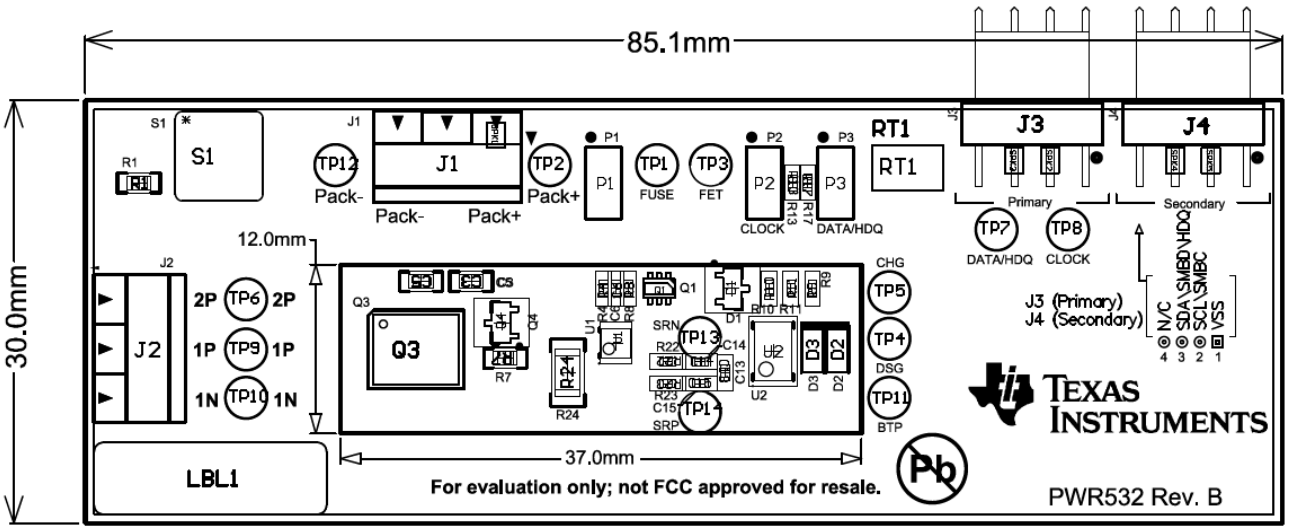

Figure 14. Top Silk Screen

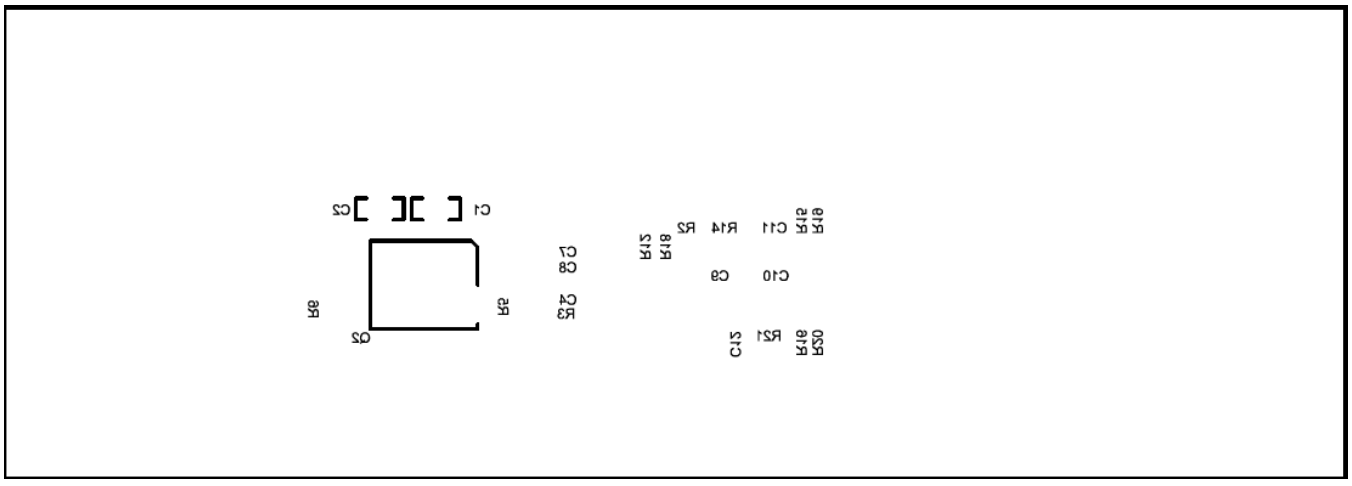

Figure 15. Bottom Silk Screen

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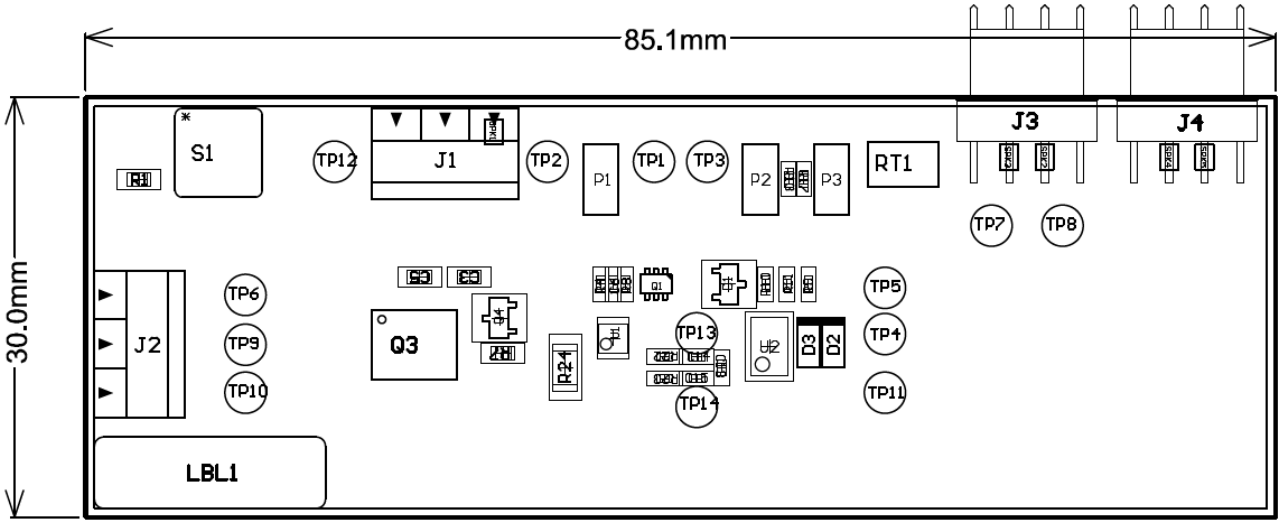

Figure 16. Top Assembly

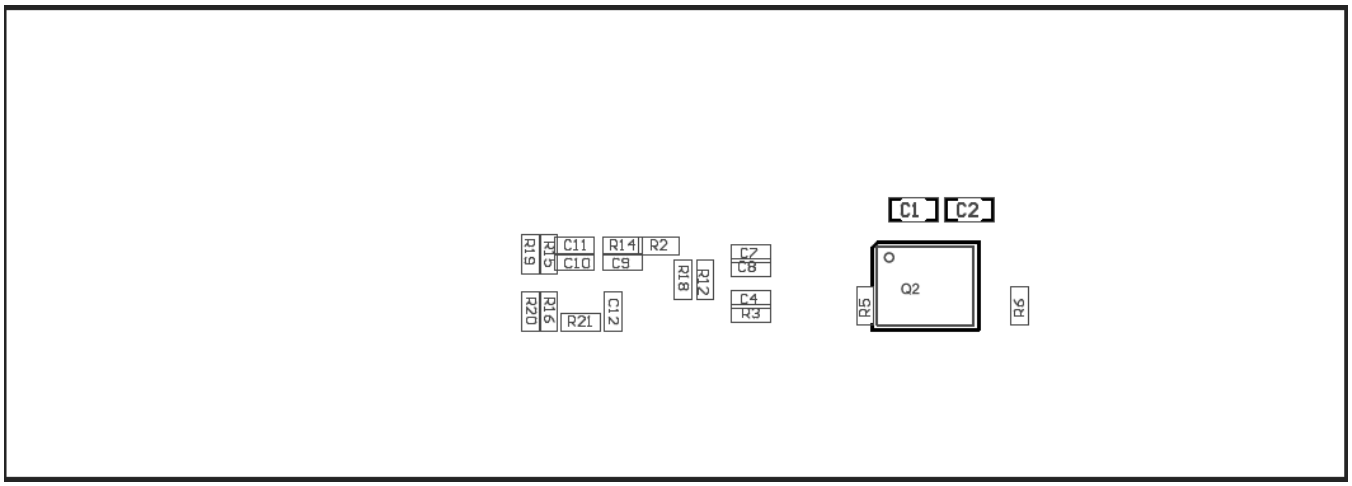

Figure 17. Bottom Assembly

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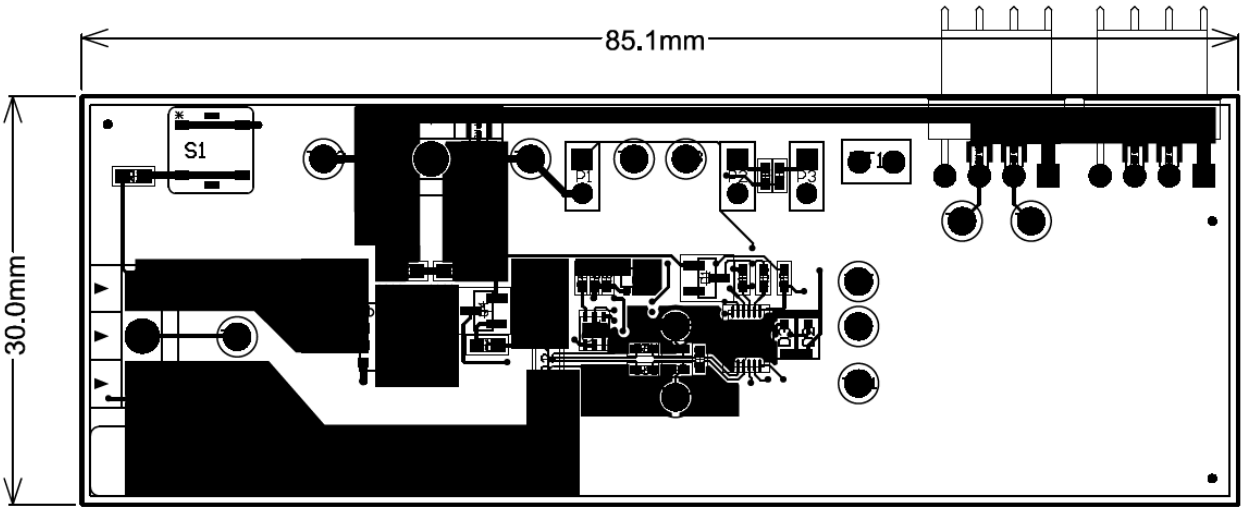

Figure 18. Top Layer

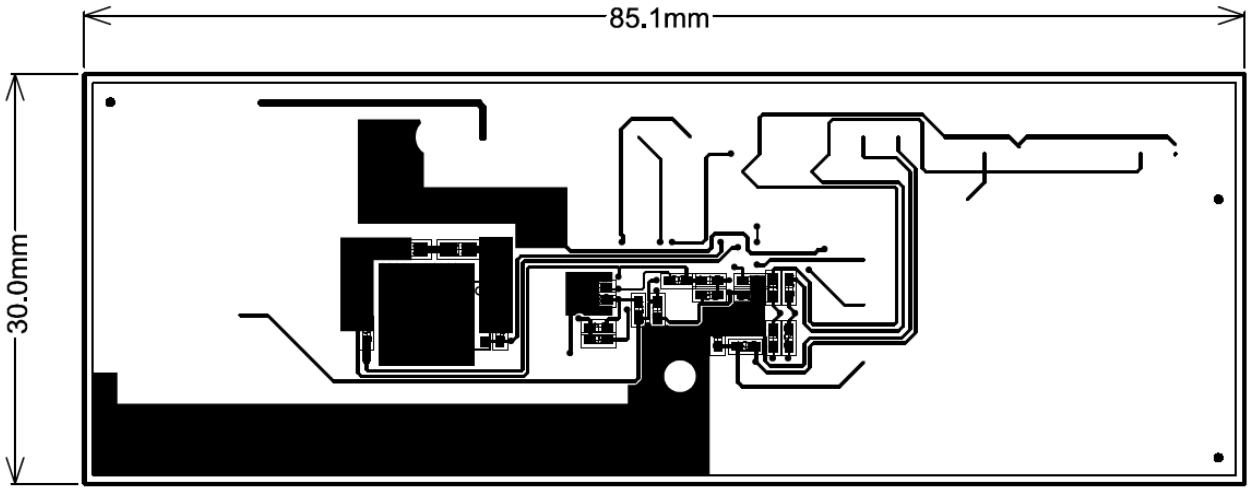

Figure 19. Bottom Layer

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4.2 Bill of Materials and Schematic

Table 3. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
C1, C2, C3, C5	4	0.1 µF	Capacitor, Ceramic, 50 V, X7R, 10%	0603	CL10B104KB8SFNC	Samsung Electromechanics
C4, C6, C7, C8, C10, C13	6	0.1 µF	Capacitor, Ceramic Chip, 16 V, X7R, 10%	0402	CL05B104KO5NNNC	Samsung Electromechanics
C9	1	1 µF	Capacitor, Ceramic Chip, 16 V, X5R, 10%	0402	CL05A105KO5NNNC	Samsung Electromechanics
C11	1	2.2 µF	Capacitor, Ceramic Chip, 16 V, X5R, 20%	0402	C1005X5R1C225M050 BC	TDK Corporation
D1	1	BAS16-7-F	Diode, Ultrafast, 75V, 0.3A, SOT-23	SOT-23	BAS16-7-F	Diodes Inc.
D2, D3	2	MM3Z5V6C	Diode, Zener, 5.6V, 200 mW	SOD323	MM3Z5V6C	Fairchild
J1, J2	2	ED555/3DS	Terminal Block, 3-pin, 6-A, 3.5 mm	0.41 x 0.25 inch	ED555/3DS	OST
J3	1		Header (friction lock), 100 mil, 4x1, R/A, TH	4x1 R/A Header	22-05-3041	Molex
P1, P2, P3	3	PEC02SAAN	Header, male 2-Pin, 100-mil spacing	0.100 x 2	PEC02SAAN	Sullins
Q1	1	SI1414DH-T1-GE3	MOSFET, Nch, 30 V, 4 A, 46 mΩ	SC-70	SI1414DH-T1-GE3	Vishay
Q2, Q3	2	25 V	MOSFET, N-CH, 25 V, 52 A, SON 5x6 mm	SON 5x6mm	CSD16412Q5A	Texas Instruments
Q4	1	2N7002K-T1-E3	MOSFET, Nch, 60 V, 300 mA, 2 Ω	SOT23	2N7002K-T1-E3	Vishay
R1	1	1K	Resistor, Chip, 1/10-W, 5%	0603	RC1608J102CS	Samsung Electromechanics
R2, R15, R16, R18, R19, R20, R22, R23	8	100	Resistor, Chip, 1/16W, 5%	0402	RC1005J101CS	Samsung Electromechanics
R3, R4, R12	3	1k	Resistor, Chip, 1/16W, 5%	0402	RC1005J102CS	Samsung Electromechanics
R5, R6	2	10M	Resistor, Chip, 1/16W,5%	0402	RC1005J106CS	Samsung Electromechanics
R7	1	10K	Resistor, Chip, 1/10-W, 5%	0603	RC1608J103CS	Samsung Electromechanics
R8	1	100k	Resistor, Chip, 1/16W, 5%	0402	RC1005J104CS	Samsung Electromechanics
R9, R10, R13, R17	4	5.1k	Resistor, Chip, 1/16W, 5%	0402	RC1005J512CS	Samsung Electromechanics
R11	1	10	Resistor, Chip, 1/16W, 5%	0402	RC1005J100CS	Samsung Electromechanics
R14	1	4.99	Resistor, Chip, 1/16W, 5%	0402	CRCW04024R99FKED	Vishay Dale
R24	1	0.001 50 ppm	Resistor, Metal Foil, 1 watt, ± 1%	1206	CSNL1206FT1L00	Vishay
RT1	1	10 K	Thermistor, NTC, 3 A	0.095 X 0.150 inch	103AT-2	Semitec
S1	1	EVQ-PLHA15	Switch, Push button, Momentary, 1P1T, 50 mA, 12 V	0.200 x 0.200 inch	EVQ-PLHA15	Panasonic
SPK1, SPK2, SPK3, SPK4, SPK5	5		Gap, 0.010" space	0.020 x 0.020 inch		
TP1, TP3, TP4, TP5, TP7, TP8, TP10, TP12, TP13, TP14	10	Black	Test Point, TH, Miniature, Black	0.100 x 0.100 inch	5001	Keystone
TP2, TP6, TP9	3	Red	Test Point, TH, Miniature, Red	0.100 x 0.100 inch	5000	Keystone

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Table 3. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
U1	1	BQ294502DRVR	Overvoltage Protection Device for 2 to 3 Cell Li-Ion Batteries, with 4.35 V OVP, -40 to 85 °C, 6-pin SON (DRV), Green (RoHS & no Sb/Br)	DRV0006A	BQ294502DRVR	Texas Instruments
U2	1	bq78z610DRZ	1-Cell to 2-Series Cell Programmable Battery Manager, DRZ0012A	DRZ0012A	bq78z100DRZ	Texas Instruments
C12	0	1 µF	Capacitor, Ceramic Chip, 16 V, X5R, 10%	0402	CL05A105KO5NNNC	Samsung Electromechanics
C14, C15	0	0.1 µF	Capacitor, Ceramic Chip, 16 V, X7R, 10%	0402	CL05B104KO5NNNC	Samsung Electromechanics
J4	0		Header (friction lock), 100mil, 4x1, R/A, TH	4x1 R/A Header	22-05-3041	Molex
R21	0	330k	Resistor, Chip, 1/16W, 5%	0402	RC1005J334CS	Samsung Electromechanics
TP11	0	Black	Test Point, TH, Miniature, Black	0.100 x 0.100 inch	5001	Keystone

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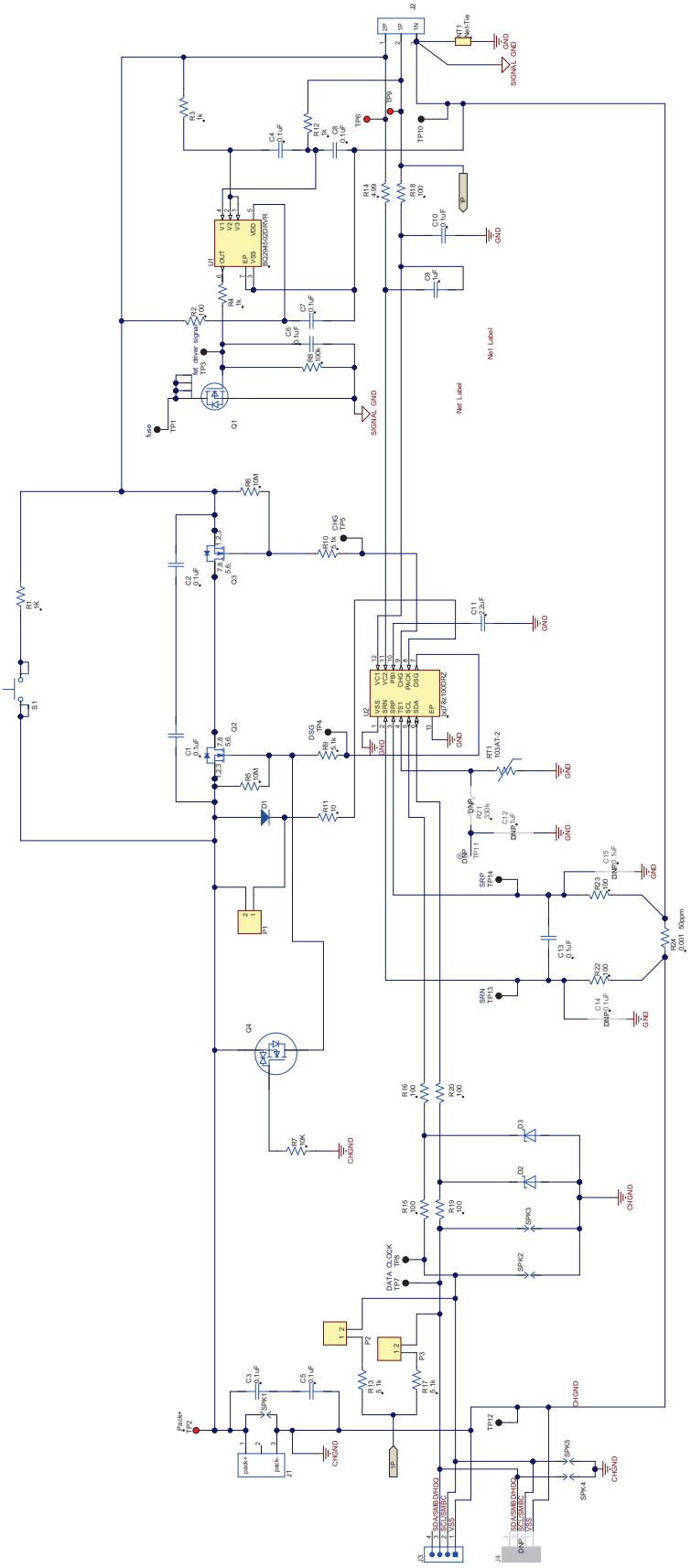

Figure 20. Schematic

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4.3 Testing Fuse-Blowing Circuit

To prevent the loss of board functionality during the fuse-blowing test, the actual chemical fuse is not provided in the circuit. FET Q1 drives TP1 low if a fuse-blow condition occurs; thus, monitoring TP1 can be used to test this condition.

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Revision History

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

Date	Revision	Notes
September 2015	*	Initial Release

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