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, power FETs, and all other onboard components necessary to protect the cells from overcharge, over discharge, short circuit, and overcurrent discharge 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, 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>
<thead>
<tr>
<th>EVM Part Number</th>
<th>Chemistry</th>
<th>Configuration</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>BQ76952EVM</td>
<td>Li-Ion</td>
<td>16 cells</td>
<td>Any</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Specification</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage BATT+ with respect to BATT–</td>
<td>6</td>
<td>–</td>
<td>72</td>
<td>V</td>
</tr>
<tr>
<td>Continuous charge or discharge current</td>
<td>0</td>
<td>–</td>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>°C</td>
</tr>
</tbody>
</table>

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.
2.1 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 Specification Table.

**CAUTION**
Some power supplies can be damaged by application of external voltages. If using more than 1 power supply, check your equipment requirements and use blocking diodes or other isolation techniques, as needed, to prevent damage to your equipment.
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. Pre-production 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 Section 4 and Section 5.

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 1 for the following steps.

2. Install the BQStudio software (see Section 4.2).
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 and make the following changes:
\[\begin{align*}
\cdot & \text{Set the VCell Mode bits for the cells connected, typically 0xFFFF} \\
\cdot & \text{Set Enabled Protections A COV bit} \\
\cdot & \text{Set Enabled Protections A CUV bit} \\
\cdot & \text{Set Chg Pump Control CPEN bit}
\end{align*}\]
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 BQStudio software and turn off the power supply.

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

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, the shunts connecting the device to uC_SCL and uC_SDA may be removed. Since the external EV2400 provides pull ups, be sure to remove the "PU" shunts. Figure 2 shows an example of the EVM connected with an 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 will be 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 BQ769x2 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 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.

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.

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 ti.com. Check periodically for software updates. Alternatively use the BQStudio installation file provided. Use the following steps to install the BQStudio software:

1. Copy the archive file to a directory of your choice, extract all files and run the Battery Management Studio-xxxxxx-Setup.exe application.

2. 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.

3. On the last window select option check-boxes desired and Finish to complete the BQStudio software installation.

4.3 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.

4.4 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 1 shows typical connections for operation with the BQStudio software.

Start the software from the desktop shortcut Battery Management Studio or the menu Start → All Programs → Texas Instruments → Battery Management Studio.
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-started. 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.

![Target Selection Wizard](image)

**Figure 3. 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 4**. 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.
Without a device, BQStudio operates with reduced functions. Tools can be browsed and data fields inspected, but data cannot 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 5 shows a register display with a connected 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 6. 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.

![Battery Management Studio Software](https://www.ti.com)

**Figure 6. 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 will reduce 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 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 7 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.
4.6.1 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 8 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.

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.
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 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 9.
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 9. 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 10. 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 11. If there is an error, a red X appears instead with a message as shown in Figure 12.

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 10. Calibration View](image-url)
4.8 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 13. 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.
5 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.

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 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.

5.2 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 14.
5.3 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.
5.4 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 16 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 16. Simulating Current Setup](image)

5.5 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 17 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 reused for a different cell count. Table 3 shows configuration recommendations for reduced cell count.

![Table 3. Reducing Cell Count](image)
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.

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 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 18 shows an example connecting cells with an EVM configuration reduced to 15 cells.
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.

For 15 cells, connect 14th cell to both CELL14 and CELL15 inputs.

Remove cell simulator shunts to avoid draining cells.

Figure 18. Example Connection with 15 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. 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 19 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.
5.8 Hardware Configuration

5.8.1 Configuration Jumpers

Certain features on the BQ76952EVM 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 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.
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 in Figure 30.

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 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.
6  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.

6.1  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 20 to Figure 27 show the board layout.

![Figure 20. Top Silk Screen](image-url)
Figure 21. Top Assembly
Figure 22. Top Layer
Figure 25. Bottom Layer
Figure 26. Bottom Silk Screen
Figure 27. Bottom Assembly
6.2 Bill of Materials

The bill of materials for the circuit module is shown in Table 4. Substitute parts may be used in the manufacturing of the assembly.

Table 4. BQ76952 Circuit Module Bill of Materials

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB1</td>
<td>1</td>
<td></td>
<td>Printed Circuit Board</td>
<td></td>
<td>BMS029</td>
<td>Any</td>
</tr>
<tr>
<td>C1</td>
<td>1</td>
<td>1uF</td>
<td>CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1206</td>
<td>1206</td>
<td>C3216X7R2A105K160AA</td>
<td>TDK</td>
</tr>
<tr>
<td>C2</td>
<td>1</td>
<td>100pF</td>
<td>CAP, CERM, 100 pF, 100 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603</td>
<td>0603</td>
<td>GCM1885C2A101JA16D</td>
<td>MuRata</td>
</tr>
<tr>
<td>C3</td>
<td>1</td>
<td>0.47uF</td>
<td>CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805</td>
<td>0805</td>
<td>GCM219R71E474KA55D</td>
<td>MuRata</td>
</tr>
<tr>
<td>C4, C5, C6, C7, C8, C9, C10, C11, C14, C16, C17, C18, C19, C21, C22, C23, C24, C26, C31, C32, C33, C35, C39, C40, C41, C43, C44, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C56, C57</td>
<td>39</td>
<td>0.1uF</td>
<td>CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603</td>
<td>0603</td>
<td>885012206095</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>C12, C15</td>
<td>2</td>
<td>1uF</td>
<td>CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0805</td>
<td>0805</td>
<td>EMK212B7105KG-T</td>
<td>Taiyo Yuden</td>
</tr>
<tr>
<td>C13, C20</td>
<td>2</td>
<td>0.01uF</td>
<td>CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0603</td>
<td>0603</td>
<td>885012206040</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>C25</td>
<td>1</td>
<td>2.2uF</td>
<td>CAP, CERM, 2.2 uF, 16 V, +/- 10%, X7R, 0805</td>
<td>0805</td>
<td>EMK212B7225KG-T</td>
<td>Taiyo Yuden</td>
</tr>
<tr>
<td>C27</td>
<td>1</td>
<td>100pF</td>
<td>CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603</td>
<td>0603</td>
<td>C0603C101J5GACTU</td>
<td>Kemet</td>
</tr>
<tr>
<td>C37, C38, C42, C45</td>
<td>4</td>
<td>0.1uF</td>
<td>CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603</td>
<td>0603</td>
<td>GCJ188R72A104KA01D</td>
<td>MuRata</td>
</tr>
<tr>
<td>C58, C59, C60, C62, C65, C66, C68</td>
<td>7</td>
<td>0.1uF</td>
<td>CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402</td>
<td>0402</td>
<td>885012205037</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>C61, C67, C69</td>
<td>3</td>
<td>0.47uF</td>
<td>CAP, CERM, 0.47 uF, 6.3 V, +/- 5%, X5R, 0402</td>
<td>0402</td>
<td>04026D474KAT2A</td>
<td>AVX</td>
</tr>
<tr>
<td>C63, C64</td>
<td>2</td>
<td>10uF</td>
<td>CAP, CERM, 10 µF, 16 V, +/- 10%, X5R, 0805</td>
<td>0805</td>
<td>CL21A106KOQNNNG</td>
<td>Samsung Electro-Mechanics</td>
</tr>
</tbody>
</table>

30 BQ76952 Evaluation Module
### Table 4. BQ76952 Circuit Module Bill of Materials (continued)

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
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</thead>
<tbody>
<tr>
<td>C70</td>
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<td>2200pF</td>
<td>CAP, CERM, 2200 pF, 10 V, +/- 10%, X7R, 0402</td>
<td>0402</td>
<td>885012205008</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>D1, D2, D9</td>
<td>3</td>
<td>100V</td>
<td>Diode, Schottky, 100 V, 0.15 A, SOD-123</td>
<td>SOD-123</td>
<td>BAT46W-7-F</td>
<td>Diodes Inc.</td>
</tr>
<tr>
<td>D3</td>
<td>1</td>
<td>Red</td>
<td>LED, Red, SMD</td>
<td>LED_0603</td>
<td>150060RS75000</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>D4, D5, D6</td>
<td>3</td>
<td>16V</td>
<td>Diode, Zener, 16 V, 500 mW, SOD-123</td>
<td>SOD-123</td>
<td>MMSZ5246B-7-F</td>
<td>Diodes Inc.</td>
</tr>
<tr>
<td>D7</td>
<td>1</td>
<td>100V</td>
<td>Diode, Ultrafast, 100 V, 0.15 A, SOD-123</td>
<td>SOD-123</td>
<td>1N4148W-7-F</td>
<td>Diodes Inc.</td>
</tr>
<tr>
<td>D8</td>
<td>1</td>
<td>10V</td>
<td>Diode, Zener, 10 V, 500 mW, SOD-123</td>
<td>SOD-123</td>
<td>MMSZ4697T1G</td>
<td>ON Semiconductor</td>
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<tr>
<td>D13</td>
<td>1</td>
<td>40V</td>
<td>Diode, Schottky, 40 V, 0.2 A, SOT-323</td>
<td>SOT-323</td>
<td>BAS40W-7-F</td>
<td>Diodes Inc.</td>
</tr>
<tr>
<td>D14, D15, D16</td>
<td>3</td>
<td>Green</td>
<td>LED, Green, SMD</td>
<td>LED_0603</td>
<td>150060VS75000</td>
<td>Wurth Elektronik</td>
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<tr>
<td>H1, H2, H3, H4</td>
<td>4</td>
<td>Clear</td>
<td>Bumper, Hemisphere, 0.44 X 0.20, Clear</td>
<td>Transparent Bumper</td>
<td>SJ-5303 (CLEAR)</td>
<td>3M</td>
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<tr>
<td>J1, J4</td>
<td>2</td>
<td></td>
<td>TERM BLOCK 3.5MM VERT 6POS PCB</td>
<td>HDR6</td>
<td>OSTTE060161</td>
<td>On Shore Technology</td>
</tr>
<tr>
<td>J2, J22</td>
<td>2</td>
<td></td>
<td>Header, 2.54mm, 5x1, Tin, TH</td>
<td>Header, 2.54mm, 5x1, TH</td>
<td>PEC05SAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>J3</td>
<td>1</td>
<td></td>
<td>TERM BLOCK 3.5MM VERT 5POS PCB</td>
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<td>OSTTE050161</td>
<td>On Shore Technology</td>
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<tr>
<td>J5</td>
<td>1</td>
<td></td>
<td>Header, 100mil, 6x1, Tin, TH</td>
<td>TH, 6-Leads, Body 608x100mil, Pitch 100mil</td>
<td>PEC06SAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>J6, J7, J11, J13, J16, J19</td>
<td>6</td>
<td></td>
<td>Header, 2.54mm, 3x1, Gold, SMT</td>
<td>Header, 2.54mm, 3x1, SMT</td>
<td>87898-0304</td>
<td>Molex</td>
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<tr>
<td>J9</td>
<td>1</td>
<td></td>
<td>TERM BLOCK 3.5MM VERT 4POS PCB</td>
<td>HDR4</td>
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<td>On Shore Technology</td>
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<tr>
<td>J10, J12, J15, J18, J20, J21</td>
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<td></td>
<td>Header, 100mil, 2x1, Tin, TH</td>
<td>Header, 2 Pin, 100mil, Tin</td>
<td>PEC02SAAN</td>
<td>Sullins Connector Solutions</td>
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<tr>
<td>J14</td>
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<td></td>
<td>Header, 100mil, 6x2, Tin, TH</td>
<td>Header, 6x2, 100mil, Tin</td>
<td>PEC06DAAN</td>
<td>Sullins Connector Solutions</td>
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<tr>
<td>J17</td>
<td>1</td>
<td></td>
<td>Header (friction lock), 100mil, 4x1, R/A, TH</td>
<td>4x1 R/A Header</td>
<td>22/05/3041</td>
<td>Molex</td>
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<tr>
<td>J23</td>
<td>1</td>
<td></td>
<td>Header, 2.54mm, 10x2, Tin, TH</td>
<td>Header, 10x2, 2.54mm, TH</td>
<td>PEC10DAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>J26</td>
<td>1</td>
<td></td>
<td>Receptacle, Micro-USB Type B, 0.65 mm, 5x1, R/A, Bottom Mount SMT</td>
<td>Receptacle, 0.65mm, 5x1, R/A, SMT</td>
<td>47346-1001</td>
<td>Molex</td>
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<td>Designator</td>
<td>Quantity</td>
<td>Value</td>
<td>Description</td>
<td>Package Reference</td>
<td>Part Number</td>
<td>Manufacturer</td>
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<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>J27</td>
<td>1</td>
<td></td>
<td>Header, 2.54 mm, 2x1, Gold, TH</td>
<td>Header, 2.54mm, 2x1, TH</td>
<td>61300211121</td>
<td>Wurth Elektronik</td>
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<tr>
<td>J29</td>
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<td>Header, 2.54mm, 4x1, Tin, TH</td>
<td>Header, 2.54mm, 4x1, TH</td>
<td>22284043</td>
<td>Molex</td>
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<td>Q1</td>
<td>1</td>
<td>150 V</td>
<td>Transistor, NPN, 150 V, 1 A, AEC-Q101, SOT-89</td>
<td>SOT-89</td>
<td>FCX495TA</td>
<td>Diodes Inc.</td>
</tr>
<tr>
<td>Q4, Q11, Q13</td>
<td>3</td>
<td>150 V</td>
<td>Transistor, PNP, 150 V, 0.5 A, SOT-23</td>
<td>SOT-23</td>
<td>MMBT5401LT1G</td>
<td>ON Semiconductor</td>
</tr>
<tr>
<td>Q5, Q6</td>
<td>2</td>
<td>-150V</td>
<td>MOSFET, P-CH, -150 V, -0.53 A, SOT-23</td>
<td>SOT-23</td>
<td>SI2325DS-T1-E3</td>
<td>Vishay-Siliconix</td>
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<tr>
<td>Q8, Q9</td>
<td>2</td>
<td>150 V</td>
<td>MOSFET, N-CH, 150 V, 56 A, PG-TDSON-8</td>
<td>PG-TDSON-8</td>
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<tr>
<td>Q10</td>
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<td>2N7002KW</td>
<td>Fairchild Semiconductor</td>
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<tr>
<td>Q12</td>
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<td>150 V</td>
<td>MOSFET, N-CH, 150 V, 3 A, PowerPAK SO-8</td>
<td>PowerPAK SO-8</td>
<td>SI7898DP-E3</td>
<td>Vishay-Siliconix</td>
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<tr>
<td>R1, R27, R28, R31, R41, R67, R81</td>
<td>7</td>
<td>100</td>
<td>RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW0603100RJNEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R2, R3, R4, R7, R8, R11, R12, R13, R14, R16, R17, R18, R19, R21, R22, R23, R24</td>
<td>17</td>
<td>20.0</td>
<td>RES, 20.0, 1%, 0.25 W, AEC-Q200 Grade 0, 1206</td>
<td>1206</td>
<td>CRCW120620R0FKEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R5, R9</td>
<td>2</td>
<td>220</td>
<td>RES, 220, 5%, 1 W, AEC-Q200 Grade 0, 2512</td>
<td>2512</td>
<td>CRCW2512220RJNEG</td>
<td>Vishay-Dale</td>
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<tr>
<td>R20, R25, R29, R57, R89, R92, R94, R97, R99, R109, R110, R111</td>
<td>12</td>
<td>10k</td>
<td>RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW060310K0JNEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R26, R91</td>
<td>2</td>
<td>100k</td>
<td>RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW0603100KJNEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R30</td>
<td>1</td>
<td>0.001</td>
<td>RES, 0.001, 1%, 1 W, 1210</td>
<td>1210</td>
<td>PMR25HZPFV1L00</td>
<td>Rohm</td>
</tr>
<tr>
<td>R32, R34, R36, R37, R47, R49, R53, R54, R63, R65, R69, R72, R75, R78, R83, R84, R85, R86</td>
<td>18</td>
<td>1.0k</td>
<td>RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW06031K00JNEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R38, R58, R66, R79</td>
<td>4</td>
<td>20k</td>
<td>RES, 20 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW060320K0JNEA</td>
<td>Vishay-Dale</td>
</tr>
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Table 4. BQ76952 Circuit Module Bill of Materials (continued)

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>R39, R40</td>
<td>2</td>
<td>4.7k</td>
<td>RES, 4.7 k, 5%, 1 W, AEC-Q200 Grade 0, 2512</td>
<td>2512</td>
<td>CRCW25124K70JNEG</td>
<td>Vishay-Dale</td>
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<tr>
<td>R42, R43, R50, R51, R52</td>
<td>5</td>
<td>10Meg</td>
<td>RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW060310M0JNEA</td>
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<tr>
<td>R44</td>
<td>1</td>
<td>95.3k</td>
<td>RES, 95.3 k, 1%, 0.1 W, 0603</td>
<td>0603</td>
<td>RC0603FR-0795K3L</td>
<td>Yageo</td>
</tr>
<tr>
<td>R45, R48</td>
<td>2</td>
<td>7.5k</td>
<td>RES, 7.5 k, 5%, 0.1 W, 0603</td>
<td>0603</td>
<td>RC0603JR-077K5L</td>
<td>Yageo</td>
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<tr>
<td>R56, R112, R113</td>
<td>3</td>
<td>0</td>
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<td>CRCW06030000Z0EA</td>
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</tr>
<tr>
<td>R59, R61, R62, R82</td>
<td>4</td>
<td>5.1k</td>
<td>RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
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<td>CRCW06035K10JNEA</td>
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<tr>
<td>R60</td>
<td>1</td>
<td>62k</td>
<td>RES, 62 k, 5%, 0.1 W, 0603</td>
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<td>RC0603JR-0762KL</td>
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<td>5.1k</td>
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<td>1206</td>
<td>CRCW12065K10JNEA</td>
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<td>R80</td>
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<td>RES, 27 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
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<td>CRCW060327K0JNEA</td>
<td>Vishay-Dale</td>
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<td>R87, R88, R90, R93, R95, R96, R98, R100, R101, R102, R103, R104, R105, R106, R107, R108</td>
<td>16</td>
<td>200</td>
<td>RES, 200, 1%, 0.25 W, AEC-Q200 Grade 0, 1206</td>
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<td>CRCW1206200RFKEA</td>
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<tr>
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<td>33</td>
<td>RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402</td>
<td>0402</td>
<td>CRCW040233R0JNED</td>
<td>Vishay-Dale</td>
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<td>R116</td>
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<td>2.0k</td>
<td>RES, 2.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402</td>
<td>0402</td>
<td>CRCW04022K00JNED</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R117, R123</td>
<td>2</td>
<td>10k</td>
<td>RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402</td>
<td>0402</td>
<td>CRCW040210K0JNED</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R118, R119</td>
<td>2</td>
<td>1.0Meg</td>
<td>RES, 1.0 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402</td>
<td>0402</td>
<td>CRCW040211M0JNED</td>
<td>Vishay-Dale</td>
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<td>R120, R121, R122</td>
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<td>330</td>
<td>RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402</td>
<td>0402</td>
<td>ERJ-2RKF3300X</td>
<td>Panasonic</td>
</tr>
<tr>
<td>Designator</td>
<td>Quantity</td>
<td>Value</td>
<td>Description</td>
<td>Package Reference</td>
<td>Part Number</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>------------</td>
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<td>-------</td>
<td>-------------</td>
<td>-------------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>RT1, RT2</td>
<td>2</td>
<td>10k</td>
<td>Thermistor NTC, 10.0k ohm, 1%, Disc, 5x8.4 mm</td>
<td>Disc, 5x8.4 mm</td>
<td>103AT-2</td>
<td>SEMITEC Corporation</td>
</tr>
<tr>
<td>S1, S2</td>
<td>2</td>
<td></td>
<td>Switch, Tactile, SPST-NO, SMT</td>
<td>Switch, 6.2X5X6.2 mm</td>
<td>KST221JLFS</td>
<td>C&amp;K Components</td>
</tr>
<tr>
<td>S3</td>
<td>1</td>
<td></td>
<td>Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD</td>
<td>3.9x2.9mm</td>
<td>PTS820 J20M SMTR LFS</td>
<td>C&amp;K Components</td>
</tr>
<tr>
<td>TP14, TP15, TP16, TP17</td>
<td>4</td>
<td>Test Point, Compact, Black, TH</td>
<td>Black Compact Testpoint</td>
<td>5006</td>
<td>Keystone</td>
<td></td>
</tr>
<tr>
<td>U1</td>
<td>1</td>
<td></td>
<td>Multicell Battery Monitor and Protection Family, PFB0048A (TQFP-48)</td>
<td>PFB0048A</td>
<td>bq76952PFBT</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U2, U3, U4, U5</td>
<td>4</td>
<td></td>
<td>Family 2-5S Overvoltage Protector with Internal Delay Timer, DPJ0008A (WSON-8)</td>
<td>DPJ0008A</td>
<td>BQ771807DPJR</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U6, U7, U8, U9</td>
<td>4</td>
<td></td>
<td>Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)</td>
<td>DPY0002A</td>
<td>TPD1E10B06DPYR</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U10</td>
<td>1</td>
<td></td>
<td>Dual-Bit Dual Supply Transceiver with Configurable Voltage Translation and 3-State Outputs, DCT0008A, LARGE T&amp;R</td>
<td>DCT0008A</td>
<td>SN74LVC2T45DCTR</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U11</td>
<td>1</td>
<td></td>
<td>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 &amp; no Sb/Br)</td>
<td>PN0080A</td>
<td>MSP430F5529IPN</td>
<td>Texas Instruments</td>
</tr>
</tbody>
</table>
Table 4. BQ76952 Circuit Module Bill of Materials (continued)

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>U12, U13, U15, U16</td>
<td>4</td>
<td></td>
<td>Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)</td>
<td>DPY0002A</td>
<td>TPD1E10B06DPYT</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U14</td>
<td>1</td>
<td></td>
<td>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 &amp; no Sn/Br)</td>
<td>DBV0005A</td>
<td>TPS76333DBVR</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>Y1</td>
<td>1</td>
<td></td>
<td>Resonator, 4 MHz, 39 pF, AEC-Q200 Grade 1, SMD</td>
<td>4.5x1.2x2 mm</td>
<td>CSTCR4M00G55B-R0</td>
<td>MuRata</td>
</tr>
<tr>
<td>C26</td>
<td>0</td>
<td>0.01μF</td>
<td>CAP, CERM, 0.01 μF, 16 V, +/- 10%, X7R, 0603</td>
<td>0603</td>
<td>885012206040</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>C29, C30, C34, C36</td>
<td>0</td>
<td>0.1μF</td>
<td>CAP, CERM, 0.1 μF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603</td>
<td>0603</td>
<td>GCJ188R72A104KA01D</td>
<td>MuRata</td>
</tr>
<tr>
<td>D10, D11, D12</td>
<td>0</td>
<td>100V</td>
<td>Diode, Schottky, 100 V, 0.15 A, SOD-123</td>
<td>SOD-123</td>
<td>BAT46W-7-F</td>
<td>Diodes Inc.</td>
</tr>
<tr>
<td>F1</td>
<td>0</td>
<td></td>
<td>Fuse, 30 A, 62 VDC, SMD</td>
<td>9.5x2x5mm</td>
<td>SFK-3030</td>
<td>Dexerials Corporation</td>
</tr>
<tr>
<td>FID1, FID2, FID3, FID4, FID5, FID6</td>
<td>0</td>
<td></td>
<td>Fiducial mark. There is nothing to buy or mount.</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>J6</td>
<td>0</td>
<td></td>
<td>Terminal Block, 3.5mm Pitch, 2x1, TH</td>
<td>7.0x8.2x6.5mm</td>
<td>ED555/2DS</td>
<td>On-Shore Technology</td>
</tr>
<tr>
<td>J24</td>
<td>0</td>
<td></td>
<td>Header, 2.54 mm, 7x1, Gold, TH</td>
<td>Header, 2.54 mm, 7x1, TH</td>
<td>PBC07SAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>J25</td>
<td>0</td>
<td></td>
<td>Header, 2.54 mm, 11x1, Gold, TH</td>
<td>Header, 2.54 mm, 11x1, TH</td>
<td>PBC11SAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>J28</td>
<td>0</td>
<td></td>
<td>Header, 2.54mm, 5x1, Tin, TH</td>
<td>Header, 2.54mm, 5x1, TH</td>
<td>PEC05SAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>Q2</td>
<td>0</td>
<td>-150V</td>
<td>MOSFET, P-CH, -150 V, -0.53 A, SOT-23</td>
<td>SOT-23</td>
<td>SI2325DS-T1-E3</td>
<td>Vishay-Siliconix</td>
</tr>
<tr>
<td>Q3</td>
<td>0</td>
<td>150V</td>
<td>MOSFET, N-CH, 150 V, 13 A, PG-TSDSON-8</td>
<td>PG-TSDSON-8</td>
<td>BSZ900N15NS3 G</td>
<td>Infineon Technologies</td>
</tr>
<tr>
<td>Q7</td>
<td>0</td>
<td>150V</td>
<td>MOSFET, N-CH, 150 V, 56 A, PG-TDSON-8</td>
<td>PG-TDSON-8</td>
<td>BSC160N15NS5ATMA1</td>
<td>Infineon Technologies</td>
</tr>
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### Table 4. BQ76952 Circuit Module Bill of Materials (continued)

<table>
<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
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</thead>
<tbody>
<tr>
<td>R6, R10</td>
<td>0</td>
<td>220</td>
<td>RES, 220, 5%, 1 W, AEC-Q200 Grade 0, 2512</td>
<td>2512</td>
<td>CRCW2512220RJNEG</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R15</td>
<td>0</td>
<td>0</td>
<td>RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW06030000Z0EA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R33</td>
<td>0</td>
<td>4.7k</td>
<td>RES, 4.7 k, 5%, 1 W, AEC-Q200 Grade 0, 2512</td>
<td>2512</td>
<td>CRCW25124K70JNEG</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R35</td>
<td>0</td>
<td>10Meg</td>
<td>RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW060310M0JNEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R46</td>
<td>0</td>
<td>0</td>
<td>RES, 0, 5%, 2 W, 2512 WIDE</td>
<td>2512 WIDE</td>
<td>RCL12250000Z0EG</td>
<td>Vishay Draloric</td>
</tr>
<tr>
<td>R55</td>
<td>0</td>
<td>51</td>
<td>RES, 51, 5%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>0603</td>
<td>CRCW060351R0JNEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R70, R71</td>
<td>0</td>
<td>5.1k</td>
<td>RES, 5.1 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206</td>
<td>1206</td>
<td>CRCW120651K0JNEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>TP1</td>
<td>0</td>
<td></td>
<td>Test Point, Multipurpose, Red, TH</td>
<td>Red Multipurpose Testpoint</td>
<td>5010</td>
<td>Keystone</td>
</tr>
<tr>
<td>TP9</td>
<td>0</td>
<td></td>
<td>Test Point, Multipurpose, Black, TH</td>
<td>Black Multipurpose Testpoint</td>
<td>5011</td>
<td>Keystone</td>
</tr>
<tr>
<td>TP43, TP44</td>
<td>0</td>
<td></td>
<td>Red Test Point, Compact, Red, TH</td>
<td>Red Compact Testpoint</td>
<td>5005</td>
<td>Keystone</td>
</tr>
</tbody>
</table>
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 5. REACH Components

<table>
<thead>
<tr>
<th>Component Manufacturer</th>
<th>Component part number</th>
<th>SVHC Substance</th>
<th>SVHC CAS (when available)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molex</td>
<td>Terminal Block 39357</td>
<td>Lead (Pb)</td>
<td>7439-92-1</td>
</tr>
<tr>
<td>Murata</td>
<td>Resonator CSTCR4M00G55B-R0</td>
<td>Lead Titanium Zirconium Oxide [(Pbx Ty Zrz) 03]</td>
<td>12626-81-2</td>
</tr>
</tbody>
</table>
6.4 Schematic

Figure 28 through Figure 31 illustrate the schematics.

Figure 28. Schematic Diagram Monitor
Figure 29. Schematic Diagram Pin Configuration
Figure 30. Schematic Diagram FETs
Figure 31. Schematic Diagram Interface
7 Related Documents from Texas Instruments

- Texas Instruments, *BQ76952 3S-16S Battery Monitor and Protector data sheet*
- Texas Instruments, *BQ7718 Overvoltage Protection for 2 to 5-Series Cell Li-Ion Batt w/ Int Delay Timer data sheet*
STANDARD TERMS FOR EVALUATION MODULES

1. Delivery: TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software.

1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 Limited Warranty and Related Remedies/Disclaimers:

2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

**WARNING**

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.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

**NOTE:**

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION 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/livds/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/livds/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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術基準適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿6丁目24番1号
西新宿三井ビル

3.3.3 Notice for EVMs for Power Line Communication: Please see http://www.tij.co.jp/livds/ti_ja/general/eStore/notice_02.page 電力線送信波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/livds/ti_ja/general/eStore/notice_02.page

3.4 European Union

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.
4 EVM Use Restrictions and Warnings:

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

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.

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