



ABSTRACT

The BQ76922EVM evaluation module (EVM) is a complete evaluation system for the BQ76922, a 3-cell to 5-cell Li-Ion battery monitor integrated circuit. The EVM consists of a BQ76922 circuit module which is used for simple evaluation of the BQ76922 monitor function. The circuit module includes one BQ76922 integrated circuit (IC), sense resistor, power FETs, and all other onboard components necessary to protect the cells from overcharge, over discharge, short circuit, and overcurrent discharge in a 5-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, adjust protection limits and enable FET control outputs.

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1 Features

- Complete evaluation system for the BQ76922 3-cell to 5-cell Li-Ion and Phosphate battery monitor
- Populated circuit module for 5-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

- BQ76922 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
BQ76922EVM	Li-Ion	5 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 BQ76922EVM Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the BQ76922 circuit module in its default 5-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	–	22	V
Continuous charge or discharge current	0	–	10	A
Operating temperature range	20	25	30	°C

1.4 Required Equipment

The following equipment is required to operate the BQ76922 EVM in a simple demonstration:

- DC power supply, 0 – 25 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 BQ76922 with a more extensive demonstration.

2 BQ76922EVM 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 BQ76922 EVM. Observe all safety precautions.

CAUTION

The default settings of the BQ76922 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 top and bottom of the board. This may result in exposed voltages, hot surfaces or sharp edges. Do not reach under the board during operation. Do not leave the EVM powered when unattended.

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.

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 PACK- 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 BQ76922 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 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. Preproduction sample configuration may differ from the production data sheet, check the documents provided with the samples. This quick start assumes a new EVM without OTP configuration settings. If your board has a part with configuration stored in OTP refer to the [Section 4](#) and [Section 5](#).

These steps describe quick connection of the BQ76922 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 4.2](#)).

3. Install the cell simulator shunts.
4. Install the interface shunts to the INT positions.
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 *CELL5* terminals and adjust to approximately 18 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 and set the Enabled Protections A CUV bit. Writing to the data memory after setting the 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 *DSG_FET* and *CHG_FET* bits in the FET Status register of the BIT Registers section are on and that the Stack voltage and the Pack pin voltage registers in the Registers section are approximately equal. The *SLEEPCHG* bit is enabled by default, if the *SLEEP* status is set *CHG_FET* will be off. Click the *SLEEP_DISABLE* command button. Measure the *PACK* voltage on the board if desired.
13. Adjust the supply voltage to approximately 22 V. In the registers view observe that the *COV* bit turns on, the *CHG_FET* bit goes off, and the Pack pin voltage drops to approximately 0.3 V below the Stack voltage.
14. Adjust the supply voltage to approximately 12 V. In the registers view observe that the *CUV* bit turns on, the *DSG_FET* bit goes off, and the Pack pin voltage drops to approximately 0 V.
15. Make other adjustments as desired, for evaluation. See other sections of this user guide for details of operation.
16. When complete with this quick start demonstration, exit BQStudio software and turn off the power supply.

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

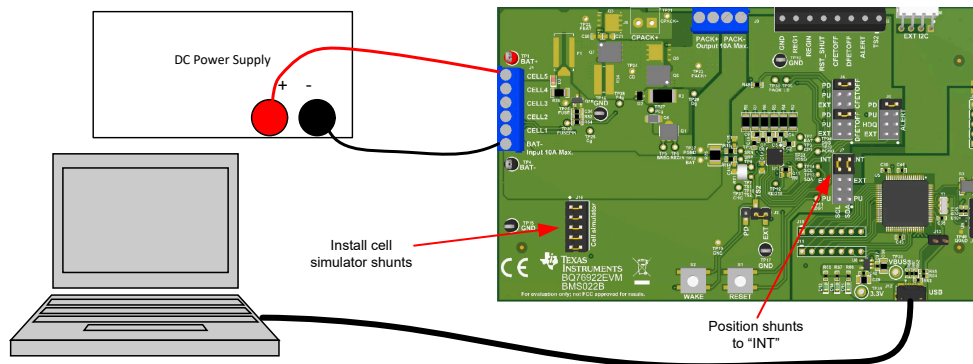


Figure 2-1. EVM Connection for Basic Operation

3 Interface Adapter

The BQStudio software uses either the on-board USB interface adapter or separate EV2400 interface board to provide communication with the EVM board from the computer. The on-board interface identifies as an EV2400. The EV2400 uses operating system drivers and no separate installation is required.

When connecting an external EV2400 change the J7 jumpers on the board from the *INT* to the *EXT* position. Since the external EV2400 provides pull ups, do not install shunts at the *PU* positions. Figure 3-1 shows an example of the EVM connected with an external EV2400.

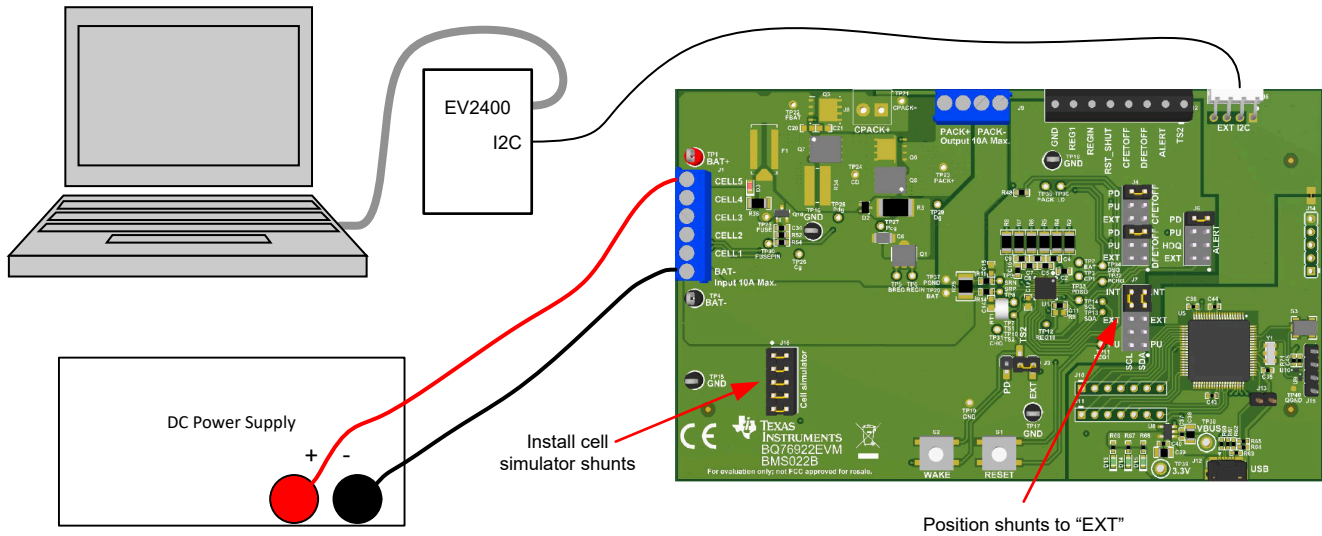


Figure 3-1. EVM Connection with External EV2400

EV2400 versions 0.28 and newer are compatible with the on-board interface. The latest version is recommended. If updates are available for the on-board interface adapter, they are available from the EV2400 tool folder on the web, www.ti.com/tool/EV2400. Do not install the EV2400 firmware version 0.18 in the on-board adapter.

The BQ76922 devices are not supported with the older EV2300 interface.

CAUTION

Do not program the on-board adapter with version 0.18 or earlier firmware.

4 Battery Management Studio Software

The Battery Management Studio software is used for evaluation of the BQ76922 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 BQ76922.

4.1 System Requirements

The BQStudio software requires a Windows 7, or later, operating system. Additional items are required and are described in the installation windows. The examples in this document are from Windows 7 or 10.

4.2 Installing BQStudio

Find the latest software version in the software section of the product folder <http://www.ti.com/tool/BQSTUDIO> or search from power.ti.com. Check periodically for software updates. Alternatively use the BQStudio installation file provided. 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 checkboxes desired and **Finish** to complete the BQStudio software installation.

4.3 BQ76922 bqz File Installation

The BQStudio software uses a bqz file to configure the displays for the BQ76922 device or family devices. 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.

4.4 BQStudio Operation and Registers View

BQStudio is used to communicate to the BQ76922 for evaluation. It includes several tools to aid in configuration, calibration and data display of the BQ76922 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 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 BQ76922 version in the list and click the **Finish** button. This selection is remembered until the software is re-started. If the device is not found, the user is 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.

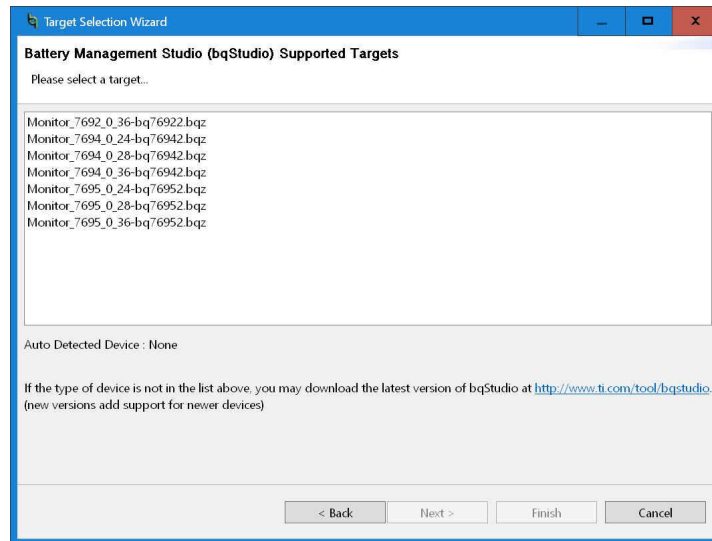


Figure 4-1. Target Selection Wizard

If the software was 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 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 4-2. 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.

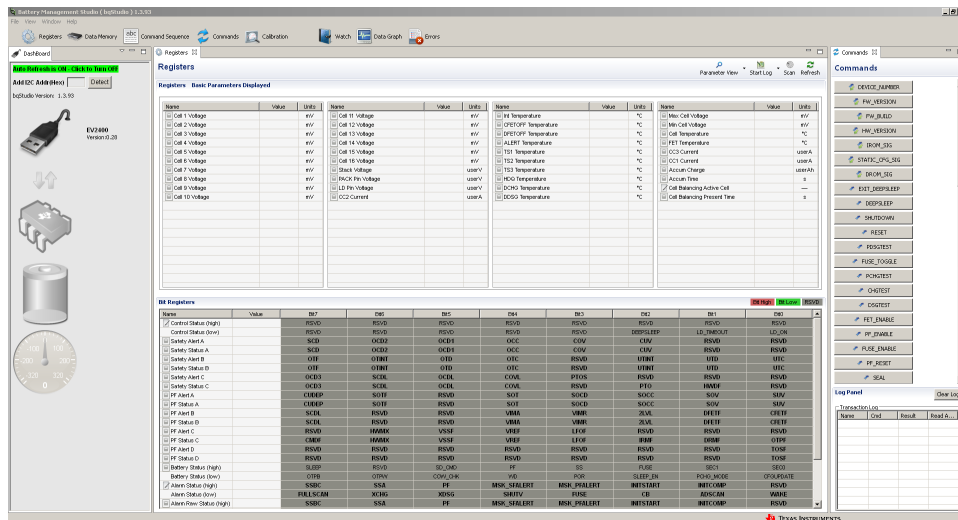


Figure 4-2. BQStudio Window without Device

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 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 4-3](#) shows a register display with a connected device.

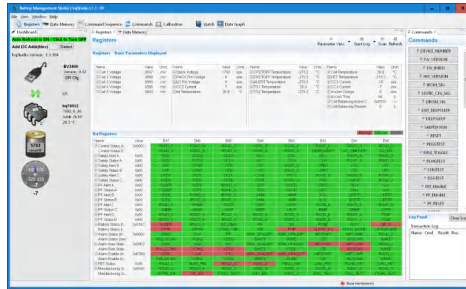


Figure 4-3. Register View with Device

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 4-4](#). 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.

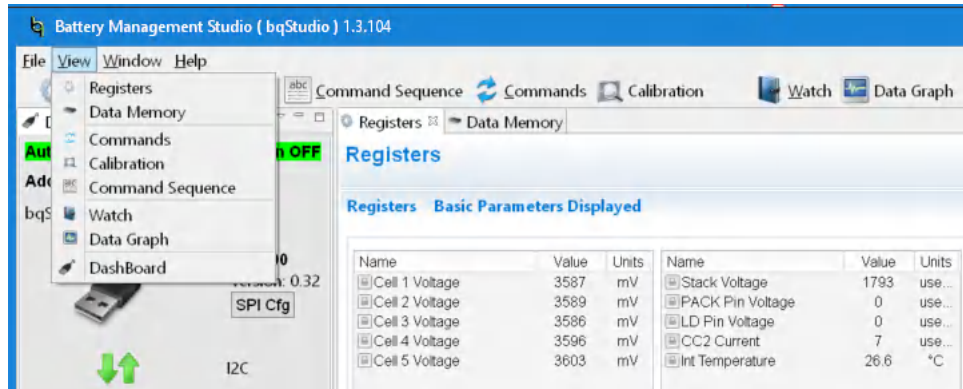


Figure 4-4. Tool Selections

4.5 Commands

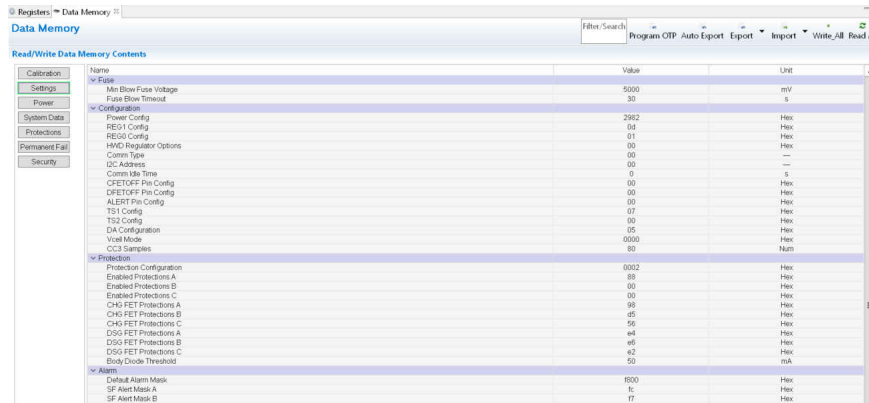
The Commands tab is displayed on the right side of the BQStudio window. Buttons allow reading various information about the device and certain operations. Commands and returned data are shown in the Log Panel of the tab. The seal function is unusual in general evaluation and is not recommended during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

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

4.6 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 has only the REG0 and REG1 settings of the BQ76922, other locations are not programmed.

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 4-5 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.

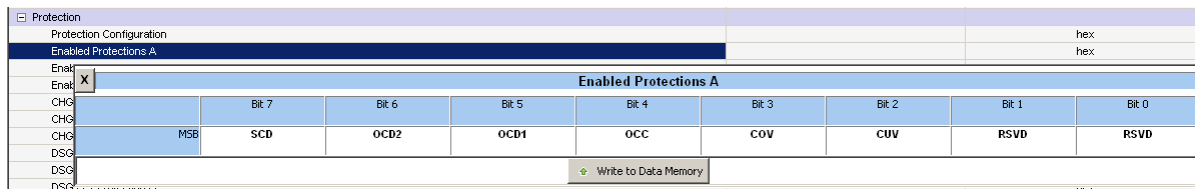


Name	Value	UNIT
Min Blow Fuse Voltage	5000	mV
Fuse Blow Timeout	30	s
Power Config	2962	Hex
REG1 Config	01	Hex
REG0 Config	01	Hex
HVMD Register Options	00	Hex
Control Type	00	Hex
I2C Address	00	Hex
Control Idle Time	0	s
CPRETOFF Pin Config	00	Hex
DPRETOFF Pin Config	00	Hex
ALERT Pin Config	00	Hex
TS1 Config	07	Hex
TS2 Config	00	Hex
DA Configuration	05	Hex
Vital Mode	0000	Hex
CC3 Samples	80	Num
Protection Configuration	0002	Hex
Enabled Protections A	89	Hex
Enabled Protections B	00	Hex
Enabled Protections C	00	Hex
CHG FET Protections A	96	Hex
CHG FET Protections B	95	Hex
CHG FET Protections C	96	Hex
DSG FET Protections A	e4	Hex
DSG FET Protections B	e5	Hex
DSG FET Protections C	e2	Hex
Body Diode Threshold	50	mA
Default Alarm Mask	R00	Hex
SF AlertMask A	fc	Hex
SF AlertMask B	ff	Hex

Figure 4-5. Data Memory View

4.6.1 Entering, Saving, and Loading Configuration

Most of the configuration of the BQ76922 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 4-6 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.



Bit	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
MSB	SCD	OCD2	OCD1	OCC	COV	CUV	RSVD	RSVD

Write to Data Memory

Figure 4-6. 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. BQStudio will enter and exit configuration update mode of the part automatically when data memory is edited. If FETs were on when config update mode was entered they will be turned off during the write and turned on after exit. Exiting config will clear some command settings such as SLEEP_DISABLE, check settings after configuration changes.

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

The data is read from the part when the Data Memory view is opened, but the window does not know when the power may have been cycled so that the data is not current. Data may be read using the *Read All* tool at the top of the pane. 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 loads the data from the part rather than values which may be only in the view. Export also has an option to export a Flash Stream format file which can be written to another part by the Command Sequence tool. The FS file can be saved with OTP programming command included. 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. The gg.csv files should not be edited with a spreadsheet program since those may add characters causing the import to fail.

4.6.2 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 BQ76922 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 4-7](#).
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.

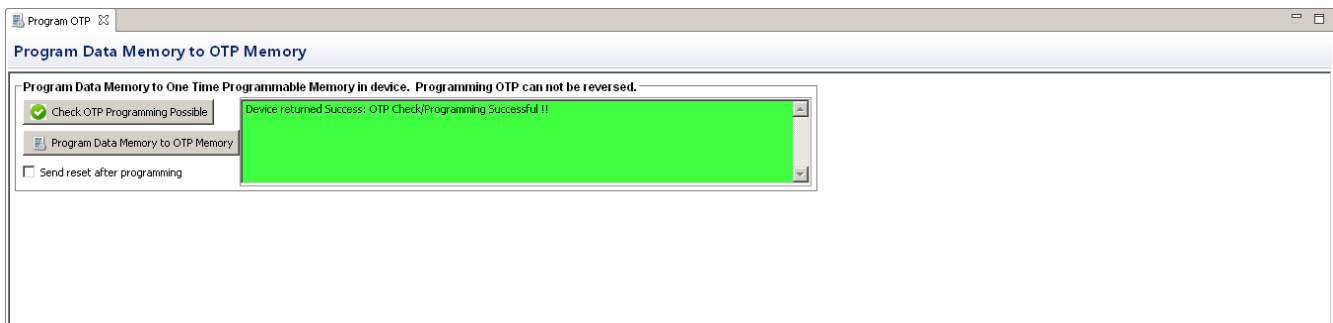


Figure 4-7. Program OTP Pane with Success Display

4.7 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 4-8](#). 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 results in some granularity from the current resolution. This may result in an apparent error at higher currents. Calibration at higher currents reduces this effect and should be done where it is important.

Voltages and temperatures may be calibrated individually or as a group. All values entered are 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 4-9](#). If there is an error, a red X appears instead as shown in [Figure 4-10](#) with a message in the bottom border.

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.

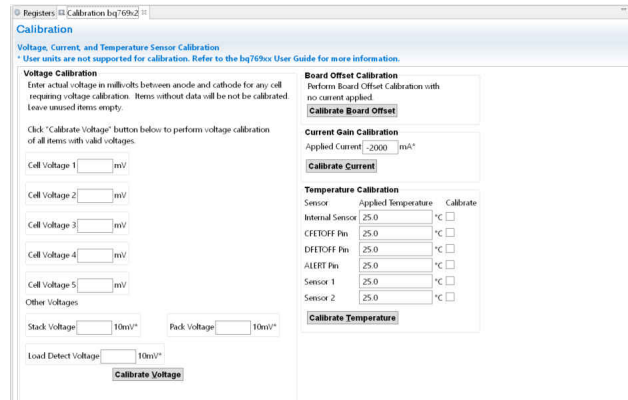


Figure 4-8. Calibration View

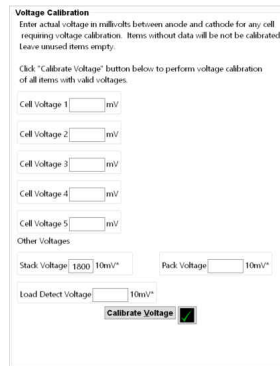


Figure 4-9. Example Voltage Calibration Success

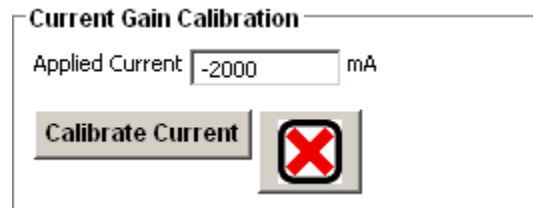


Figure 4-10. Example Current Calibration Failure

4.8 Command Sequences

Features are controlled by commands as described in the BQ76922 technical reference manual (SLUUCG7). 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 4-11. 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.

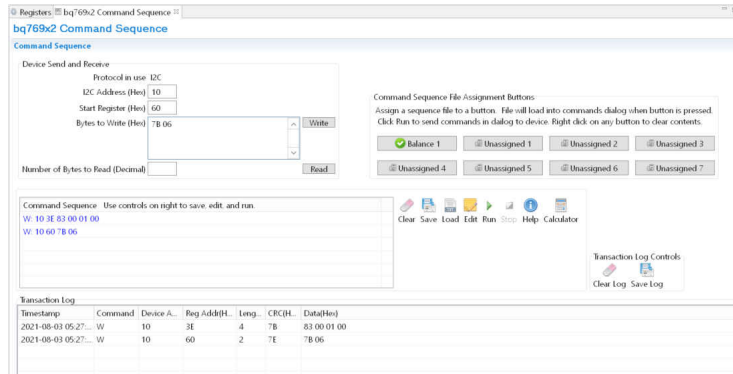


Figure 4-11. Command Sequence View

5 BQ76922EVM Circuit Module Use

The BQ76922 circuit module contains the BQ76922 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 [quick start guide](#). For details of the circuit, refer to the [physical construction](#) section.

5.1 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 J16 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 connects the input to the simulated voltage. There is no indication of the cell simulator connection, the user must be aware of the shunt installation.

5.2 Evaluating with Load Current

With the BQ76922 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 5-1](#).

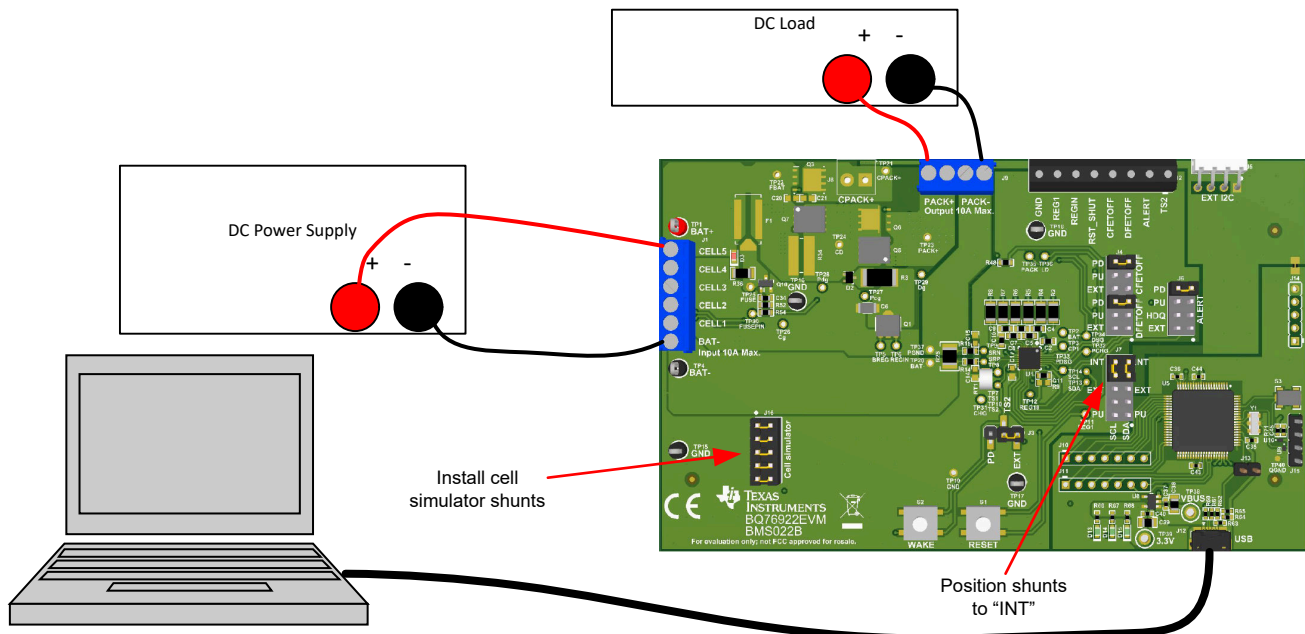


Figure 5-1. Evaluating with Load Current

5.3 Evaluating Charge and Discharge Currents

Bipolar power supplies source or sink currents 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.

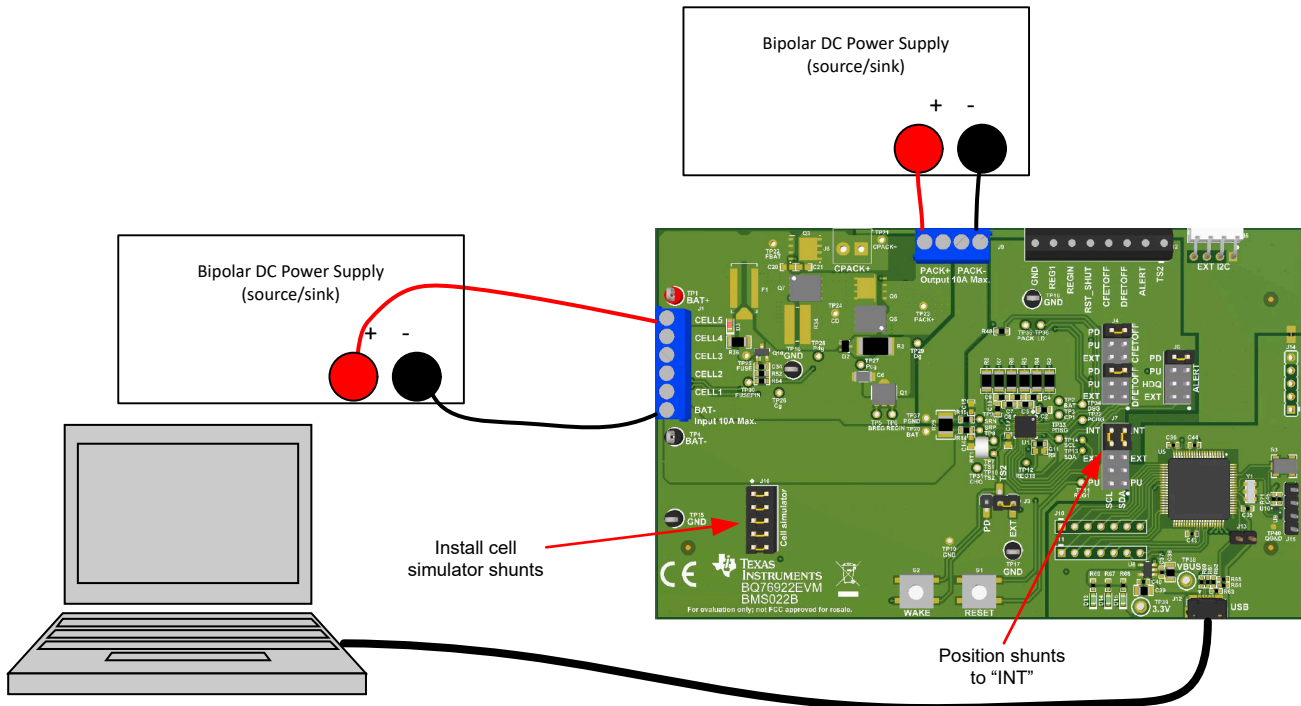


Figure 5-2. Evaluating with Charge or Discharge Current

5.4 Evaluating with Simulated Current

The [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 5-3 shows a method to force current through the sense 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.

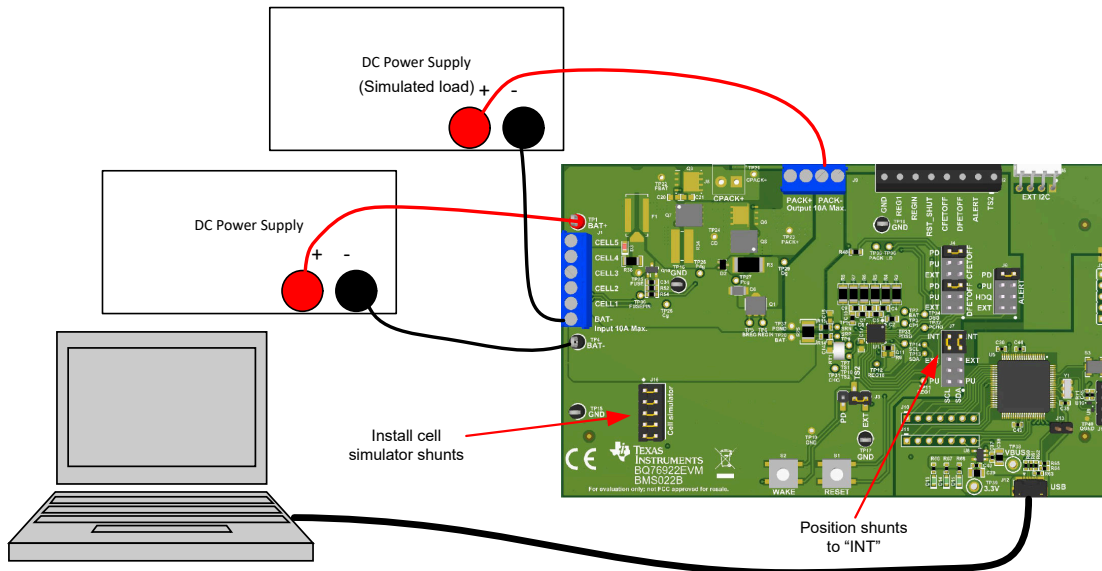


Figure 5-3. Simulating Current Setup

5.5 Reducing the Cell Count

The BQ76922 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 5-4](#) for an example of simple reduced cell configuration for 3 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 5-1](#) shows configuration recommendations for reduced cell count.

Table 5-1. Reducing Cell Count

Unused Cell (Numbered from Bottom Cell 1)	Short Cell Input Terminals	Input Resistor To Remove	Replace Capacitor With 0 Ω	IC Inputs Shorted
Cell 4	CELL4 to CELL3	R4	C5	VC4 to VC3
Cell 3	CELL3 to CELL2	R5	C7	VC3 to VC2

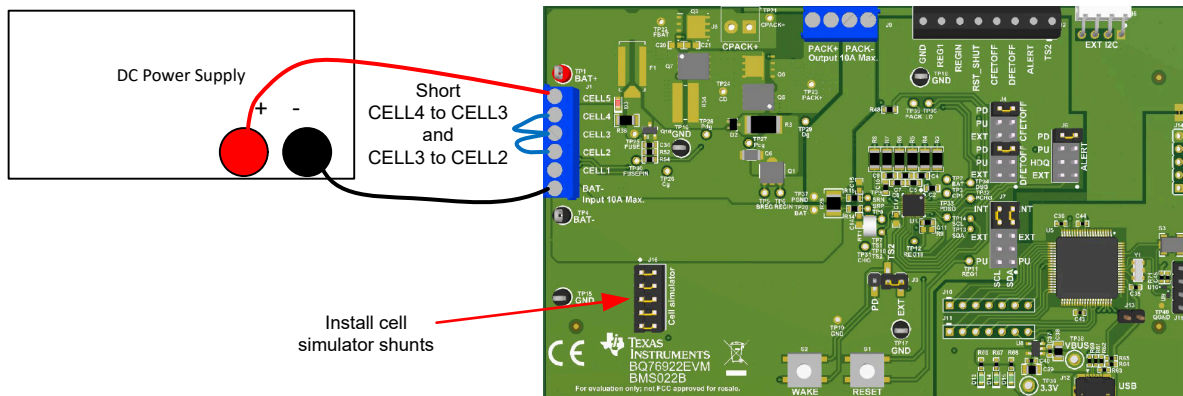


Figure 5-4. Example 3-Cell Simple Evaluation Configuration

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 typically function on the EVM, when implementing a design the configuration of the data sheet is recommended.

After changing the physical connection the Vcell Mode must be changed in Data Memory Settings for proper operation. The default setting of 0x0000 selects all cells and will be the same as 0x001F. For 3 cells as shown above set the Vcell Mode to 0x0013.

5.6 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 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 are 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 5-5 shows an example connecting cells with an EVM configuration reduced to 4 cells. Be sure the Vcell mode is configured for the cells used. In this example 0x0017.

If connecting cells confirm operation before connecting. Use all appropriate fusing, insulation, isolation and shielding necessary for safe operation. Board has exposed contacts. Do not leave unattended

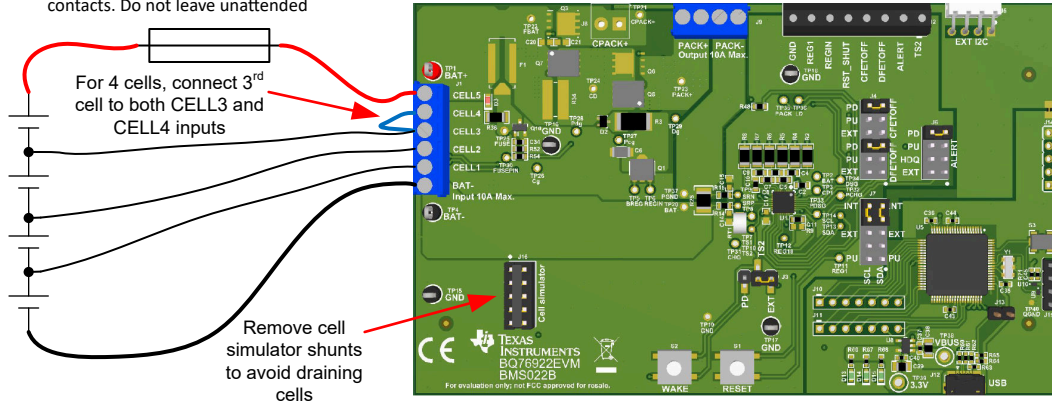


Figure 5-5. Example Connection with 4 Cells

5.7 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. J5 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 BQ76922 VSS and BAT- while the J5 reference is PACK-. With the connection shown in Figure 5-6 the MCU runs from the battery voltage inside the protection FETs. The shunts on J7 must be positioned to connect the BQ76922 I2C lines to the external connector. If the MCU board provides pull ups for the I2C lines, remove any PU shunts from J7. If 10kohm pull ups are desired to REG1 for the SCL and SDA install shunts on the PU pins of J7. The microcontroller board GND could alternately be referenced to the PACK- at J5. 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 GND reference to both the J2 GND and the J5 PACK- since this shorts 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 J5 PACK- terminals, this shorts the sense resistor and could result in damage to equipment or unexpected results.

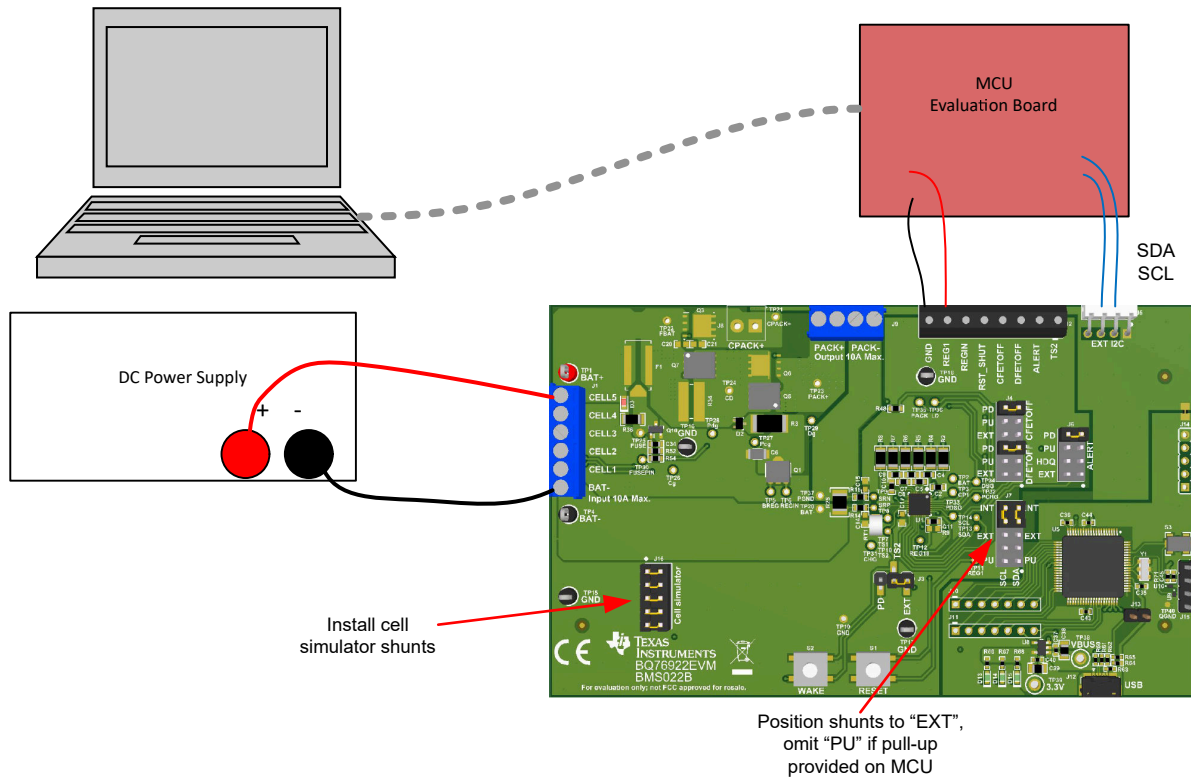


Figure 5-6. Host Connection Concept

5.8 Hardware Configuration

5.8.1 Configuration Jumpers

Certain features on the BQ76922EVM may be configured by jumpers or shunts on headers. See [Section 6.4](#) 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 J16 cell simulator header and J7 I2C configuration are discussed with board connection diagrams.

J4 selects the connection of the DFETOFF and CFETOFF pins. Pins may be pulled low, high to REG1 or brought to a terminal block for external connection.

J3 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 R22 simulates a nominal temperature.

J6 selects the connection of ALERT. It may be connected to a terminal block for external connection, to the on-board interface for HDQ, or pulled up to REG1 or down to VSS.

5.8.2 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 page [Figure 6-10](#).

5.9 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 BQ76922 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 typically involves 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 loads 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.

6 BQ76922EVM Circuit Module Physical Construction

This section contains the PCB layout, bill of materials, and schematic of the BQ76922EVM circuit module.

The BQ76922EVM consists of one circuit module assembly, BMS022.

6.1 Board Layout

The BQ76922EVM circuit module is a 3.0-inch × 4.9-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 BQ76922 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 6-1](#) to [Figure 6-8](#) show the board layout.

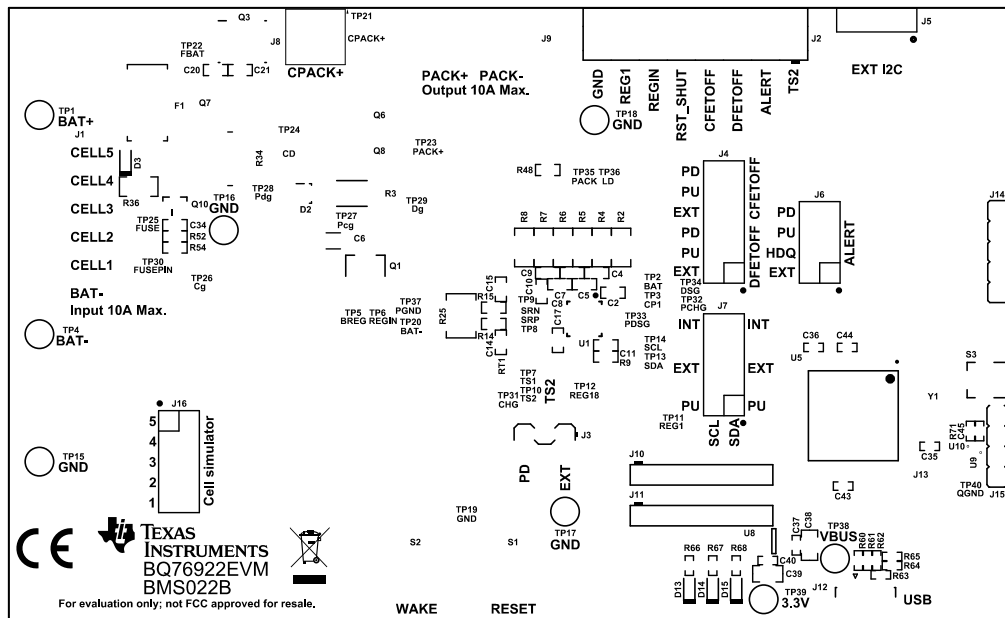


Figure 6-1. Top Silk Screen

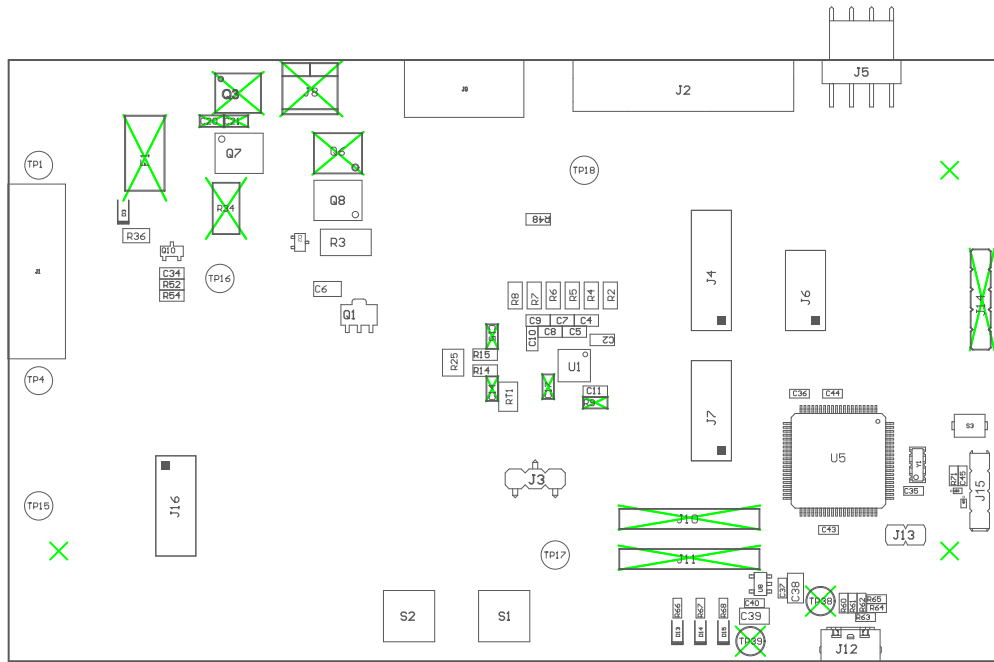


Figure 6-2. Top Assembly

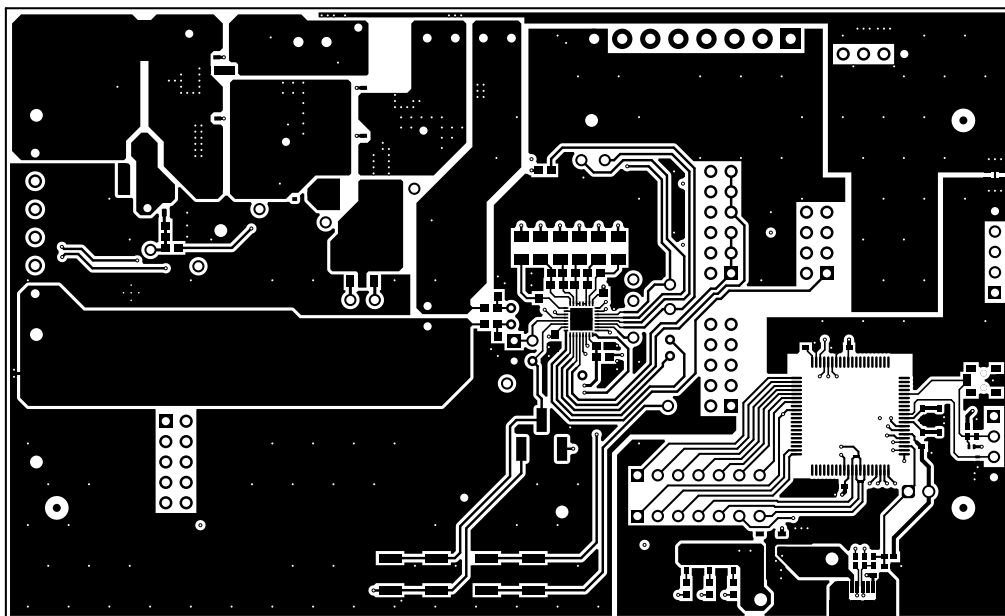


Figure 6-3. Top Layer

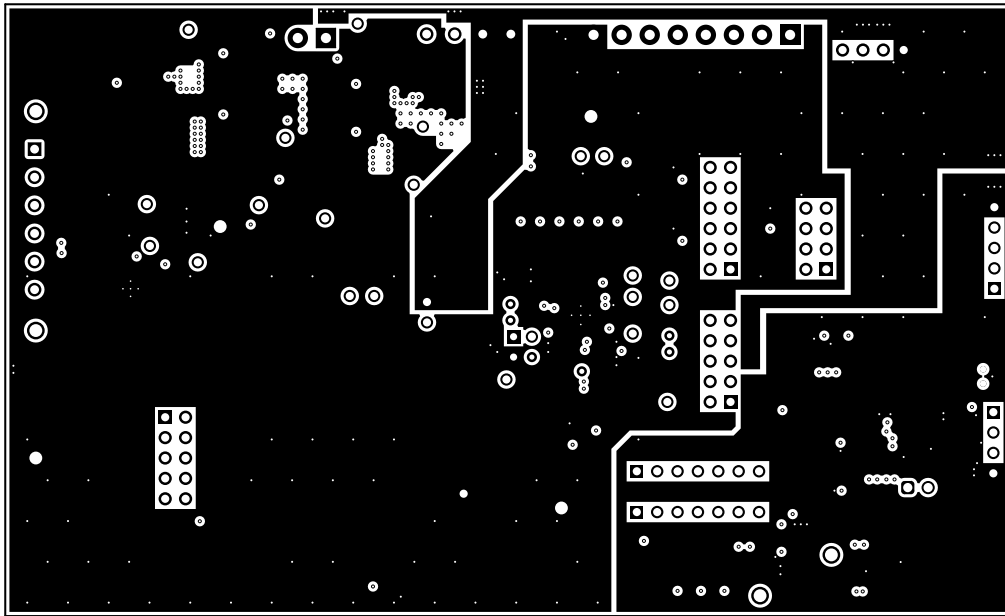


Figure 6-4. Layer 2

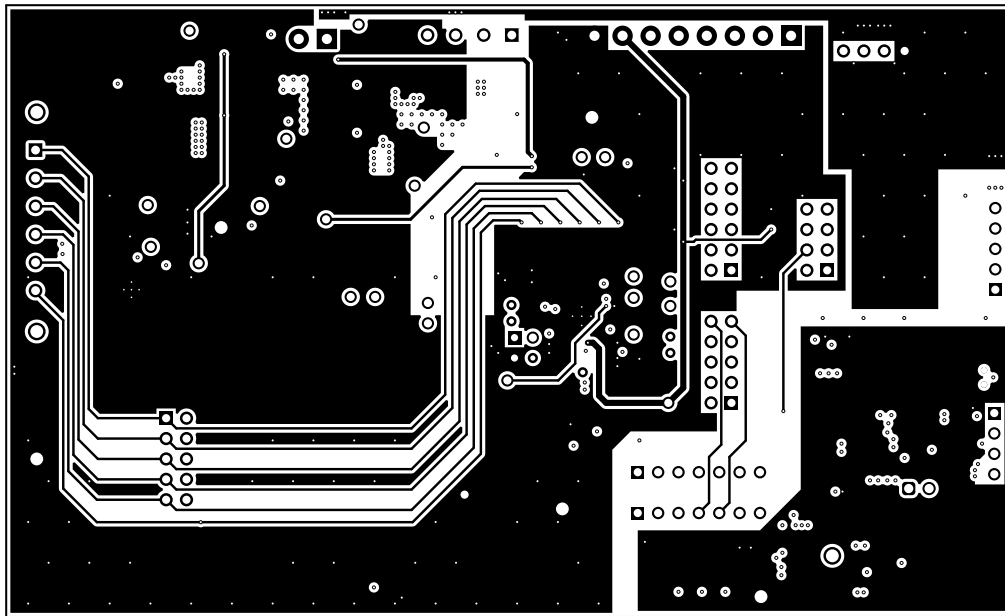


Figure 6-5. Layer 3

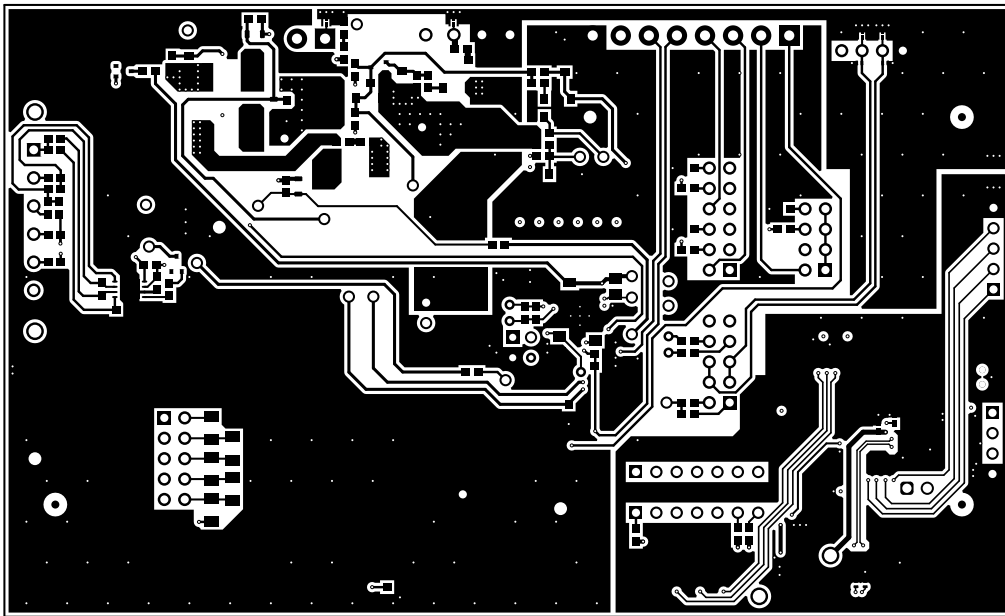


Figure 6-6. Bottom Layer

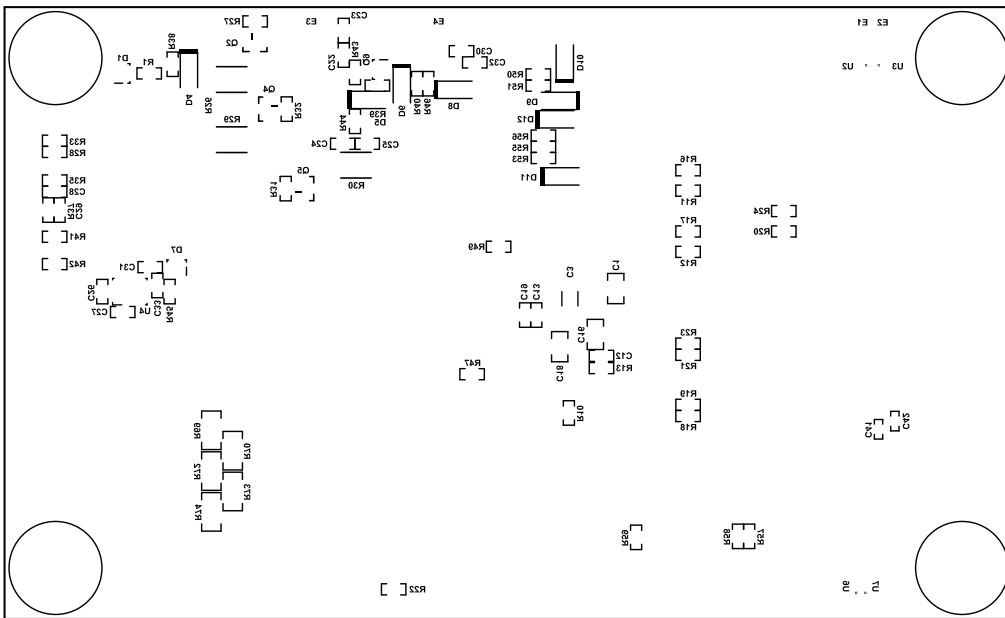


Figure 6-7. Bottom Silk Screen

6.2 Bill of Materials

The bill of materials for the circuit module is shown in [Table 6-1](#). Substitute parts may be used in the manufacturing of the assembly.

Table 6-1. BQ76922 Circuit Module Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	MFG	Alternate Part Number	Alternate MFG
!PCB1	1		Printed Circuit Board		BMS022	Any		
C1	1	0.47uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	GCM219R71E474KA55D	MuRata		
C2, C13	2	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	C0603C101J5GACTU	Kemet		
C3, C6	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L3X7R1H105K160A B	TDK		
C4, C5, C7, C8, C9, C10	6	0.22uF	CAP, CERM, 0.22 uF, 50 V, +/- 10%, X7R, 0603	0603	C1608X7R1H224K080AB	TDK		
C19, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34	12	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	885012206095	Würth Elektronik		
C11	1	0.022uF	CAP, CERM, 0.022 uF, 16 V, +/- 10%, X7R, 0603	0603	C0603C223K4RACTU	Kemet		
C12	1	0.01uF	CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0603	0603	885012206040	Würth Elektronik		
C16	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0805	0805	EMK212B7105KG-T	Taiyo Yuden		
C18	1	2.2uF	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X7R, 0805	0805	EMK212B7225KG-T	Taiyo Yuden		
C35, C37, C40, C41, C43	5	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	0402	885012205037	Würth Elektronik		
C36, C42, C44	3	0.47uF	CAP, CERM, 0.47 uF, 6.3 V, +/- 10%, X5R, 0402	0402	04026D474KAT2A	AVX		
C38, C39	2	10uF	CAP, CERM, 10 uF, 16 V, +/- 10%, X5R, 0805	0805	CL21A106KOQNNNG	Samsung Electro-Mechanics		
C45	1	2200pF	CAP, CERM, 2200 pF, 10 V, +/- 10%, X7R, 0402	0402	885012205008	Würth Elektronik		
D1, D2, D7	3	40V	Diode, Schottky, 40 V, 0.2 A, SOT-323	SOT-323	BAS40W-7-F	Diodes Inc.		
D3	1	Red	LED, Red, SMD	LED_0603	150060RS75000	Würth Elektronik		
D4, D5, D6	3	16V	Diode, Zener, 16 V, 500 mW, SOD-123	SOD-123	MMSZ5246B-7-F	Diodes Inc.		
D8	1	100V	Diode, Ultrafast, 100 V, 0.15 A, SOD-123	SOD-123	1N4148W-7-F	Diodes Inc.		
D9	1	100V	Diode, Schottky, 100 V, 0.15 A, SOD-123	SOD-123	BAT46W-7-F	Diodes Inc.		
D13, D14, D15	3	Green	LED, Green, SMD	LED_0603	150060VS75000	Würth Elektronik		
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M		
J1	1		TERM BLOCK 3.5MM VERT 6POS PCB	HDR6	OSTTE060161	On Shore Technology		
J2	1		Terminal Block, 3.5mm, 8-Pos, TH	Terminal Block, 3.5mm, 8-Pos, TH	ED555/8DS	On-Shore Technology		
J4	1		Header, 100mil, 6x2, Tin, TH	Header, 6x2, 100mil, Tin	PEC06DAAN	Sullins Connector Solutions		
J3	1		Header, 2.54mm, 3x1, Gold, SMT	Header, 2.54mm, 3x1, SMT	87898-0304	Molex		
J5	1		Header (friction lock), 100mil, 4x1, R/A, TH	4x1 R/A Header	22/05/3041	Molex		
J7, J16	2		Header, 100mil, 5x2, Tin, TH	Header, 5x2, 100mil, Tin	PEC05DAAN	Sullins Connector Solutions		
J6	1		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100mil, Tin	PEC04DAAN	Sullins Connector Solutions		
J9	1		TERM BLOCK 3.5MM VERT 4POS PCB	HDR4	OSTTE040161	On Shore Technology		
J12	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		
J13	1		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Würth Elektronik		
J15	1		Header, 2.54mm, 4x1, Tin, TH	Header, 2.54mm, 4x1, TH	22284043	Molex		

Table 6-1. BQ76922 Circuit Module Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	MFG	Alternate Part Number	Alternate MFG
Q1	1	80 V	Transistor, NPN, 80 V, 1 A, SOT-89	SOT-89	BCX5616TA	Diodes Inc.		
Q4, Q5	2	-60V	MOSFET, P-CH, -60 V, -0.9 A, SOT-23	SOT-23	ZXMP6A13FTA	Diodes Inc.		None
Q7, Q8	2	60V	MOSFET, N-CH, 60 V, 172 A, DNK0008A (VSON-CLIP-8)	DNK0008A	CSD18532Q5B	Texas Instruments		None
Q9	1	60V	MOSFET, N-CH, 60 V, 0.31 A, SOT-323	SOT-323	2N7002KW	Fairchild Semiconductor		None
Q10	1	60V	MOSFET, N-CH, 60 V, 2 A, AEC-Q101, SOT-23	SOT-23	DMN6075S-7	Diodes Inc.		None
R1, R14, R15, R21, R23, R28	6	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RJNEA	Vishay-Dale		
R2, R4, R5, R6, R7, R8	6	20.0	RES, 20.0, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW120620R0FKEA	Vishay-Dale		
R3	1	200	RES, 200, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW2512200RJNEG	Vishay-Dale		
R11, R12, R13, R18, R19, R20, R22, R46, R50, R55, R56, R57, R58, R59	14	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale		
R16, R17, R24	3	100k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale		
R25	1	0.001	RES, 0.001, 1%, 1 W, 1210	1210	PMR25HZPFV1L00	Rohm		
R29, R30	2	1.0k	RES, 1.0 k, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25121K00JNEG	Vishay-Dale		
R10, R31, R32, R38, R39, R40	6	10Meg	RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310M0JNEA	Vishay-Dale		
R33, R35, R37, R41, R42, R51	6	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K00JNEA	Vishay-Dale		
R36	1	3.9k	RES, 3.9 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12063K90JNEA	Vishay-Dale		
R44	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R45, R47, R48, R49, R54	5	5.1k	RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06035K10JNEA	Vishay-Dale		
R52	1	20k	RES, 20 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060320K0JNEA	Vishay-Dale		
R60, R61	2	33	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233R0JNED	Vishay-Dale		
R62	1	2.0k	RES, 2.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K00JNED	Vishay-Dale		
R63, R71	2	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0JNED	Vishay-Dale		
R64, R65	2	1.0Meg	RES, 1.0 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M00JNED	Vishay-Dale		
R66, R67, R68	3	330	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKf3300X	Panasonic		
R69, R70, R72, R73, R74	5	200	RES, 200, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RFKEA	Vishay-Dale		
RT1	1	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, SM	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	11	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec	969102-0000-DA	3M
TP1	1		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone		
TP4	1		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone		
TP13, TP14, TP15, TP16	4		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone		
U1	1		Multicell Battery Monitor and Protection Family, RSN0032B (WQFN-32)	RSN0032B	BQ76922RSNT	Texas Instruments	BQ76922RSNR	Texas Instruments
U2, U3	2		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYR	Texas Instruments	TPD1E10B06DPYT	Texas Instruments
U4	1		Family 2-5S Overvoltage Protector with Internal Delay Timer, DPJ0008A (WSON-8)	DPJ0008A	BQ771807DPJR	Texas Instruments	BQ771807DPJT	Texas Instruments
U5	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 6-1. BQ76922 Circuit Module Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	MFG	Alternate Part Number	Alternate MFG
U6, U7, U9, U10	4		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYT	Texas Instruments	TPD1E10B06DPYR	Texas Instruments
U8	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		
C17	0	0.01uF	CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0603	0603	885012206040	Würth Elektronik		
C14, C15, C20, C21	0	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	885012206095	Würth Elektronik		
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		
J10, J11	0		Header, 2.54 mm, 7x1, Gold, TH	Header, 2.54 mm, 7x1, TH	PBC07SAAN	Sullins Connector Solutions		
J14	0		Header, 2.54mm, 5x1, Tin, TH	Header, 2.54mm, 5x1, TH	PEC05SAAN	Sullins Connector Solutions		
Q2	0	-60V	MOSFET, P-CH, -60 V, -0.9 A, SOT-23	SOT-23	ZXMP6A13FTA	Diodes Inc.		None
Q3	0	40V	MOSFET, N-CH, 40 V, 15 A, DQJ0008A (VSONP-8)	DQJ0008A	CSD18504Q5A	Texas Instruments		None
Q6	0	60V	MOSFET, N-CH, 60 V, 172 A, DNK0008A (VSON-CLIP-8)	DNK0008A	CSD18532Q5B	Texas Instruments		None
R9	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603000Z0EA	Vishay-Dale		
R26	0	1.0k	RES, 1.0 k, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25121K00JNEG	Vishay-Dale		
R27	0	10Meg	RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310M0JNEA	Vishay-Dale		
R34	0	0	RES, 0, 5%, 2 W, 2512 WIDE	2512 WIDE	RCL1225000Z0EG	Vishay Draloric		
R43	0	51	RES, 51, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060351R0JNEA	Vishay-Dale		
R53	0	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale		
TP38, TP39	0	Red	Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone		

Note: Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

6.3 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 6-2. 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

6.4 Schematic

Figure 6-9 through Figure 6-11 illustrate the schematics.

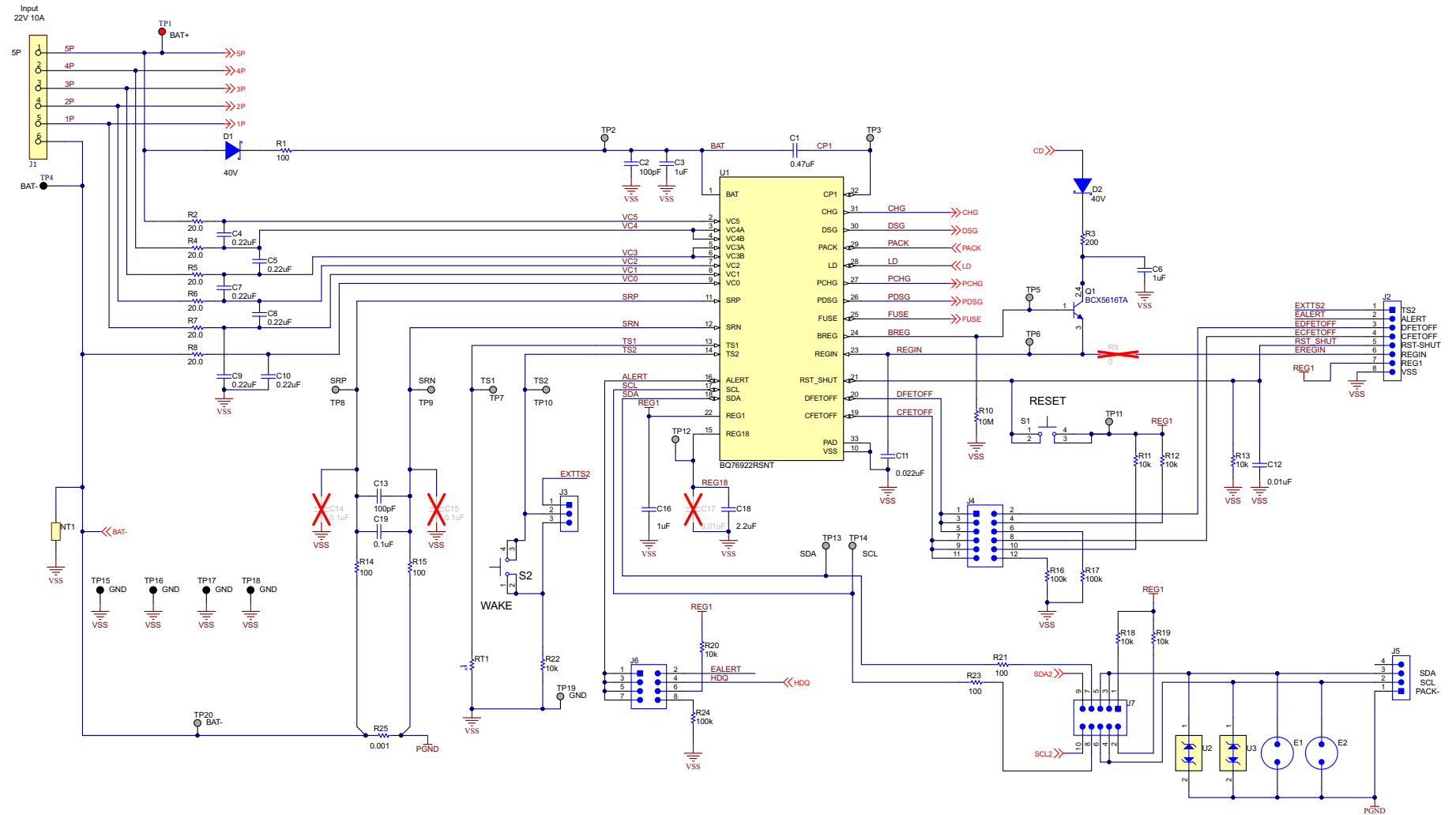


Figure 6-9. Schematic Diagram Monitor

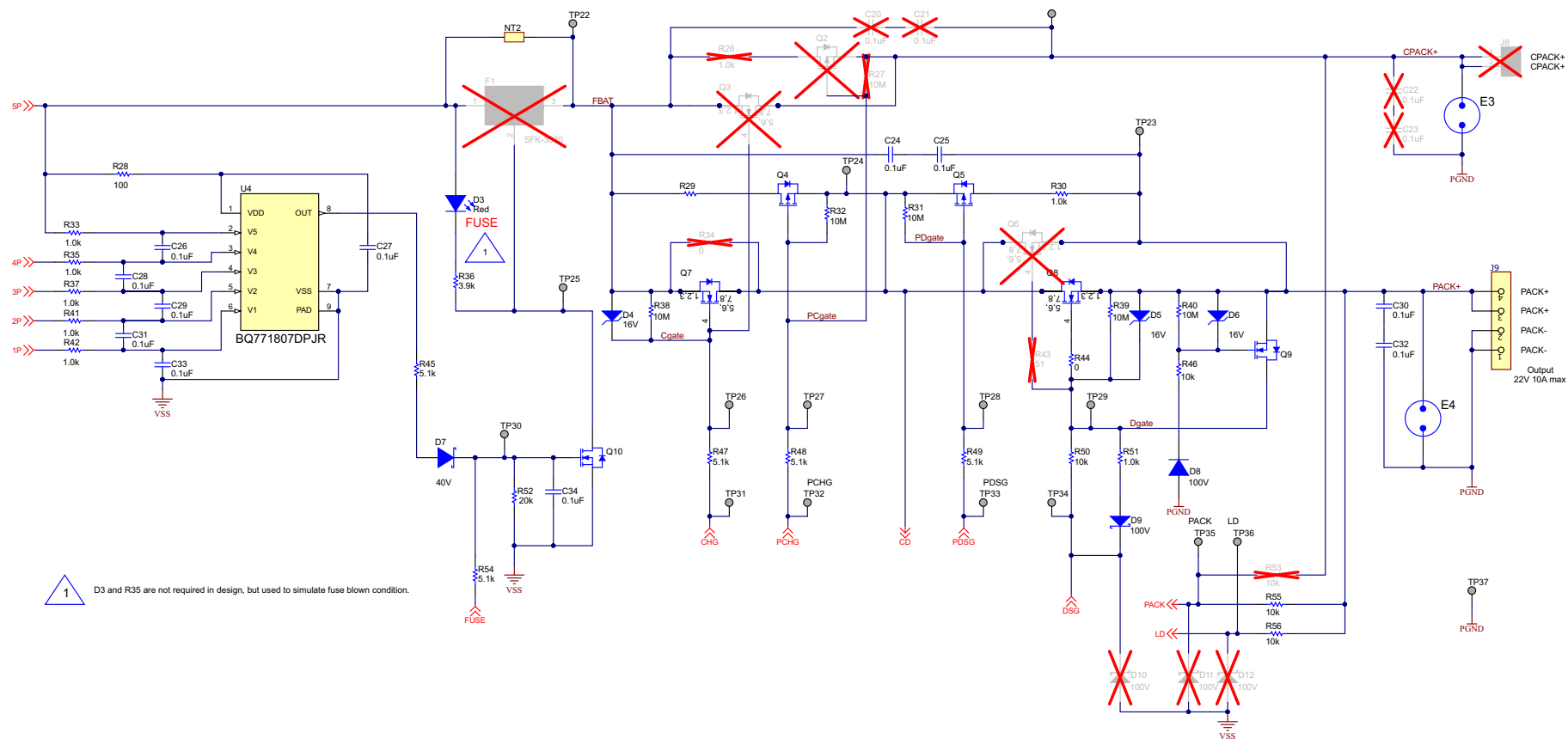


Figure 6-10. Schematic Diagram FETs

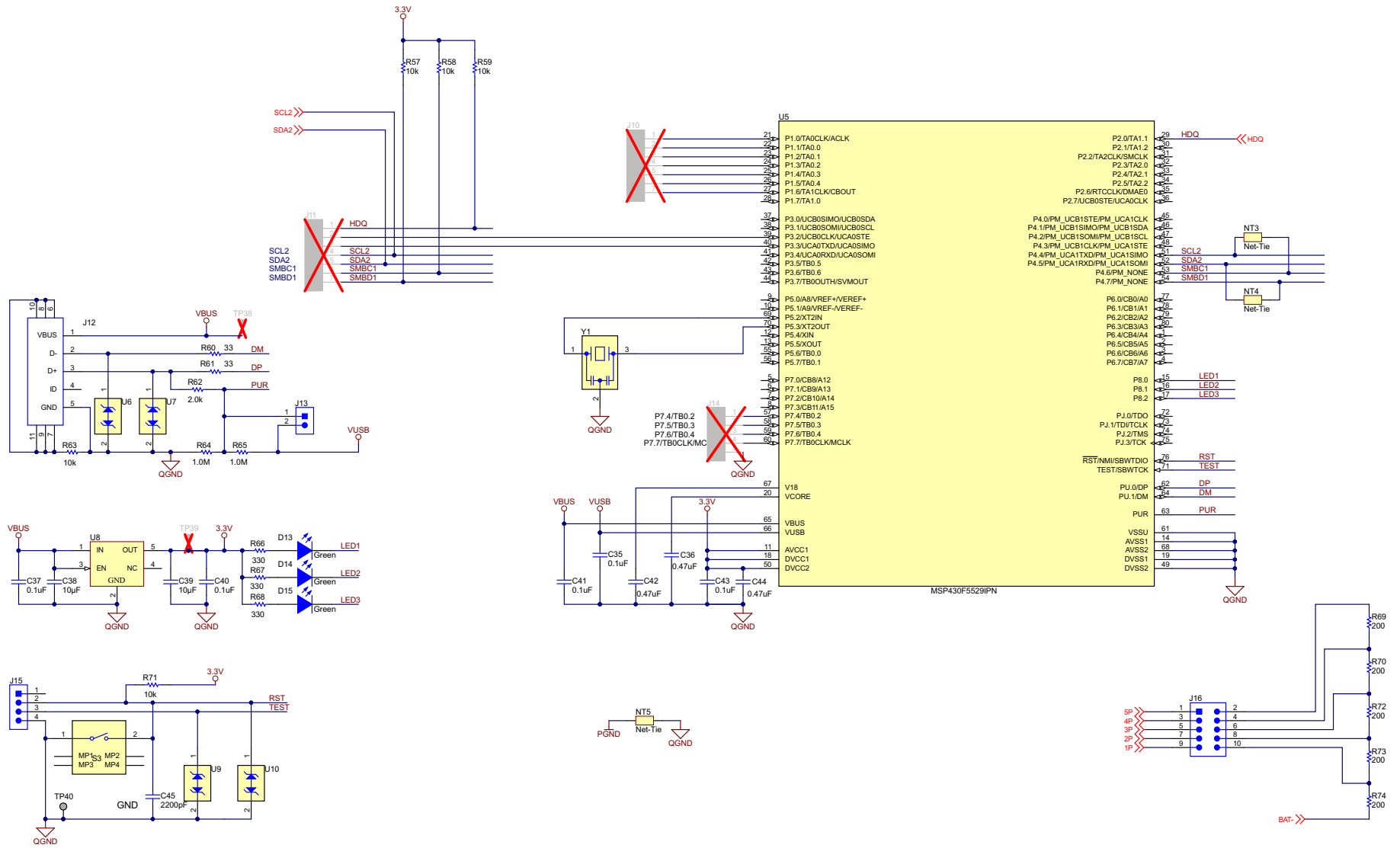


Figure 6-11. Schematic Diagram Interface Adapter

7 Related Documents from Texas Instruments

- Texas Instruments, [BQ76922 3S-5S Battery Monitor and Protector data sheet](#)
- Texas Instruments, [BQ76922 Technical Reference Manual](#)
- Texas Instruments, [BQ7718 Overvoltage Protection for 2 to 5-Series Cell Li-Ion Batt w/ Int Delay Timer data sheet](#)

8 Revision History

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

Changes from Revision * (September 2019) to Revision A (November 2021)	Page
• Deleted preproduction note.....	4
• Changed settings and figure in Quick Start	4
• Changed text and figure in Interface Adapter	6
• Instructions and figures updated in Battery Management Studio Software	7
• Changed figures, minor text updates in BQ76922EVM Circuit Module Use	14
• Changed board layout figures.....	20
• Changed Bill of materials for board revision B.....	25
• Changed schematics.....	29
• Updated data sheet and added technical reference manual in Related Documents from Texas Instruments	32

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