User's Guide

BQ76952 Evaluation Module

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ABSTRACT

The BQ76952EVM evaluation module (EVM) is a complete evaluation system for the BQ76952, a 3-cell to 16-cell Li-Ion battery monitor integrated circuit. The EVM consists of a BQ76952 circuit module which is used for simple evaluation of the BQ76952 monitor function. The circuit module includes one BQ76952 integrated circuit (IC), sense resistor, thermistors, 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 in a 16-series cell Li-Ion or Li-Polymer battery pack. 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, perform calibration, adjust protection limits and enable FET control outputs.

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1 Features

- Complete evaluation system for the BQ76952 3-cell to 16-cell Li-Ion and Phosphate battery monitor
- Populated circuit module for 16-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

- BQ76952 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
BQ76952EVM	Li-Ion	16 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 BQ76952 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the BQ76952 circuit module in its default 16-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–	6	–	72	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 BQ76952 EVM in a simple demonstration:

- DC power supply, 0–80 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 BQ76952 with a more extensive demonstration.

2 BQ76952 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 BQ76952 EVM. Observe all safety precautions.

Warning The BQ76952EVM 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.

Warning The bq76952EVM is not rated as a high voltage EVM, has smaller clearances than normally used on high voltage boards and does not have an isolation boundary. If you apply high voltage to this board, all terminals should be considered high voltage. Electric shock is possible when connecting the board to live wire. The board should be handled with care by a professional. For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

Caution Do not leave the EVM powered when unattended.

CAUTION

The default settings of the BQ76952 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. This 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 Sepcification 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 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 BQ76952 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. Once all registers are configured, the values may be written to One Time Programmable memory (OTP) for use on the next reset of the device, but since that is a permanent change it is not part of this quick start procedure. This quick start assumes a new EVM without OTP configuration settings. If your board has a part with configuration stored in OTP refer to Section 3 and Section 4.

These steps describe quick connection of the BQ76952 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 to uC_SCL and uC_SDA.
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 "*CELL16*" terminals and adjust to approximately 48 V.
7. Press and release the *WAKE* switch.
8. Start the BQStudio software. The GUI should open with a register display. 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.
9. Select the Data Memory button in the BQStudio window.
10. Select the Settings button. Set the Enabled Protections A CUV bit
11. In the Commands panel click on the FET_EN button.
12. In the Registers view click on the Scan icon so that the registers update periodically. Observe that the CHG_FET and DSG_FET bits in the FET Status register are on and that the Stack voltage and the PACK pin voltage registers are approximately equal. Measure the PACK voltage on the board if desired.
13. Adjust the supply voltage to approximately 38 V. In the registers view observe that the DSG_FET bit goes off and the PACK voltage drops to approximately 0 V.
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.

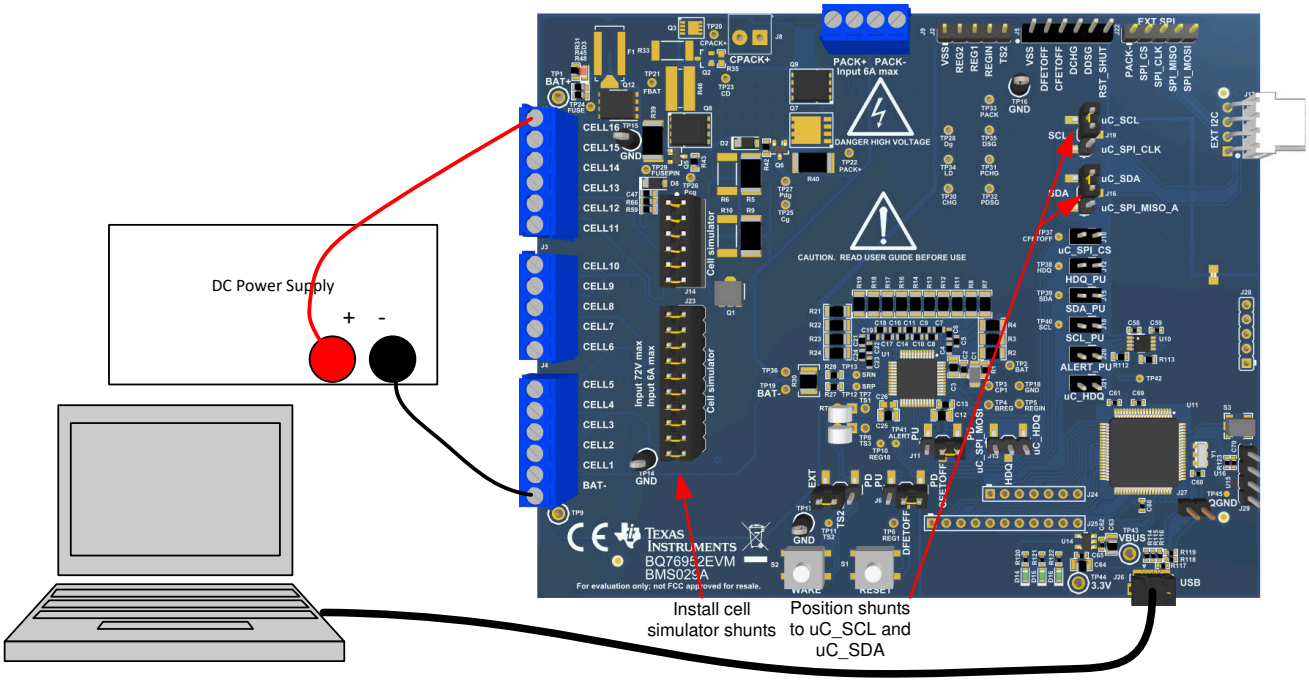

Figure 2-1. EVM Connection for Basic Operation

3 Battery Management Studio Software

The Battery Management Studio software is used for evaluation of the BQ769x2 monitor. It is also identified as BQStudio for a compact name. If an earlier version of the BQStudio software is already installed from another product evaluation, it should still be installed again to load the configuration files and tools specific to the current version of the BQ76952.

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 and the BQSTUDIO-TEST version should be used with the BQ76952 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 BatteryManagmentStudio 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 BQ769x2 bqz File Installation

The BQStudio software uses a bqz file to configure the displays for the BQ769x2 device family or specific family device. This 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 BQ769x2 for evaluation. It includes several tools to aid in configuration, calibration and data display of the BQ769x2 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 the 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 BQ769x2 version in the list and click the **Finish** button. This selection will be remembered until the software is re-stared. If the device is not found, the user will be presented with a *Proceed?* window which must be acknowledged. If the software still can not find the device, a *Battery Management Studio* popup window appears indicating communication status. Acknowledge the message to proceed.

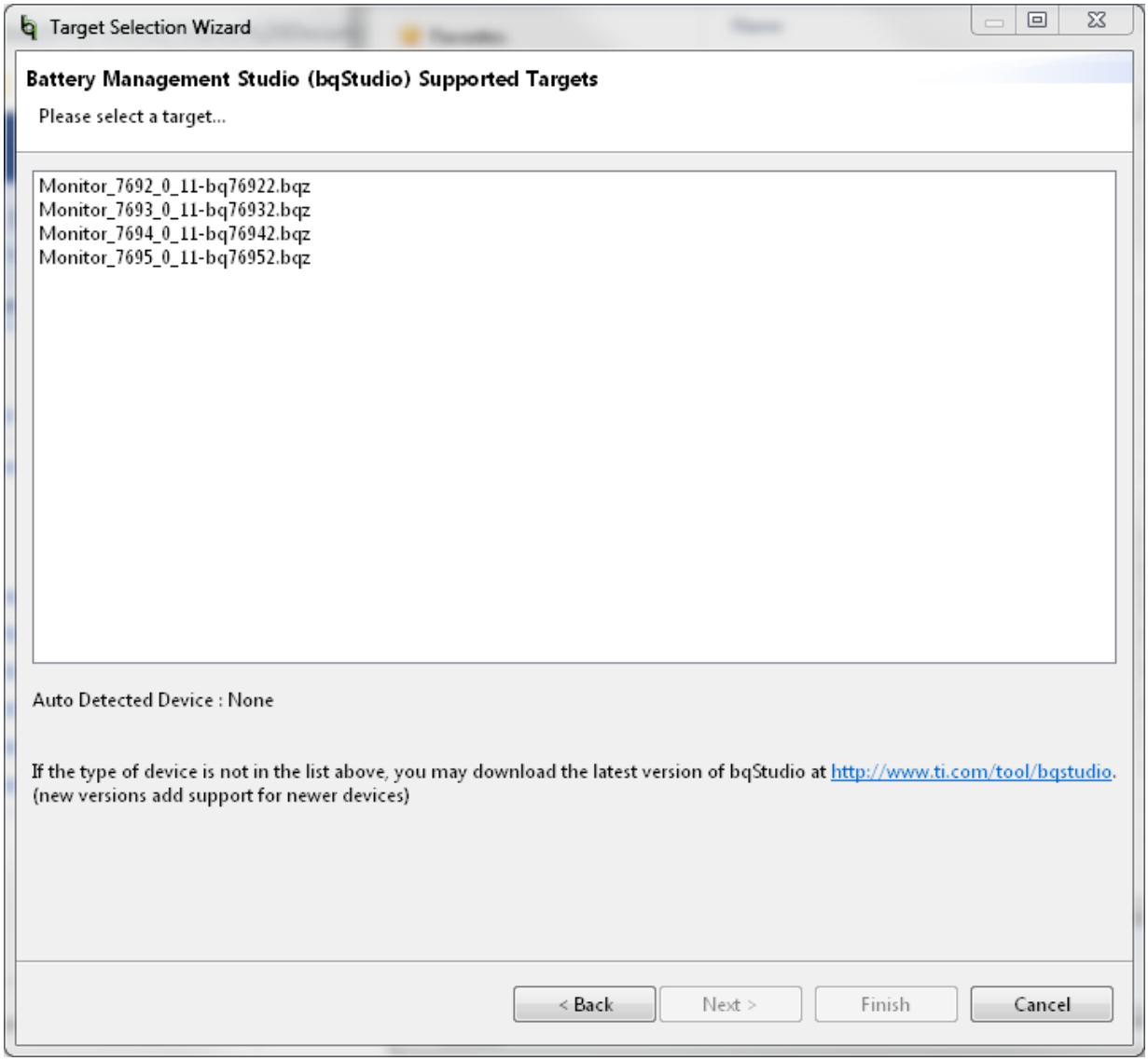

Figure 3-1. Target Selection Wizard

If the software was started without a communication interface adapter, a Battery Management Studio popup window will indicate 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 pane 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 pane.

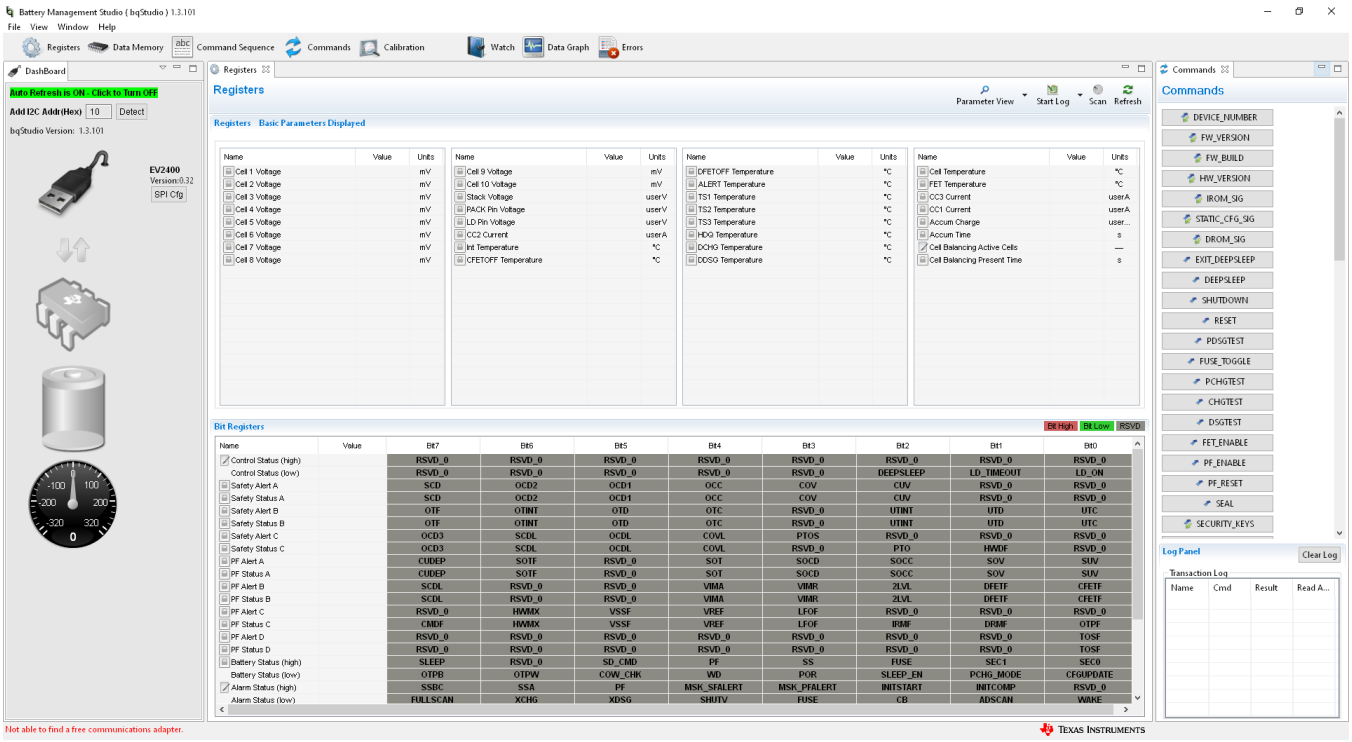

Figure 3-2. BQStudio Window without Device

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

On the left side of the window is the dashboard which shows the adapter, device and simple voltage and current displays. The dashboard also shows the communication protocol the EV2400 is using to interface to the device - this is set to I2C by default, but SPI and HDQ options are available as well which will be described in more detail with the device configuration. The dashboard updates periodically unless Auto Refresh is stopped by clicking on the banner. The right side of the window has the commands pane.

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, dashboard may auto detect the device and update the device and register display. Figure 3-3 shows a register display with a connected device.

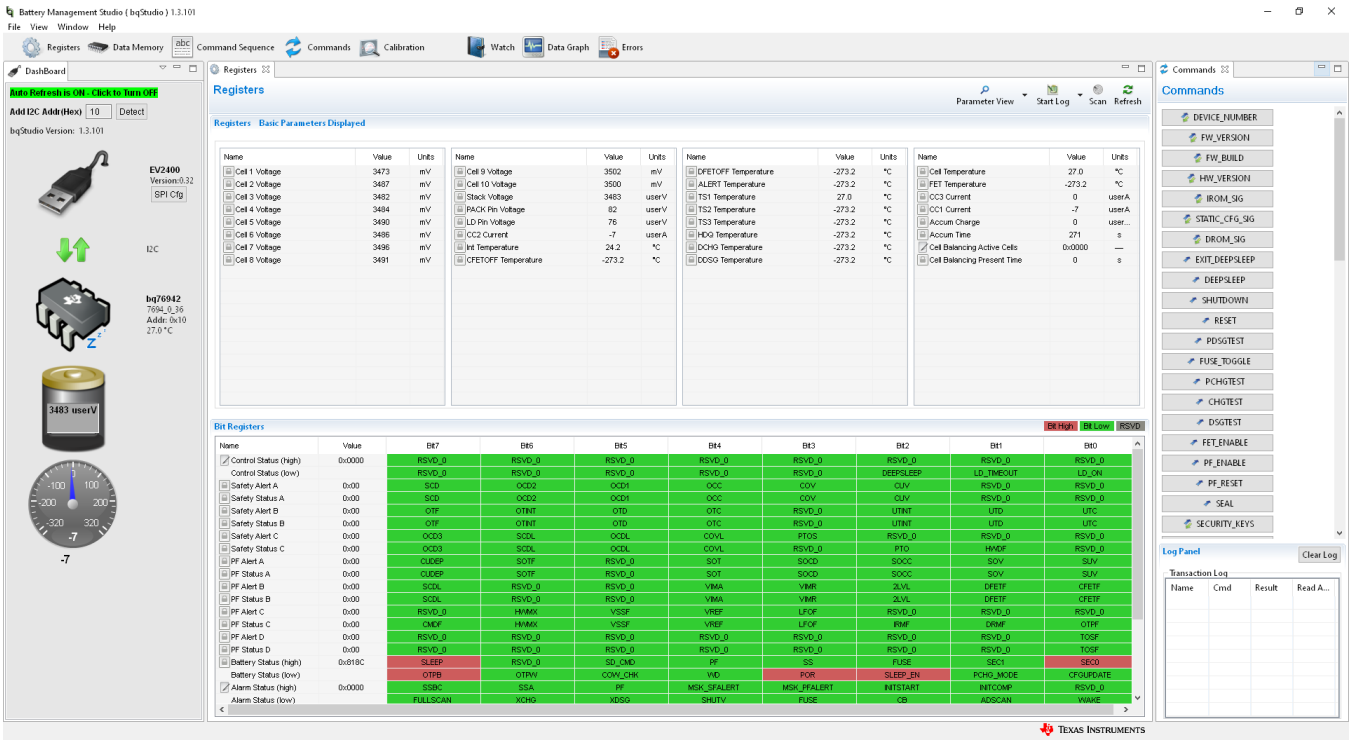

Figure 3-3. Register View with Device

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 pane 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.

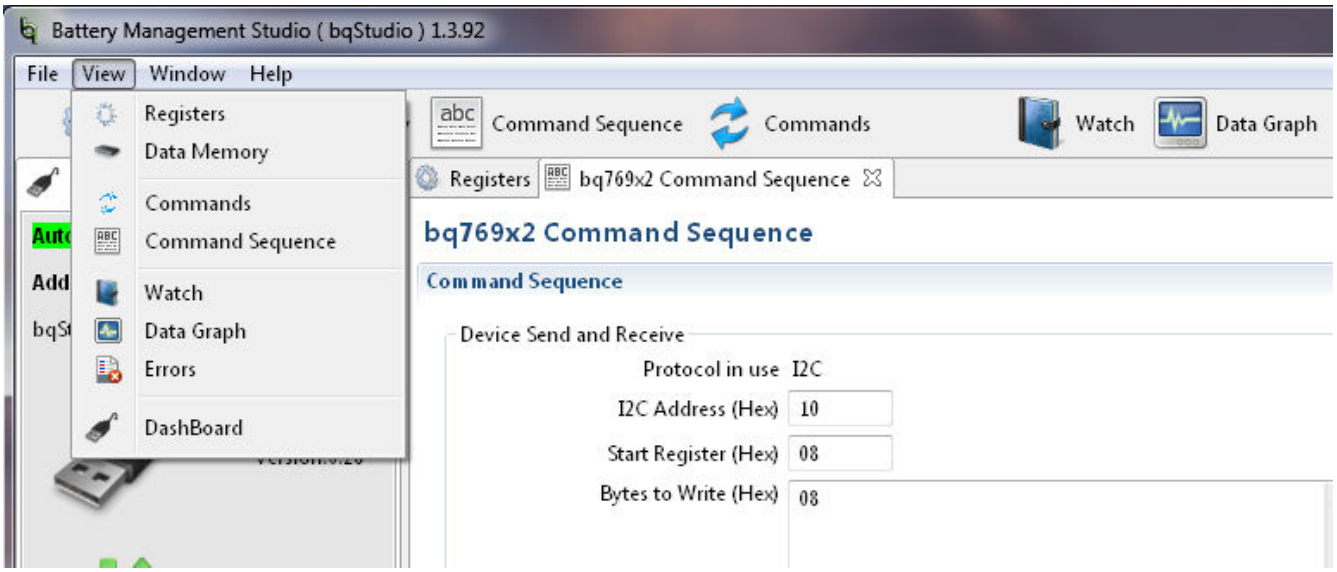

Figure 3-4. Tool Selections

3.5 Commands

The Commands tab is displayed on the right side of the BQStudio window. Buttons allow reading various information about the device and 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 will reduce the function of the EVM.

3.6 Data Memory

The data memory tool is used to configure the device. The device has both volatile registers and One Time Programmable (OTP) memory. Most evaluation can be performed without writing OTP. Configuration files may be saved and loaded later to resume evaluation. At power up, the device is configured from the OTP. On a new EVM, the OTP is blank. 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 pane. The Calibration section is displayed on initial selection. Other functional sections can be displayed by clicking on the named button.

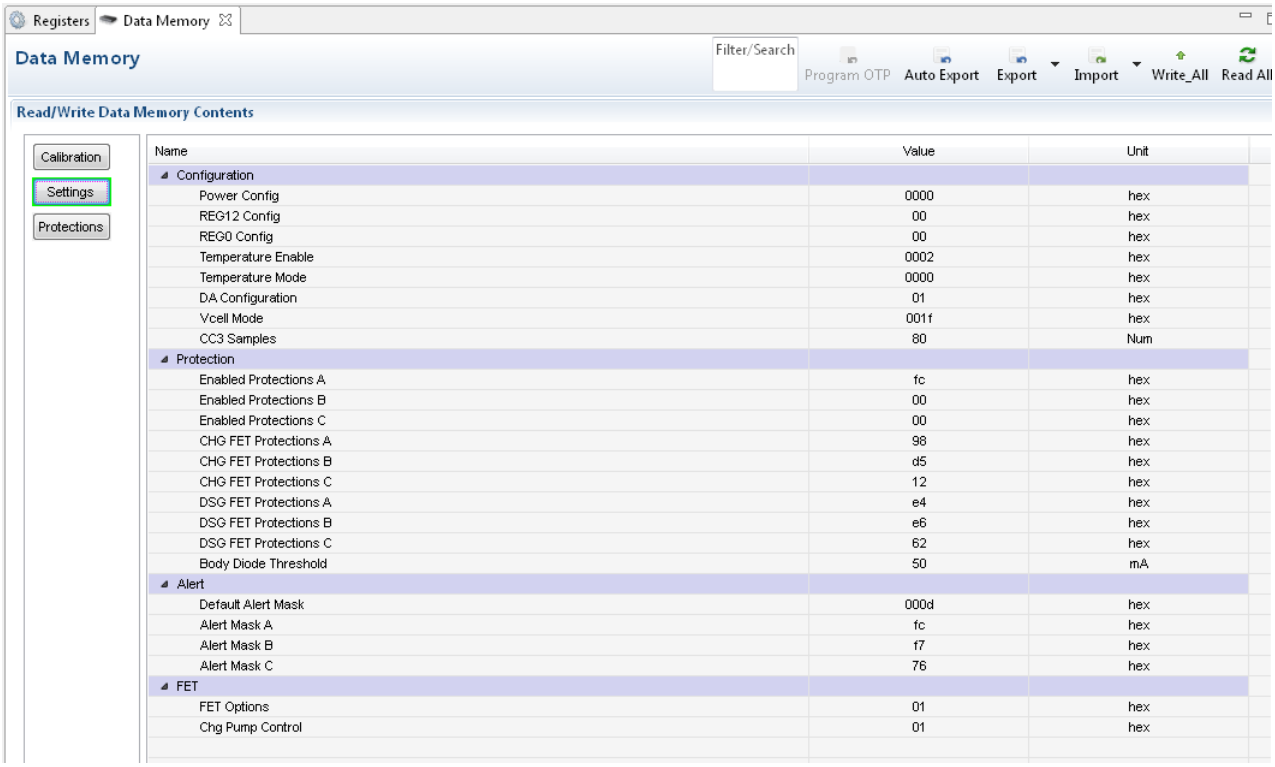

Figure 3-5. Data Memory View

3.6.1 Entering, Saving, and Loading Configuration

Most of the configuration of the BQ769x2 is accomplished through setting values in 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 pane 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. 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.

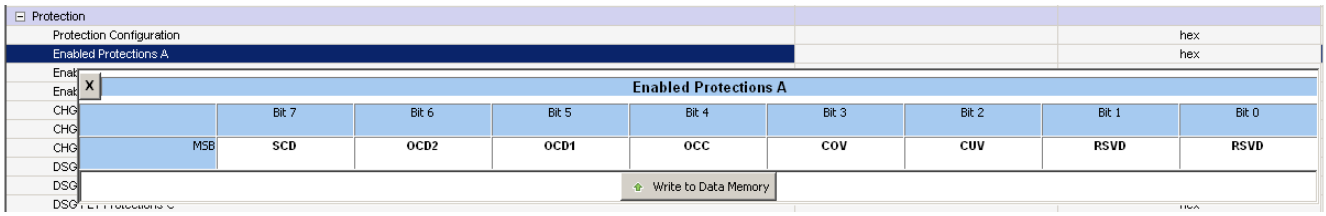

Figure 3-6. Data Memory Bit Field Change

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

Calibration data is also located in data memory. Calibration values may be loaded manually or calculated by a tool.

The *Export* tool in the Data Memory view allows saving the configuration data to a comma-separated-value file format which can be accessed by a spreadsheet program. Reading data before export with the *Read All* button will load the data from the part rather than values which may be only in the view. The *Import* tool allows loading such 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.

3.6.2 OTP Programming

CAUTION

OTP programming is a permanent change to the device. Be sure all configuration and calibration are set before programming settings into the device. Casual programming may leave the board inoperable. Writes to OTP are not incremental, all OTP is written at the same time.

Once the configuration and calibration has been determined and loaded in the registers, it may be programmed to the BQ76952 OTP memory using the *Program OTP* button at the top of the pane. Note that this is a permanent programming and is not reversible. There are 2 writes possible, if the device has been programmed once, a second memory is available. Additional memories are not available. OTP memory is programmed using the OTP memory view. Programming typically takes about 40 s. To program the OTP memory:

1. OTP write requires 12V at the board stack and room temperature. Calibrate the device if needed.
2. Be sure the desired settings are written to the data memory.
3. Select the Program OTP tool at the top of the Data Memory window. This opens a Program OTP pane.
4. Adjust the board voltage to 12.0 +/- 0.1 V for programming.
5. Select the Check OTP Programming Possible button. If not successful make the recommended adjustments if possible. If successful, the display is similar to Figure 3-7.
6. Select the Program Data Memory to OTP Memory button. If successful, the display is similar to the check.
7. Adjust the board voltage back to normal operating conditions, cycle power, and test as desired.

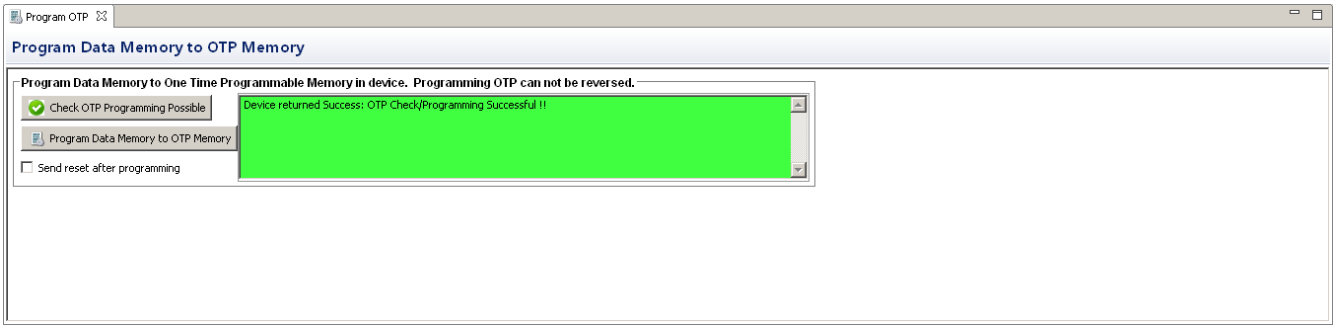

Figure 3-7. Program OTP Pane with Success Display

3.7 Calibration

The calibration tool may not be available for all versions of devices. When the calibration tool is not available calibration of the device can be performed by entering values in the calibration section of the data memory.

The calibration writes to the volatile registers in the device which are available in the Data Memory view. When calibration values are complete they can be written to the OTP with other configuration settings. Calibration cannot be written to OTP separately from configuration settings.

The EVM and all new boards should be calibrated before operation. The calibration view is shown in Figure 3-8. Temperature is typically calibrated first. Board Offset should be calibrated with no current flow and should be calibrated before Current Gain. The EVM uses a 1-mΩ sense resistor and calibration at low current will result in some granularity from the current resolution. This may result in an apparent error at higher currents. Calibration at higher currents will reduce this effect and should be done where it is important.

Voltages and temperatures may be calibrated individually or as a group. All values entered will be calibrated. If individual values are to be calibrated, leave all the other entries blank. As an example, measure the battery voltage, calculate the average cell value and enter the value in the box. Clicking the Calibrate Voltage button runs the calibration. Values left blank or entered as '0' are not calibrated. When successful, a green check appears next to the button as shown in Figure 3-9. If there is an error, a red X appears instead with a message as shown in Figure 3-10.

When calibrating the EVM voltage, remember the EVM uses 1% values for the cell simulator resistors. Measuring each cell voltage value is recommended rather than using a common value if individual cell voltage calibration is desired.

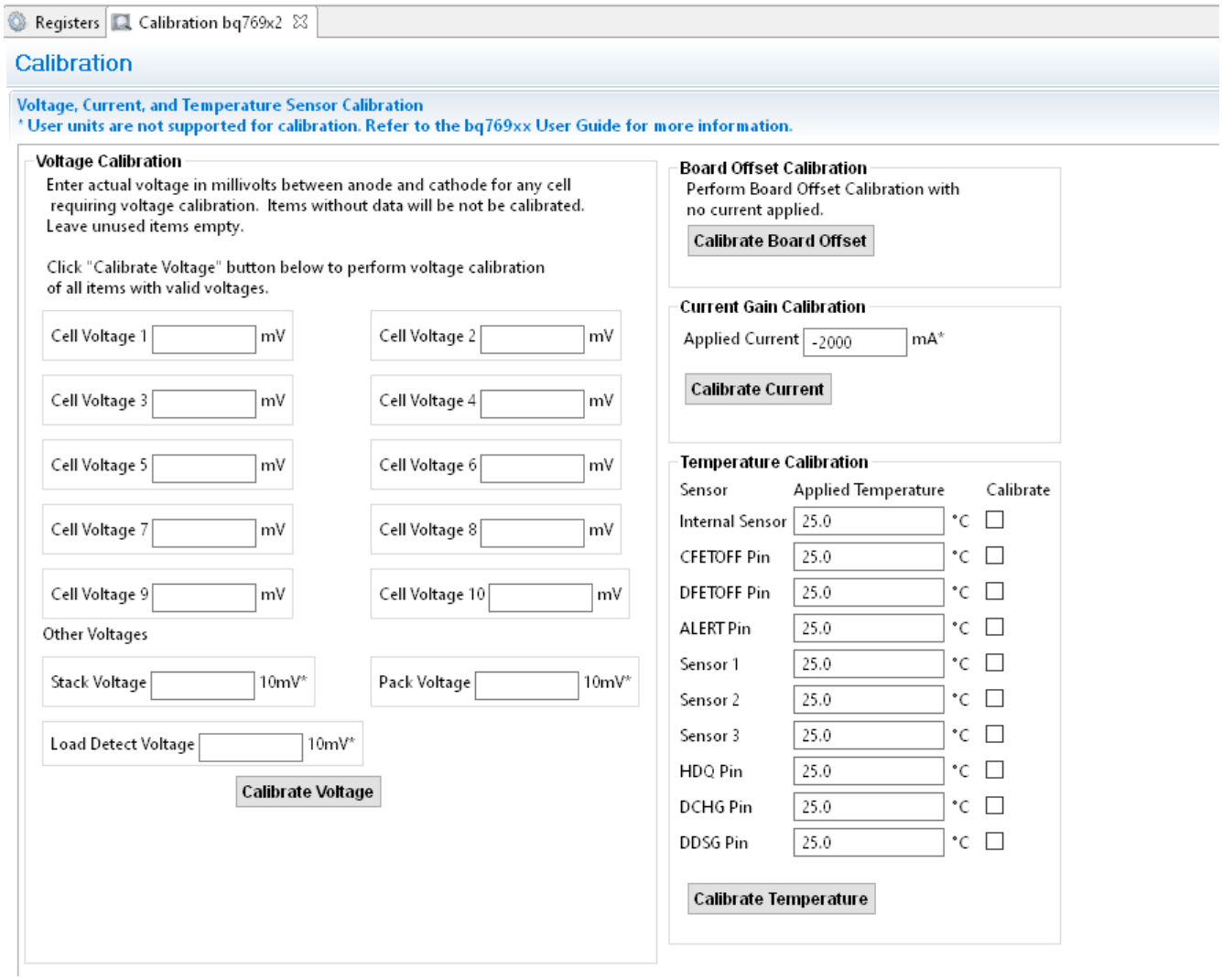

Figure 3-8. Calibration View

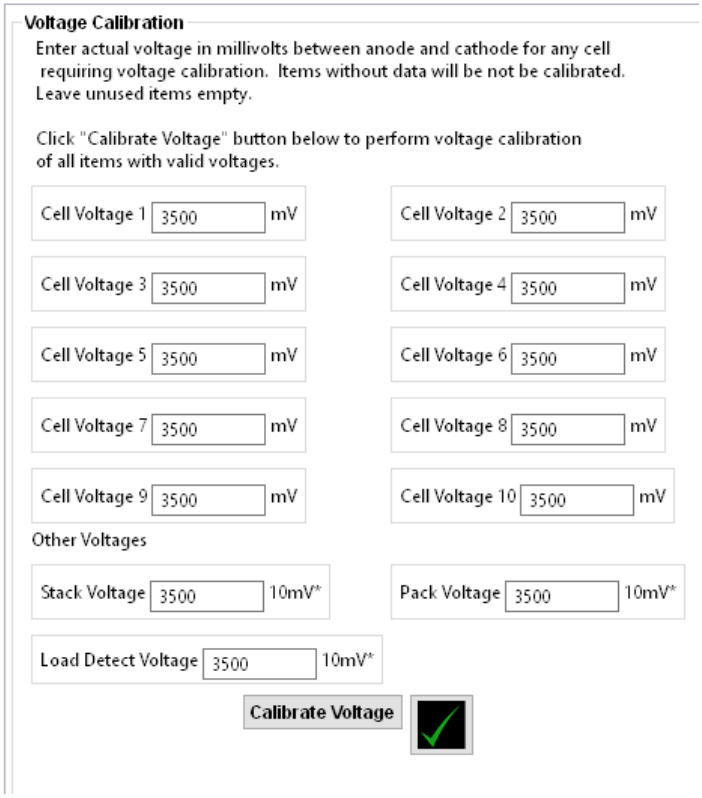

Figure 3-9. Example Voltage Calibration Success

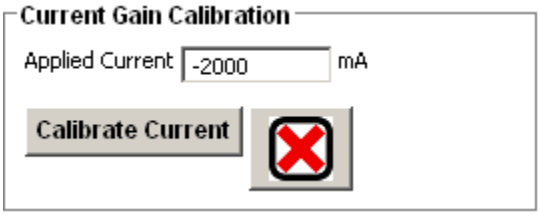

Figure 3-10. Example Current Calibration Failure

3.8 Command Sequences

Features are controlled by commands as described in the BQ769x2 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 3-11. 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.

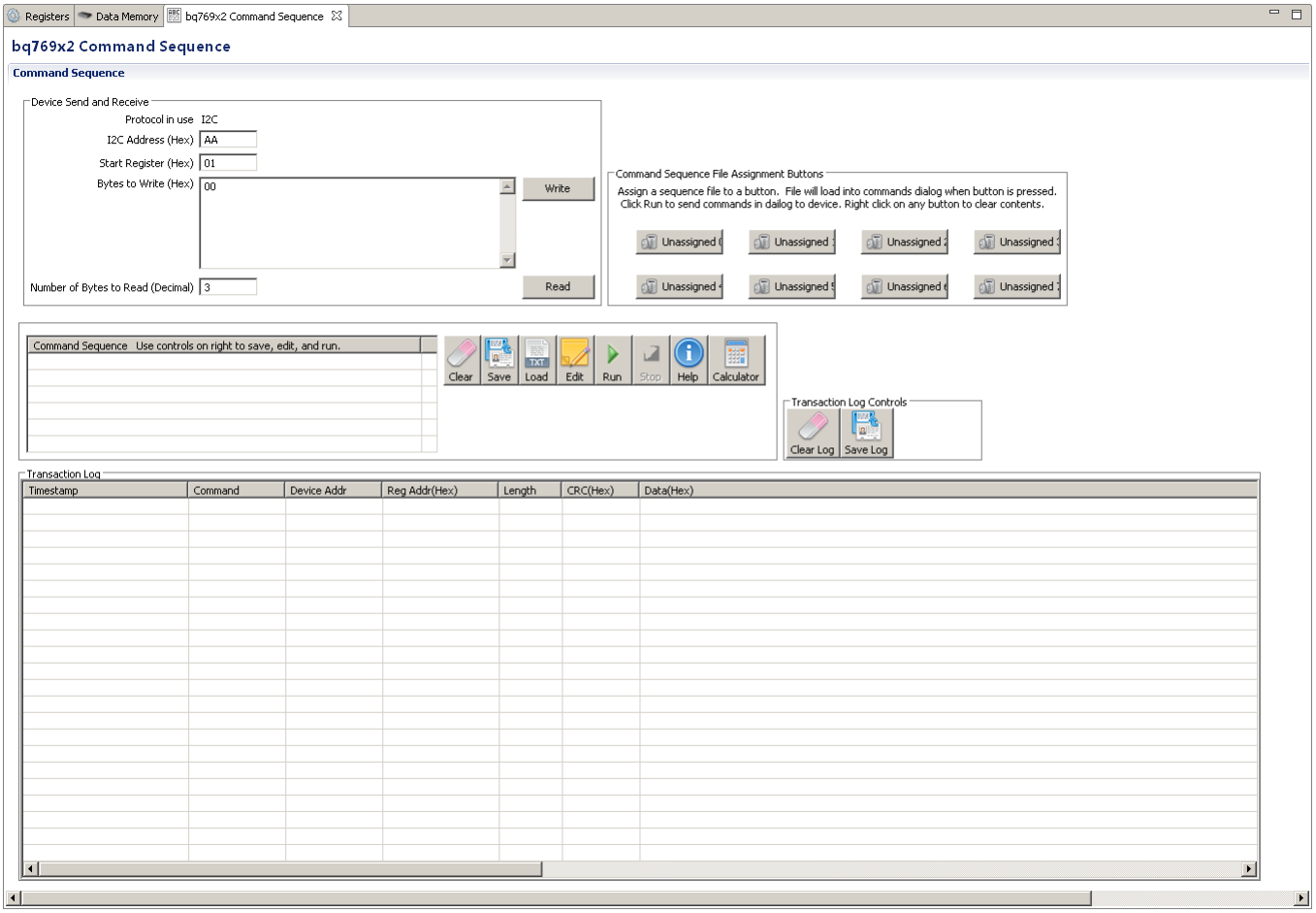

Figure 3-11. Command Sequence View

4 BQ76952 Circuit Module Use

The BQ76952 circuit module contains the BQ76952 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 BQ76952 EVM Quick Start Guide section. For details of the circuit, refer to the BQ76952EVM 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 J14 and J23 headers. 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 BQ769x2 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.

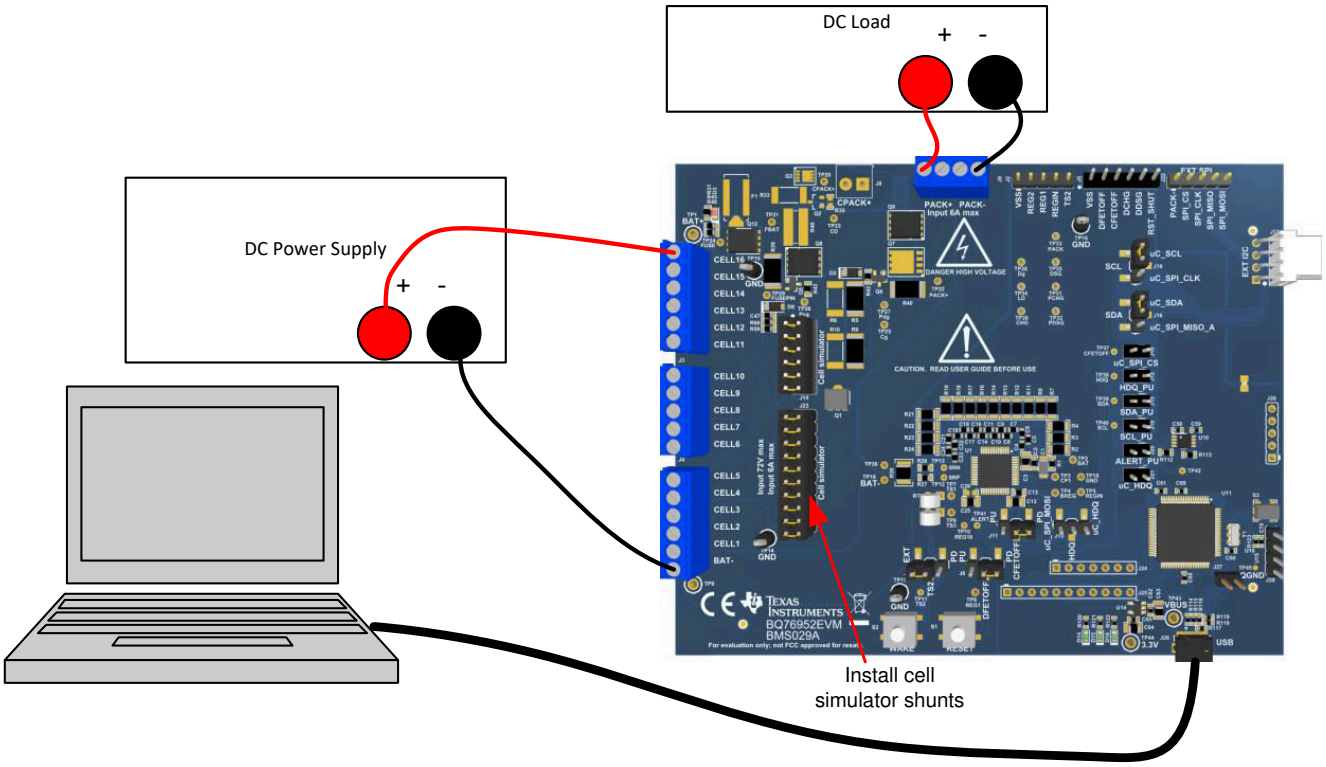

Figure 4-1. Evaluating with Load Current

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.

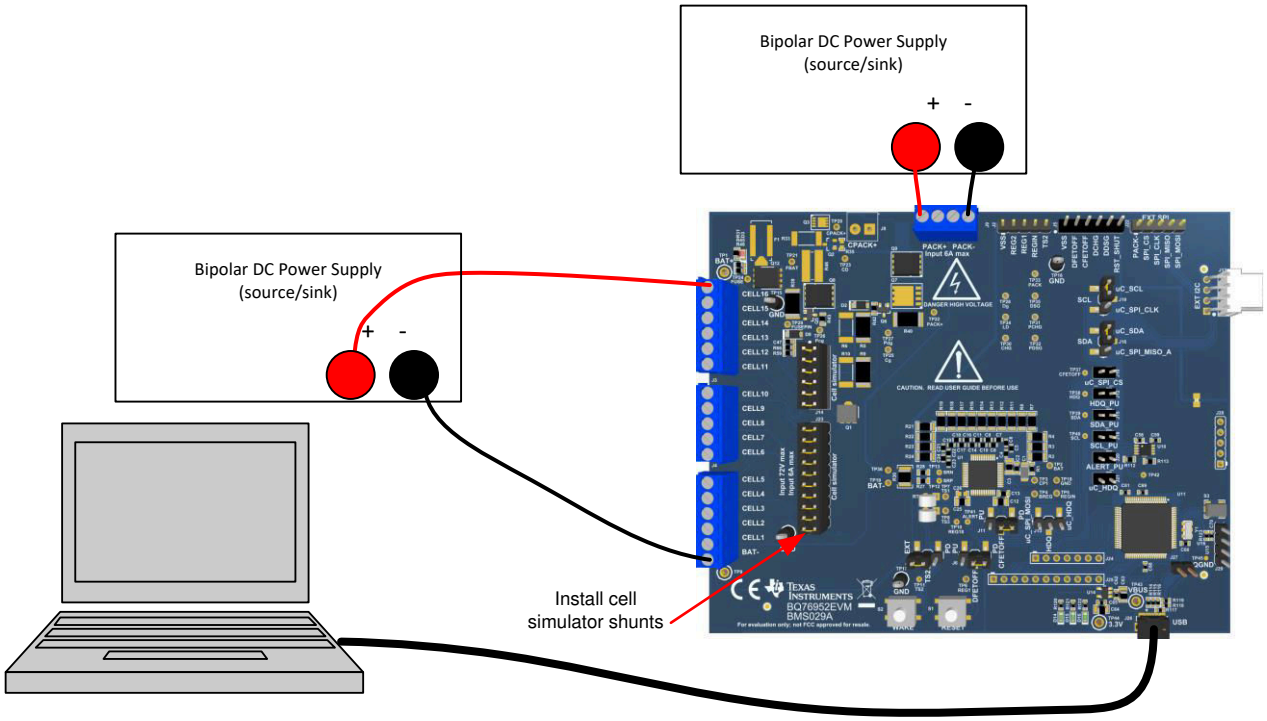

Figure 4-2. Evaluating with Charge or Discharge Current

4.4 Evaluating with Simulated Current

The BQ76952 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 should 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.

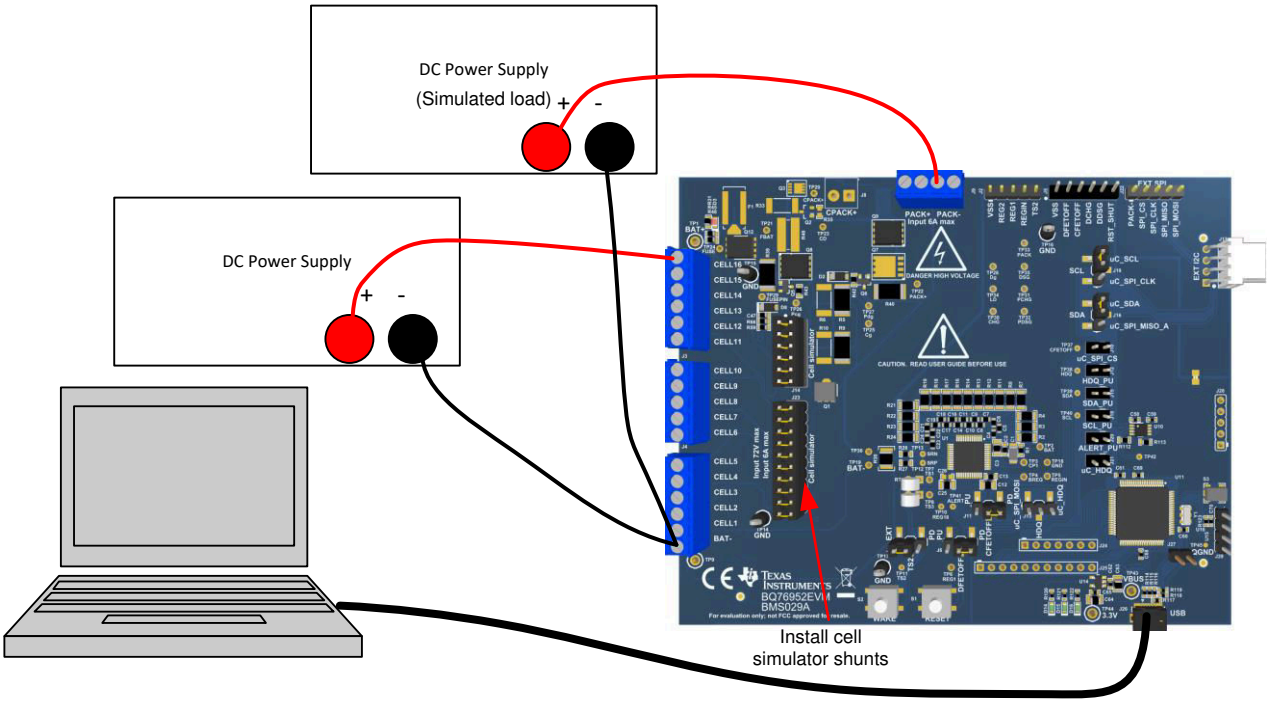

Figure 4-3. Simulating Current Setup

4.5 Reducing the Cell Count

The BQ76952 must have the top and bottom cells used for proper operation. 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 datasheet for which cells to short. This 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 14 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 should 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 15	CELL15 to CELL14	R3	C5	VC15 to VC14
Cell 14	CELL14 to CELL13	R4	C6	VC14 to VC13

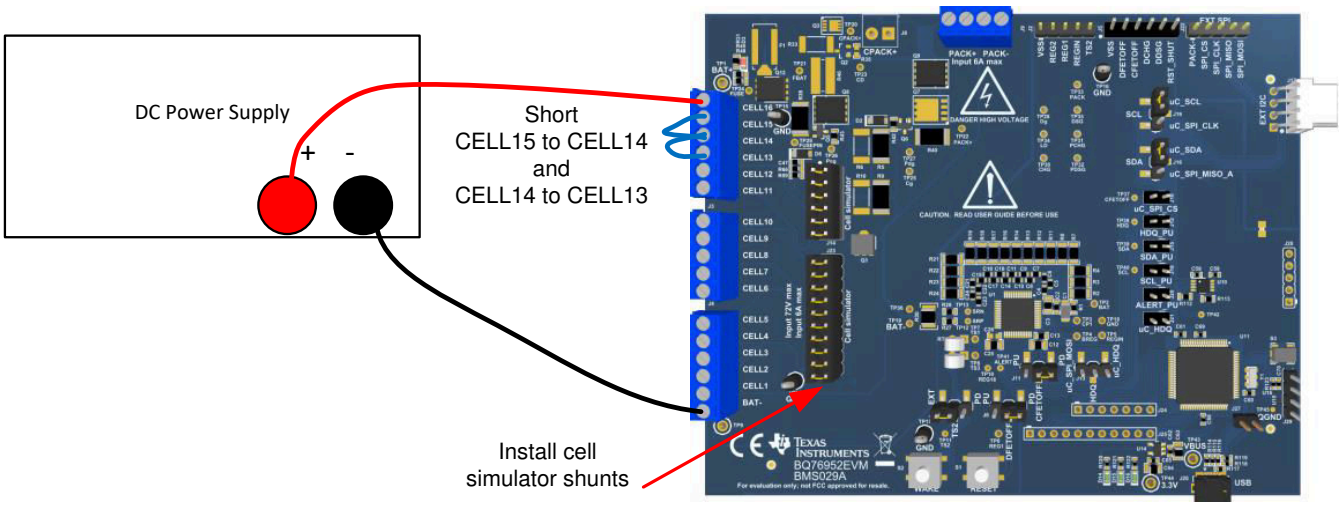

Figure 4-4. Example 14 Cell Simple Evaluation Configuration

When reducing the cell count with the top cell used, the resulting configuration of the BQ7718 secondary protector does not match its data sheet configuration. While the circuit will typically function on the EVM, when implementing a design the configuration of the data sheet is recommended.

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.

While the EVM has a place to mount an activated fuse, the pattern is shorted to allow easy evaluation without the concern of activating the fuse. When connecting cells use a fuse in the current path and any other signal path appropriate for your application.

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 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 should 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 15 cells.

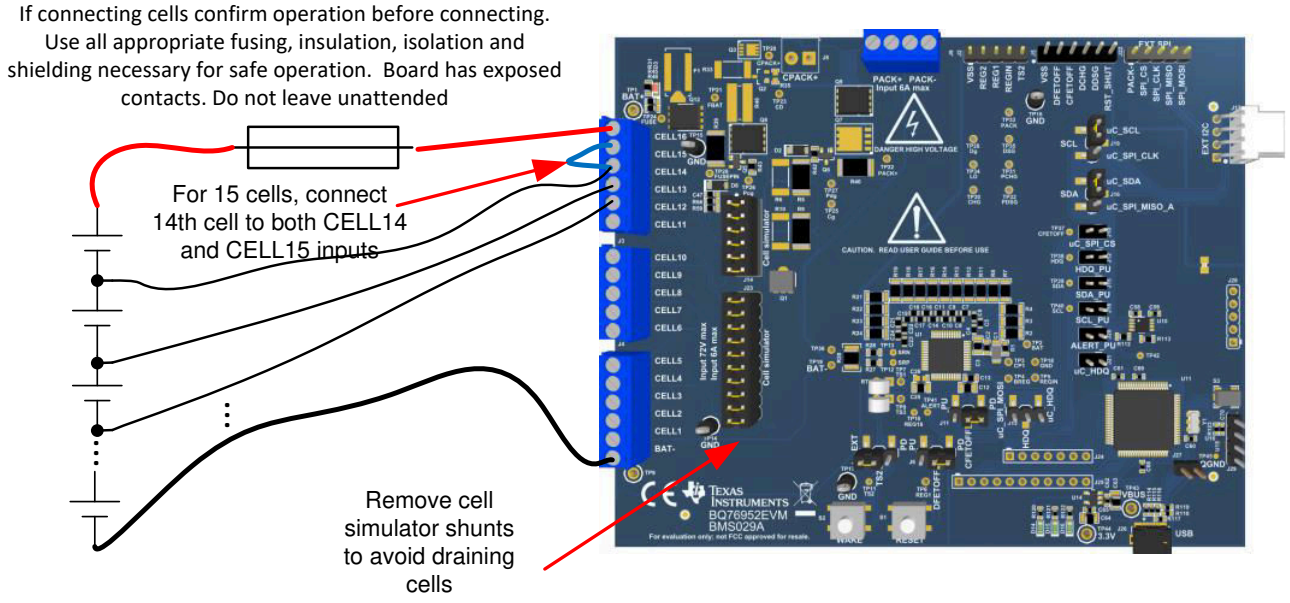

Figure 4-5. Example Connection with 15 Cells

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. J17 could be used to connect I2C signals to the microcontroller board with GND and REG1 for a power supply from J2. The user should note that the J2 GND is connected to the BQ76952 VSS and BAT- while the J17 reference is PACK-. With the connection shown in Figure 4-6 the MCU runs from the battery voltage inside the protection FETs. If the MCU board provides pull ups for the I2C lines, remove the PU shunts from J15 and J18. Alternately, the microcontroller board GND could be referenced to the PACK- at J17. In this case the REG1 power supply would be modulated by the battery current. Since the sense resistor is small, this is not normally a concern, but the user should be aware of the difference. Do not connect the same reference to both the J2 GND and the J17 PACK- since this will short the sense resistor through the external equipment and may lead to damage or unexpected results.

CAUTION

Do not connect the MCU board to both the J2 GND and J17 PACK- terminals, this will short the sense resistor and could result in damage to equipment or unexpected results.

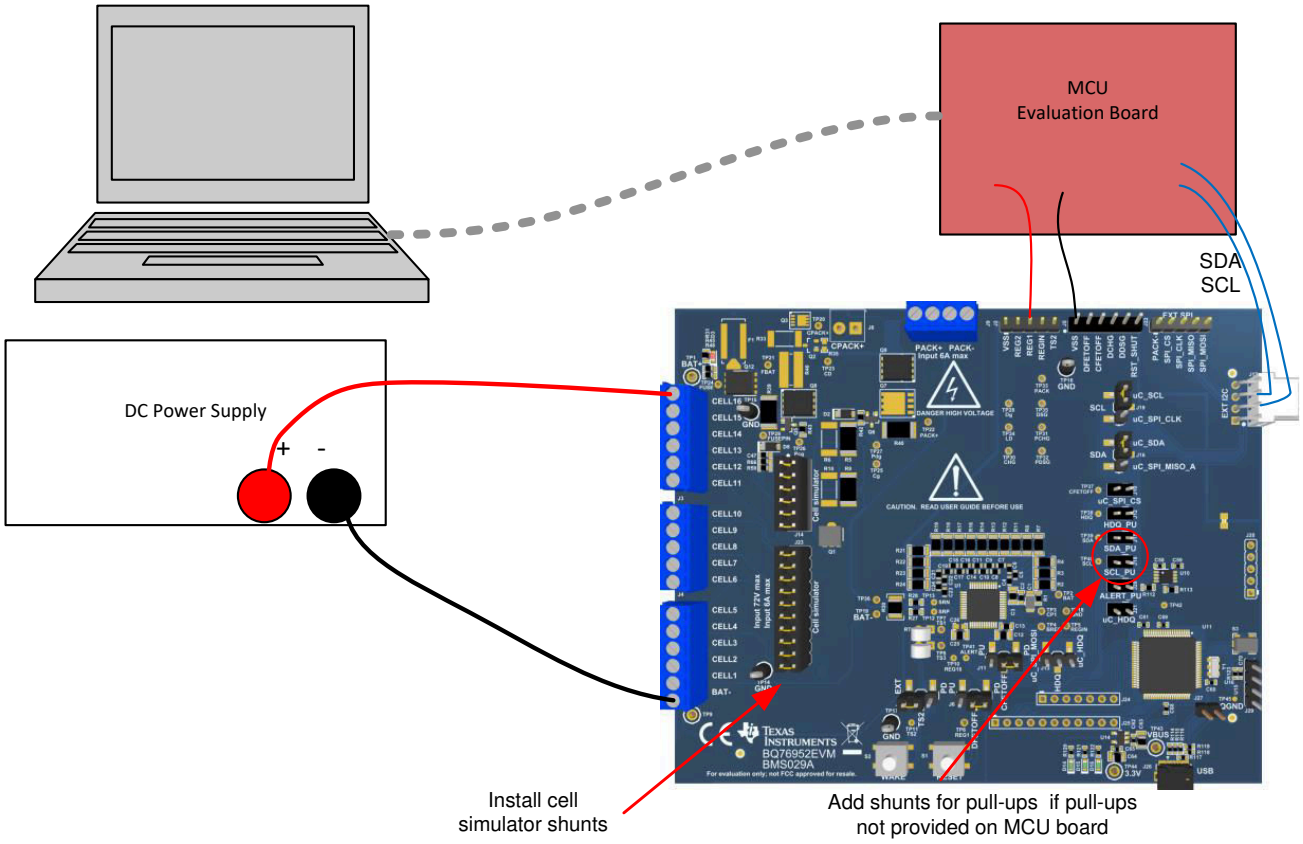

Figure 4-6. Host Connection Concept

4.8 Hardware Configuration

4.8.1 Configuration Jumpers

Certain features on the BQ76952EVM may be configured by jumpers or shunts on headers. See Section 5.4 for details of the header pins. Not all configurations are compatible with all register settings, the user should set pins appropriately for the register settings planned. For example pins must not be pulled above REG18 when used as thermistor inputs. Pull up to REG1 is not acceptable when registers configure a pin as a thermistor input.

CAUTION

Multi-function pins must be connected to compatible signal levels before programming registers to avoid device damage.

The cell simulator headers and I2C configuration are discussed with board connection diagrams.

J6 and J11 select the connection of the DFETOFF and CFETOFF pins. Pins may be pulled low or high to REG1.

J7 selects the connection of TS2. It may be taken to a terminal block for connection of an external wake or thermistor. It may also be pulled to VSS. The 10k R29 simulates a nominal temperature.

J20 and J21 select the connection of ALERT. It may be connected to the on-board interface for HDQ or pulled up to REG1.

4.8.2 Unused Components

The EVM contains a number of component patterns which may be useful for evaluation. Unpopulated headers at the MCU may provide future signal access. Parallel FET configuration is possible by changing the component population in the FET area. See the FET schematic in Figure 5-11.

4.9 Configuration Register Programming

Configuration register programming should 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 BQ76952 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 should 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 will typically involve the following general principles selected in various register names:

1. Selection of the function for multi-function pins
2. Selection of the protection features to be enabled
3. Selection of the protection thresholds for the enabled features
4. Setting the FET control options
5. Exporting (saving) the configuration register file for future use

When no additional changes are anticipated to the configuration and extended validation is planned, the user may write the configuration to OTP. OTP is written using the "Program OTP" button on the Data memory window of BQStudio. Once programmed the device will load the register values from OTP after reset. Additional register changes may be made, but the user should realize the part features have been permanently changed. OTP settings may be incompatible with additional hardware configuration changes and could result in damage. The user should check settings or replace the IC or EVM as required.

CAUTION

Hardware changes after OTP programming may result in damage to the IC or board after reset if incompatible configuration is selected.

Changing the Communcation Mode

The BQ76952 device and EVM support SPI and HDQ protocols in addition to I2C. Changing the communication protocol can be done with the following steps.

1. Select the communication type on the Data Memory screen under ***Settings->Comm Type***.
2. If using SPI or HDQ, enable REG0 and REG1 (the MCU on the EVM is operating at 3.3V logic levels). In Data Memory set ***REG0 Config*** to 0x1 and set ***REG1 Config*** to 0xD (REG1 enabled at 3.3V).
3. If using SPI mode: In Data Memory configure ***SPI Configuration*** to 0x60. This sets the MISO output to the REG1 voltage level.
4. If using HDQ mode: In Data Memory configure ***HDQ Pin Config*** to desired settings. Setting this register to 0x28 configures the HDQ pin to drive to the REG1 voltage level when it is an output. (Similarly, HDQ can also be configured to use the Alert pin using the ***Alert Pin Config*** register.)
5. After communication settings are complete, click the **SWAP_COMM_MODE** command button in the Commands window. At this point BQStudio will lose communication with the device if the communication mode has changed.
6. Reconfigure the communication jumpers on the EVM (J7, J10, J12, J15, J17) based on the communication mode selected. By default, these jumpers are configured for I2C communication.
7. Restart BQStudio. BQStudio should now automatically detect the device and the updated communication protocol.

5 BQ76952EVM Circuit Module Physical Construction

This section contains the PCB layout, bill of materials, and schematic of the BQ76952EVM circuit module.

The BQ76952EVM consists of one circuit module assembly, BMS029.

5.1 Board Layout

The BQ76952EVM circuit module is a 4.0-inch × 5.0-inch 4-layer circuit card assembly. It is designed for easy assembly with cell connections on the left edge to a terminal block. Pack terminals are on the top edge using a terminal block. Wide trace areas are used reducing voltage drops on the high current paths. Optional connections for hardware feature pins are on a separate terminal block on the top edge of the board. An on-board interface adapter with USB connector is located in the right lower corner. Configuration headers are toward the right side of the board. Pushbutton switches for wake up and reset of the BQ76952 are located near the bottom edge of the board. The EVM layout and construction allows easy understanding of the connections and access to the test points for evaluation, but the connector area and programming features result in a large board.

The board layout includes spark gaps with the reference designator prefix "E". These spark gaps are fabricated with the board and no component is installed.

See additional information in the configuration and operation sections of this document. Figure 5-1 to Figure 5-8 show the board layout.

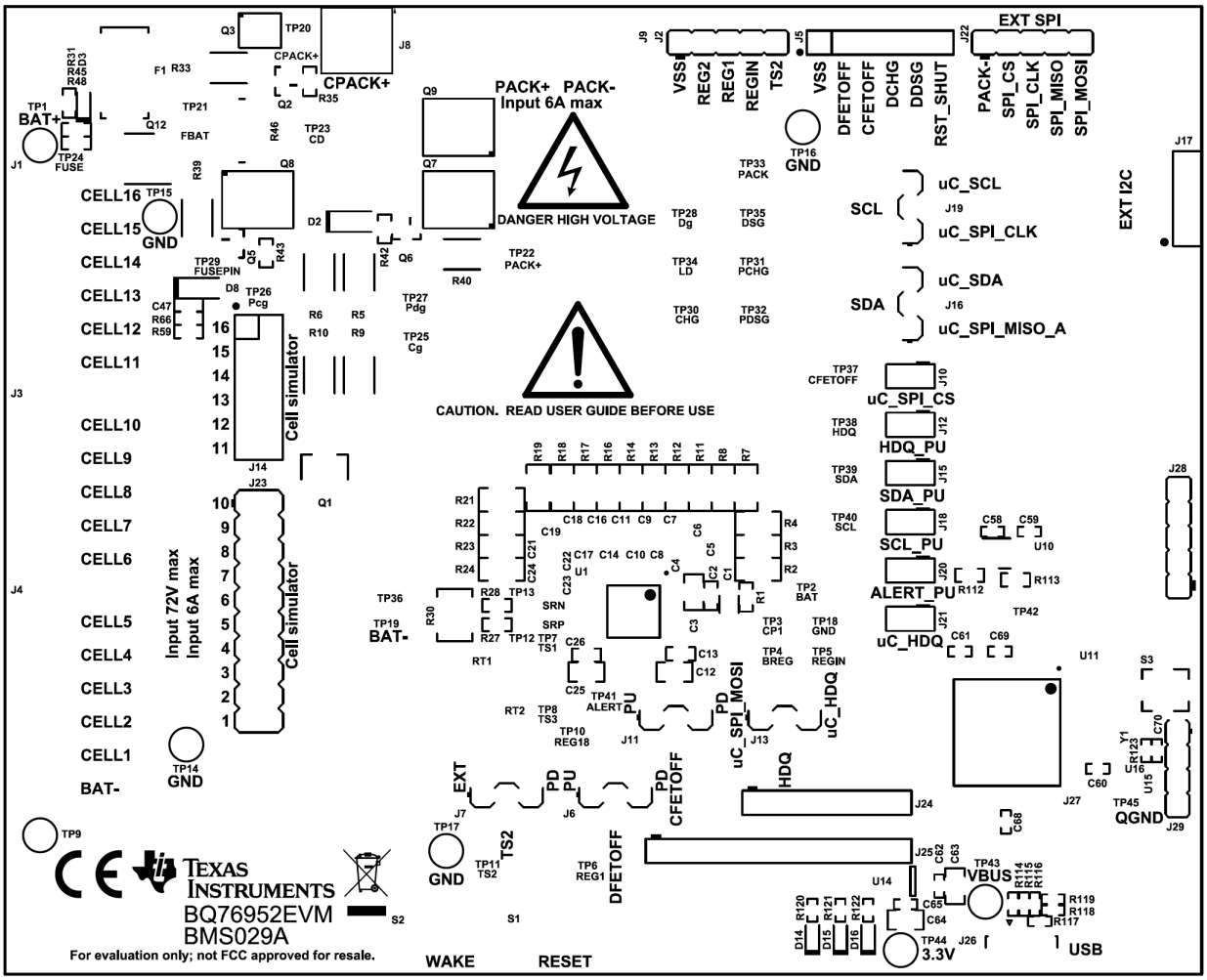

Figure 5-1. Top Silk Screen

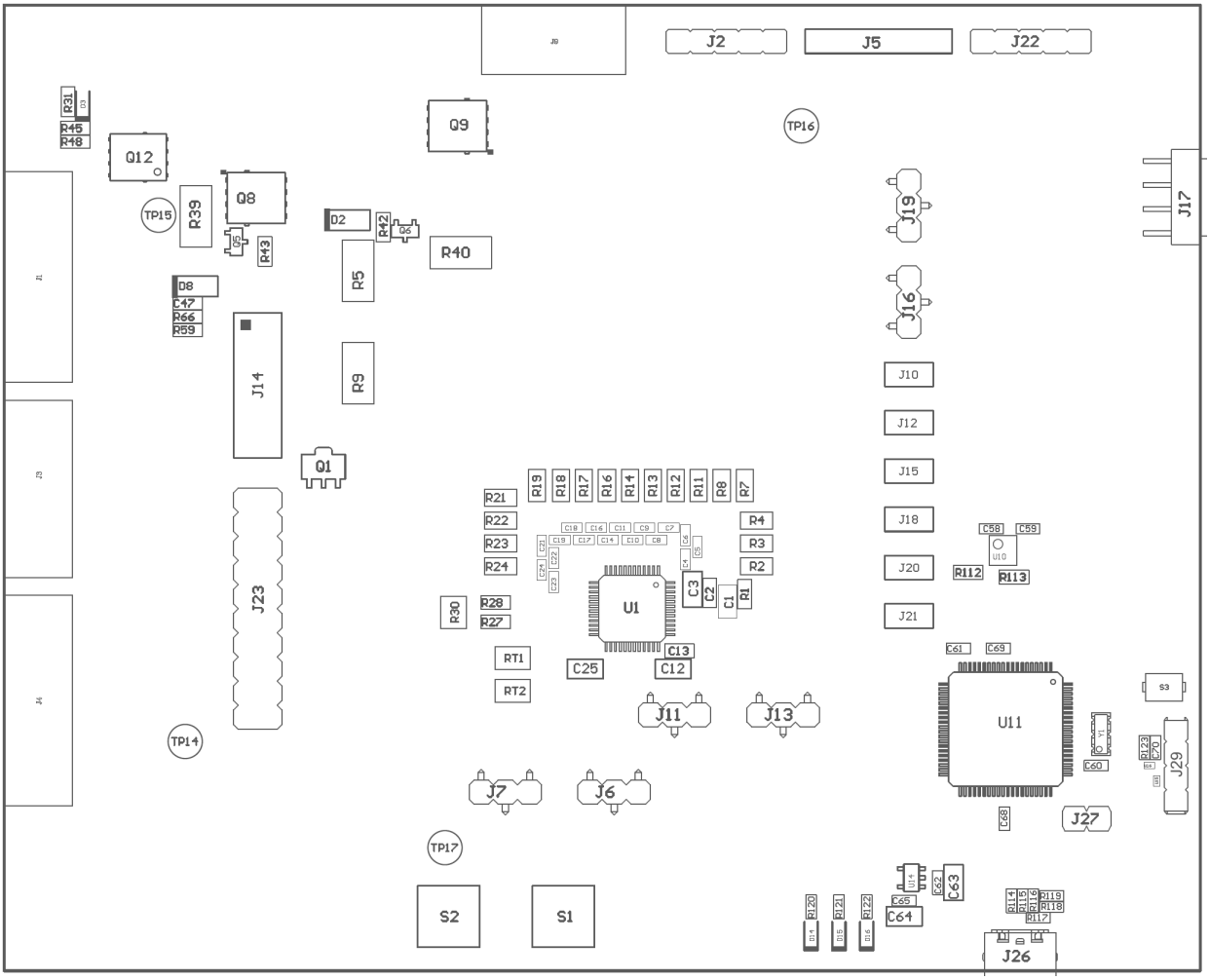

Figure 5-2. Top Assembly

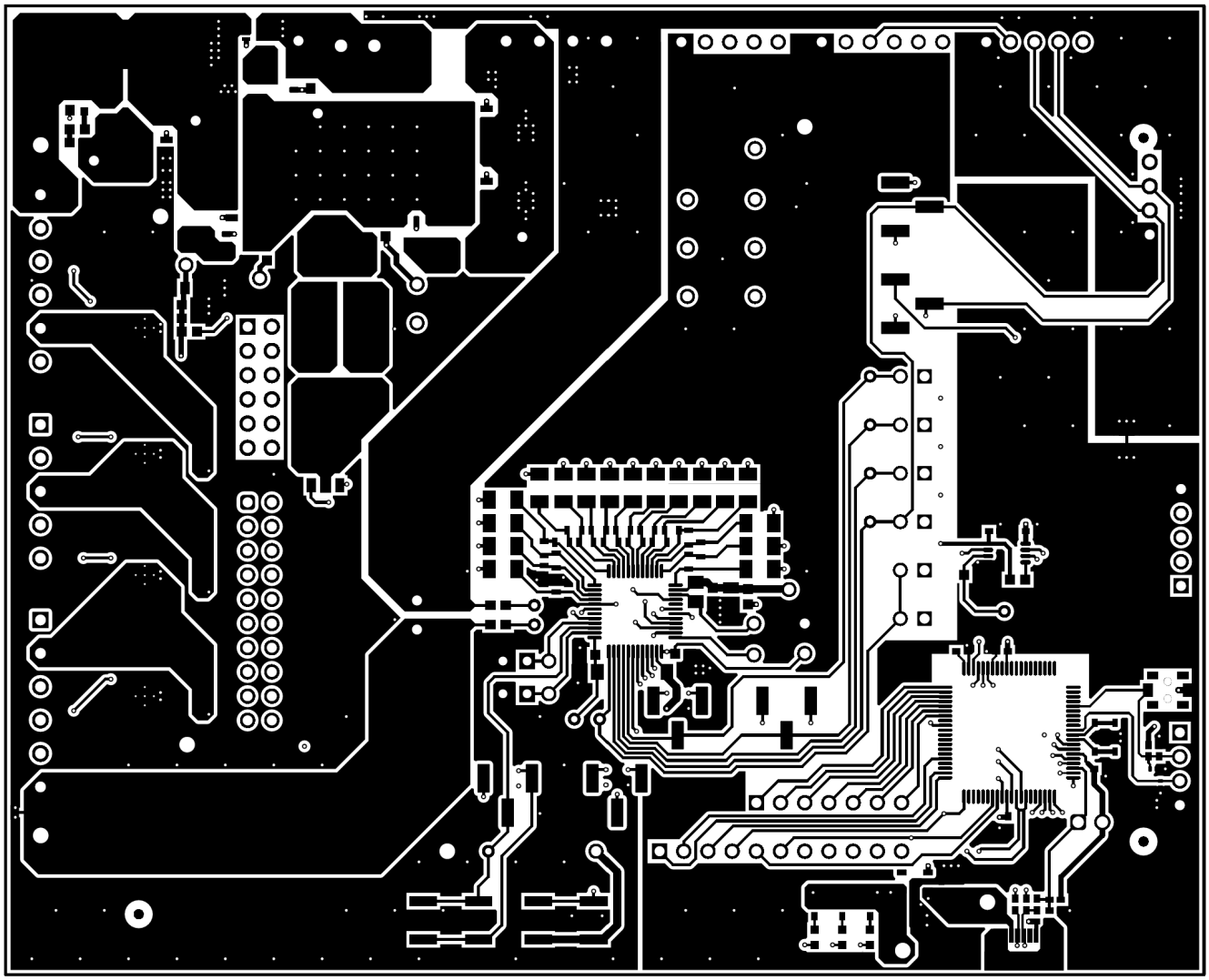

Figure 5-3. Top Layer

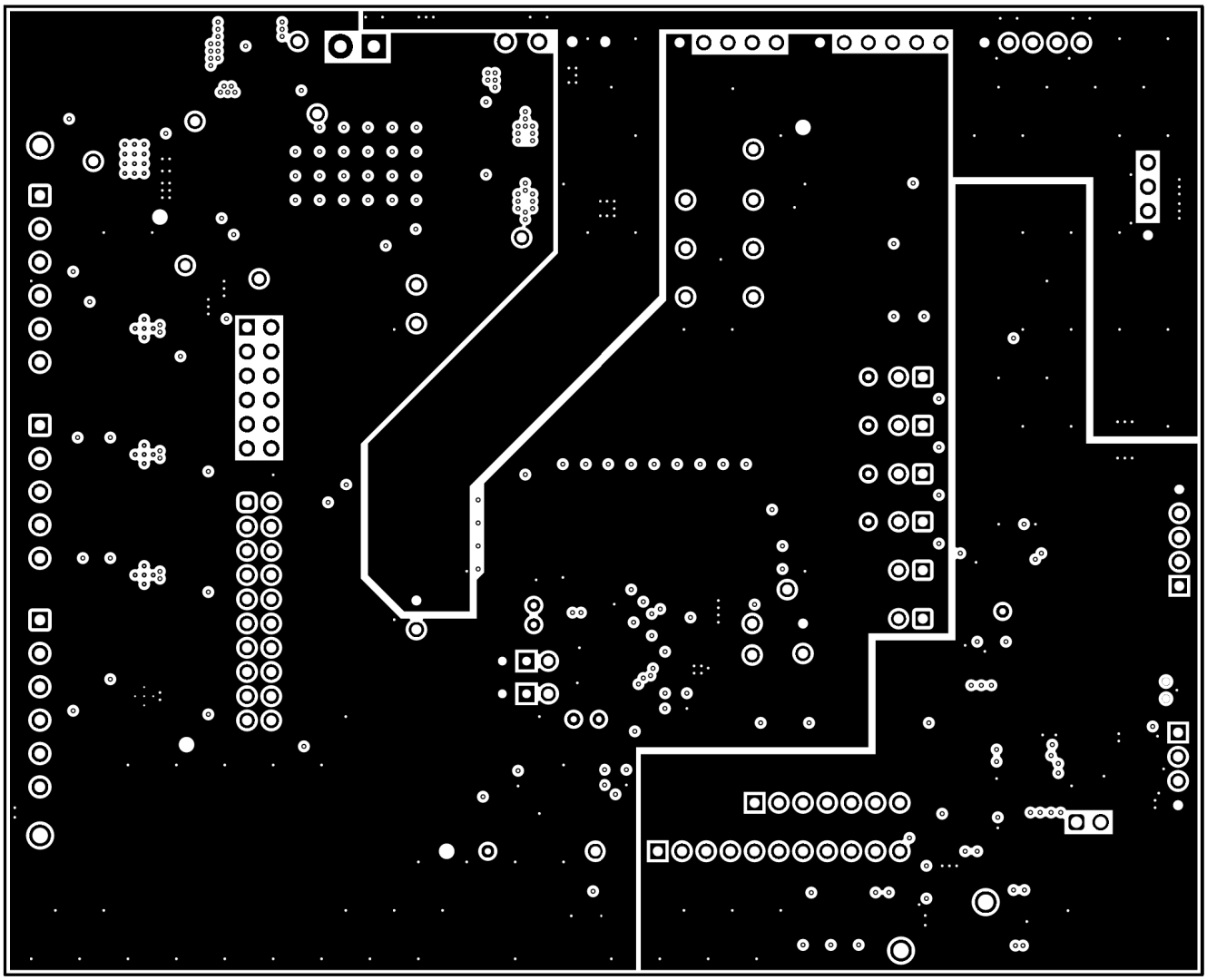

Figure 5-4. Layer 2

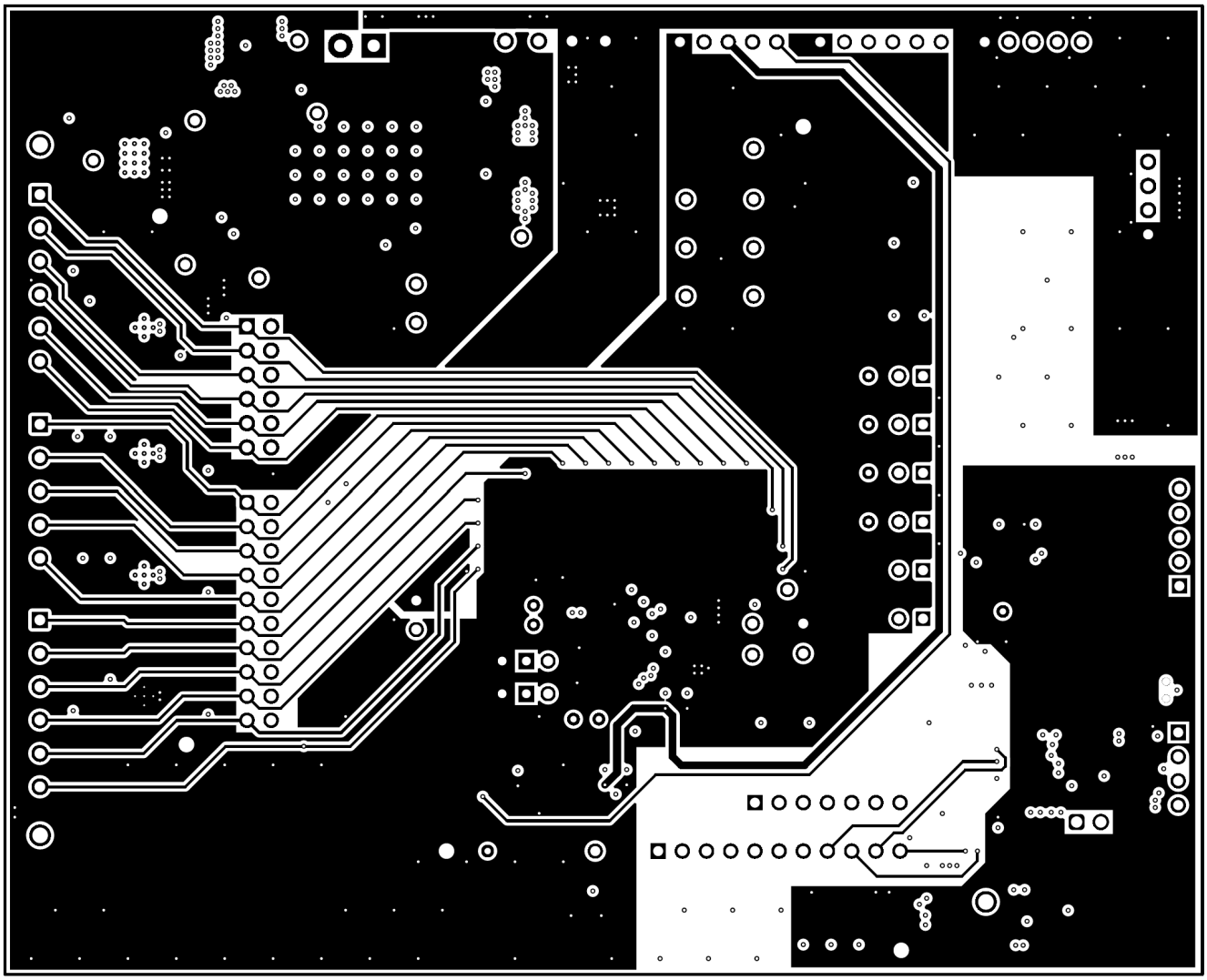

Figure 5-5. Layer 3

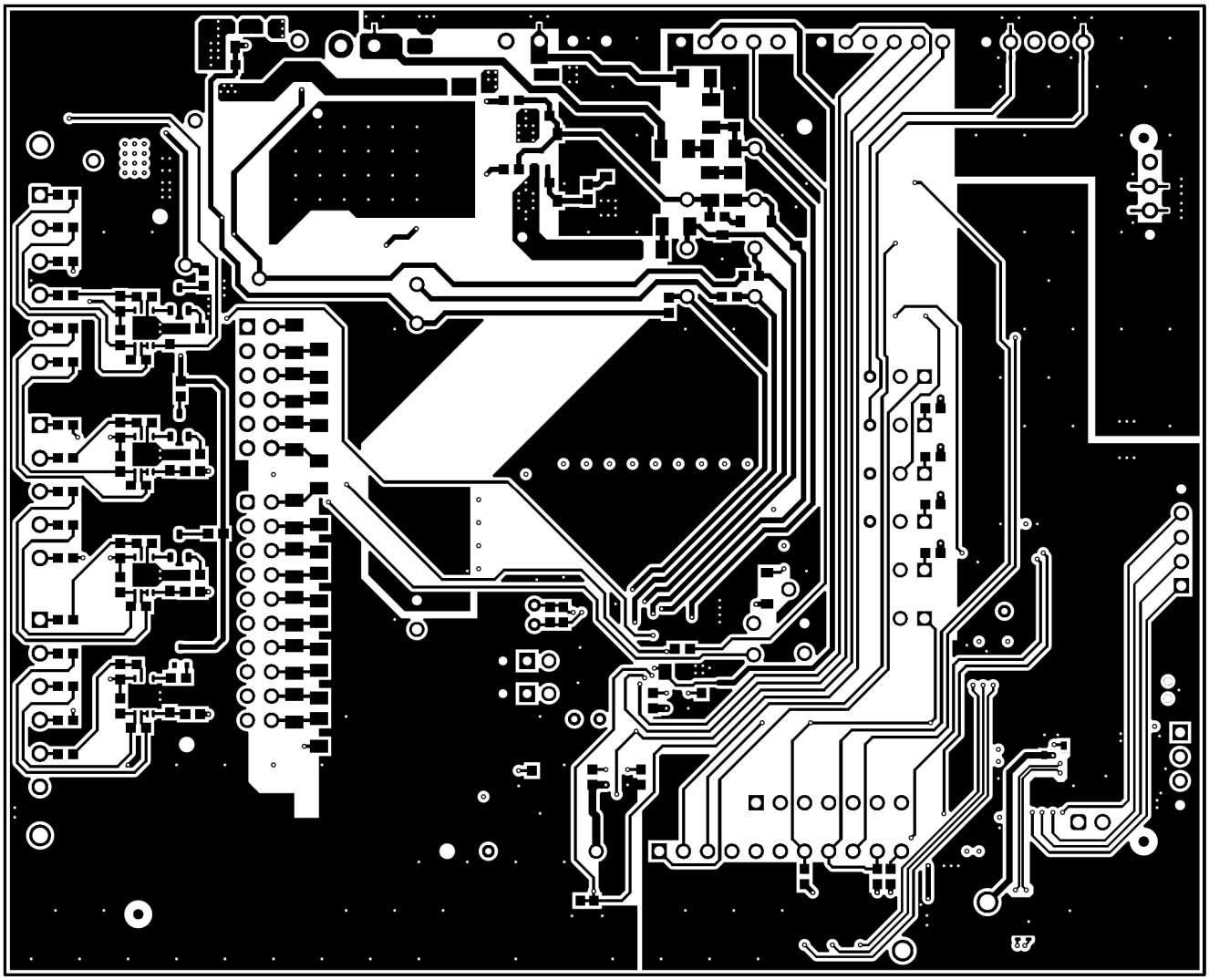

Figure 5-6. Bottom Layer

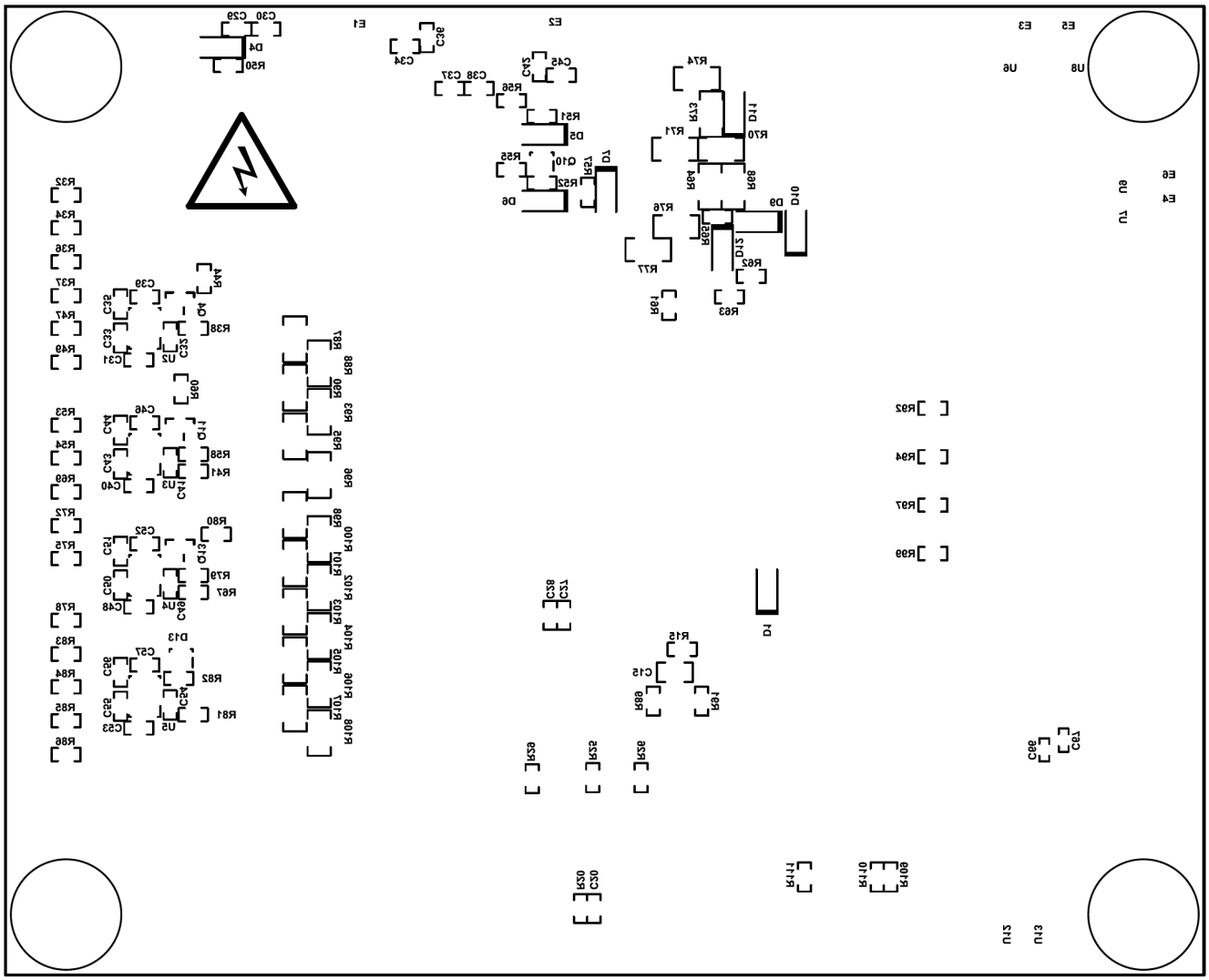

Figure 5-7. Bottom Silk Screen

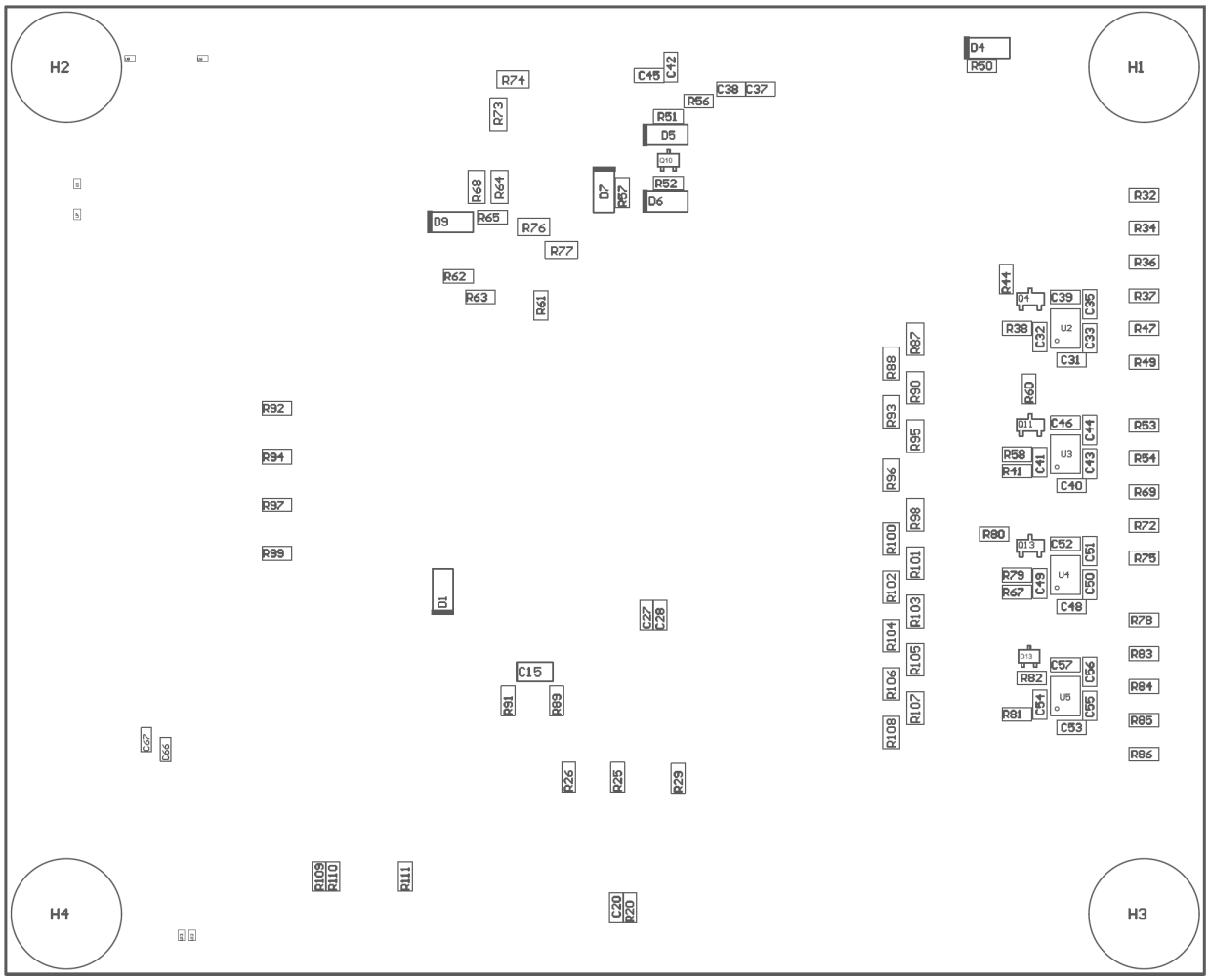

Figure 5-8. Bottom Assembly

5.2 Bill of Materials

The bill of materials for the circuit module is shown in Table 5-1. Substitute parts may be used in the manufacturing of the assembly.

Table 5-1. BQ76952 Circuit Module Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		BMS029	Any
C1, C71	2	1uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1206	1206	C3216X7R2A105K160AA	TDK
C2	1	100pF	CAP, CERM, 100 pF, 100 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	603	GCM1885C2A101JA16D	MuRata
C3	1	0.47uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	GCM219R71E474KA55D	MuRata
C4, C5, C6, C7, C8, C9, C10, C11, C14, C16, C17, C18, C19, C21, C22, C23, C24	17	0.22uF	CAP, CERM, 0.22 uF, 50 V, +/- 10%, X7R, 0603	603	C1608X7R1H224K080AB	TDK
C12, C15	2	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0805	805	EMK212B7105KG-T	Taiyo Yuden
C13	1	0.022uF	CAP, CERM, 0.022 uF, 16 V, +/- 10%, X7R, 0603	603	C0603C223K4RACTU	Kemet
C20	1	0.01uF	CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0603	603	8.85012E+11	Wurth Elektronik
C25	1	2.2uF	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X7R, 0805	805	EMK212B7225KG-T	Taiyo Yuden
C27	1	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	603	C0603C101J5GACTU	Kemet
C28, C31, C32, C33, C35, C39, C40, C41, C43, C44, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C56, C57	22	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	603	8.85012E+11	Wurth Elektronik
C37, C38, C42, C45	4	0.1uF	CAP, CERM, 0.1 uF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	GCJ188R72A104KA01D	MuRata
C58, C59, C60, C62, C65, C66, C68	7	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	402	8.85012E+11	Wurth Elektronik

Table 5-1. BQ76952 Circuit Module Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C61, C67, C69	3	0.47uF	CAP, CERM, 0.47 uF, 6.3 V, +/- 10%, X5R, 0402	402	04026D474KAT2A	AVX
C63, C64	2	10uF	CAP, CERM, 10 µF, 16 V,+/- 10%, X5R, 0805	805	CL21A106KOQNNNG	Samsung Electro-Mechanics
C70	1	2200pF	CAP, CERM, 2200 pF, 10 V, +/- 10%, X7R, 0402	402	8.85012E+11	Wurth Elektronik
D1, D2, D9	3	100V	Diode, Schottky, 100 V, 0.15 A, SOD-123	SOD-123	BAT46W-7-F	Diodes Inc.
D3	1	Red	LED, Red, SMD	LED_0603	150060RS75000	Wurth Elektronik
D4, D5, D6	3	16V	Diode, Zener, 16 V, 500 mW, SOD-123	SOD-123	MMSZ5246B-7-F	Diodes Inc.
D7	1	100V	Diode, Ultrafast, 100 V, 0.15 A, SOD-123	SOD-123	1N4148W-7-F	Diodes Inc.
D8	1	10V	Diode, Zener, 10 V, 500 mW, SOD-123	SOD-123	MMSZ4697T1G	ON Semiconductor
D13	1	40V	Diode, Schottky, 40 V, 0.2 A, SOT-323	SOT-323	BAS40W-7-F	Diodes Inc.
D14, D15, D16	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, J4	2		TERM BLOCK 3.5MM VERT 6POS PCB	HDR6	OSTTE060161	On Shore Technology
J2, J22	2		Header, 2.54mm, 5x1, Tin, TH	Header, 2.54mm, 5x1, TH	PEC05SAAN	Sullins Connector Solutions
J3	1		TERM BLOCK 3.5MM VERT 5POS PCB	HDR5	OSTTE050161	On Shore Technology
J5	1		Header, 100mil, 6x1, Tin, TH	TH, 6-Leads, Body 608x100mil, Pitch 100mil	PEC06SAAN	Sullins Connector Solutions
J6, J7, J11, J13, J16, J19	6		Header, 2.54mm, 3x1, Gold, SMT	Header, 2.54mm, 3x1, SMT	87898-0304	Molex
J9	1		TERM BLOCK 3.5MM VERT 4POS PCB	HDR4	OSTTE040161	On Shore Technology
J10, J12, J15, J18, J20, J21	6		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions
J14	1		Header, 100mil, 6x2, Tin, TH	Header, 6x2, 100mil, Tin	PEC06DAAN	Sullins Connector Solutions
J17	1		Header (friction lock), 100mil, 4x1, R/A, TH	4x1 R/A Header	22/05/3041	Molex

Table 5-1. BQ76952 Circuit Module Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J23	1		Header, 2.54mm, 10x2, Tin, TH	Header, 10x2, 2.54mm, TH	PEC10DAAN	Sullins Connector Solutions
J26	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
J27	1		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
J29	1		Header, 2.54mm, 4x1, Tin, TH	Header, 2.54mm, 4x1, TH	22284043	Molex
Q1	1	150 V	Transistor, NPN, 150 V, 1 A, AEC-Q101, SOT-89	SOT-89	FCX495TA	Diodes Inc.
Q4, Q11, Q13	3	150 V	Transistor, PNP, 150 V, 0.5 A, SOT-23	SOT-23	MMBT5401LT1G	ON Semiconductor
Q5, Q6	2	-150V	MOSFET, P-CH, -150 V, -0.53 A, SOT-23	SOT-23	SI2325DS-T1-E3	Vishay-Siliconix
Q8, Q9	2	150V	MOSFET, N-CH, 150 V, 56 A, PG-TDSON-8	PG-TDSON-8	BSC160N15NS5ATMA1	Infineon Technologies
Q10	1	60V	MOSFET, N-CH, 60 V, 0.31 A, SOT-323	SOT-323	2N7002KW	Fairchild Semiconductor
Q12	1	150V	MOSFET, N-CH, 150 V, 3 A, PowerPAK SO-8	PowerPAK SO-8	SI7898DP-E3	Vishay-Siliconix
R1, R27, R28, R31, R41, R67, R81	7	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW0603100RJNEA	Vishay-Dale
R2, R3, R4, R7, R8, R11, R12, R13, R14, R16, R17, R18, R19, R21, R22, R23, R24	17	20	RES, 20.0, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW120620R0FKEA	Vishay-Dale
R5, R9	2	220	RES, 220, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW2512220RJNEG	Vishay-Dale
R20, R25, R29, R57, R89, R92, R94, R97, R99, R109, R110, R111	12	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060310K0JNEA	Vishay-Dale
R26, R91	2	100k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW0603100KJNEA	Vishay-Dale
R30	1	0.001	RES, 0.001, 1%, 1 W, 1210	1210	PMR25HZPFV1L00	Rohm

Table 5-1. BQ76952 Circuit Module Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R32, R34, R36, R37, R47, R49, R53, R54, R69, R72, R75, R78, R83, R84, R85, R86	16	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06031K00JNEA	Vishay-Dale
R38, R58, R66, R79	4	20k	RES, 20 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060320K0JNEA	Vishay-Dale
R39, R40	2	4.7k	RES, 4.7 k, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25124K70JNEG	Vishay-Dale
R42, R43, R50, R51, R52	5	10Meg	RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060310M0JNEA	Vishay-Dale
R44	1	95.3k	RES, 95.3 k, 1%, 0.1 W, 0603	603	RC0603FR-0795K3L	Yageo
R45, R48	2	7.5k	RES, 7.5 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12067K50JNEA	Vishay-Dale
R56, R112, R113	3	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06030000Z0EA	Vishay-Dale
R59, R61, R62, R63, R82	5	5.1k	RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06035K10JNEA	Vishay-Dale
R60	1	62k	RES, 62 k, 5%, 0.1 W, 0603	603	RC0603JR-0762KL	Yageo
R64, R68, R73, R74, R76, R77	6	5.1k	RES, 5.1 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12065K10JNEA	Vishay-Dale
R65	1	7.5k	RES, 7.5 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06037K50JNEA	Vishay-Dale
R80	1	27k	RES, 27 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060327K0JNEA	Vishay-Dale
R87, R88, R90, R93, R95, R96, R98, R100, R101, R102, R103, R104, R105, R106, R107, R108	16	200	RES, 200, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RFKEA	Vishay-Dale
R114, R115	2	33	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW040233R0JNED	Vishay-Dale
R116	1	2.0k	RES, 2.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW04022K00JNED	Vishay-Dale
R117, R123	2	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW040210K0JNED	Vishay-Dale
R118, R119	2	1.0Meg	RES, 1.0 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW04021M00JNED	Vishay-Dale

Table 5-1. BQ76952 Circuit Module Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R120, R121, R122	3	330	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2RKF3300X	Panasonic
RT1, RT2	2	10k	Thermistor NTC, 10.0k ohm, 1%, Disc, 5x8.4 mm	Disc, 5x8.4 mm	103AT-2	SEMITEC Corporation
S1, S2	2		Switch, Tactile, SPST-NO, SMT	Switch, 6.2X5X6.2 mm	KST221JLFS	C&K Components
S3	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, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16, SH-J17, SH-J18, SH-J19, SH-J20, SH-J21	21	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP14, TP15, TP16, TP17	4		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone
U1	1		Multicell Battery Monitor and Protection Family, PFB0048A (TQFP-48)	PFB0048A	bq76952PFBT	Texas Instruments
U2, U3, U4, U5	4		Family 2-5S Overvoltage Protector with Internal Delay Timer, DPJ0008A (WSON-8)	DPJ0008A	BQ771807DPJR	Texas Instruments
U6, U7, U8, U9	4		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYR	Texas Instruments
U10	1		Dual-Bit Dual Supply Transceiver with Configurable Voltage Translation and 3-State Outputs, DCT0008A, LARGE T&R	DCT0008A	SN74LVC2T45DCTR	Texas Instruments
U11	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

Table 5-1. BQ76952 Circuit Module Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U12, U13, U15, U16	4		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYT	Texas Instruments
U14	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
C26	0	0.01uF	CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0603	603	8.85012E+11	Wurth Elektronik
C29, C30, C34, C36	0	0.1uF	CAP, CERM, 0.1 uF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	GCJ188R72A104KA01D	MuRata
D10, D11, D12	0	100V	Diode, Schottky, 100 V, 0.15 A, SOD-123	SOD-123	BAT46W-7-F	Diodes Inc.
F1	0		Fuse, 30 A, 62 VDC, SMD	9.5x2x5mm	SFK-3030	Dexerials Corporation
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J8	0		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
J24	0		Header, 2.54 mm, 7x1, Gold, TH	Header, 2.54 mm, 7x1, TH	PBC07SAAN	Sullins Connector Solutions
J25	0		Header, 2.54 mm, 11x1, Gold, TH	Header, 2.54 mm, 11x1, TH	PBC11SAAN	Sullins Connector Solutions
J28	0		Header, 2.54mm, 5x1, Tin, TH	Header, 2.54mm, 5x1, TH	PEC05SAAN	Sullins Connector Solutions
Q2	0	-150V	MOSFET, P-CH, -150 V, -0.53 A, SOT-23	SOT-23	SI2325DS-T1-E3	Vishay-Siliconix
Q3	0	150V	MOSFET, N-CH, 150 V, 13 A, PG-TSDSON-8	PG-TSDSON-8	BSZ900N15NS3 G	Infineon Technologies
Q7	0	150V	MOSFET, N-CH, 150 V, 56 A, PG-TDSON-8	PG-TDSON-8	BSC160N15NS5ATMA1	Infineon Technologies

Table 5-1. BQ76952 Circuit Module Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R6, R10	0	220	RES, 220, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW2512220RJNEG	Vishay-Dale
R15	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06030000Z0EA	Vishay-Dale
R33	0	4.7k	RES, 4.7 k, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25124K70JNEG	Vishay-Dale
R35	0	10Meg	RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060310M0JNEA	Vishay-Dale
R46	0	0	RES, 0, 5%, 2 W, 2512 WIDE	2512 WIDE	RCL12250000Z0EG	Vishay Draloric
R55	0	51	RES, 51, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060351R0JNEA	Vishay-Dale
R70, R71	0	5.1k	RES, 5.1 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12065K10JNEA	Vishay-Dale
TP1	0		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP9	0		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP43, TP44	0	Red	Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone

5.3 REACH Compliance

In compliance with the Article 33 provision of the EU REACH regulation we are notifying you that this EVM includes component(s) containing at least one Substance of Very High Concern (SVHC) above 0.1%. These uses from Texas Instruments do not exceed 1 ton per year. The SVHC's are:

Table 5-2. REACH Components

Component Manufacturer	Component part number	SVHC Substance	SVHC CAS (when available)
Murata	Resonator CSTCR4M00G55B-R0	Lead Titanium Zirconium Oxide [(Pbx Tiy Zrz) 03]	12626-81-2

5.4 Schematic

Figure 5-9 through Figure 5-12 illustrate the schematics.

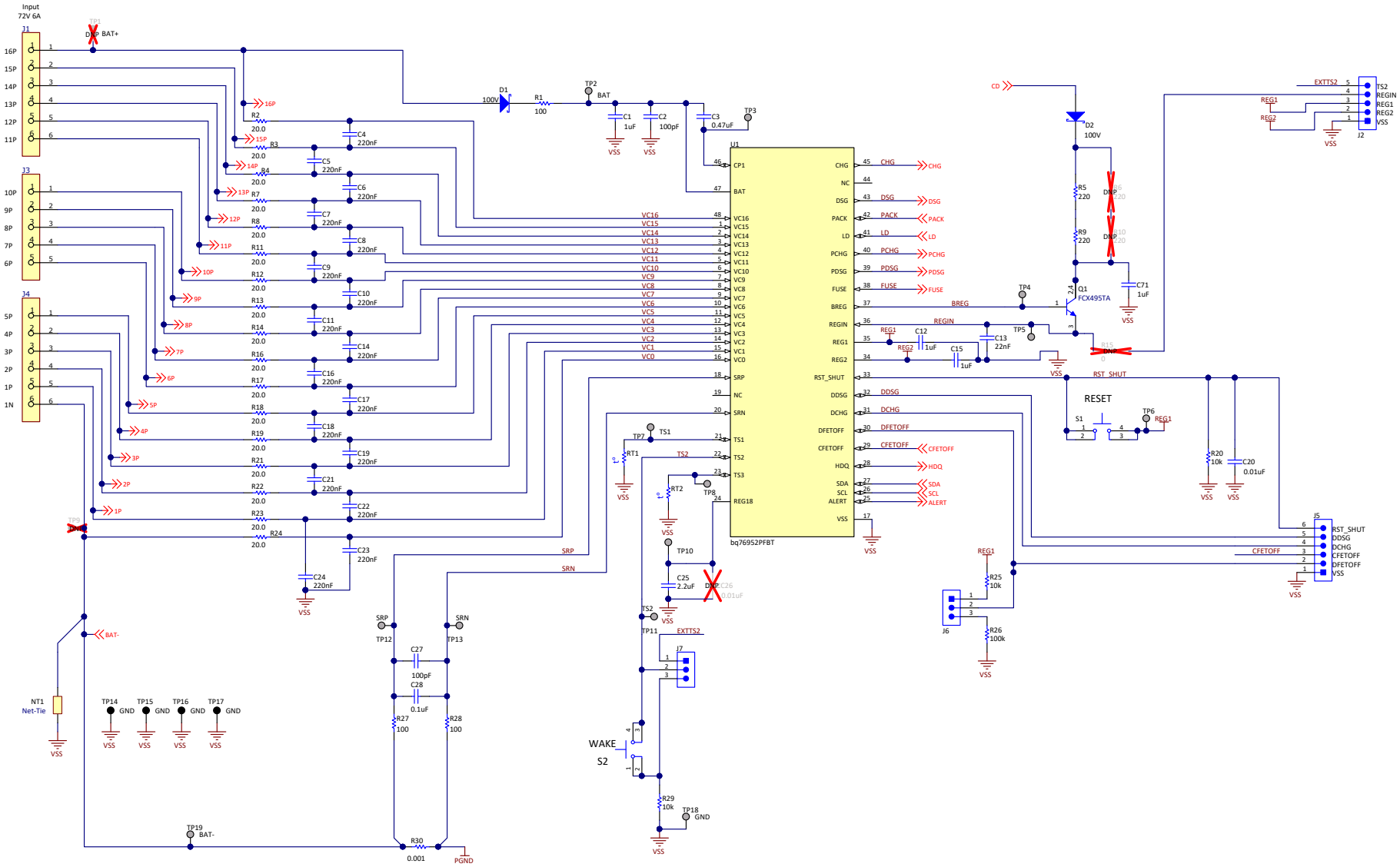

Figure 5-9. Schematic Diagram Monitor

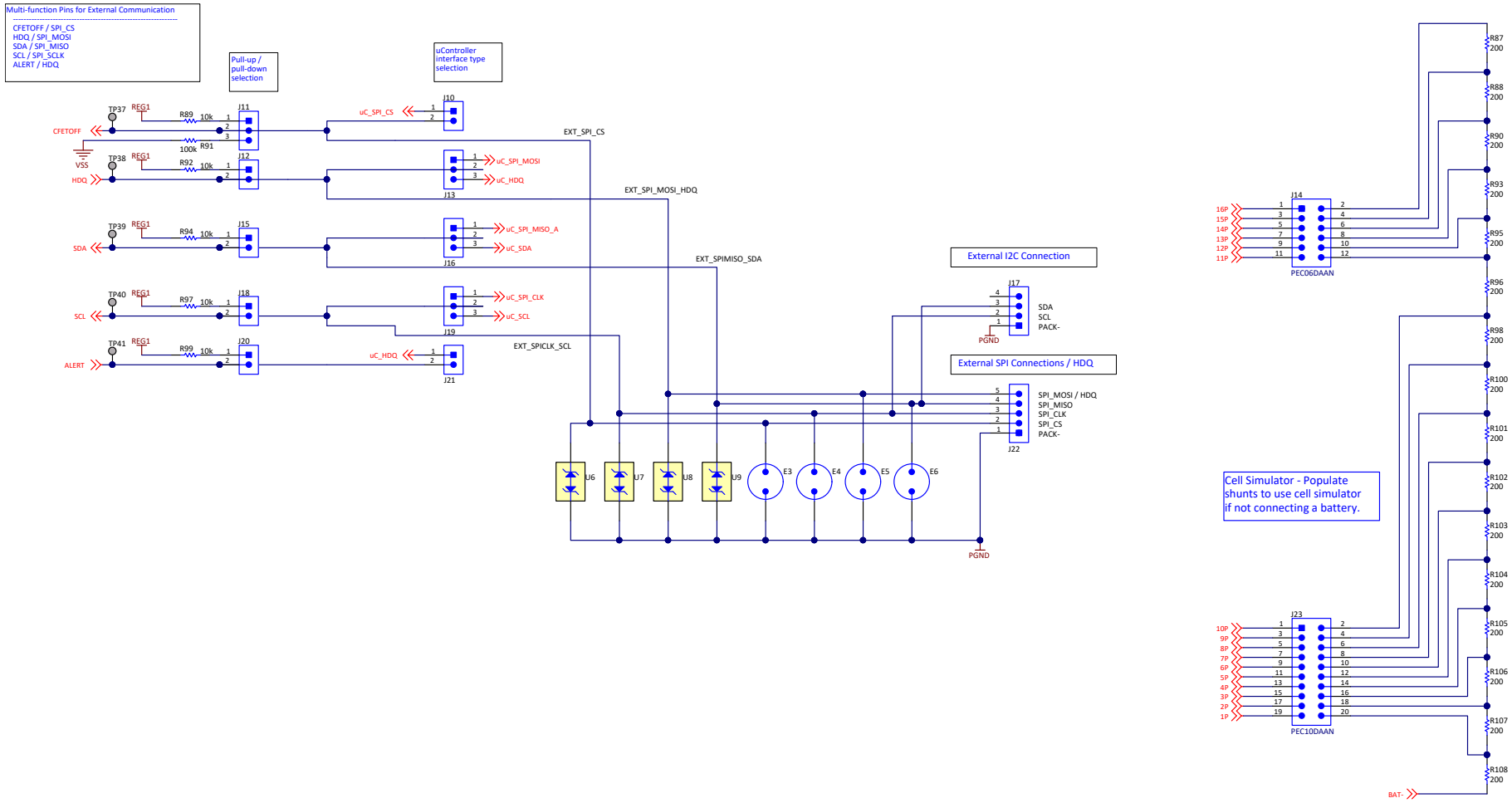

Figure 5-10. Schematic Diagram Pin Configuration

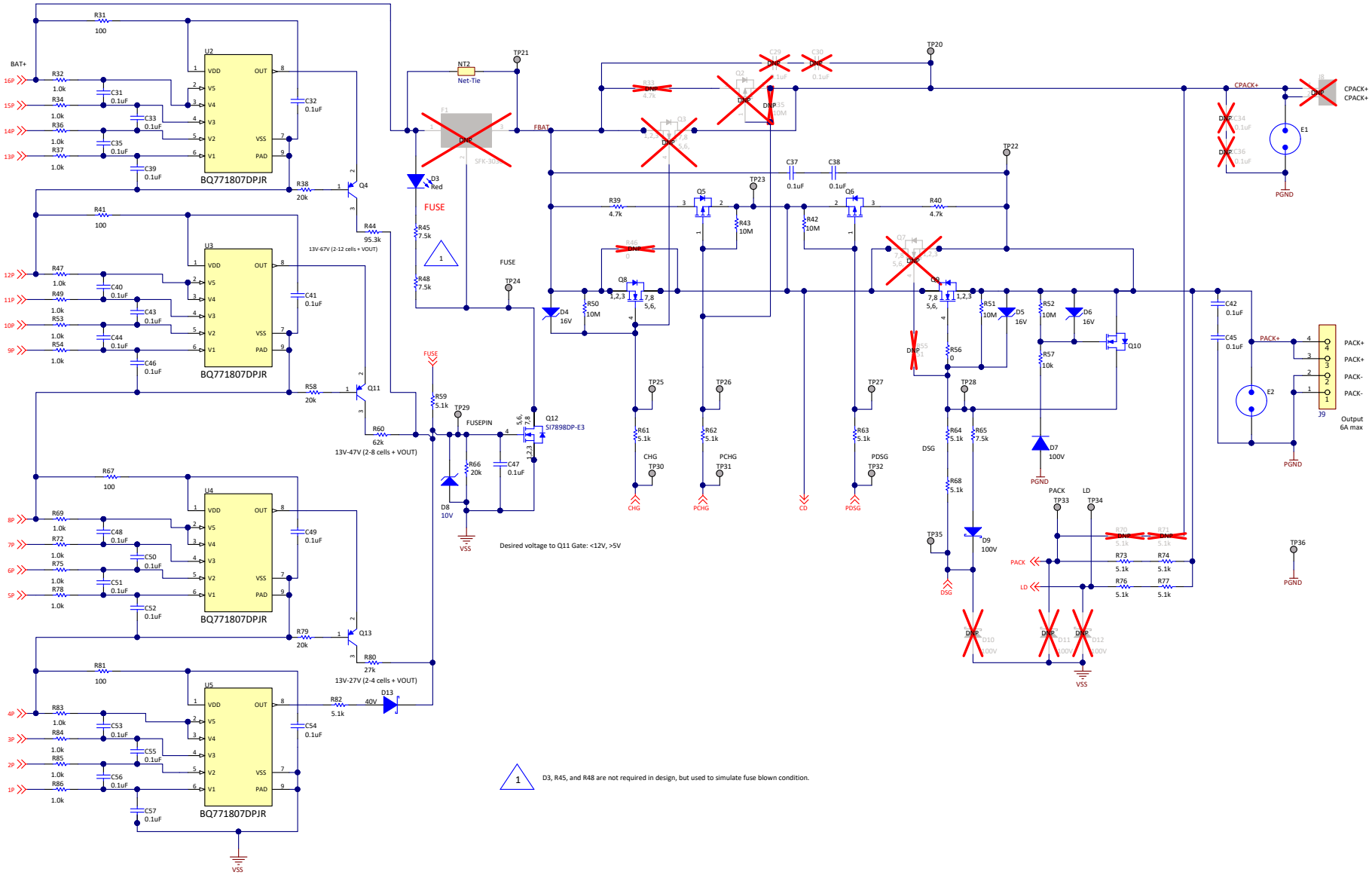

Figure 5-11. Schematic Diagram FETs

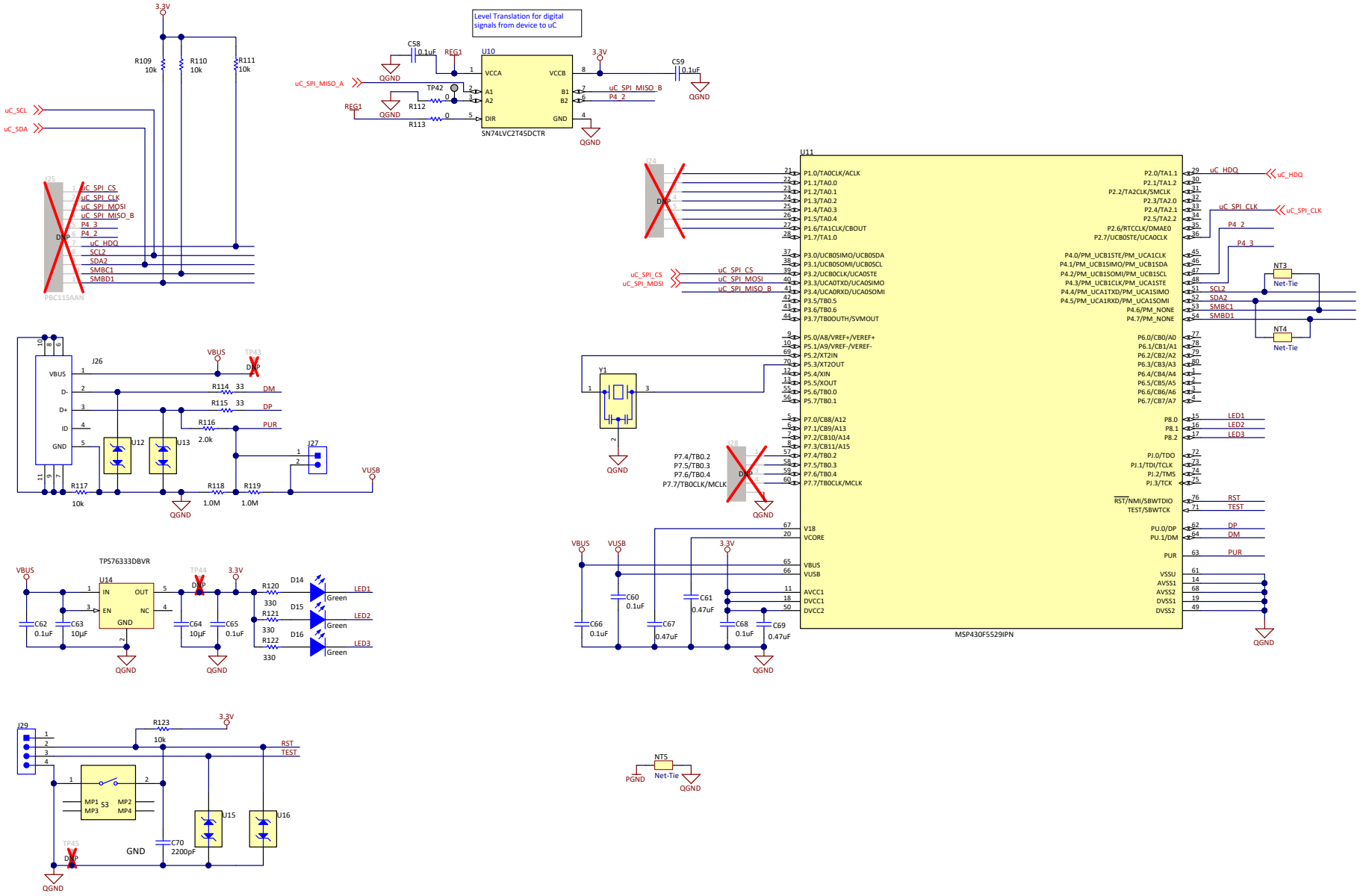

Figure 5-12. Schematic Diagram Interface

6 Related Documents from Texas Instruments

- Texas Instruments, *BQ76952 3S-16S Battery Monitor and Protector* data sheet
- Texas Instruments, *BQ76952 Technical Reference Manual*
- Texas Instruments, *Easy Configuration of BQ76942, BQ76952 Battery Monitors*
- Texas Instruments, *BQ76942, BQ76952 Software Development Guide*
- Texas Instruments, BQ7718 *Overvoltage Protection for 2 to 5-Series Cell Li-Ion Batt w/ Int Delay Timer* data sheet

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2 *Limited Warranty and Related Remedies/Disclaimers*:

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

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NOTE:

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

3 *Regulatory Notices:*

3.1 *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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

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

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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.

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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.

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