User's Guide

BQ76907 Evaluation Module

ABSTRACT

The Texas Instruments BQ76907EVM is a complete evaluation system for the BQ76907, The BQ76907 is a highly integrated, high accuracy battery monitor and protector for 2-series to 7-series Li-Ion, LiPolymer, and LiFePO4 battery packs. The BQ76907 features a high accuracy monitoring system with dedicated coulomb counter and accumulated charge integration, a highly configurable protection subsystem, and support for host controlled cell balancing. Integration includes low-side protection NFET drivers, a programmable LDO for external system use, and an I2C host communication interface supporting up to 400-kHz operation with optional CRC. The evaluation module includes one BQ76907 integrated circuit (IC), sense resistor, one thermistor, power FETs, and all other onboard components necessary to protect the cells from overcharge, over discharge, short circuit, overcurrent discharge, over temperature, and under temperature. The circuit module connects directly across the cells in a battery, or can be connected with a power supply and the included cell simulator resistors. With the on-board interface or compatible external interface board and Microsoft® Windows® based PC graphical user interface (GUI) software, the user can view the device registers, evaluate voltage, current and temperature accuracy, adjust protection limits, and enable FET control outputs.

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1 Features

- Complete evaluation system for the BQ76907 2-cell to 7-cell Li-Ion, LiPolymer, and LiFePO4 battery monitor
- Populated circuit module for 7-cell configuration for quick setup
- Power connections available on test points
- Communication available with included USB interface adapter or available on 4-pin connector
- Resistor cell simulator for quick setup with only a power supply
- PC software available for configuration

1.1 Kit Contents

- BQ76907 circuit module
- USB cable

1.2 Ordering Information

For complete ordering information, refer to the product folder at www.ti.com.

Table 1-1. Ordering Information

EVM Part Number	Chemistry	Configuration	Capacity
BQ76907EVM	Li-Ion	7 cells	Any

Note

Although capacity is shown as *Any*, practical limits of the physical construction of the module typically limits the operation of the EVM to a 1P or 2P battery construction. Refer to the physical construction section for board details.

1.3 BQ76907 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the BQ76907 circuit module in its default 7-cell series FET configuration.

Typical voltage depends on the number of cells configured. Typical current depends on the application. Board cooling may be required for continuous operation at or below maximum current.

Table 1-2. Performance Specification Summary

Specification	Min	Typ	Max	Unit
Input voltage BATT+ with respect to BATT–	3	–	40	V
Continuous charge or discharge current	0	–	6	A
Operating temperature range	20	25	30	°C

1.4 Required Equipment

The following equipment is required to operate the BQ76907 EVM in a simple demonstration:

- DC power supply, 0–50 V at 2.5 A
- DC voltmeter
- Computer with USB port and compatible Windows operating system and access to the internet
- Test leads to connect equipment
- Electronic load or assorted resistors

Additional equipment may be desired to operate the BQ76907 with a more extensive demonstration.

2 BQ76907 EVM Quick Start Guide

2.1 Before You Begin

The following warnings and cautions are noted for the safety of anyone using or working close to the BQ76907 EVM. Observe all safety precautions.

Warning The BQ76907EVM circuit module may become hot during operation due to dissipation of heat. Avoid contact with the board. Follow all applicable safety procedures applicable to your laboratory.

Caution Do not leave the EVM powered when unattended.

CAUTION

The default settings of the BQ76907 do not limit performance to the ratings of the EVM. Set all protections appropriately and limit current for safe operation.

CAUTION

The circuit module has signal traces, components, and component leads on the bottom of the board, which may result in exposed voltages, hot surfaces or sharp edges. Do not reach under the board during operation.

CAUTION

The circuit module may be damaged by over temperature. To avoid damage, monitor the temperature during evaluation and provide cooling, as needed, for your system environment. Do not operate beyond the current and voltage limits in the Specification Table.

CAUTION

Some power supplies can be damaged by application of external voltages. If using more than 1 power supply, check your equipment requirements and use blocking diodes or other isolation techniques, as needed, to prevent damage to your equipment.

CAUTION

The communication interface is not isolated on the EVM. Be sure no ground potential difference exists between the computer and the EVM. Also, be aware that the computer is referenced to the battery-potential of the EVM.

CAUTION

Connections for rated current must be made at the terminal block. Test points are not rated for the board current.

2.2 Quick Start

The BQ76907 registers must be configured to enable most protections, select the monitored cells, and enable the protection FETs on the EVM. This quick start section does not describe current protection settings.

These steps describe quick connection of the BQ76907 EVM to demonstrate operation of the AFE portion of the EVM. For more detailed descriptions, refer to other sections of the user guide.

Refer to Figure 2-1 for the following steps.

1. Download the BQSTUDIO software from the tool folder link www.ti.com/tool/BQSTUDIO or search from www.ti.com.
2. Install the BQStudio software (see Section 3.2).
3. Install the cell simulator shunts.
4. Position shunts for the I2C to MCU connection.
5. Attach the on-board communication adapter USB connector to the PC using USB cable.
6. Connect a 0-V DC power supply capable of 250 mA minimum between the “*BAT-*” and "7*P*" terminals and adjust to approximately 21 V.
7. Start the BQStudio software. The GUI will open with a register display if communication to the BQ76907 is made. Click on the *Scan* button to enable repeated update of the display. The power supply may be adjusted within range of the part to observe voltage changes in the GUI register display.
8. Select the Data Memory button in the BQStudio window.
9. Select the Settings button. Set the Enabled Protections A CUV bit.
10. Select the Protections button. Set the Cell Undervoltage Protection Threshold to 2800.
11. In the Commands panel click on the FET_ENABLE button.
12. In the Registers view click on the Scan icon so that the registers update periodically. Observe that the CHG and DSG bits in the Battery Status register are on. Measure the PACK voltage on the board if desired.
13. Adjust the supply voltage to approximately 17.5 V. In the registers view observe that the DSG bit goes off.
14. Make other adjustments as desired for evaluation. See other sections of this user guide for details of operation.
15. When complete with this quick start demonstration, exit the BQStudio software and turn off the power supply.

Refer to other sections of this user guide for additional details.

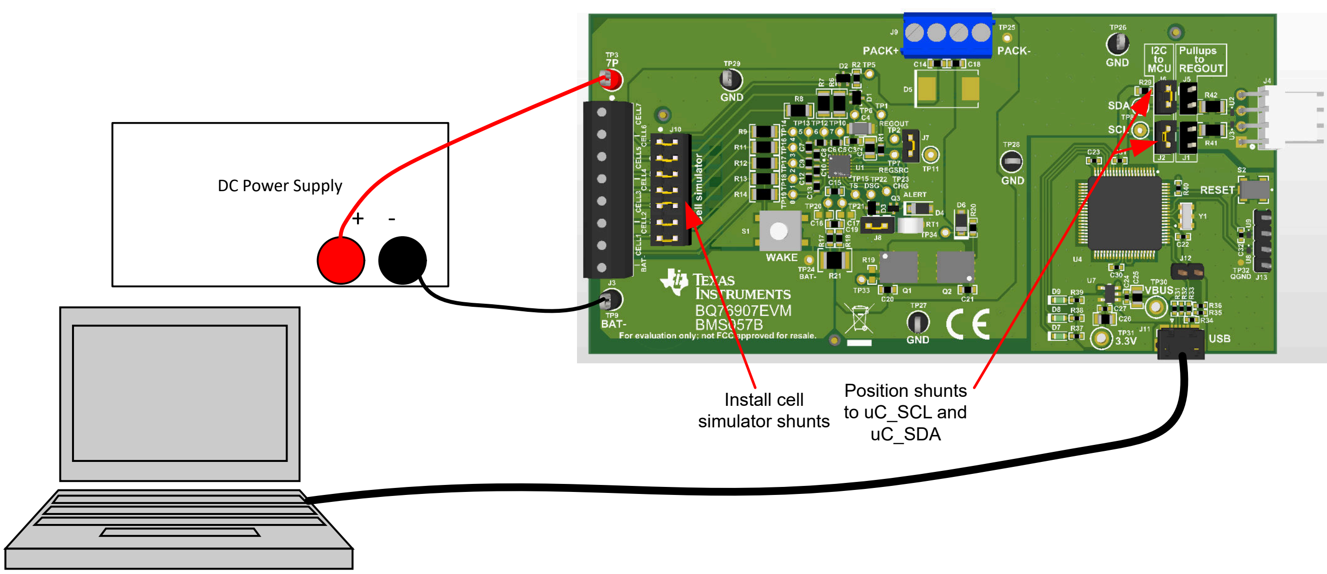

Figure 2-1. EVM Connection for Basic Operation

3 Battery Management Studio Software

The Battery Management Studio software is used for evaluation of the BQ76907 monitor. This software can also identified as BQStudio for a compact name. If an earlier version of the BQStudio software is already installed from another product evaluation, it must still be installed again to load the configuration files and tools specific to the current version of the BQ76907.

3.1 System Requirements

The BQStudio software requires a Windows 7, or later, operating system. Additional items are required and are described in the installation windows.

3.2 Installing BQStudio

Find the latest software version in the software section of the product folder http://www.ti.com/tool/BQSTUDIO or search from ti.com. There are multiple versions available, the BQSTUDIO-TEST version is recommended to be used with the BQ76907 EVM. Check periodically for software updates. Use the following steps to install the BQStudio software:

1. Uninstall older versions of BQStudio software. After uninstalling, delete the BatteryManagementStudio program directory.
2. Copy the archive file to a directory of your choice, extract all files and run the ***Battery Management Studio-xxxxxx-Setup.exe*** application.
3. Follow the instructions and make selections as required on the setup windows selecting ***Next***, as required. TI recommends installing the software in the default location.
4. On the last window select option check-boxes desired and ***Finish*** to complete the BQStudio software installation.

3.3 BQ76907 bqz File Installation

The BQStudio software uses a .bqz file to configure the displays for the BQ76907 device family or specific family device. This .bqz file is normally provided in the BQStudio installation. If provided separately, copy the .bqz file to the \config directory in the installation, typically C:\ti\BatteryManagementStudio\config.

3.4 BQStudio Operation and Registers View

BQStudio is used to communicate to the BQ76907 for evaluation, it includes several tools to aid in configuration, calibration and data display of the BQ76907 during evaluation.

Although the software runs without connection to an interface board or powered device, it is recommended to have both connected and the device on when starting the software. Follow the directions in the Quick Start section. Figure 2-1 shows typical connections for operation with the BQStudio software.

Start the software from the desktop shortcut *Battery Management Studio* or from the Start menu.

When started, the software looks for the communication interface and the device. If the device is not found, it opens a Target Selection Wizard. On the first window select the Monitor or All class and click the *Next* button. On the second window select the newest or appropriate BQ76907 version in the list and click the **Finish** button. This selection will be remembered until the software is re-started. If the device is not found, the user will be presented with a *Proceed?* window which must be acknowledged. If the software still cannot find the device, a *Battery Management Studio* popup window appears indicating communication status. Acknowledge the message to proceed.

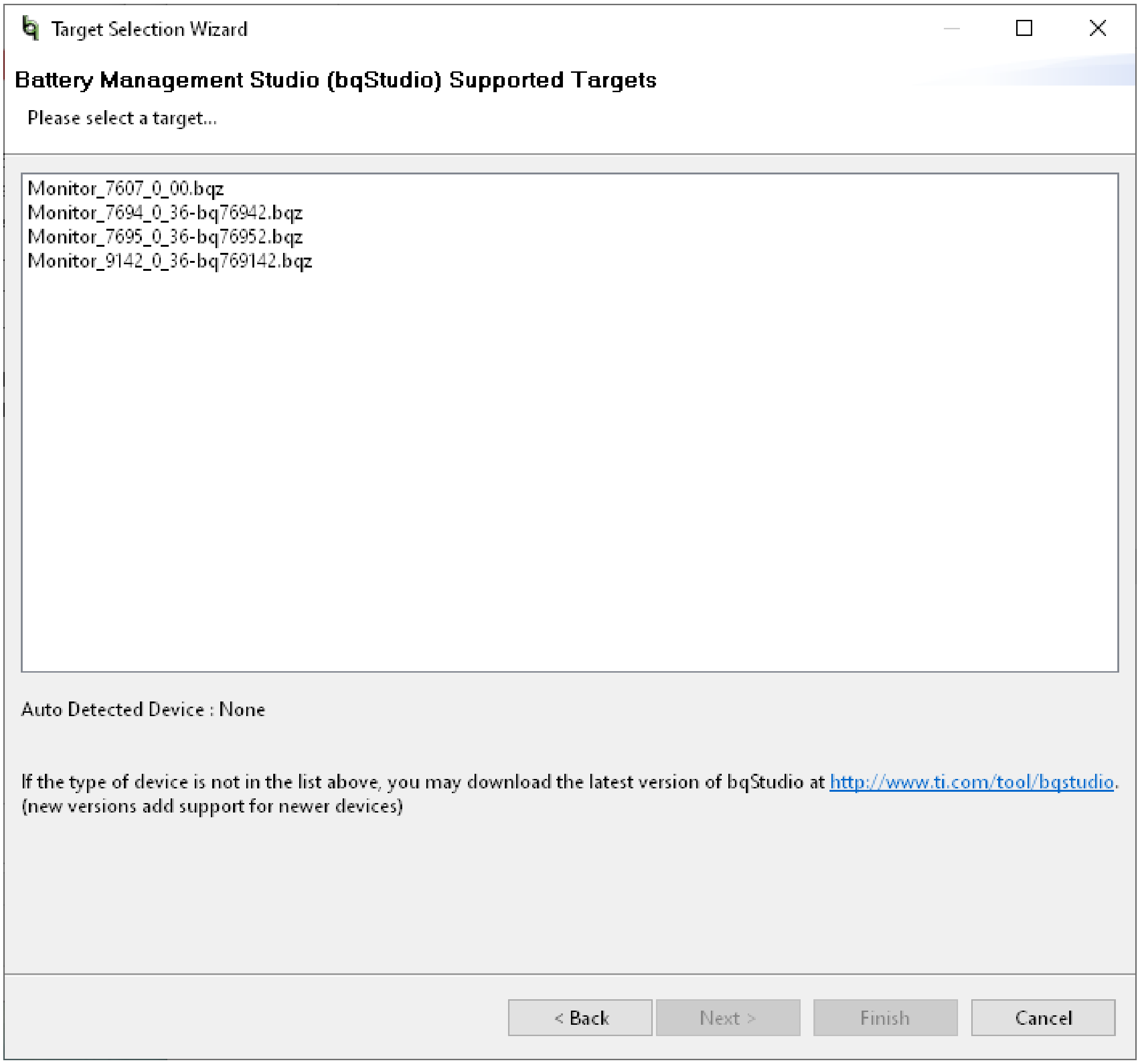

Figure 3-1. Target Selection Wizard

If the software started without a communication interface adapter, a Battery Management Studio popup window indicates a free adapter is not available. Acknowledge the message to proceed. Errors will appear in the left bottom border of the Battery Management Studio screen. Correct the problem with the adapter and restart the software.

BQStudio contains a user guide for general operation of the software. Refer to the menu selection *Help* | *Help Contents* for information.

The BQStudio window appears as shown in Figure 3-2. The register area is blank since the device is not attached.

The center panel of BQStudio displays tool tips when the cursor is held over an item name. The tool tip provides some description of the item. The tool tip closes after approximately 30 seconds. To avoid the tool tip display move the cursor to the value or units column, or to the *Dashboard* panel.

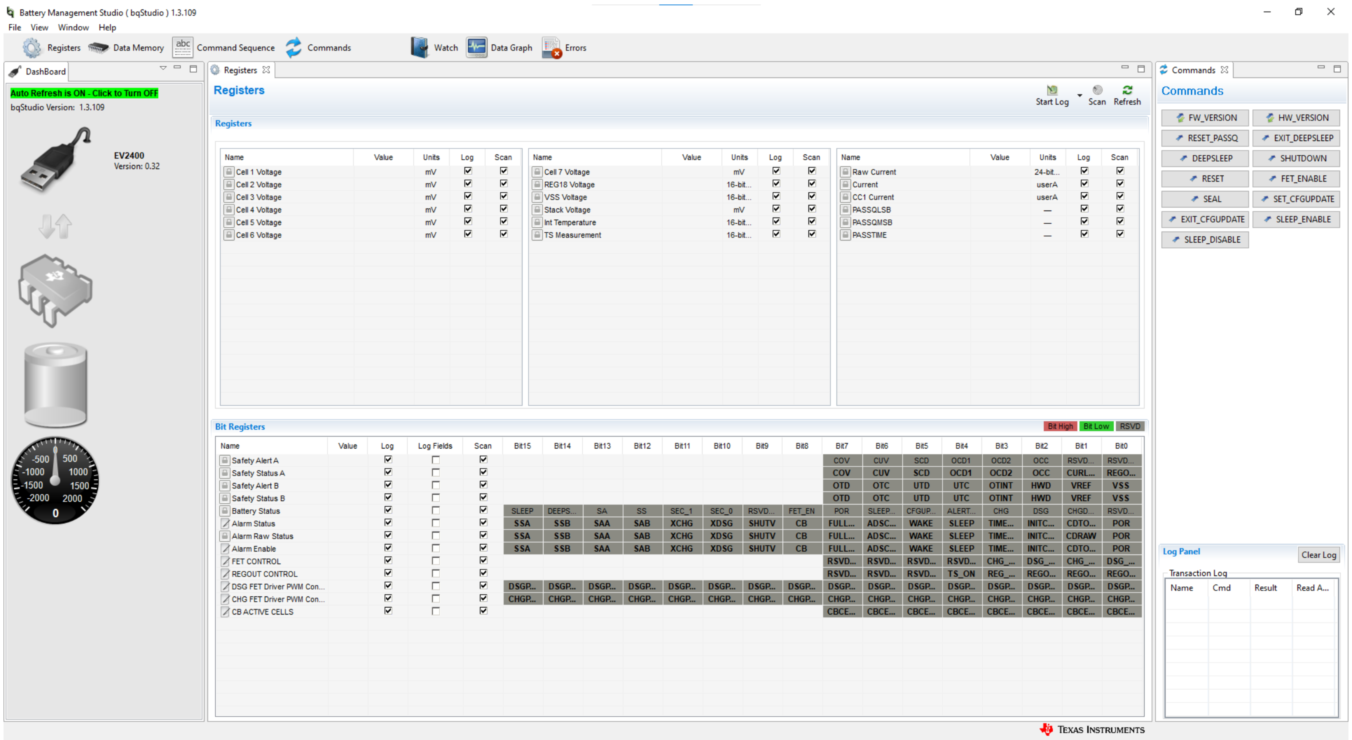

Figure 3-2. BQStudio Window without Device

Without a device, BQStudio operates with reduced functions. Tools can be browsed and data fields inspected, but data cannot be entered.

The *Dashboard* on the left-side of the window shows the adapter, device and simple voltage and current displays. The dashboard updates periodically unless Auto Refresh is stopped by clicking on the banner. The right side of the window has the *Commands* panel.

The center panel of the window initially shows the register tab. The register display shows device status registers and is read once when the device is detected. To update the register values select the *Refresh* button at the top of the Registers tab. To repeatedly read the registers select the *Scan* button. To repeatedly read and log the register values to a file select the *Start Log* button and follow the prompts to save a log file. When a log is running, select *Stop Log* to end the log and close the file. The *Parameter View* selection allows the choice of basic parameters which shows commonly used registers, or all parameters which shows more registers.

If a device is connected and powered after BQStudio is powered, the *Dashboard* panel may auto detect the device and update the device and register display. Figure 3-3 shows a register display with a connected device.

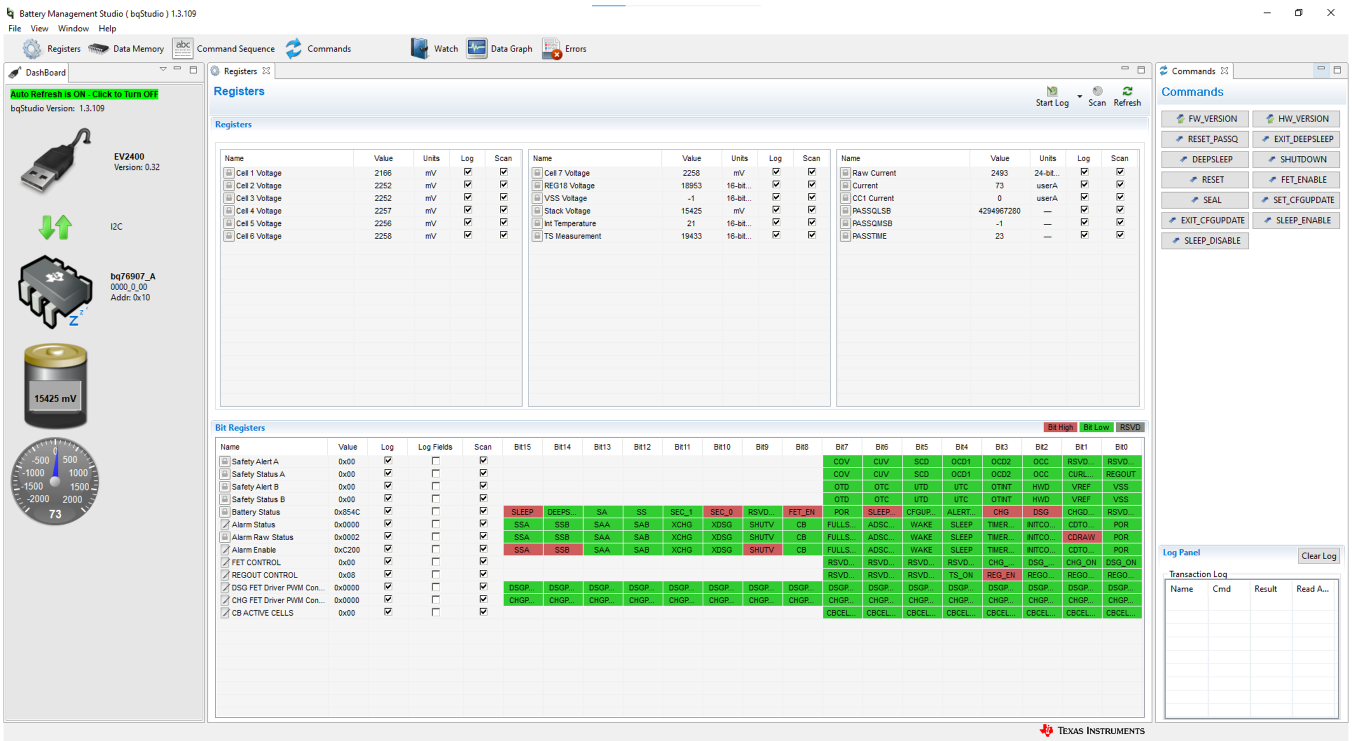

Figure 3-3. Register View with Device

The available tools for the device are shown at the top of the window and may be selected by clicking on the tool icon. Tools may also be selected from the "View" menu as shown in Figure 3-4. Opening a new tool may change the center tab of the window. These tools are described in following sections. Not all devices have all the tools described. Multiple tools can be active at one time, tools which use the center panel for display are shown as a tabs at the top of the center section. These tabs can be closed with the "X" as desired, but closing the tab may terminate the operation running in the tab.

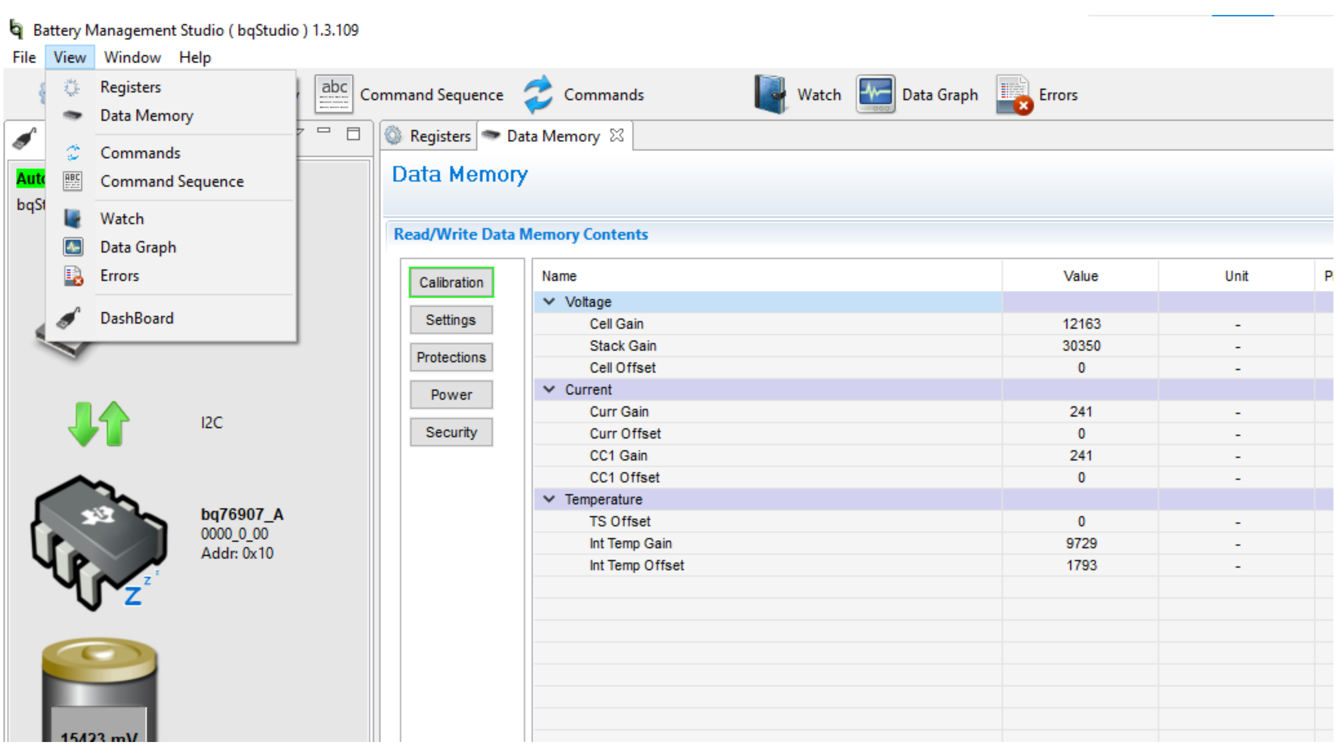

Figure 3-4. Tool Selections

3.5 Commands

The Commands tab is displayed on the right side of the BQStudio window. Buttons in this panel allow the use of commands that can be used for reading various information about the device and for certain operations. Commands and returned data are shown in the Log Panel of the tab. The seal function is unusual in general evaluation and is not recommended during initial evaluation.

CAUTION

Sealing the device without remembering the key reduces the function of the EVM.

3.6 Data Memory

The data memory tool is used to configure the device. Configuration files may be saved and loaded later to resume evaluation. At power up, the device is loaded with factory configurations. Different device's configuration can be entered in the volatile registers using the Data Memory tool. The Data Memory tool displays as a tab in the center pane of the BQStudio window. Figure 3-5 shows the initial data memory view with a device connected. Configuration settings are grouped into different functions accessed with buttons on the left side of the panel. Other functional sections can be displayed by clicking on the named button.

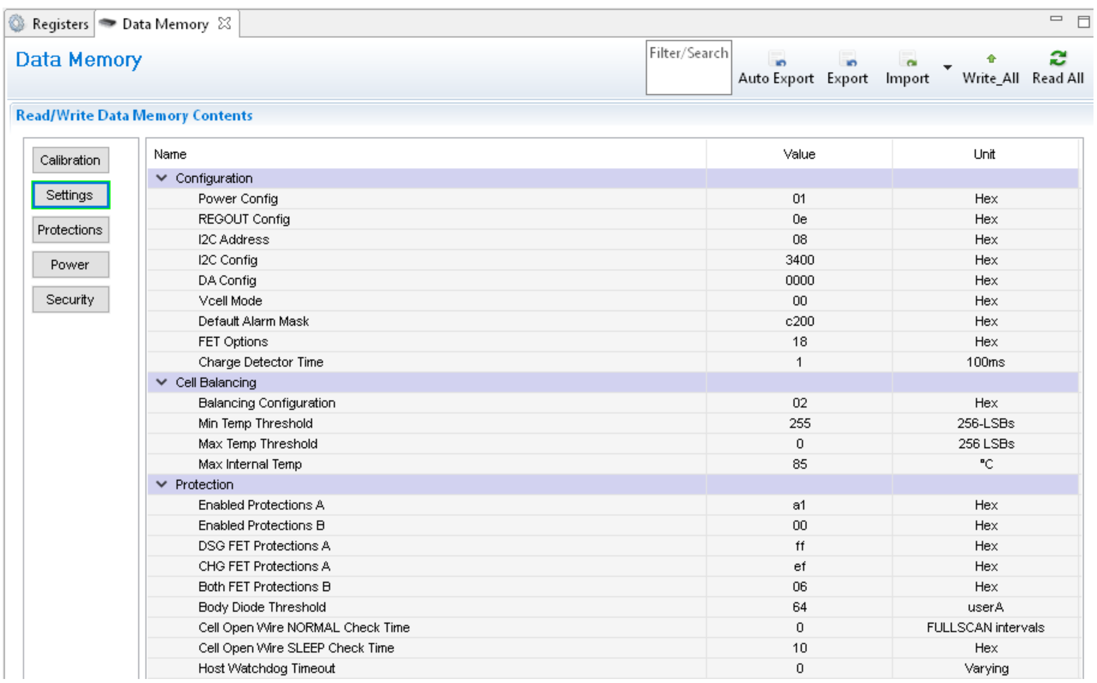

Figure 3-5. Data Memory View

3.6.1 Entering, Saving, and Loading Configuration

Most of the configuration of the BQ76907 is accomplished through setting values in the data memory. The data memory locations are accessed using the buttons in the Data Memory view. The *Parameter View* selection at the top of the panel allows the choice of basic parameters which shows commonly used parameters, or all parameters which shows more configuration parameters. Data values may be changed by selecting and entering a value. Parameter registers, which are bit fields, may be changed by selecting the bit in the pop up when the register or its value is selected. Data Memory must be written after bit changes, a button is provided under the bit field to write to Data Memory. Figure 3-6 shows the bit field for the Enabled Protections A which is one of the most basic settings that must typically be changed with the EVM.

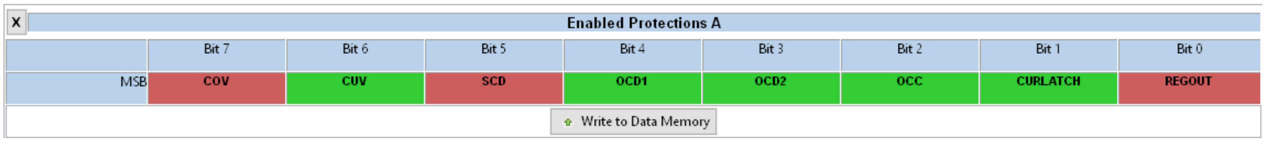

Figure 3-6. Data Memory Bit Field Change

Changes to configuration by memory changes take place immediately, however the FETs are enabled using the FET_ENABLE command. Enabling a protection and enabling the protection action on a FET are not sufficient, the FETs must be enabled with the command.

The *Export* tool in the Data Memory view can be used to save the configuration data to a comma-separated-value file format which can be accessed by a spreadsheet program. Reading data before exporting with the *Read All* button loads the data from the part rather than values which may be only in the view. The *Import* tool allows loading a saved file into the view so that it can be written to the device. The *Write All* tool writes all values in the view, into registers in the device.

3.7 Command Sequences

Features are controlled by commands as described in the BQ76907 data sheet. Data is available from registers, and the registers view shows data, but a user may want to send specific commands to the device. The Command sequences tool allows this operation and is shown in Figure 3-7. The *Device Send and Receive* section allows read or write to a single or consecutive locations. The *Command Sequence* section allows reads and writes to be intermixed in a sequence. Sequences may be stored to files or called from files. Files may be assigned to buttons in the *Command Sequence File Assignment Buttons* section. Results can be viewed in the *Transaction Log* and saved to a file if desired.

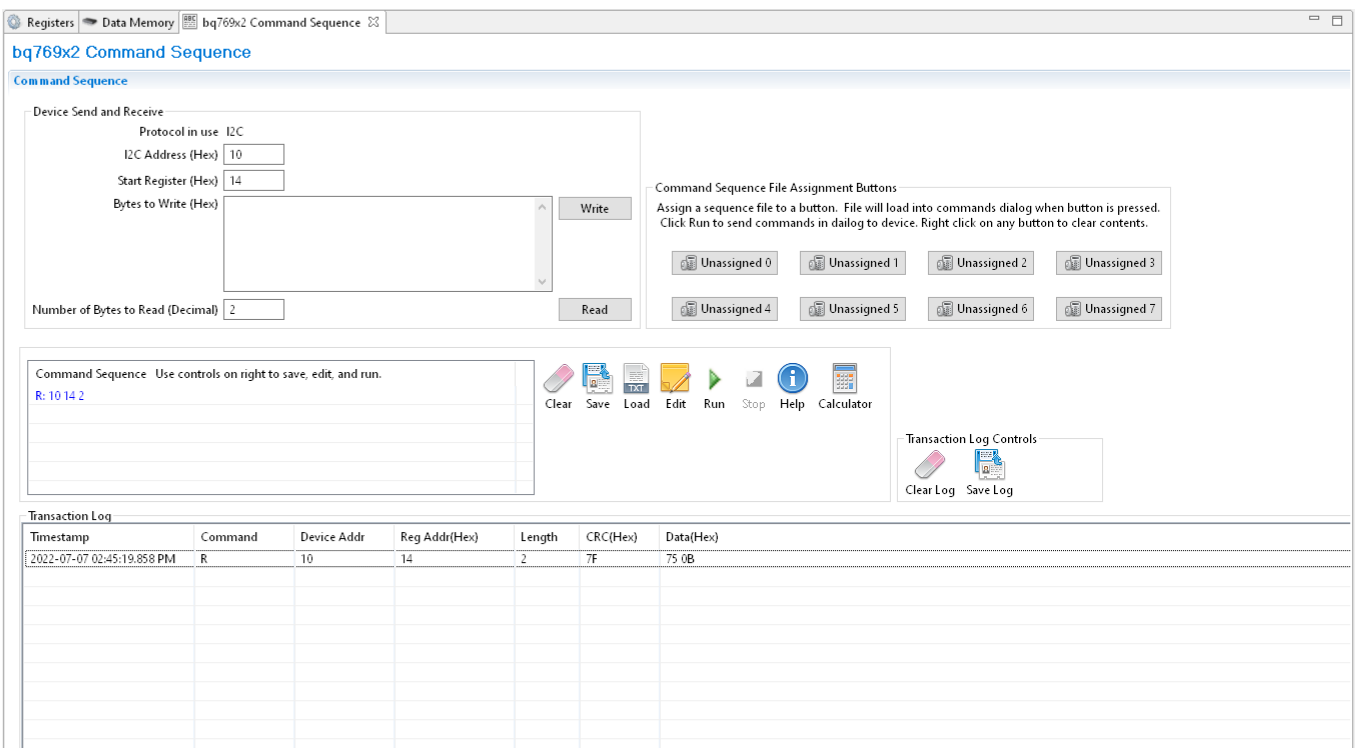

Figure 3-7. Command Sequence View

4 BQ76907 Circuit Module Use

The BQ76907 circuit module contains the BQ76907 IC and related circuitry to demonstrate the features of the IC. Surface mount FETs are provided for the high current path. A thermistor provides temperature sensing on the board. Other components provide support for the IC and connections to the board. Basic operation is described in the BQ76907 EVM Quick Start Guide section. For details of the circuit, refer to the BQ76907EVM Circuit Module Physical Construction section.

4.1 Cell Simulator

The EVM includes a resistive cell simulator made up of 200-Ω series resistors. The taps of the resistor network are connected to the cell inputs using shunts on the J10 header. BAT- is always connected to the resistor divider network. Installing a shunt on the top cell location connects the top cell input to the resistor divider to provide simulated voltages for the other cell inputs. If the shunt is not installed on the top cell position of the header all lower inputs are pulled to VSS. Installing shunts for the lower cell positions will connect the input to the simulated voltage. There is no indication of the cell simulator connection, the user must be aware of the shunt installation.

4.2 Evaluating with Load Current

With the BQ76907 configured and the FETs enabled discharge current can be demonstrated by attaching suitable resistors or a DC load at the PACK terminals as shown in Figure 4-1.

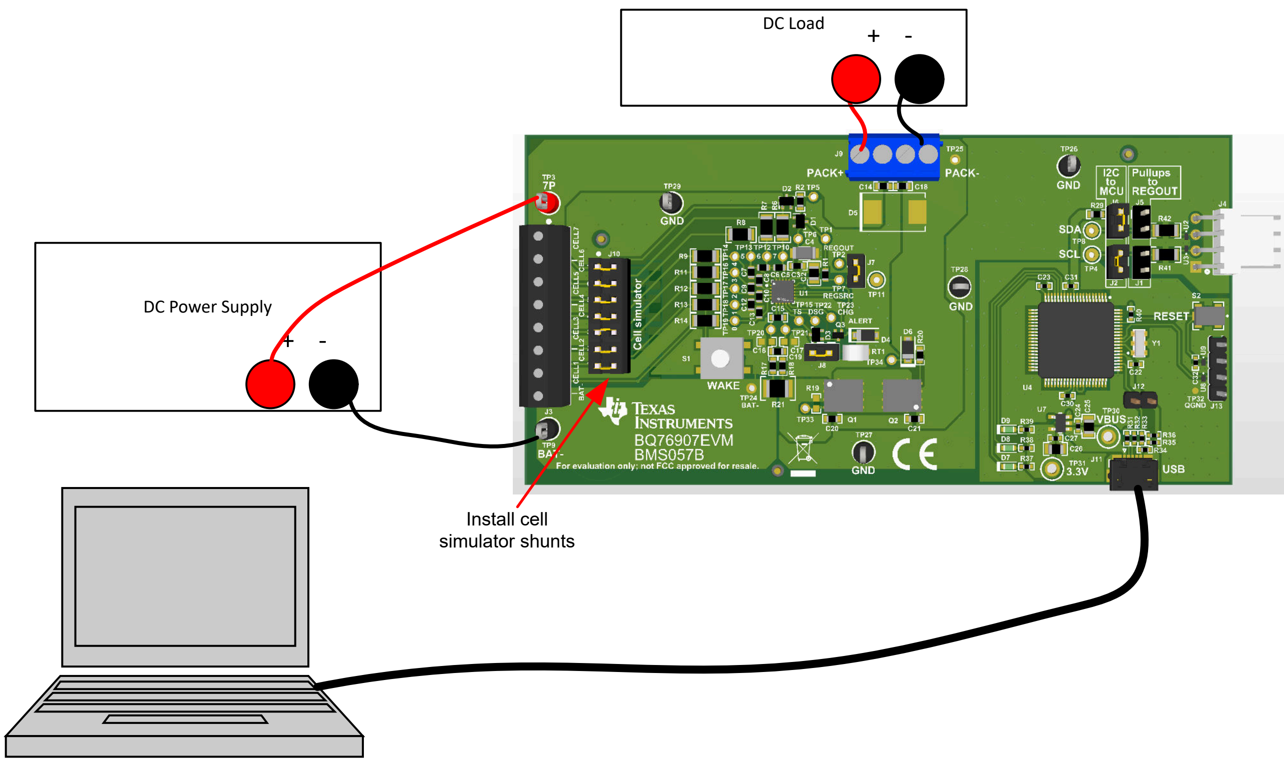

Figure 4-1. Evaluating with Load Current

4.3 Evaluating Charge and Discharge Currents

Bipolar power supplies will source or sink current to maintain the set voltage. When bipolar supplies are available, they may be used for both the battery and pack side of the board to allow charge and discharge currents without re-connecting the equipment. Be sure to set the supplies appropriately to prevent exceeding the ratings of the EVM.

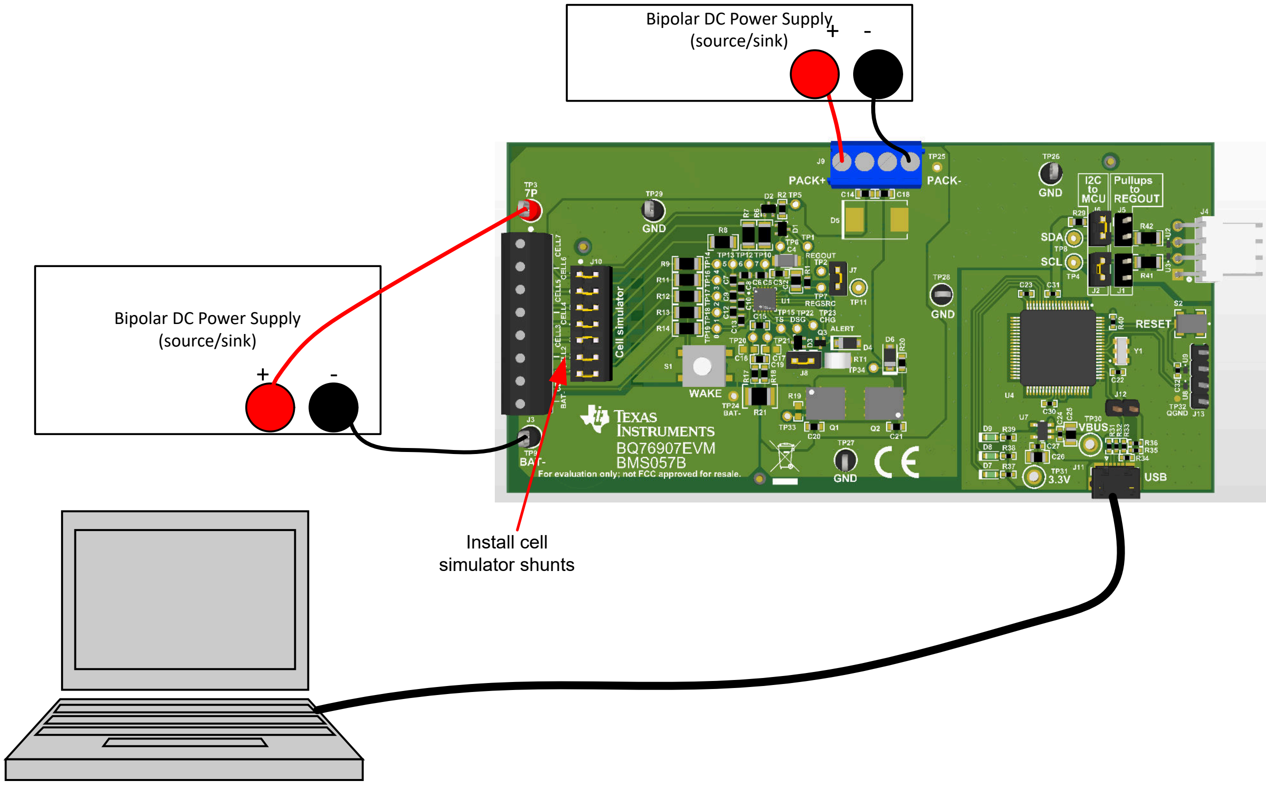

Figure 4-2. Evaluating with Charge or Discharge Current

4.4 Evaluating with Simulated Current

The BQ76907 EVM Quick Start Guide describes connection for basic operation. Providing more than recognizable current in that configuration can require a power supply with a significant power rating. Applying a charge current can damage some power supplies. Figure 4-3 shows a method to force current through the control path without a high wattage power supply or special equipment. The *load* power supply needs to be set at a low voltage in a constant current mode. Polarity can be reversed on the *load* supply to simulate a charge current. The battery simulation supply must never be reversed.

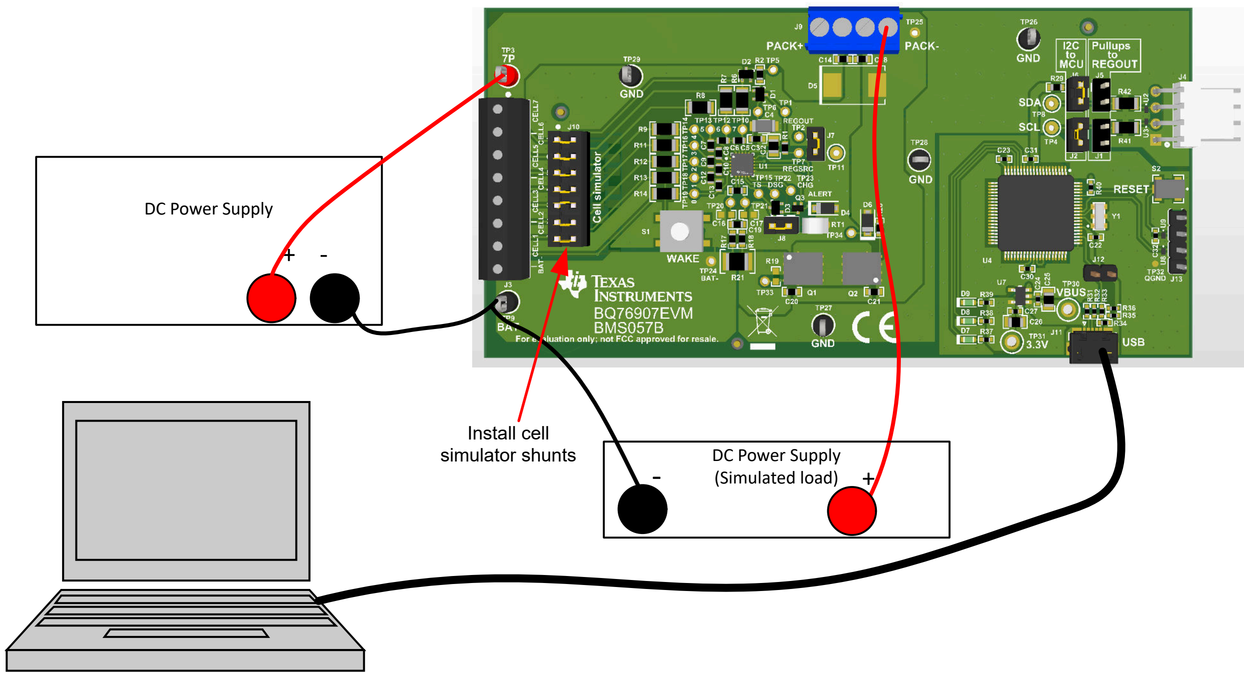

Figure 4-3. Simulating Current Setup

4.5 Reducing the Cell Count

For proper operation, the top and bottom cells of the BQ76907 must be used. Cell count can be reduced by shorting the unused cell inputs from the next-to-top down. Cell count can be reduced for basic evaluation by shorting unused cells at the input terminal block. Follow the recommendations in the data sheet for which cells to short. Shorting at the input terminal block works for both operation with the cell simulator and cells, but can have some side effects in transient tests because it parallels the shorted resistors to the cell IC where the capacitor provides a signal path to the used input. See Figure 4-4 for an example of simple reduced cell configuration for 5 cells. For the best evaluation with reduced cells in a transient environment, short the VCx pins at the capacitor and remove the unused input resistor. When using the cell simulator, shorting the unused cell at the terminal block is still required to eliminate the simulated cell voltage. Shorting the cell inputs at the terminal block screw terminals is suggested since it will be apparent if the board is re-used for a different cell count. Table 4-1 shows configuration recommendations for reduced cell count.

Table 4-1. Reducing Cell Count

Unused cell (numbered from bottom cell 1)	Short cell input terminals	Input resistor to remove	Replace capacitor with 0 ohm	IC inputs shorted
Cell 6	CELL6 to CELL5	R7	C6	VC6 to VC5
Cell 4	CELL4 to CELL3	R9	C8	VC4 to VC3

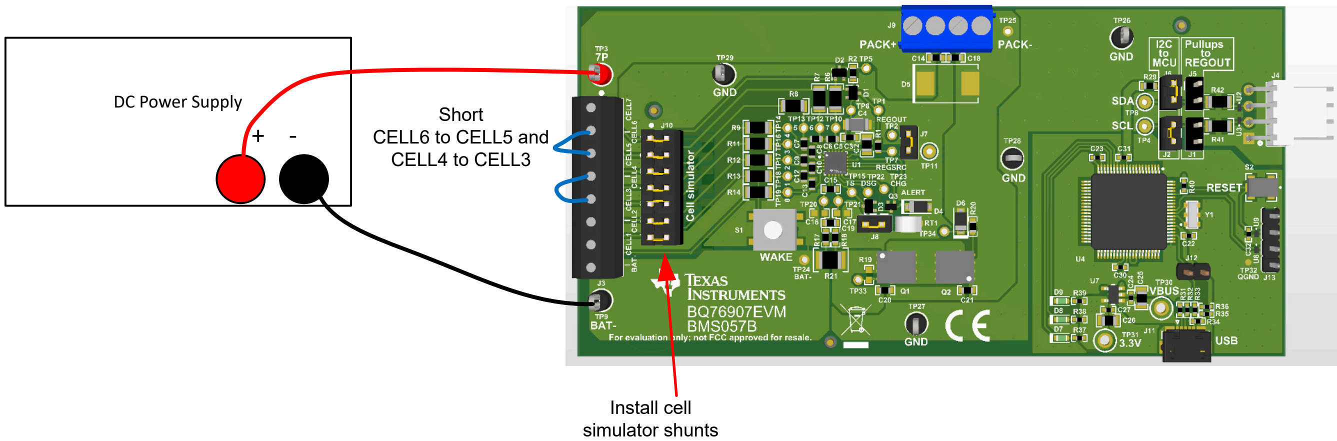

Figure 4-4. Example 5 Cell Simple Evaluation Configuration

4.6 Connecting Cells

The EVM is constructed with a single connection to the top and bottom of the cell stack. Cell voltage for these cells is sensed on the board.

The cell simulator provides resistors between the cell inputs. When the cell simulator shunts are installed, these resistors will load the cells and divide the voltage to any unconnected inputs as cells are connected. If desired, the cell simulator shunts can be installed during cell connection and removed after cell connection. The cell simulator shunts must be removed after connection of cells or the cells will be discharged by the constant drain of the cell simulator resistors.

BAT- is the reference voltage for the IC and it is recommended to be connected first. After BAT- cells may be connected in any order. Cell connection from the bottom up minimizes the voltage step size applied to the board. Recommended connection sequence for the EVM when connecting cells is bottom up:

1. Connect BAT–
2. Connect cells bottom up; CELL1, CELL2, CELL3 ...
3. Be sure the cell simulator shunts are removed

Figure 4-5 shows an example connecting cells with an EVM configuration reduced to 6 cells.

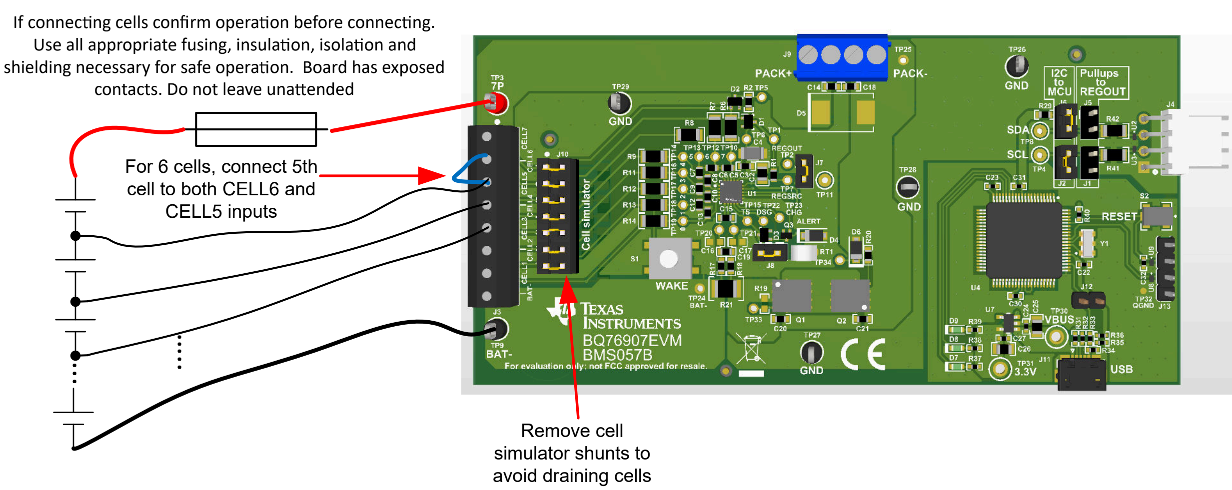

Figure 4-5. Example Connection with 6 Cells

4.7 Connecting to a Host

After initial operation of the monitor with the BQStudio software, it may be desirable to operate the board connected to and controlled by a microcontroller board. To do this, depopulate J6 and J2, and populate J1 and

J5. J6 and J2 disconnect the I2C lines of the BQ76907 from the on-board MCU. J1 and J5 connect the I2C pullup resistors to REGOUT.

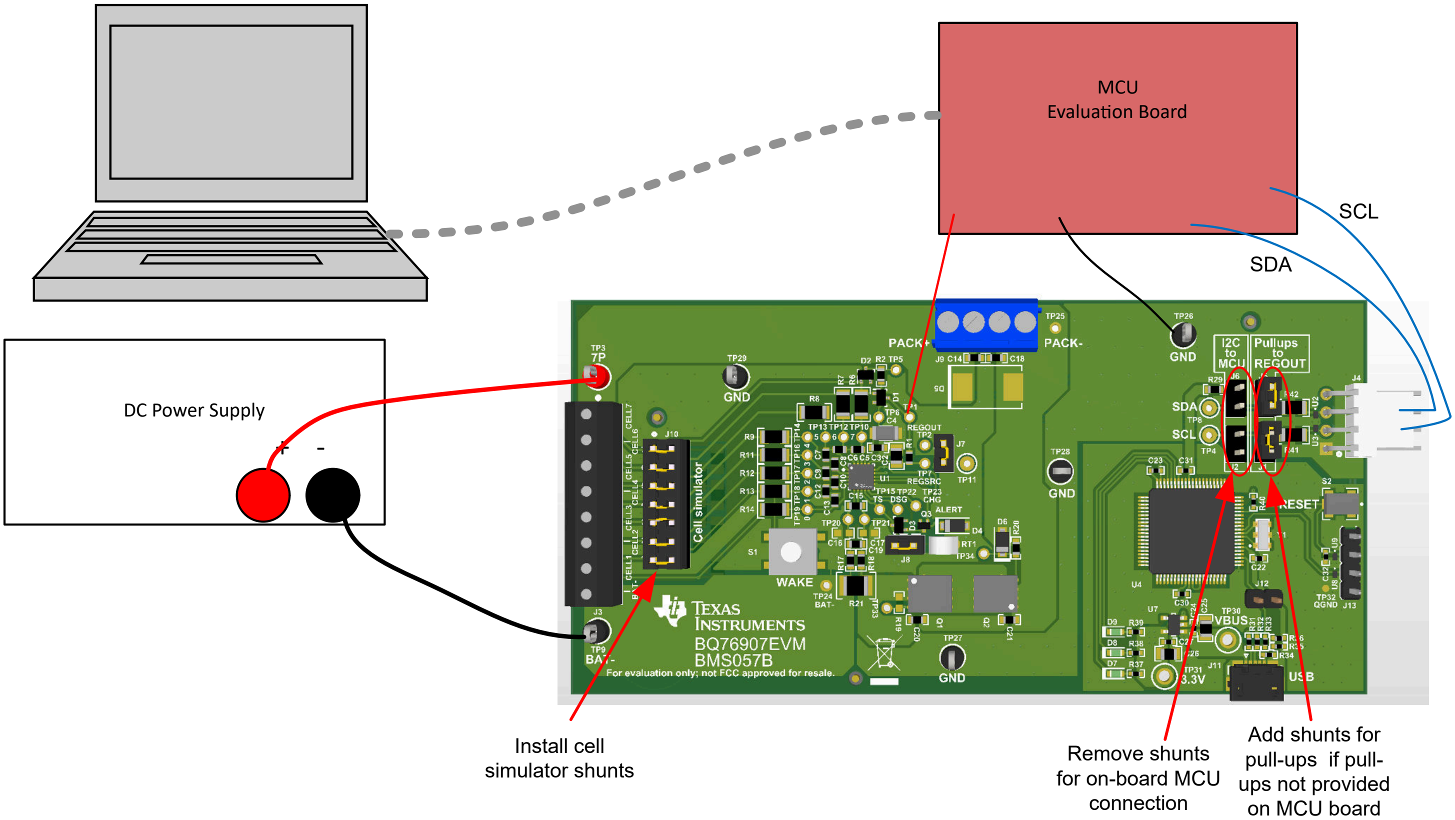

Figure 4-6. Host Connection Concept

4.8 Hardware Configuration

4.8.1 Configuration Jumpers

Certain features on the BQ76907EVM may be configured by jumpers or shunts on headers. See Section 5.3 for details of the header pins.

J1 and J5 connect the BQ76907 I2C lines to pull-up resistors at REGOUT for off-board MCU communications.

J2 and J6 connect the I2C lines of the BQ76907 to the on-board MCU.

J7 connects the ALERT pin to a pull-up resistor at REGOUT.

J8 connects/disconnects the on-board thermistor from the TS pin.

J10 cell simulator connections.

The cell simulator headers and are discussed in board connection diagrams.

4.9 Configuration Register Programming

Configuration register programming can be done once hardware configuration is set with jumpers. Configuration registers are set in the Data Memory screen and are different from the status registers displayed in the Registers screen. See the BQ76907 data sheet and supporting documentation for register information. When a configuration file is available it may be imported to set all operational selections at once. However, a configuration file loaded with Data Memory Import can load as little as 1 parameter, so the user needs to be familiar with the contents of imported files. With a new device or after loading a configuration file, individual register changes may be made. Configuration register programming typically involves the following general principles selected in various register names:

1. Selection of the protection features to be enabled

2. Selection of the protection thresholds for the enabled features
3. Setting the FET control options
4. Exporting (saving) the configuration register file for future use

5 BQ76907EVM Circuit Module Physical Construction

This section contains the PCB layout, bill of materials, and schematic of the BQ76907EVM circuit module.

The BQ76907EVM consists of one circuit module assembly, BMS057.

5.1 Board Layout

The BQ76907EVM circuit module is a 2.175-inch × 4.4-inch 2-layer circuit card assembly. The layout is designed for easy assembly with cell connections on the left edge to a terminal block. Pack terminals are on the bottom edge using a terminal block. Wide trace areas are used reducing voltage drops on the high current paths. An on-board interface adapter with USB connector is located in the right lower corner.

See additional information in the configuration and operation sections of this document.

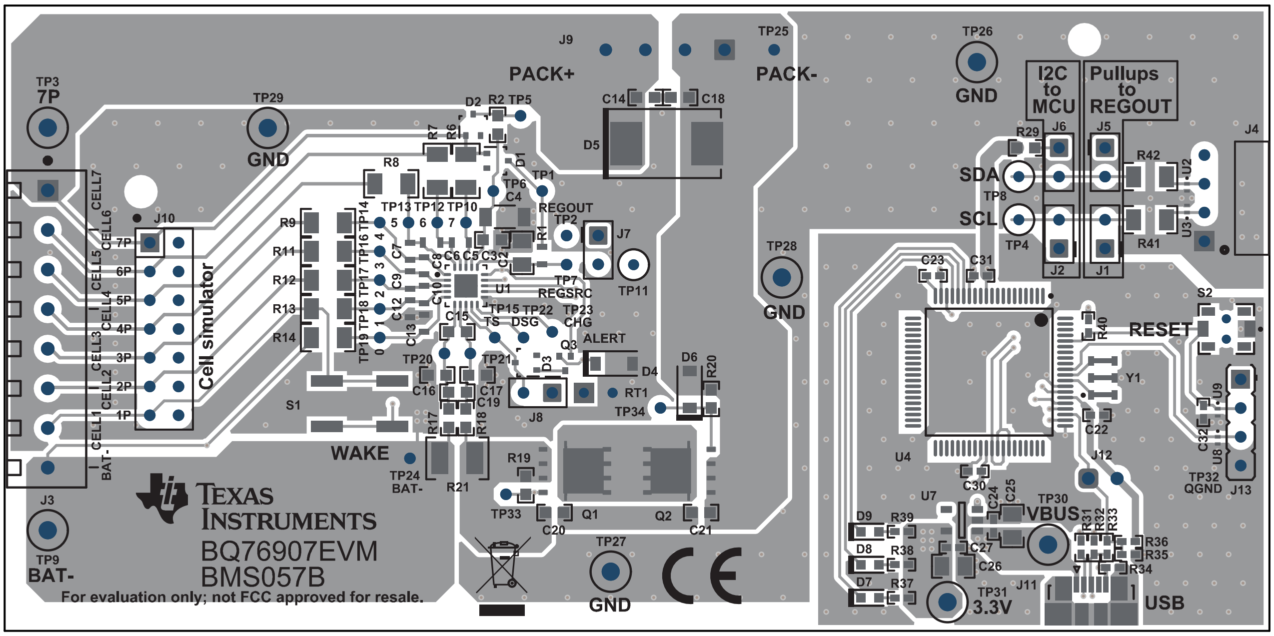

Figure 5-1. Top Layer

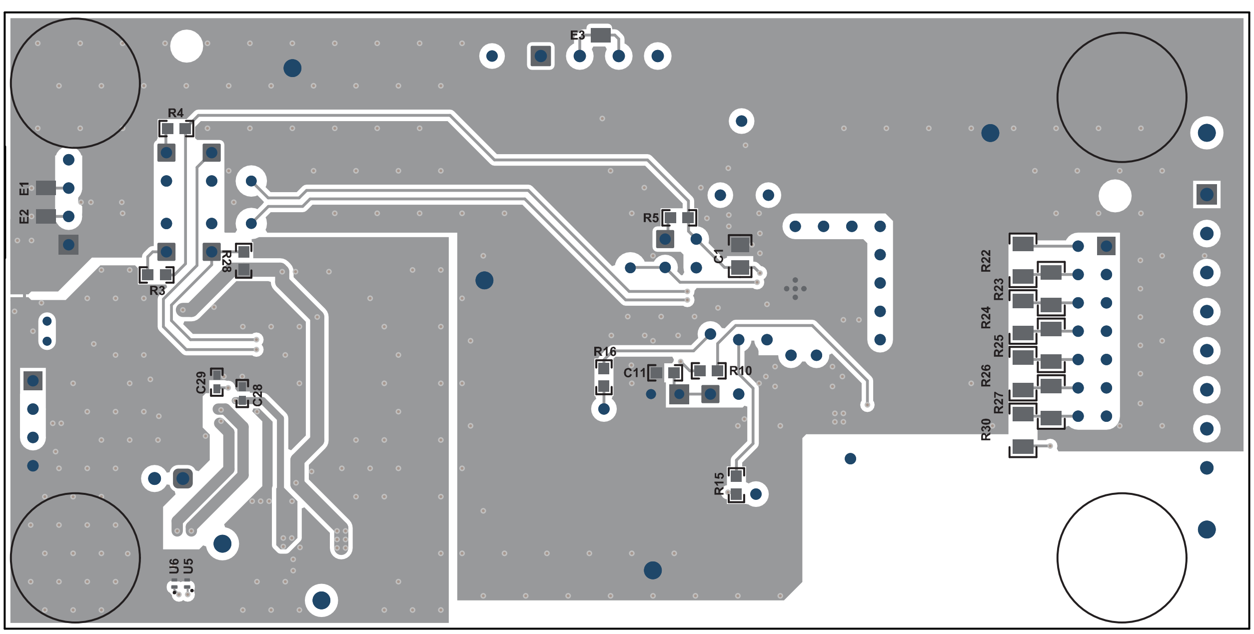

Figure 5-2. Bottom Layer

5.2 Bill of Materials

The bill of materials for the circuit module is shown in BQ76907 Circuit Module Bill of Materials. Substitute parts may be used in the manufacturing of the assembly.

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		BMS057	Any
C1	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0805	0805	EMK212B7105KG-T	Taiyo Yuden
C2	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	885012207103	Wurth Elektronik
C3, C15	2	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	C0603C101J5GACTU	Kemet
C4	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L3X7R1H105K160AB	TDK
C5, C6, C7, C8, C9, C10, C12, C13	8	0.22uF	CAP, CERM, 0.22 uF, 50 V, +/- 10%, X7R, 0603	0603	C1608X7R1H224K080AB	TDK
C11	1	470pF	CAP, CERM, 470 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603C471K5RACTU	Kemet
C14, C18, C19, C20, C21	5	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	885012206095	Wurth Elektronik
C22, C24, C27, C28, C30	5	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	0402	885012205037	Wurth Elektronik
C23, C29, C31	3	0.47uF	CAP, CERM, 0.47 uF, 6.3 V, +/- 10%, X5R, 0402	0402	04026D474KAT2A	AVX

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C25, C26	2	10uF	CAP, CERM, 10 µF, 16 V,+/- 10%, X5R, 0805	0805	CL21A106KOQNNNG	Samsung Electro-Mechanics
C32	1	2200pF	CAP, CERM, 2200 pF, 10 V, +/- 10%, X7R, 0402	0402	885012205008	Wurth Elektronik
D1, D2, D3	3	40V	Diode, Schottky, 40 V, 0.2 A, SOT-323	SOT-323	BAS40W-7-F	Diodes Inc.
D4	1	1.8V	Diode, Zener, 1.8 V, 500 mW, SOD-123	SOD-123		
D6	1	16V	Diode, Zener, 16 V, 500 mW, SOD-123	SOD-123	MMSZ5246B-7-F	Diodes Inc.
D7, D8, D9	3	Green	LED, Green, SMD	LED_0603	150060VS75000	Wurth Elektronik
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1, J2, J5, J6, J7, J8	6		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions
J3	1		Terminal Block, 8x1, 3.5mm, TH	8x1 Terminal Block	OSTTE080161	On-Shore Technology
J4	1		Header (friction lock), 100mil, 4x1, R/A, TH	4x1 R/A Header	22/05/3041	Molex
J9	1		TERM BLOCK 3.5MM VERT 4POS PCB	HDR4	OSTTE040161	On Shore Technology
J10	1		Header, 100mil, 7x2, Tin, TH	Header, 7x2, 100mil, Tin	PEC07DAAN	Sullins Connector Solutions
J11	1		Receptacle, Micro-USB Type B, 0.65 mm, 5x1, R/A, Bottom Mount SMT	Receptacle, 0.65mm, 5x1, R/A, SMT	47346-1001	Molex
J12	1		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J13	1		Header, 2.54mm, 4x1, Tin, TH	Header, 2.54mm, 4x1, TH	22284043	Molex
Q1, Q2	2	60V	MOSFET, N-CH, 60 V, 172 A, DNK0008A (VSON-CLIP-8)	DNK0008A	CSD18532Q5B	Texas Instruments
Q3	1	-20V	MOSFET, P-CH, -20 V, -0.2 A, SOT-416	SOT-416		
R1	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R2, R17, R18	3	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RJNEA	Vishay-Dale
R3, R4, R5, R28, R29	5	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale
R6, R7, R8, R9, R11, R12, R13, R14	8	10.0	RES, 10.0, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW120610R0FKEA	Vishay-Dale
R10	1	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K00JNEA	Vishay-Dale
R15, R16	2	5.1k	RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RC0603FR-072KL	Yageo
R20	1	10Meg	RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310M0JNEA	Vishay-Dale
R21	1	0.001	RES, 0.001, 1%, 1 W, 1210	1210	PMR25HZPFV1L00	Rohm
R22, R23, R24, R25, R26, R27, R30	7	200	RES, 200, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RFKEA	Vishay-Dale

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R31, R32	2	33	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233R0JNED	Vishay-Dale
R33	1	2.0k	RES, 2.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K00JNED	Vishay-Dale
R34, R40	2	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0JNED	Vishay-Dale
R35, R36	2	1.0Meg	RES, 1.0 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M00JNED	Vishay-Dale
R37, R38, R39	3	330	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3300X	Panasonic
R41, R42	2	100	RES, 100, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206100RFKEA	Vishay-Dale
RT1	1	10k	Thermistor NTC, 10.0k ohm, 1%, Disc, 5x8.4 mm	Disc, 5x8.4 mm	103AT-2	SEMITEC Corporation
S1	1		Switch, Tactile, SPST-NO, SMT	Switch, 6.2X5X6.2 mm	KST221JLFS	C&K Components
S2	1		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	C&K Components
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11	11	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP3	1		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP9, TP26, TP27, TP28, TP29	5		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		2-s to 7-s High Accuracy Battery Monitor and Protector for Li-Ion, LiPolymer, and LiFePO4 Battery Packs	RGR20	BQ76907RGR	Texas Instruments
U2, U3	2		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYR	Texas Instruments
U4	1		25 MHz Mixed Signal Microcontroller with 128 KB Flash, 8192 B SRAM and 63 GPIOs, -40 to 85 degC, 80-pin QFP (PN), Green (RoHS & no Sb/Br)	PN0080A	MSP430F5529IPN	Texas Instruments
U5, U6, U8, U9	4		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A		Texas Instruments

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U7	1		Single Output LDO, 150 mA, Fixed 3.3 V Output, 2.7 to 10 V Input, with Low IQ, 5-pin SOT-23 (DBV), -40 to 125 degC, Green (RoHS & no Sb/Br)	DBV0005A	TPS76333DBVR	Texas Instruments
Y1	1		Resonator, 4 MHz, 39 pF, AEC-Q200 Grade 1, SMD	4.5x1.2x2 mm	CSTCR4M00G55B-R0	MuRata
C16, C17	0	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	885012206095	Wurth Elektronik
D5	0	200V	Diode, Ultrafast, 200 V, 3 A, SMC	SMC	ES3D-E3/57T	Vishay-Semiconductor
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R19	0	10Meg	RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310M0JNEA	Vishay-Dale
TP30, TP31	0	Red	Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone

5.3 Schematic

Figure 5-3 through Figure 5-4 illustrate the schematics.

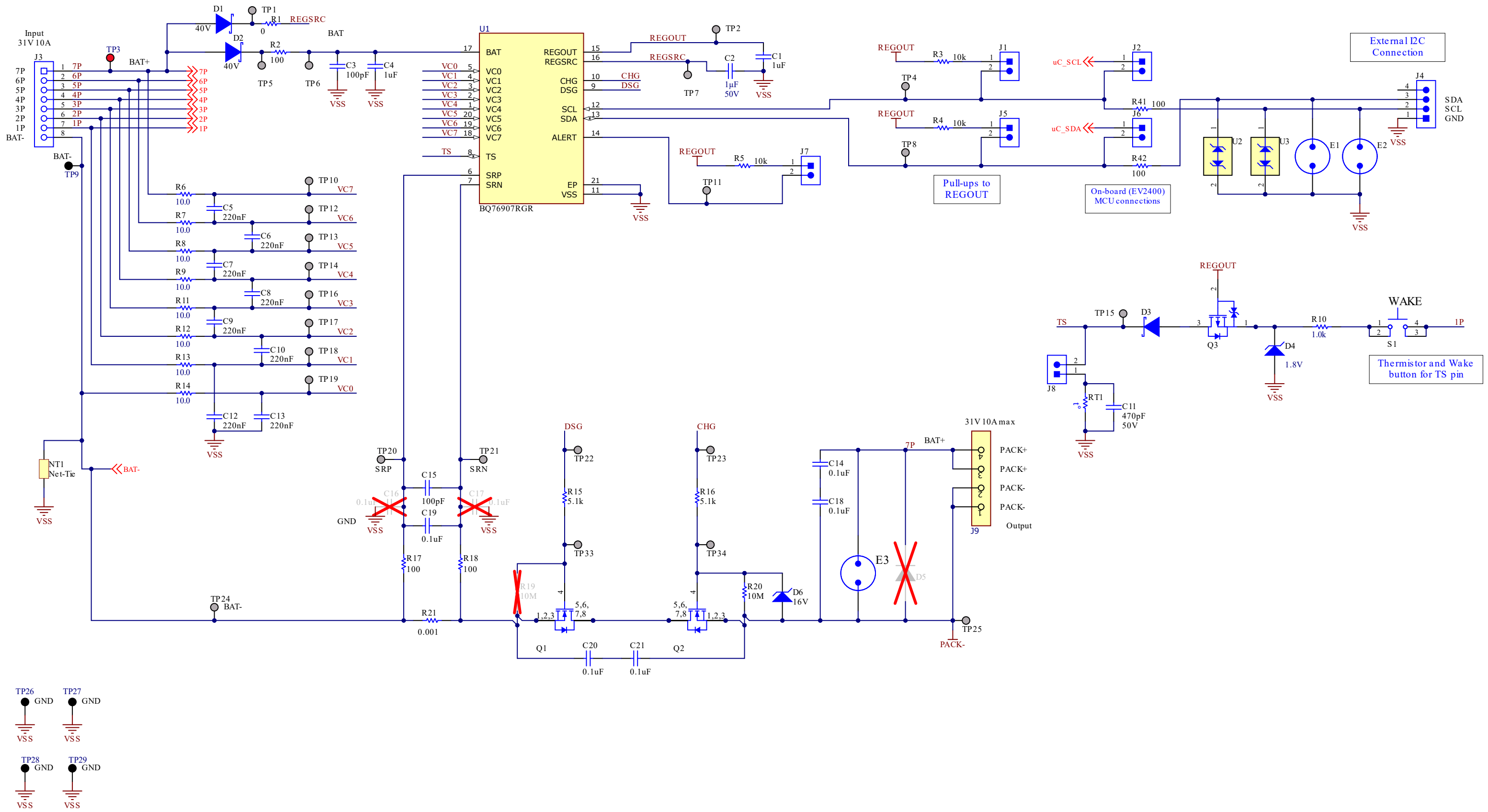

Figure 5-3. Schematic Diagram Monitor

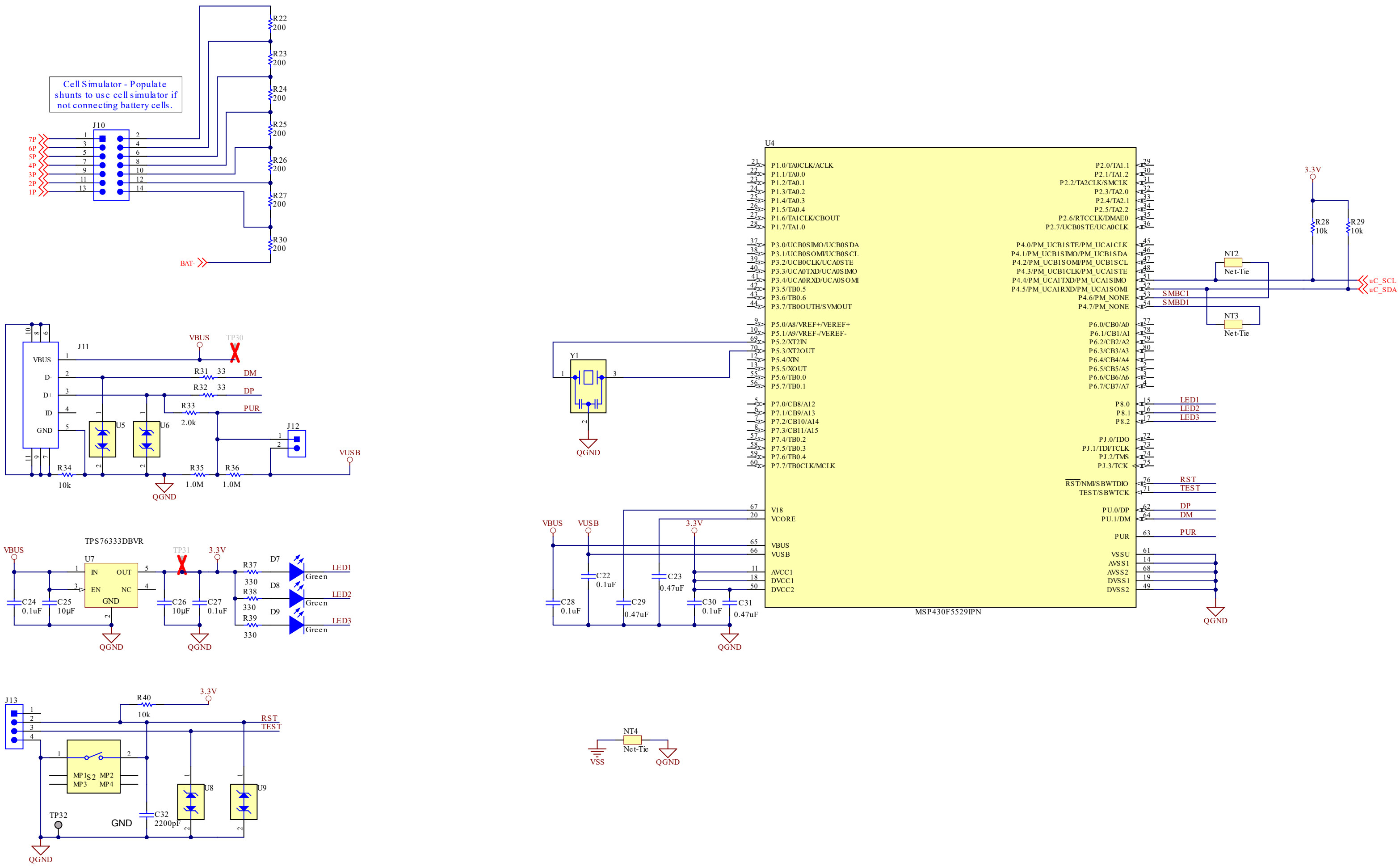

Figure 5-4. Schematic Diagram Adapter

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