EVM User's Guide: BQ76905EVM
BQ76905 Evaluation Module

TEXAS INSTRUMENTS

Description

The Texas Instruments' BQ76905EVM is a complete evaluation system for the BQ76905, The BQ76905 is a highly integrated, high accuracy battery monitor and protector for 2-series to 5-series Li-Ion, LiPolymer, and LiFePO4 battery packs.

The circuit module connects directly to the cells in a battery, or can be connected with a power supply and the included cell simulator resistors. With the on-board interface or compatible external interface board and Microsoft® Windows® based PC graphical user interface (GUI) software, the user can view the device registers, evaluate voltage, current and temperature accuracy, adjust protection limits and enable FET control outputs.

Get Started

1. Order the BQ76905 EVM from ti.com.
2. Download the latest BQSTUDIO-TEST from the BQSTUDIO tool page.

3. Follow the instructions in this user's guide to get started.

Features

- Complete evaluation system for the BQ76905 2-cell to 5-cell Li-Ion, LiPolymer, and LiFePO4 high accuracy battery monitor
- 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

Applications

- Cordless power tools and garden tools
- Vacuum cleaners
- Non-military drones
- Other industrial battery pack (2-series to 5-series)
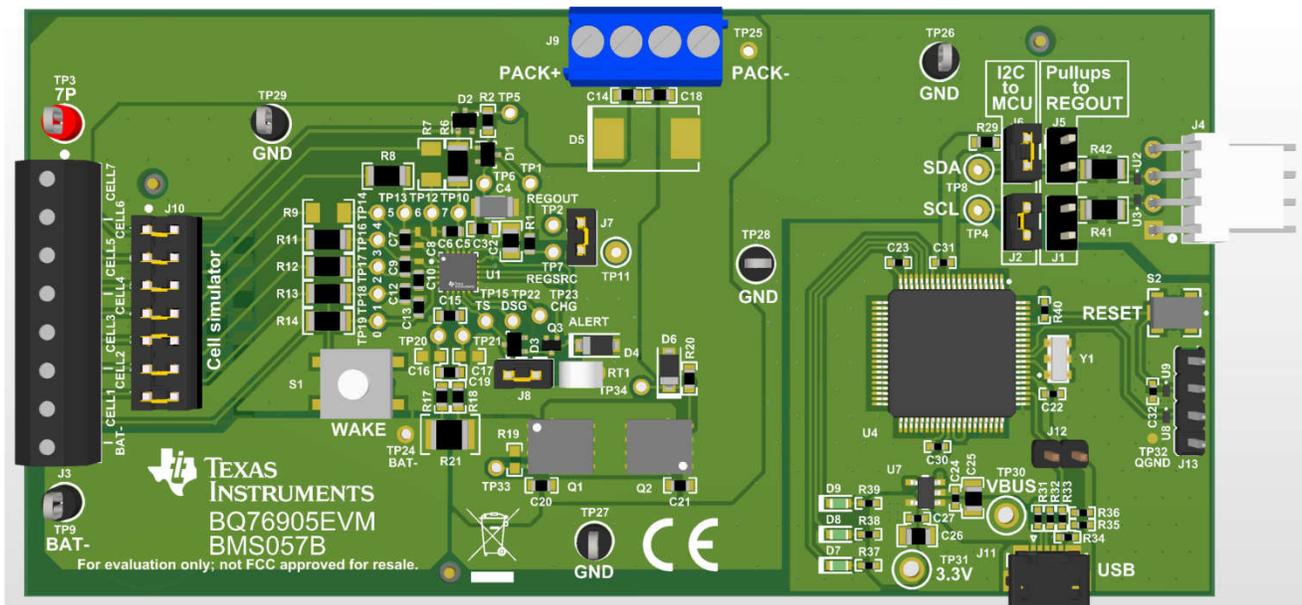
1 Evaluation Module Overview
1.1 Introduction

The BQ76905 features a high accuracy monitoring system with dedicated coulomb counter and accumulated charge integration, a highly configurable protection subsystem, and support for host controlled cell balancing. Integration includes low-side protection NFET drivers, a programmable LDO for external system use, and an I^2C host communication interface supporting up to 400-kHz operation with optional CRC. The evaluation module includes one BQ76905 integrated circuit (IC), sense resistor, one thermistor, power FETs, and all other onboard components necessary to protect the cells from overcharge, over discharge, short circuit, overcurrent discharge, over temperature, and under temperature.

1.2 Kit Contents

• BQ76905 circuit module
• USB A to microUSB cable

1.3 Specification

This section summarizes the performance specifications of the BQ76905 circuit module in the default 5-cell series FET configuration.

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

Table 1-1. Performance Specification Summary

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

1.4 Device Information

Table 1-2. Device Information

EVM Part Number	Chemistry	Configuration	Capacity
BQ76905EVM	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.

2 Hardware

2.1 Before You Begin

The following warnings and cautions are noted for the safety of anyone using or working close to the BQ76905 EVM. Observe all safety precautions.

	Warning	The BQ76905EVM circuit module can become hot during operation due to dissipation of heat. Avoid contact with the board. Follow all applicable safety procedures applicable to your laboratory.
	Caution	Do not leave the EVM powered when unattended.

CAUTION

The default settings of the BQ76905 do not limit performance to the ratings of the EVM. Set all protections appropriately and limit current for safe operation.

CAUTION

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

CAUTION

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

CAUTION

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

CAUTION

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

CAUTION

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

2.2 Required Equipment

The following equipment is required to operate the BQ76905 EVM in a simple demonstration:

- DC power supply, 0–35 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 can be desired to operate the BQ76905 with a more extensive demonstration.

2.3 BQ76905 Circuit Module Use

The BQ76905 circuit module contains the BQ76905 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 Section 3. For details of the circuit, refer to Section 5.

2.3.1 Cell Simulator

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

2.3.2 Evaluating with Load Current

With the BQ76905 configured and the FETs enabled, discharge current can be demonstrated by attaching appropriate resistors or a DC load at the PACK terminals as shown in Figure 2-1.
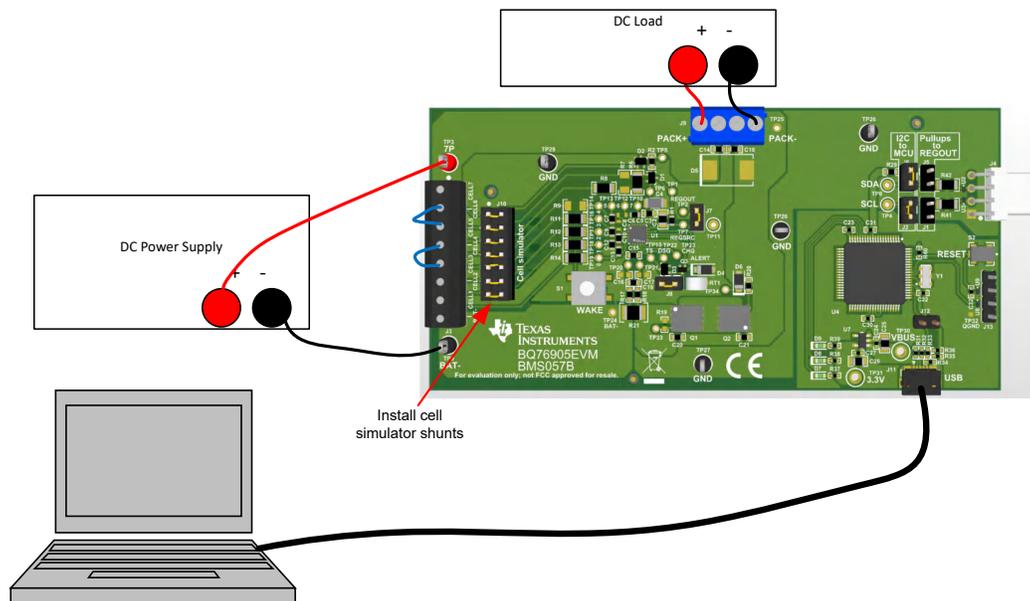
Figure 2-1. Evaluating with Load Current

2.3.3 Evaluating Charge and Discharge Currents

Bipolar power supplies source or sink currents to maintain the set voltage. When bipolar supplies are available, the bipolar supplies can 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.
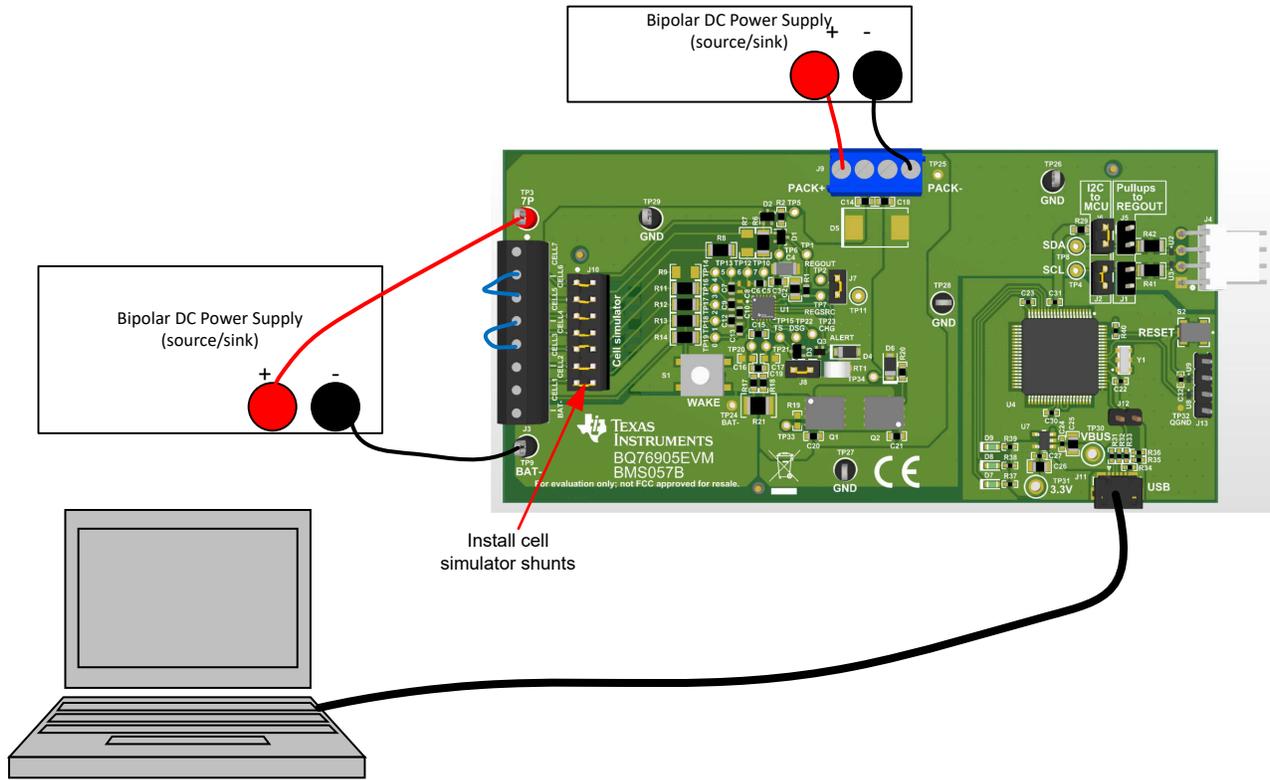

Figure 2-2. Evaluating with Charge or Discharge Current

2.3.4 Evaluating with Simulated Current

Section 3 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 2-3 shows a method to force current through the control path without a high wattage power supply or special equipment. The *load* power supply must 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.
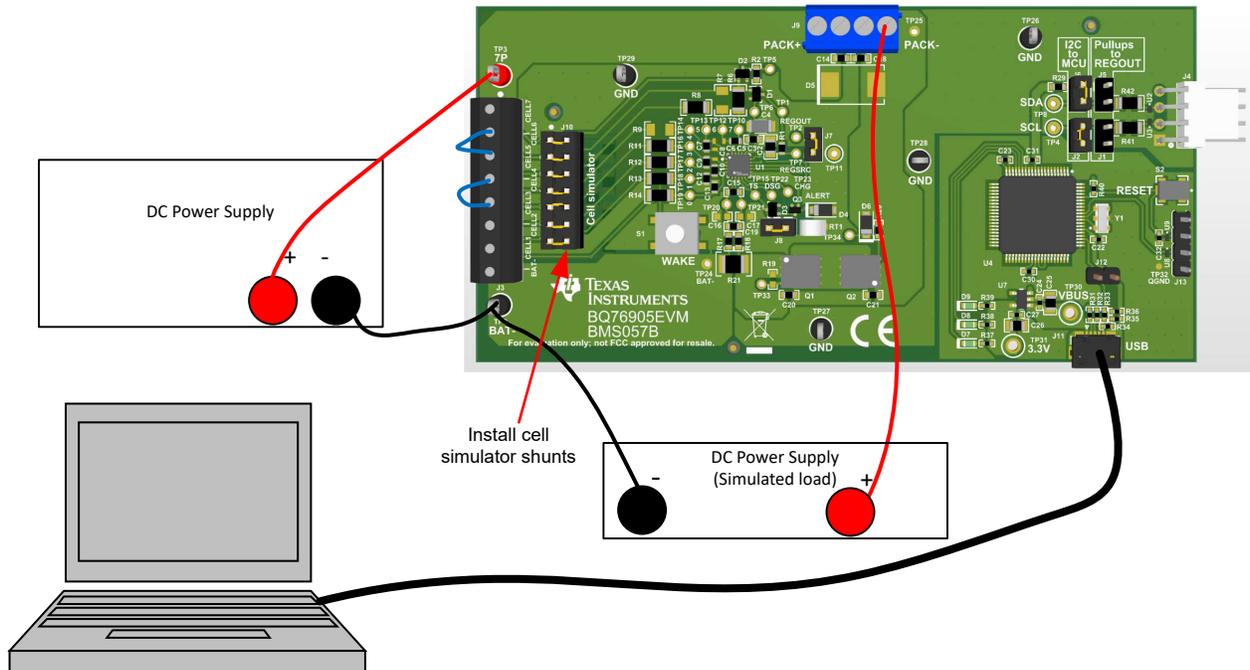
Figure 2-3. Simulating Current Setup

2.3.5 Reducing the Cell Count

The BQ76905 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 data sheet 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 the shorted resistors are parallel to the cell IC where the capacitor provides a signal path to the used input. See Figure 2-4 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 the cell inputs are apparent if the board is re-used for a different cell count. Table 2-1 shows configuration recommendations for reduced cell count, this table assumes the board has been set-up as detailed in Section 3.

By default, the BQ76905 EVM has VC4A/B and VC3A/B shorted at the IC inputs. However, the user must make sure to also short **CELL6** to **CELL5** and **CELL4** to **CELL3** on the cell input terminals prior to making any cell reduction, as explained in Section 3.

Table 2-1. Reducing Cell Count

| Unused cell (numbered from bottom cell 1)	Short cell input terminals	Input resistor to remove	Replace capacitor with 0 ohm	IC inputs shorted
Cell 4	CELL5 to CELL4	R8	C7	VC4A/B to VC3A/B
Cell 3	CELL3 to CELL2	R11	C9	VC3A/B to VC2
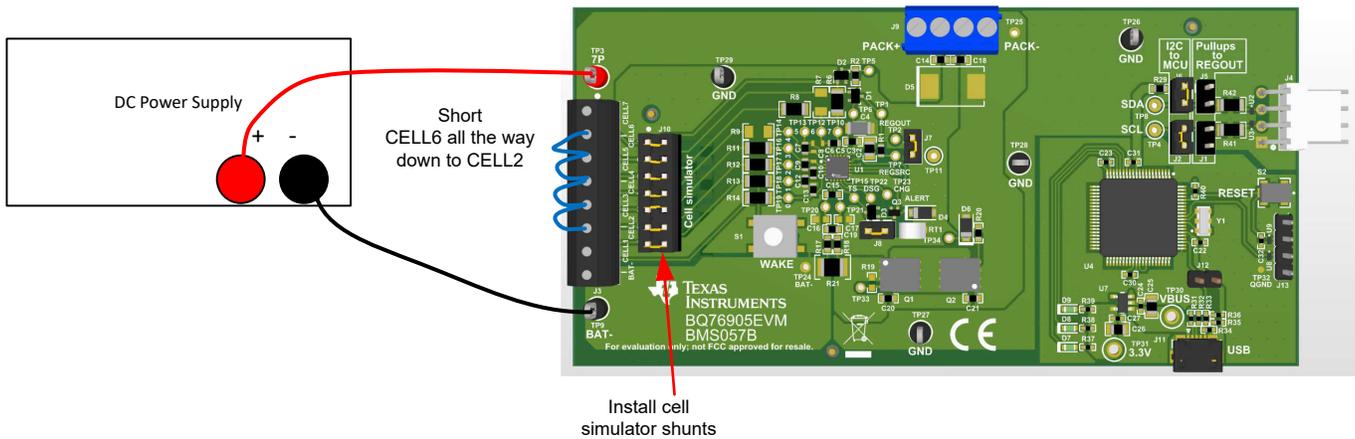
Figure 2-4. Example 3 Cell Simple Evaluation Configuration

2.3.6 Connecting Cells

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

The cell simulator provides resistors between the cell inputs. When the cell simulator shunts are installed, these resistors load the cells and divide the voltage to any unconnected inputs as cells are connected. If desired, then 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 must be connected first. After BAT- cells can 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 2-5 shows an example connecting cells with an EVM configuration reduced to 4 cells.
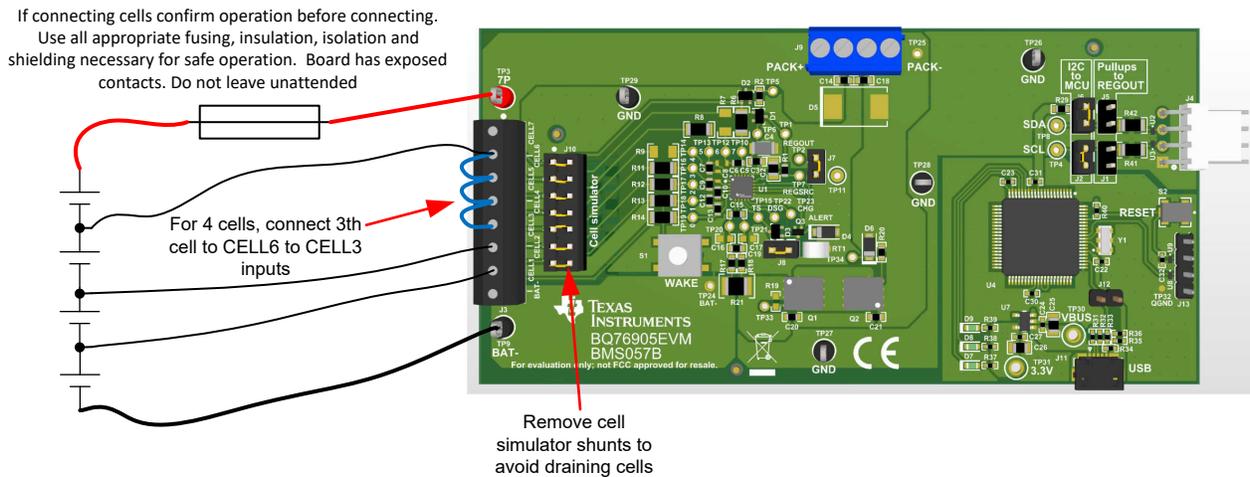
Figure 2-5. Example Connection with 4 Cells

2.3.7 Connecting to a Host

After initial operation of the monitor with the BQStudio software, consider operating the board connected to and controlled by a microcontroller board. To do this, unpopulate J6 and J2, and populate J1 and J5. J6 and J2 disconnect the I2C lines of the BQ76905 from the on-board MCU. J1 and J5 connect the I2C pullup resistors to REGOUT.
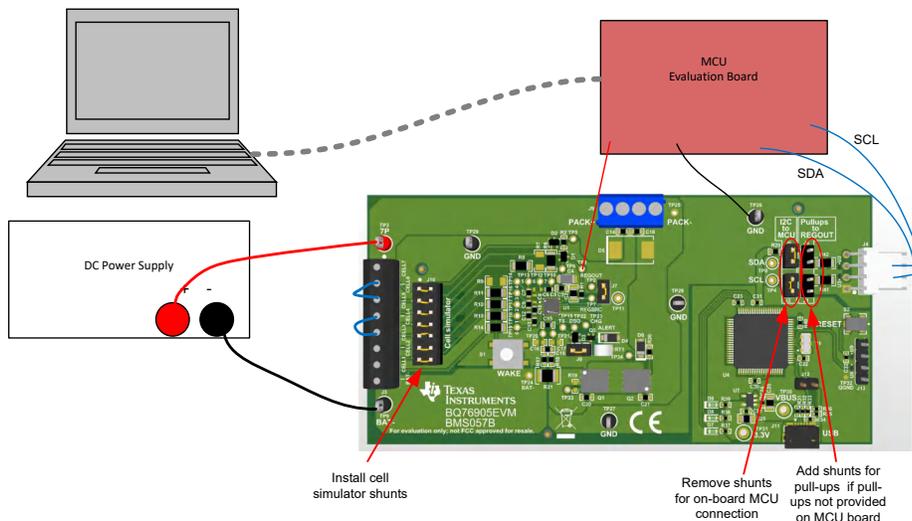

Figure 2-6. Host Connection Concept

2.3.8 Hardware Configuration

2.3.8.1 Configuration Jumpers

Certain features on the BQ76905EVM can be configured by jumpers or shunts on headers. See Section 5.1 for details of the header pins.

J1 and J5 connect the BQ76905 I2C lines to pull-up resistors at REGOUT for off-board MCU communications.

J2 and J6 connect the I2C lines of the BQ76905 to the on-board MCU.

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

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

J10 cell simulator connections.

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

2.3.9 Configuration Register Programming

Configuration register programming is 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 BQ76905 data sheet (SLUSF45) and supporting documentation for register information. When a configuration file is available, the file can 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 must be familiar with the contents of imported files. With a new device or after loading a configuration file, individual register changes can be made. Configuration register programming typically involves the following general principles selected in various register names:

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

3 Quick Start Guide

The BQ76905 registers must be configured to enable most protections, select the monitored cells, and enable the protection FETs on the EVM. This section does not describe current protection settings.

These steps describe quick connection of the BQ76905 EVM to demonstrate operation of the AFE portion of the EVM. For more detailed descriptions, refer to other sections of the user's guide.

Refer to Figure 3-1 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 4.1.2).
3. Install the cell simulator shunts.
4. VC4A to VC4B and VC3A to VC3B are shorted directly at the pins. However, CELL6 to CELL 5 and CELL4 to CELL 3 must also be shorted at the cell-side for proper circuit module functionality.
5. Position shunts for the I2C to MCU connection.
6. Attach the on-board communication adapter USB connector to the PC using USB cable.
7. Connect a 0-V DC power supply capable of 250 mA minimum between the "*BAT-*" and "7*P*" terminals and adjust to approximately 15 V.
8. Start the BQStudio software. If there is proper communication, then the GUI opens with a register display. Click on the *Scan* button to enable repeated update of the display. The power supply can be adjusted within range of the part to observe voltage changes in the GUI register display.
9. Select the Data Memory button in the BQStudio window.
10. Select the Settings button. Set the Enabled Protections A CUV bit.
11. Select the Protections button. Set the Cell Undervoltage Protection Threshold to 2800.
12. In the Commands panel click on the FET_ENABLE button.
13. In the Registers view click on the Scan icon so that the registers update periodically. Observe that the CHG and DSG bits in the Battery Status register are on. Measure the PACK voltage on the board if desired.
14. Adjust the supply voltage to approximately 12.5 V. In the registers view observe that the DSG bit goes off.
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 the BQStudio software and turn off the power supply.

Refer to other sections of this user's guide for additional details.
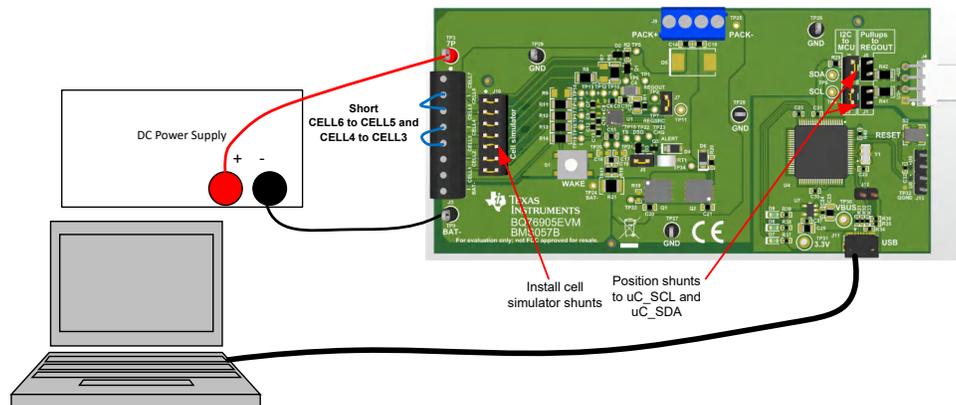
Figure 3-1. EVM Connection for Basic Operation

4 Software

4.1 Battery Management Studio Software

The Battery Management Studio software is used for evaluation of the BQ76905 monitor. This software is also identified as BQStudio for a compact name. If an earlier version of the BQStudio software is already installed from another product evaluation, then install BQStudio software again to load the configuration files and tools specific to the current version of the BQ76905.

4.1.1 System Requirements

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

4.1.2 Installing BQStudio

Find the latest software version in the software section of the product folder http://www.ti.com/tool/BQSTUDIO or search from ti.com. There are multiple versions available, but the BQSTUDIO-TEST version needs to be the version used with the BQ76905 EVM. Check periodically for software updates. Use the following steps to install the BQStudio software:

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

4.1.3 BQ76905 bqz File Installation

The BQStudio software uses a .bqz file to configure the displays for the BQ76905 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.

4.1.4 BQStudio Operation and Registers View

BQStudio is used to communicate to the BQ76905 for evaluation. BQStudio includes several tools to aid in configuration, calibration and data display of the BQ76905 during evaluation.

Although the software runs without connection to an interface board or powered device, TI recommends to have the interface connected and the device on when starting the software. Follow the directions in Section 3. Figure 3-1 shows typical connections for operation with the BQStudio software.

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

When started, the software looks for the communication interface and the device. If the device is not found, then the device 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 BQ76905 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, then the user is presented with a *Proceed?* window, which must be acknowledged. If the software still cannot find the device, then a *Battery Management Studio* pop-up window appears indicating communication status. Acknowledge the message to proceed.
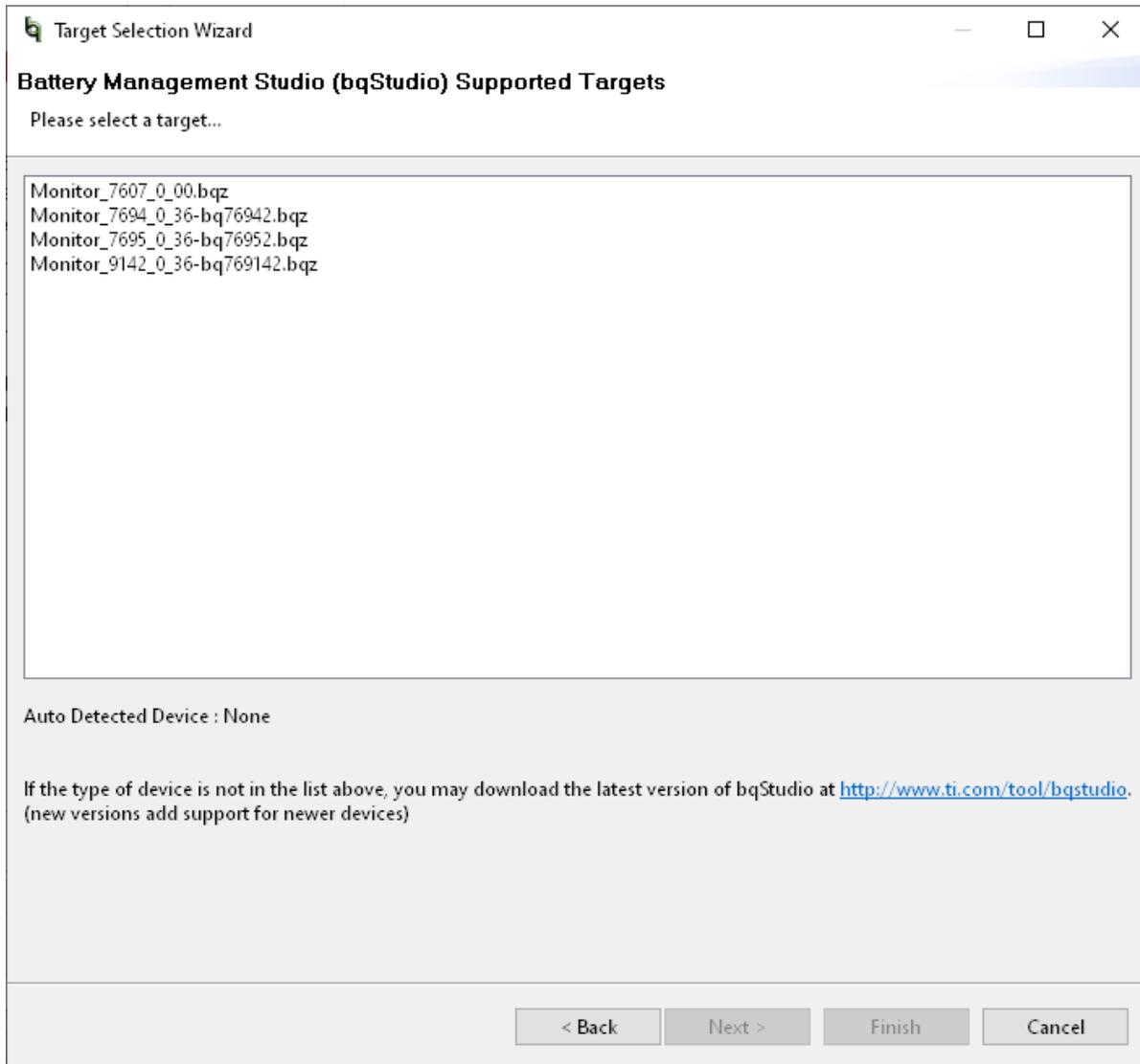
Figure 4-1. Target Selection Wizard

If the software was started without a communication interface adapter, then a Battery Management Studio pop-up 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's 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 panel of BQStudio displays tool tips when the cursor is held over an item name. The tool tip provides some description of the item. The tool tip closes after approximately 30 seconds. To avoid the tool tip display move the cursor to the value or units column, or to the *Dashboard* panel.
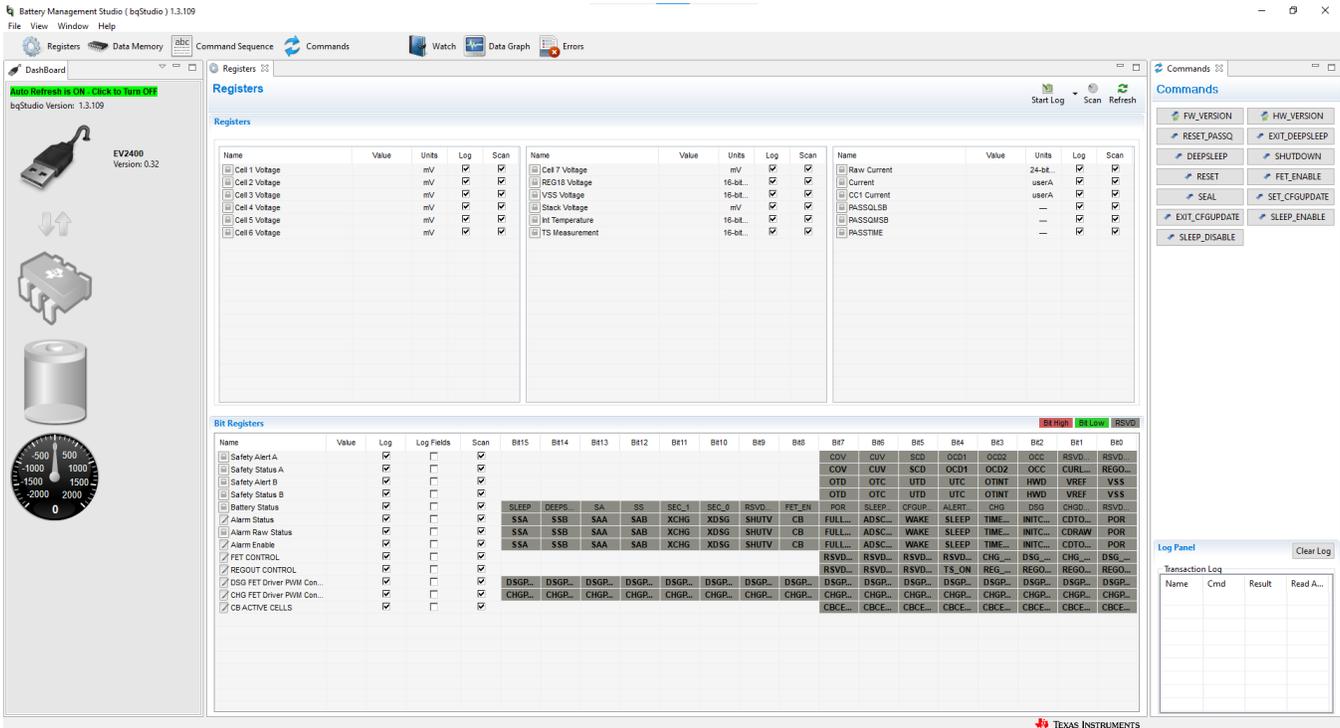
Figure 4-2. BQStudio Window without Device

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

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

The center panel of the window initially shows the *Registers* 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, then the dashboard auto-detects the device and update the device and register display. Figure 4-3 shows a register display with a connected device.
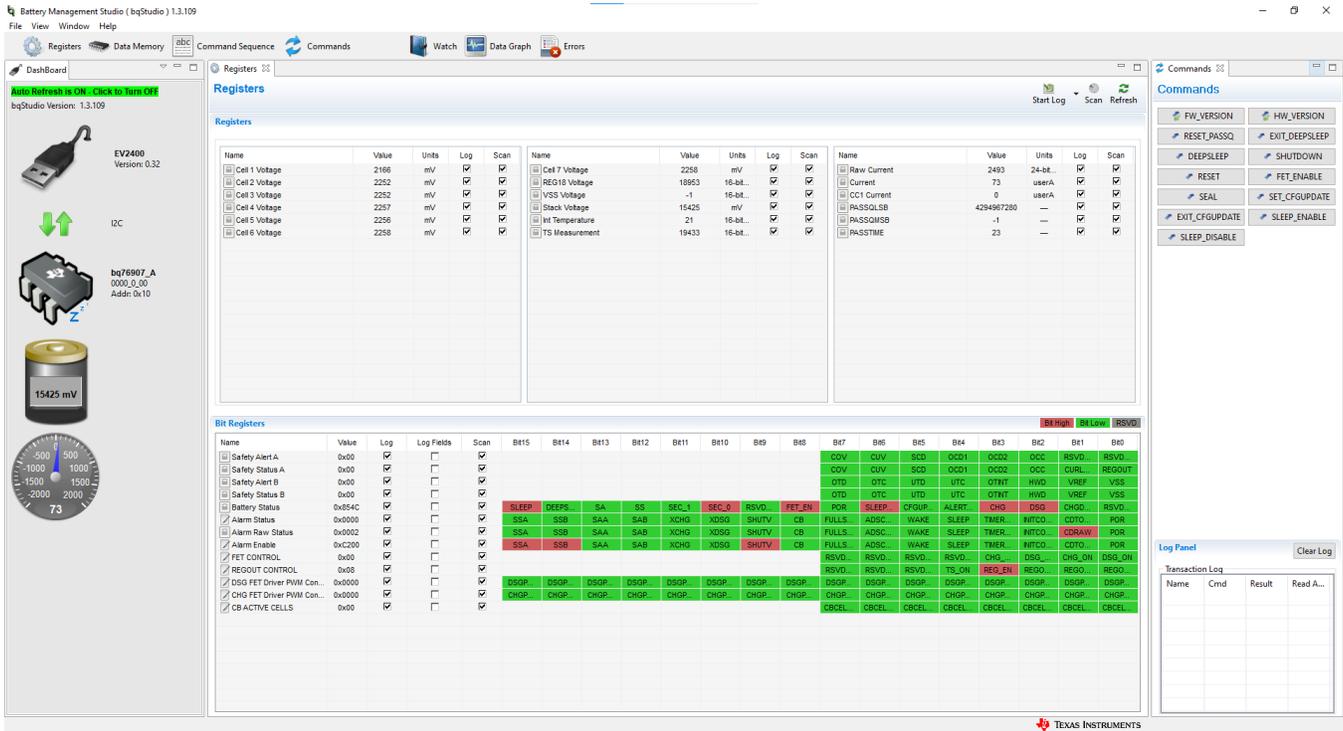
Figure 4-3. Register View with Device

The available tools for the device are shown at the top of the window and can be selected by clicking on the tool icon. Tools can also be selected from the *View* menu as shown in Figure 4-4. Opening a new tool can change the center tab of the window. Not all devices have all the tools described. Multiple tools can be active at one time, 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 can terminate the operation running in the tab.
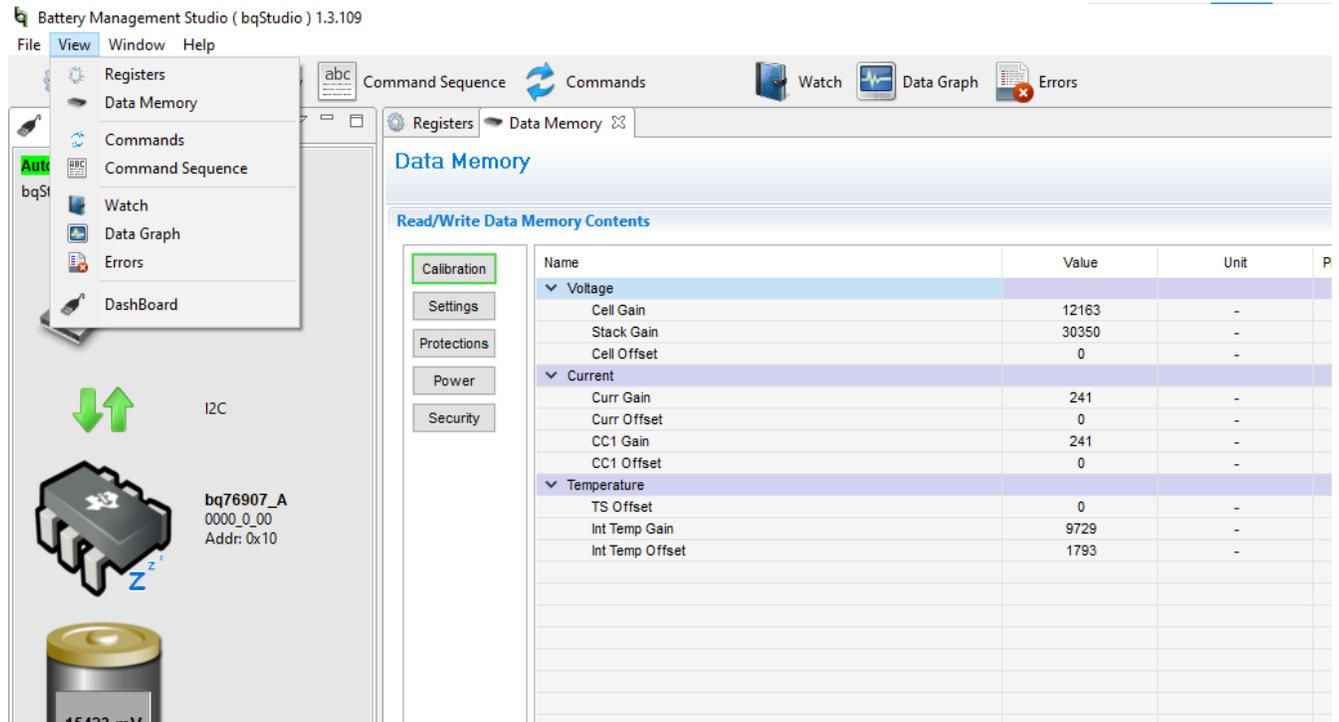
Figure 4-4. Tool Selections

4.1.5 Commands

The Commands tab is displayed on the right side of the BQStudio window. Buttons in this tab allow reading various information about the device and certain operations by sending a command to the device. 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.

4.1.6 Data Memory

The data memory tool is used to configure the device. Configuration files can be saved and loaded later to resume evaluation. At power up, the device is loaded with factory configurations. 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 panel. Other functional sections can be displayed by clicking on the named button.

Figure 4-5. Data Memory View

4.1.6.1 Entering, Saving, and Loading Configuration

Most of the configuration of the BQ76905 is accomplished through setting values in the data memory. The data memory locations are accessed using the buttons in the Data Memory view. The *Parameter View* selection at the top of the panel allows the choice of basic parameters, which shows commonly used parameters, or all parameters which shows more configuration parameters. Data values can be changed by selecting and entering a value. Parameter registers, which are bit fields, can be changed by selecting the bit in the pop up when the register or the value is selected. Data Memory must be written after bit changes, and 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.

Figure 4-6. Data Memory Bit Field Change

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

The *Export* tool in the Data Memory view 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 can be only in the view. The *Import* tool allows loading such a saved file into the view so that the file can be written to the device. The *Write All* tool writes all values in the view into registers in the device.

4.1.7 Command Sequences

Features are controlled by commands as described in the BQ76905 data sheet. Data is available from registers, and the registers view shows data, but a user can send specific commands to the device. The Command sequences tool allows this operation and is shown in Figure 4-7. The *Device Send and Receive* section allows read or write to a single or consecutive locations. The *Command Sequence* section allows reads and writes to be intermixed in a sequence. Sequences can be stored to files or called from files. Files can 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 4-7. Command Sequence View

5 Hardware Design Files

5.1 Schematic

Figure 5-1 through Figure 5-2 illustrate the schematics.
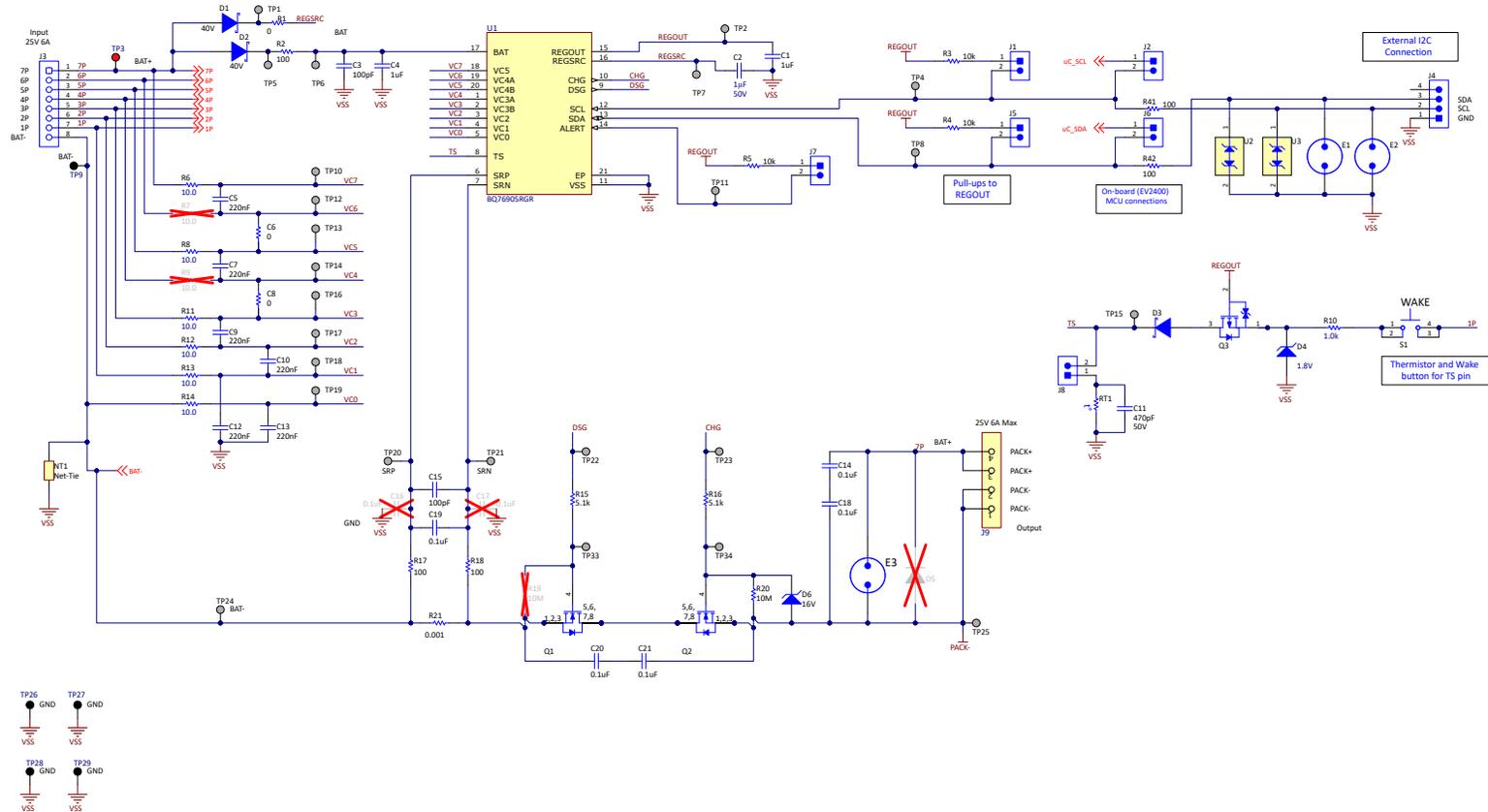
Figure 5-1. Schematic Diagram Monitor
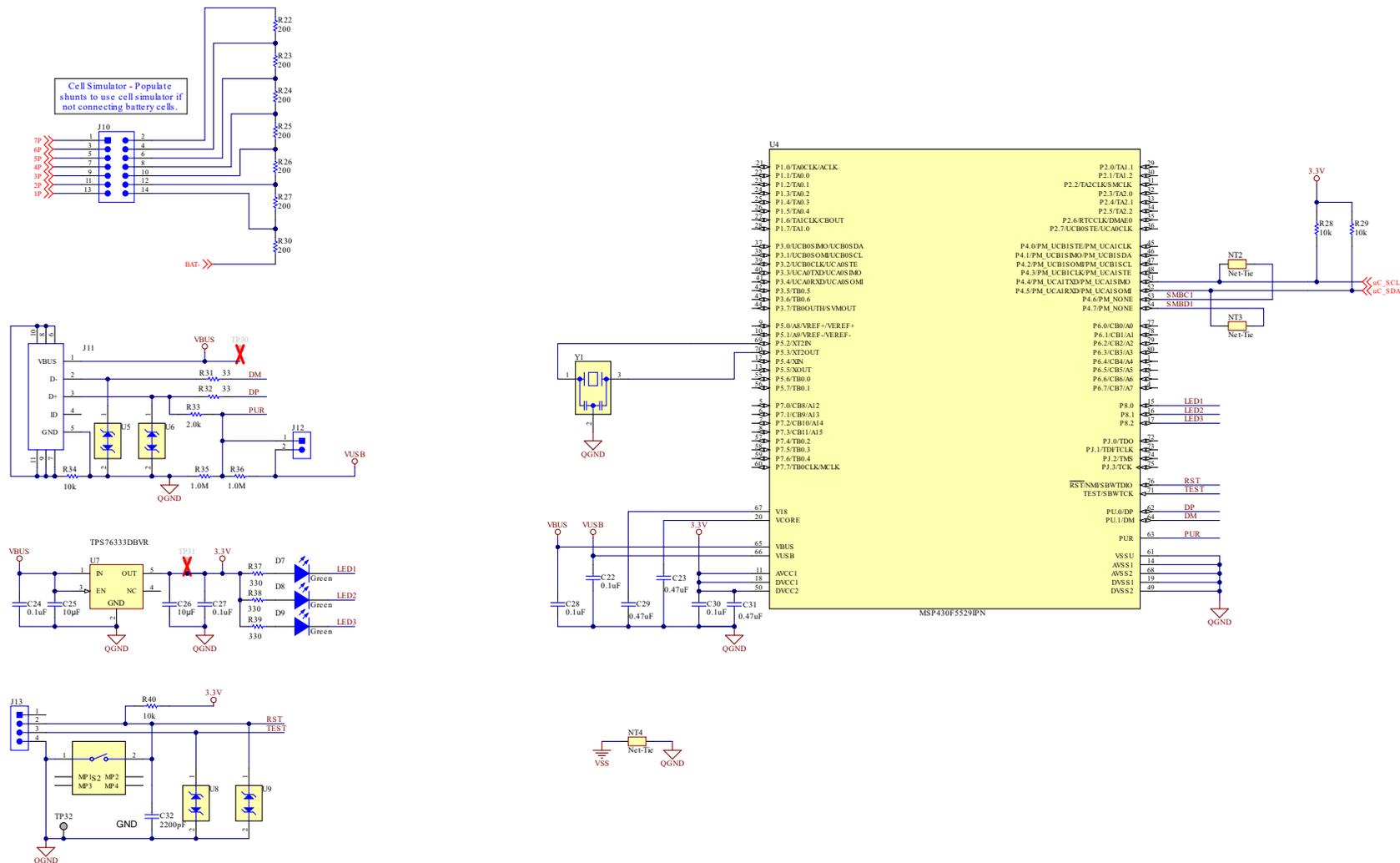
Figure 5-2. Schematic Diagram Adapter

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5.2 Board Layout

The BQ76905EVM circuit module is a 2.175-inch × 4.4-inch 2-layer circuit card assembly. The BQ76905EVM is designed for easy assembly with cell connections on the left edge to a terminal block. Pack terminals are on the bottom edge using a terminal block. Wide trace areas are used reducing voltage drops on the high current paths. An on-board interface adapter with USB connector is located in the right lower corner.

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

Figure 5-3. Top Layer

Figure 5-4. Bottom Layer

5.3 Bill of Materials

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

Table 5-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		BMS057	Any
C1	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0805	0805	EMK212B7105KG-T	Taiyo Yuden
C2	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	885012207103	Wurth Elektronik
C3, C15	2	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	C0603C101J5GACTU	Kemet
C4	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L3X7R1H105K160AB	TDK
C5, C7, C9, C10, C12, C13	6	0.22uF	CAP, CERM, 0.22 uF, 50 V, +/- 10%, X7R, 0603	0603	C1608X7R1H224K080AB	TDK
C6, C8	2	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
C11	1	470 pF	CAP, CERM, 470 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603C471K5RACTU	Kemet
C14, C18, C19, C20, C21	5	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	885012206095	Wurth Elektronik
C22, C24, C27, C28, C30	5	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	0402	885012205037	Wurth Elektronik
C23, C29, C31	3	0.47uF	CAP, CERM, 0.47 uF, 6.3 V, +/- 10%, X5R, 0402	0402	04026D474KAT2A	AVX
C25, C26	2	10uF	CAP, CERM, 10 μF, 16 V,+/- 10%, X5R, 0805	0805	CL21A106KOQNNNG	Samsung Electro-Mechanics
C32	1	2200 pF	CAP, CERM, 2200 pF, 10 V, +/- 10%, X7R, 0402	0402	885012205008	Wurth Elektronik
D1, D2, D3	3	40 V	Diode, Schottky, 40 V, 0.2 A, SOT-323	SOT-323	BAS40W-7-F	Diodes Inc.
D4	1	1.8V	Diode, Zener, 1.8 V, 500 mW, SOD-123	SOD-123		
D6	1	16 V	Diode, Zener, 16 V, 500 mW, SOD-123	SOD-123	MMSZ5246B-7-F	Diodes Inc.
D7, D8, D9	3	Green	LED, Green, SMD	LED_0603	150060VS75000	Wurth Elektronik
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1, J2, J5, J6, J7, J8	6		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J3	1		Terminal Block, 8x1, 3.5mm, TH	8x1 Terminal Block	OSTTE080161	On-Shore Technology
J4	1		Header (friction lock), 100mil, 4x1, R/A, TH	4x1 R/A Header	22/05/3041	Molex
J9	1		TERM BLOCK 3.5MM VERT 4POS PCB	HDR4	OSTTE040161	On Shore Technology
J10	1		Header, 100mil, 7x2, Tin, TH	Header, 7x2, 100mil, Tin	PEC07DAAN	Sullins Connector Solutions
J11	1		Receptacle, Micro-USB Type B, 0.65 mm, 5x1, R/A, Bottom Mount SMT	Receptacle, 0.65mm, 5x1, R/A, SMT	47346-1001	Molex
J12	1		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
J13	1		Header, 2.54mm, 4x1, Tin, TH	Header, 2.54mm, 4x1, TH	22284043	Molex
Q1, Q2	2	60 V	MOSFET, N-CH, 60 V, 172 A, DNK0008A (VSON-CLIP-8)	DNK0008A	CSD18532Q5B	Texas Instruments
Q3	1	-20V	MOSFET, P-CH, -20 V, -0.2 A, SOT-416	SOT-416		
R1	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R2, R17, R18	3	100	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100RJNEA	Vishay-Dale
R3, R4, R5, R28, R29	5	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale
R6, R8, R11, R12, R13, R14	6	10.0	RES, 10.0, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW120610R0FKEA	Vishay-Dale
R10	1	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K00JNEA	Vishay-Dale
R15, R16	2	5.1k	RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RC0603FR-072KL	Yageo
R20	1	10Meg	RES, 10 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310M0JNEA	Vishay-Dale
R21	1	0.001	RES, 0.001, 1%, 1 W, 1210	1210	PMR25HZPFV1L00	Rohm
R22, R23, R24, R25, R26, R27, R30	7	200	RES, 200, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206200RFKEA	Vishay-Dale
R31, R32	2	33	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233R0JNED	Vishay-Dale
R33	1	2.0k	RES, 2.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K00JNED	Vishay-Dale

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R34, R40	2	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0JNED	Vishay-Dale
R35, R36	2	1.0Meg	RES, 1.0 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M00JNED	Vishay-Dale
R37, R38, R39	3	330	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3300X	Panasonic
R41, R42	2	100	RES, 100, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206100RFKEA	Vishay-Dale
RT1	1	10k	Thermistor NTC, 10.0k ohm, 1%, Disc, 5x8.4 mm	Disc, 5x8.4 mm	103AT-2	SEMITEC Corporation
S1	1		Switch, Tactile, SPST-NO, SMT	Switch, 6.2X5X6.2 mm	KST221JLFS	C&K Components
S2	1		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	C&K Components
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11	11	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP3	1		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP9, TP26, TP27, TP28, TP29	5		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		2-s to 5-s High Accuracy Battery Monitor and Protector for Li-Ion, LiPolymer, and LiFePO4 Battery Packs	RGR20	BQ76905RGR	Texas Instruments
U2, U3	2		Single-Channel ESD in 0402 Package With 10 pF Capacitance and 6 V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYR	Texas Instruments
U4	1		25 MHz Mixed Signal Microcontroller with 128 KB Flash, 8192 B SRAM and 63 GPIOs, -40 to 85 degC, 80-pin QFP (PN), Green (RoHS & no Sb/Br)	PN0080A	MSP430F5529IPN	Texas Instruments
U5, U6, U8, U9	4		Single-Channel ESD in 0402 Package With 10 pF Capacitance and 6 V Breakdown, DPY0002A (X1SON-2)	DPY0002A		Texas Instruments

Table 5-1. Bill of Materials (continued)

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

6 Additional Information

Trademarks

Microsoft® and Windows® are registered trademarks of Microsoft Corporation.

All trademarks are the property of their respective owners.

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 DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3   *Regulatory Notices:*

3.1   *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2   *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に 輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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、上記の「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。 上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

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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/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送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。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

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.

        4.3.2   EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

    4.4   User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5.   *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6.   *Disclaimers:*

    6.1   EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

    6.2   EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7.   *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

 8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

 8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

IMPORTANT NOTICE AND DISCLAIMER