

# **BQ28Z620EVM 1- to 2-Series Li-Ion Battery Pack Manager Evaluation Module**

---



## **Table of Contents**

<b>1 BQ28Z620EVM 1- to 2-Series Li-Ion Battery Pack Manager Evaluation Module</b> .....	<b>2</b>
1.1 Features.....	2
1.2 BQ28Z620EVM Quick Start Guide.....	3
1.3 Battery Management Studio.....	6
1.4 Circuit Module Physical Layouts and Bill of Materials.....	15
<b>2 Revision History</b> .....	<b>19</b>

# 1 BQ28Z620EVM 1- to 2-Series Li-Ion Battery Pack Manager Evaluation Module

This evaluation module (EVM) is a complete evaluation system for the BQ28Z620 and BQ294502 battery management system. The EVM includes one BQ28Z620 and BQ294502 circuit module and a link to Windows® based PC software. The circuit module includes one BQ28Z620 integrated circuit (IC), one BQ294502 IC, and all other onboard components necessary to monitor and predict capacity, perform cell balancing, monitor critical parameters, protect the cells from overcharge, over-discharge, short-circuit, and over-current in 1- or 2-series cell Li-Ion or Li-Polymer battery packs. The circuit module connects directly across the cells in a battery. With the EV2400 interface board and software, the user can read the BQ28Z620 data registers, program the chipset for different pack configurations, log cycling data for further evaluation, and evaluate the overall functionality of the solution under different charge and discharge conditions using I2C communication protocol.

## 1.1 Features

- Complete evaluation system for the BQ28Z620EVM 1- to 2-Series Battery Pack Manager Evaluation Module and BQ294502 independent overvoltage protection IC
- Populated circuit module for quick setup
- Software that allows data logging for system analysis

### 1.1.1 Kit Contents

- BQ28Z620 circuit module
- Cable to connect the EVM to an EV2400 Communications Interface adapter

### 1.1.2 Ordering Information

For complete ordering information, see the product page at [www.ti.com](http://www.ti.com).

**Table 1-1. Ordering Information**

EVM PART NUMBER	CHEMISTRY	CONFIGURATION	MAX CAPACITY
BQ28Z620EVM	Li-Ion	1-, 2-cell	32,000 mAh

### 1.1.3 Documentation

For information on the BQ28Z620 and BQ294502 device firmware and hardware, see the following documentation:

- *BQ28Z620 Impedance Track™ Gas Gauge and Protection Solution for 1-Series to 2-Series Cell Li-Ion Battery Packs* ([SLUSET3](#))
- *BQ28Z620 Technical Reference Manual* ([SLUUCO9](#))
- *BQ2945xx Overvoltage Protection For 2-Series and 3-Series Cell Li-Ion Batteries* ([SLUSAJ3](#))
- *BQ294502 EVM User's Guide* ([SLUU659](#))

### 1.1.4 BQ28Z620 and BQ294502 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the BQ28Z620 EVM.

**Table 1-2. Performance Specification Summary**

SPECIFICATION	MINIMUM	TYPICAL	MAXIMUM	UNITS
Input voltage Pack+ to Pack–	3	7	25	V
Charge and discharge current	0	2	7	A

## 1.2 BQ28Z620EVM Quick Start Guide

This section provides the step-by-step procedures required to use a new EVM and configure it for operation in a laboratory environment.

### 1.2.1 Items Needed for EVM Setup and Evaluation

- BQ28Z620 circuit module
- EV2400 communications interface adapter
- Cable to connect the EVM to an EV2400 communications interface adapter
- USB cable to connect the communications interface adapter to the computer
- Computer setup with Windows® X, or higher operating system
- Access to the Internet to download the Battery Management Studio software setup program
- One or two battery cells or 1-k $\Omega$  resistors to configure a cell simulator
- A DC power supply that can supply 8.4 V and 2 A (constant current and constant voltage capability is desirable)

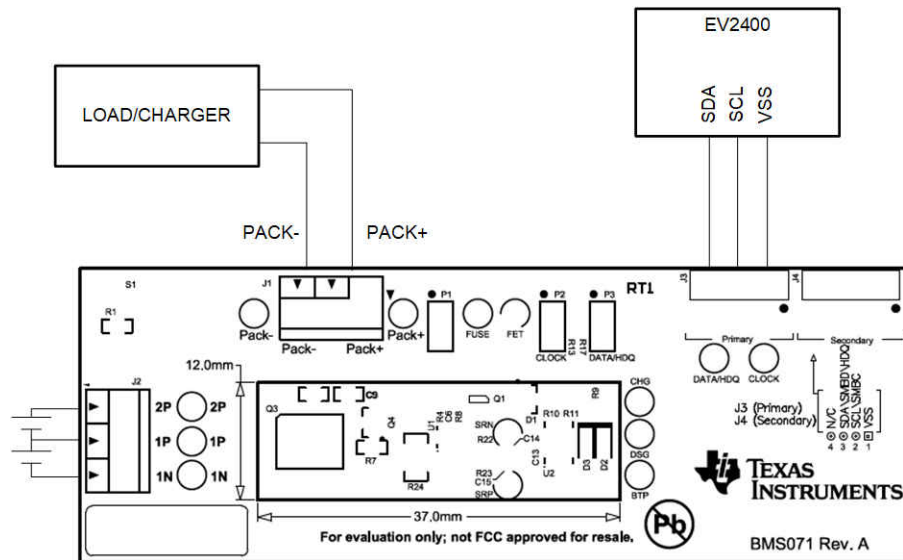
### 1.2.2 Software Installation

Find the latest software version in the BQ28Z620 tool folder on [www.ti.com](http://www.ti.com). Use the following steps to install the BQ28Z620 Battery Management Studio software:

1. Download and run the Battery Management Studio setup program from the Development Tools section of the BQ28Z620EVM product folder on [www.ti.com](http://www.ti.com). See [Section 1.3](#) for detailed information on using the tools in the Battery Management Studio.

### 1.2.3 EVM Connections Module Connections

This section covers the hardware connections for the EVM. See [Figure 1-1](#).



**Figure 1-1. BQ28Z620 Circuit Module Connection to Cells and System Load or Charger**

- Direct connection to the cells: 1N (BAT-), 1P, 2P (BAT+)

Attach the cells to the J2 terminal block. A specific cell connection sequence is not required, although it is a good practice to start with lowest cell in the stack (cell1) and then add cell 2. The U1 and U2 devices should not get damaged by other cell connection sequences, but there is a possibility that the BQ294502 could blow the fuse in a module that has one. Attaching cells starting with cell 1 should eliminate this risk.

Number of Cells	J2 Terminal Block Connections				
	1N		1P		2P
1	⊖	-cell1+	⊖	short	⊖
2	⊖	-cell1+	⊖	-cell2+	⊖

**Figure 1-2. Cell Connection Configuration**

A resistor cell simulator can be used instead of battery cells. Connect a resistor between each of the contacts on the J2 connector; that is, from 1N to 1P and from 1P to 2P. If being used for a 1-series configuration no resistor is needed, simply short 1P and 2P. A power supply can provide power to the cell simulator. Set the power supply to the desired cell voltage x the number of cells and attach the ground wire to 1N and the positive wire to 2P. For example, for a 2-series configuration with a 3.6-V cell voltage, set the power supply to  $2 \times 3.6 = 7.2$  V.

- I2C™ (SDA, SCL)

Attach the communications interface adapter cable to J3 and to the I2C™ port on the EV2400.

---

#### Note

The EV2400 has internal pull-up resistors, P2 and P3 jumpers can be left floating.

---

- System load and charger connections across PACK+ and PACK–

Attach the load or power supply to the J1 terminal block. The positive terminal of the load or power supply wire should be connected to the terminal block position labeled PACK+. The ground wire for the load or power supply should be connected to the other terminal block position labeled PACK–.

- Wake-up the device up from SHUTDOWN (WAKE)

Press the **Wake** pushbutton switch S1 to temporarily connect BAT+ to PACK+. This applies voltage to the PACK pin on the BQ28Z620 to power-up the regulators and start the initialization sequence.

- Parameter setup

The default data flash default settings is configured for 2-series Li-ion cells. The user should change the | Data Memory | Settings | DA Configuration register to set up the number of series cells to match the physical pack configuration by clearing the CCO flag for 1-series configuration or setting it for 2-series configuration. This provides basic functionality to the setup. Other data flash parameters should also be updated to fine tune the gauge to the pack. See the [BQ28Z620 Technical Reference Manual](#) for help with setting the parameters.

## 1.3 Battery Management Studio

### 1.3.1 Starting the Program

Run Battery Management Studio from the Start | Programs | Texas Instruments | Battery Management Studio sequence or the Battery Management Studio shortcut. As long as the device has been woken up from shutdown mode by momentarily pressing button **S1** or applying a charger voltage, the gauge will be automatically detected and the register screen will appear as seen in **Figure 1-3**. If your device contains an earlier firmware version, then auto detection of the device may not occur. If that happens, on the window that pops up as shown in **Figure 1-4**, select any BQ28Z620 variants. This action will enable the program to get started and the user can update the firmware using the latest .srec file for the device downloadable from the product folder of the gauge at [www.ti.com](http://www.ti.com).

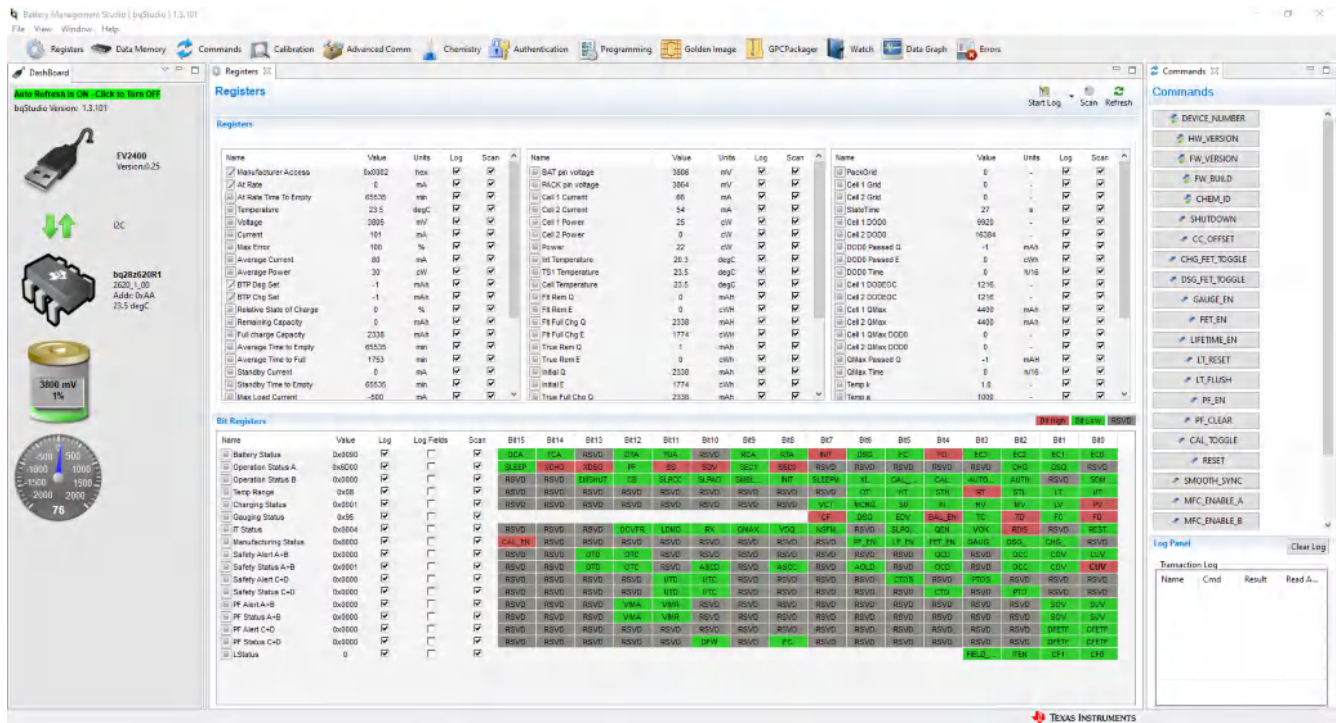
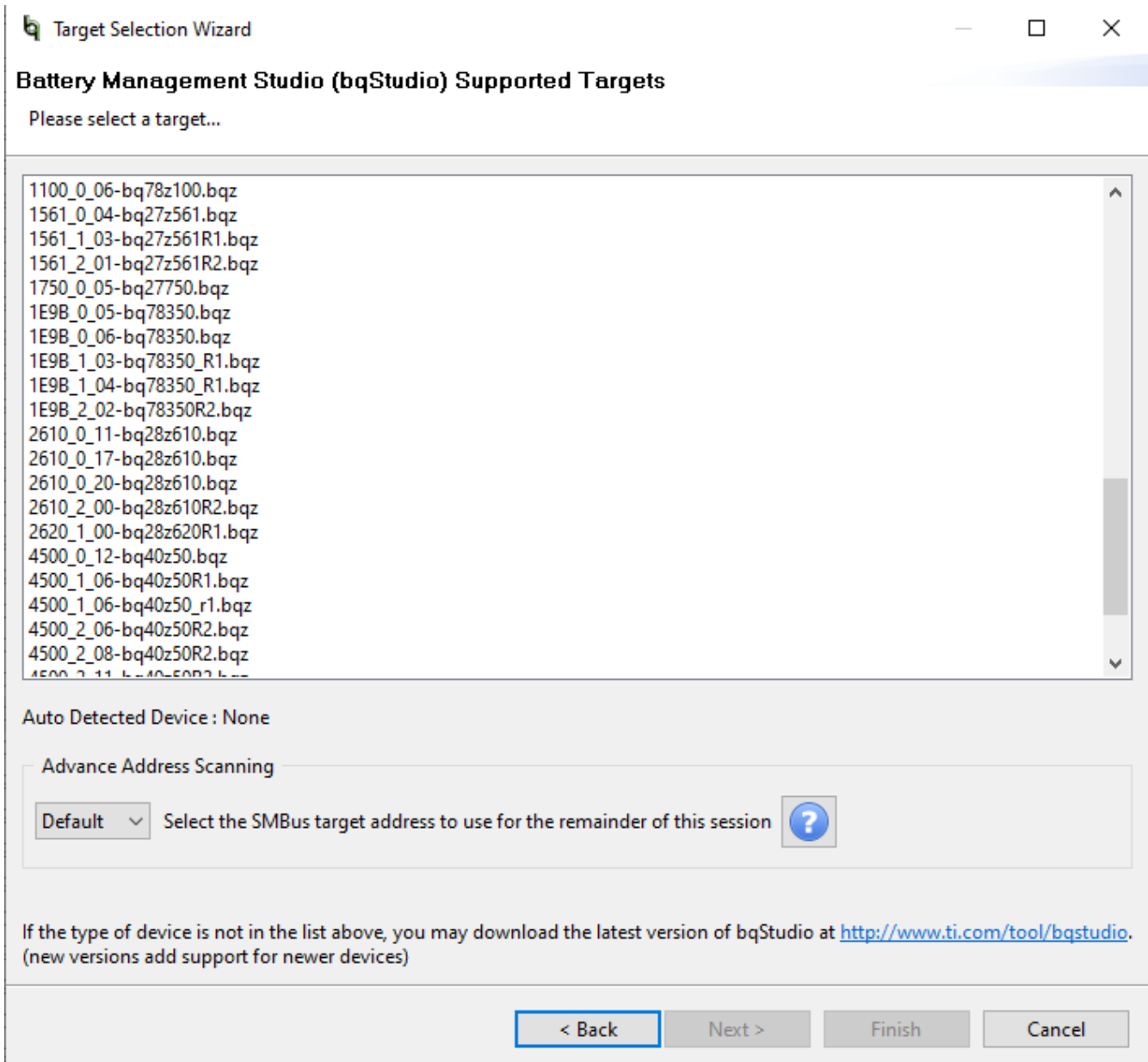


Figure 1-3. Registers Screen



**Figure 1-4. Battery Management Studio Supported Targets**

### 1.3.2 Registers Screen

The Registers section contains parameters used to monitor gauging. The Bit Registers section provides bit level picture of status and fault registers. A green flag indicates that the bit is 0 (low state) and a red flag indicates that the bit is 1 (high state). A greyed out bit indicated that bit is reserved. Data begins to appear once the **Refresh** (single-time scan) button is selected, or it scans continuously if the **Scan** button is selected. The continuous scanning period can be set via the | Windows |preferences| register selections. Please see [Register Screen](#) for green and red flags reference.

The Battery Management Studio program provides a logging function which logs all the values of the parameters in the Register section if running the program in “Show basic view mode”. In order to selectively choose the parameters of Register section that are scanned and logged, the user needs to set Battery Management Studio to “Show Advanced view mode”. This mode can be set via | Windows |preferences| All Global Settings| Show Advanced Views. Uncheck the fields that are not needed to be scanned or logged. To enable logging, select the **Log** button; this causes the **Scan** button to be selected. When logging is stopped, the **Scan** button is still selected and has to be manually deselected.

### 1.3.3 Data Memory Screen

The BQ28Z620 data flash comes configured per the default settings detailed in the BQ28Z620 TRM. Ensure that the settings are correctly changed to match the pack and application for the solution being evaluated. For ease of configuration, a text file with a gg.csv extension can be extracted, modified and imported back on the device. Use the export and import buttons as seen in [Data Memory Screen](#) to export and import gg.csv files. The auto export button enables gg files to be exported periodically at intervals. This is useful when debugging issues with the gauge. A write all command is necessary if a gg.csv file is imported to ensure that all the changes made on the gg.csv file are effected on the gauge. The read all command is used to read back all of the data written to the gauge so that the changes made can be verified. The filter/search field enables the user to search for a particular parameter in the data memory content.

#### Note

Do not make modifications to the gg.csv file using Microsoft Excel® as it makes changes to file, which BQStudio rejects. Make sure to use a text editor like notepad or similar to edit a gg.csv file.

Name	Value	Unit	Physical Start Addr...	Data Length	Row Number	Row Offset	Native Units
<b>Current Thresholds</b>							
Dsg Current Threshold	100	mA	0x46a1	2	53	1	mA
Chg Current Threshold	50	mA	0x46a3	2	53	3	mA
Quit Current	10	mA	0x46a5	2	53	5	mA
Dsg Relax Time	1	s	0x46a7	1	53	7	s
Chg Relax Time	60	s	0x46a8	1	53	8	s
<b>Standby</b>							
StandbyCurrent	-10	mA	0x4618	2	48	24	mA
<b>Max Load</b>							
Max Load Current	-500	mA	0x461a	2	48	26	mA
Max Load Raoc	50	%	0x461c	1	48	28	%
<b>Design</b>							
Design Capacity mAh	4400	mAh	0x4625	2	49	5	mAh
Design Capacity cWh	6336	cWh	0x4627	2	49	7	cWh
Design Voltage	7200	mV	0x4629	2	49	9	mV
<b>Cycle</b>							
Cycle Count Percentage	90	%	0x462b	1	49	11	%
<b>FD</b>							
Set Voltage Threshold	3000	mV	0x4630	2	49	16	mV
Clear Voltage Threshold	3100	mV	0x4632	2	49	18	mV
Set % RSOC Threshold	0	%	0x4634	1	49	20	%
Clear % RSOC Threshold	5	%	0x4635	1	49	21	%
<b>FC</b>							
Set Voltage Threshold	4200	mV	0x4636	2	49	22	mV
Clear Voltage Threshold	4100	mV	0x4638	2	49	24	mV
Set % RSOC Threshold	100	%	0x463a	1	49	26	%
Clear % RSOC Threshold	95	%	0x463b	1	49	27	%
<b>TD</b>							
Set Voltage Threshold	3200	mV	0x463c	2	49	28	mV
Clear Voltage Threshold	3300	mV	0x463e	2	49	30	mV
Set % RSOC Threshold	6	%	0x4640	1	50	0	%
Clear % RSOC Threshold	8	%	0x4641	1	50	1	%
<b>TC</b>							
Set Voltage Threshold	4200	mV	0x4642	2	50	2	mV
Clear Voltage Threshold	4100	mV	0x4644	2	50	4	mV
Set % RSOC Threshold	100	%	0x4646	1	50	6	%
Clear % RSOC Threshold	95	%	0x4647	1	50	7	%
<b>State</b>							
Cycle Count	0	-	0x4240	2	18	0	-
SOH Temp k	1.00	°C/256mW	0x4723	2	57	3	0.1 °C/256cW
SOH Temp a	1000	s	0x4725	2	57	5	s
Qmax Cell 1	4400	mAh	0x4206	2	16	6	mAh
Qmax Cell 2	4400	mAh	0x4208	2	16	8	mAh
Qmax Pack	4400	mAh	0x420a	2	16	10	mAh
Qmax Cycle Count	0	-	0x420c	2	16	12	-

Figure 1-5. Data Memory Screen

#### Note

To see the Data Memory Screen with Physical Start Address, Data Length, Row Number, Row Offset, and Native Units tabs. Please navigate to Window -> Preferences -> All Global Settings -> Show Advanced Views -> Apply -> OK

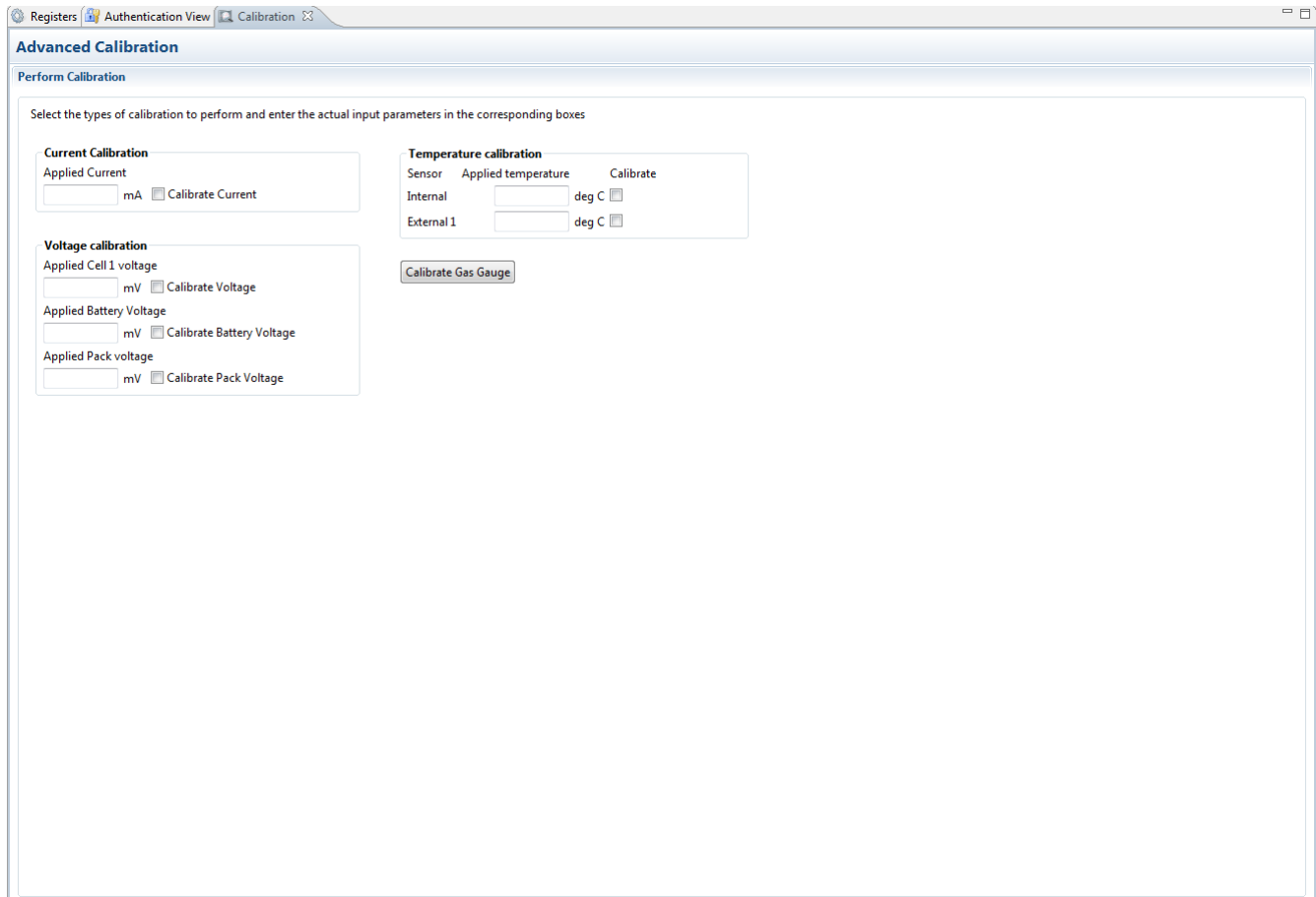


### 1.3.4 Calibration Screen

The voltages, temperatures, and currents should be calibrated to provide good gauging performance. Press the **Calibration** button while in the “Show Advanced view mode” to select the **Advanced Calibration** window. See [Figure 1-6](#). If in the “Show basic view mode”, the basic calibration window shows when the **Calibration** button is clicked. The **Advanced Calibration** window enables the internal temperature sensor as well as the external thermistor to be calibrated.

**Note**

For best results, please use a power supply with a 1mV and 1mA accuracy.



**Figure 1-6. Calibration Screen**

#### 1.3.4.1 Voltage Calibration

- Measure the voltage from Cell 1 to 1N and enter this value in the *Applied Cell 1 Voltage* field and select the **Calibrate Voltage** box.
- Measure the voltage from Bat+ (2P) to Bat– (1N) and enter this value in the *Applied Battery Voltage* field and select the **Calibrate Battery Voltage** box.
- Measure the voltage from Pack+ to Pack– and enter this value in the *Applied Pack Voltage* field and select the **Calibrate Pack Voltage** box. If the voltage is not present, then turn the charge and discharge FETs on by entering a 0x22 command in the Manufacturer Access register on the **Register** screen.
- Press the **Calibrate Gas Gauge** button to calibrate the voltage measurement system.
- Deselect the **Calibrate Voltage**

#### 1.3.4.2 Temperature Calibration

- Enter the room temperature in each of the *Applied Temperature* fields and select the **Calibrate** box for each thermistor to be calibrated. The temperature values must be entered in degrees Celsius.
- Press the **Calibrate Gas Gauge** button to calibrate the temperature measurement system.
- Deselect the **Calibrate** boxes after temperature calibration has completed.

#### 1.3.4.3 Current Calibration

The Board Offset calibration option is not offered in Battery Management Studio, because it is not required when using the BQ28Z620EVM. The Board Offset calibration option is available in BQProduction.

- Connect and measure a 2-A current source from 1N (–) and Pack– to calibrate without using the FETs. (TI does not recommend calibration using the FETs.)
- Enter –2000 in the *Applied Current* field and select the **Calibrate Current** box.
- Press the **Calibrate Gas Gauge** button to calibrate.
- Deselect the **Calibrate Current** box after current calibration has completed.

### 1.3.5 Authentication Screen

The BQ28Z620 supports SHA-1 HMAC authentication with the host system. The authentication screen of BQStudio allows for the SHA-1 calculator to be tested, perform gauge authentication by the host and change the gauge authentication key.

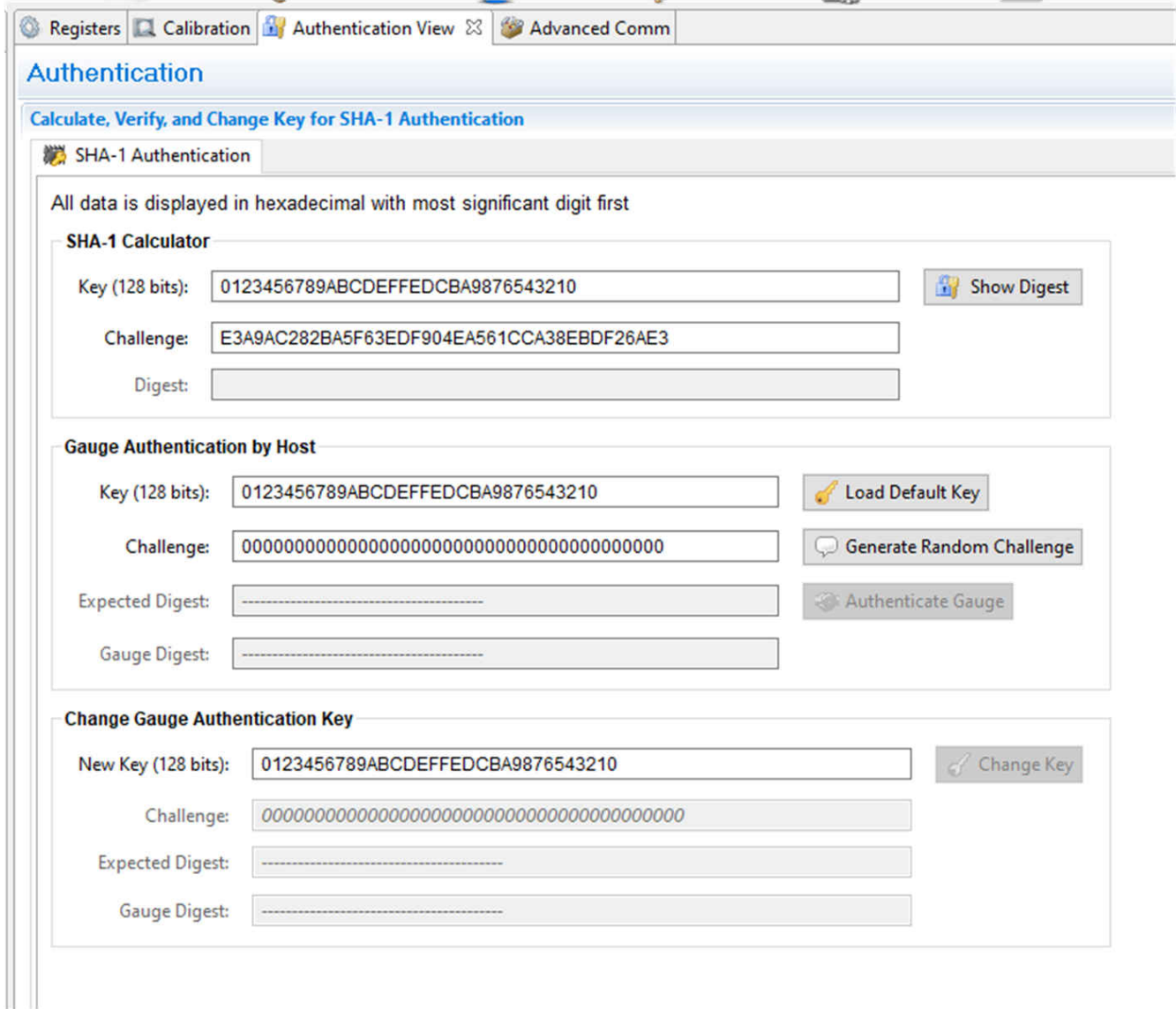


Figure 1-7. Authentication Screen

### 1.3.6 Chemistry Selection

The chemistry file contains parameters that the simulations use to model the cell and its operating profile. It is critical to program a Chemistry ID that matches the cell into the device. Some of these parameters can be viewed in the Data Flash section of the Battery Management Studio.

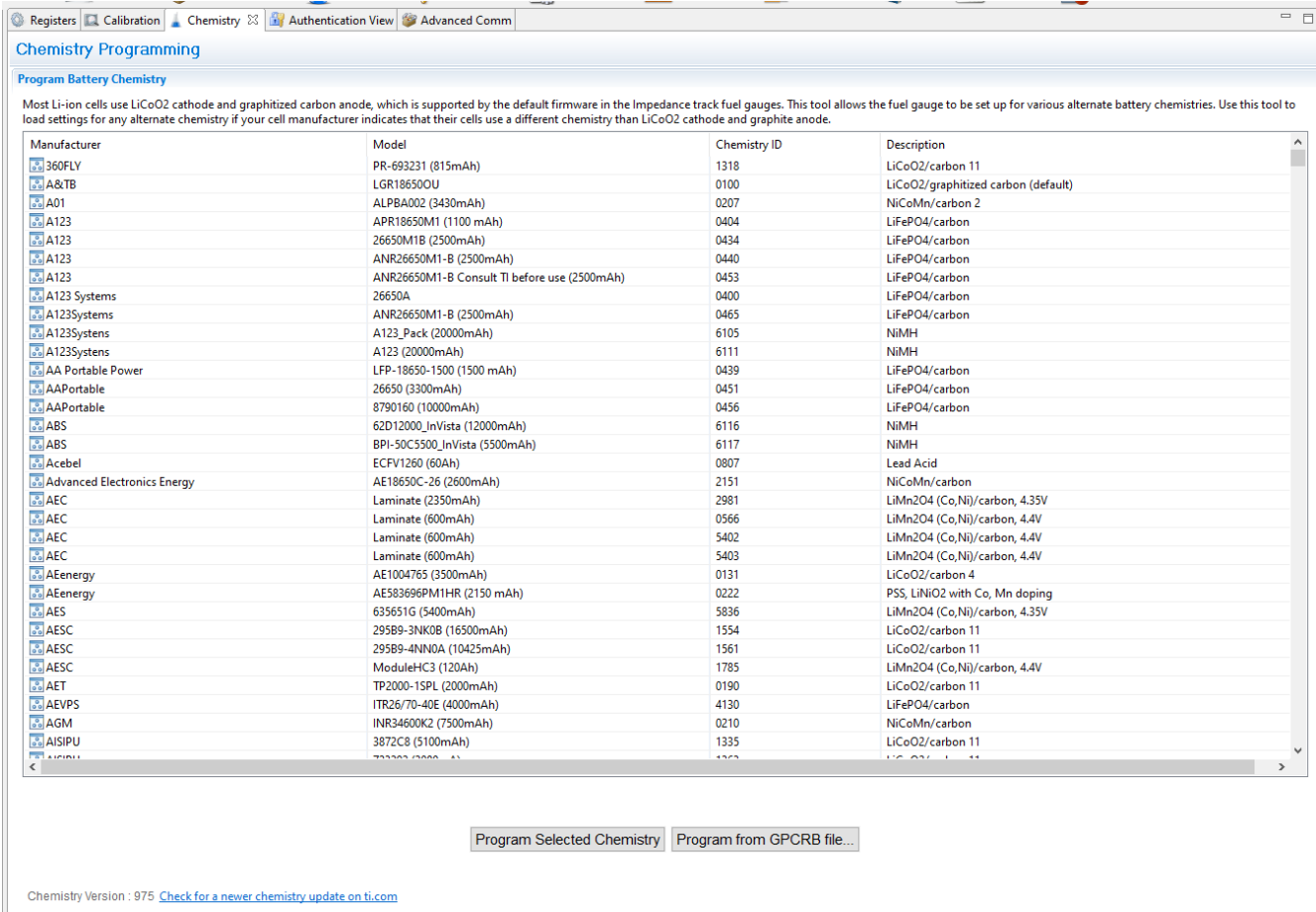
Press the **Chemistry** button to select the **Chemistry** window.

- The table can be sorted by clicking the desired column. For example: Click the *Chemistry ID* column header.
- Select the ChemID that matches your cell from the table (see [Figure 1-8](#)).
- Press **Update Chemistry from Database** to update the chemistry in the device.

#### Note

In the bottom of the [Chemistry Screen](#), there is a link for chemistry updater. Make sure the latest Chemistries from our database is being used. Please see this [FAQ](#) on how to update the chemistry table.

Remember to use our [GPCCHEM](#) tool to match the cell chemistry to one of our database.



**Chemistry Programming**

Program Battery Chemistry

Most Li-ion cells use LiCoO<sub>2</sub> cathode and graphitized carbon anode, which is supported by the default firmware in the Impedance track fuel gauges. This tool allows the fuel gauge to be set up for various alternate battery chemistries. Use this tool to load settings for any alternate chemistry if your cell manufacturer indicates that their cells use a different chemistry than LiCoO<sub>2</sub> cathode and graphite anode.

Manufacturer	Model	Chemistry ID	Description
360FLY	PR-693231 (815mAh)	1318	LiCoO <sub>2</sub> /carbon 11
A&TB	LGR18650OU	0100	LiCoO <sub>2</sub> /graphitized carbon (default)
A01	ALPBA002 (3430mAh)	0207	NiCoMn/carbon 2
A123	APR18650M1 (1100 mAh)	0404	LiFePO <sub>4</sub> /carbon
A123	26650M1B (2500mAh)	0434	LiFePO <sub>4</sub> /carbon
A123	ANR26650M1-B (2500mAh)	0440	LiFePO <sub>4</sub> /carbon
A123	ANR26650M1-B Consult TI before use (2500mAh)	0453	LiFePO <sub>4</sub> /carbon
A123 Systems	26650A	0400	LiFePO <sub>4</sub> /carbon
A123Systems	ANR26650M1-B (2500mAh)	0465	LiFePO <sub>4</sub> /carbon
A123Systems	A123_Pack (20000mAh)	6105	NiMH
A123Systems	A123 (20000mAh)	6111	NiMH
AA Portable Power	LFP-18650-1500 (1500 mAh)	0439	LiFePO <sub>4</sub> /carbon
AAPortable	26650 (3300mAh)	0451	LiFePO <sub>4</sub> /carbon
AAPortable	8790160 (10000mAh)	0456	LiFePO <sub>4</sub> /carbon
ABS	62D12000_InVista (12000mAh)	6116	NiMH
ABS	BPI-50C5500_InVista (5500mAh)	6117	NiMH
Acebel	ECFV1260 (60Ah)	0807	Lead Acid
Advanced Electronics Energy	AE18650C-26 (2600mAh)	2151	NiCoMn/carbon
AEC	Laminate (2350mAh)	2981	LiMn <sub>2</sub> O <sub>4</sub> (Co,Ni)/carbon, 4.35V
AEC	Laminate (600mAh)	0566	LiMn <sub>2</sub> O <sub>4</sub> (Co,Ni)/carbon, 4.4V
AEC	Laminate (600mAh)	5402	LiMn <sub>2</sub> O <sub>4</sub> (Co,Ni)/carbon, 4.4V
AEC	Laminate (600mAh)	5403	LiMn <sub>2</sub> O <sub>4</sub> (Co,Ni)/carbon, 4.4V
AEnergy	AE1004765 (3500mAh)	0131	LiCoO <sub>2</sub> /carbon 4
AEnergy	AE583696PM1HR (2150 mAh)	0222	PSS, LiNiO <sub>2</sub> with Co, Mn doping
AES	635651G (5400mAh)	5836	LiMn <sub>2</sub> O <sub>4</sub> (Co,Ni)/carbon, 4.35V
AESC	295B9-3NK0B (16500mAh)	1554	LiCoO <sub>2</sub> /carbon 11
AESC	295B9-4NN0A (10425mAh)	1561	LiCoO <sub>2</sub> /carbon 11
AESC	ModuleHC3 (120Ah)	1785	LiMn <sub>2</sub> O <sub>4</sub> (Co,Ni)/carbon, 4.4V
AET	TP2000-1SPL (2000mAh)	0190	LiCoO <sub>2</sub> /carbon 11
AEVPS	ITR26/70-40E (4000mAh)	4130	LiFePO <sub>4</sub> /carbon
AGM	INR34600K2 (7500mAh)	0210	NiCoMn/carbon
AlSIPU	3872C8 (5100mAh)	1335	LiCoO <sub>2</sub> /carbon 11

Chemistry Version : 975 [Check for a newer chemistry update on ti.com](#)

**Figure 1-8. Chemistry Screen**

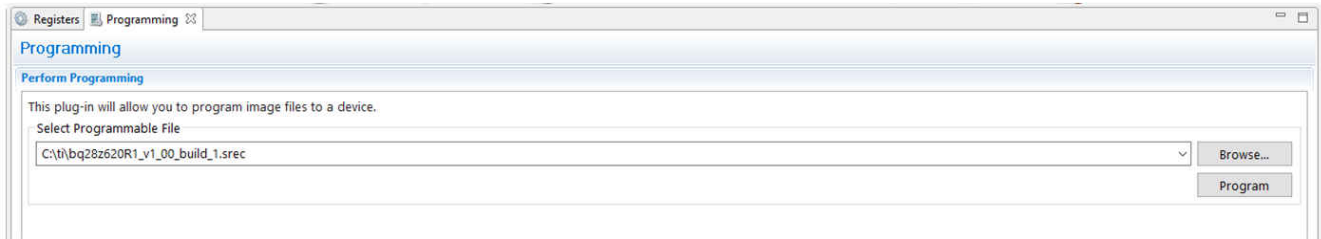
### 1.3.7 Programming Screen

Press the **Programming** button to select the **Programming** window. This window allows the user to import the device firmware.

#### 1.3.7.1 Programming the Flash Memory

The upper section of the Programming screen is used to initialize the device by loading the default .srec into the flash memory (see [Figure 1-9](#)).

- Search for the .srec file using the **Browse** button.
- Press the **Program** button and wait for the download to complete.
  - The updated version should be displayed on the left dashboard window within 2 minutes after programming has been completed. If not, reboot BQStudio.
  - It is recommended to reboot BQStudio after programming the new firmware.

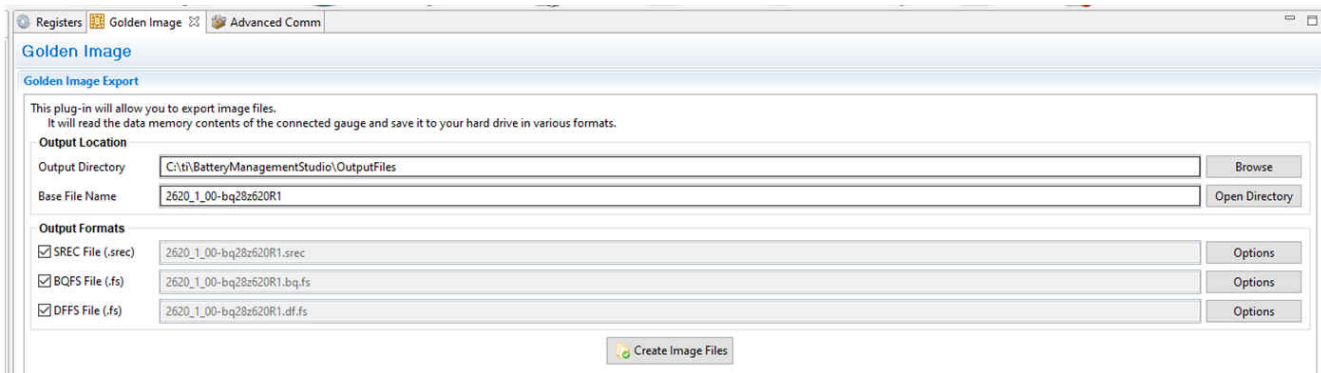


**Figure 1-9. Programming Screen**

#### 1.3.7.2 Generating The Golden Image

The lower section of the Golden Image Screen is used to export all of the flash memory from the device (see [Figure 1-10](#)).

- Press the **Browse** button to navigate to where the flash file will be saved.
- Press the *Open Directory* to rename the flash memory file.
- In the *Output Formats* sub-tab, check the desired types of flash files to be exported.



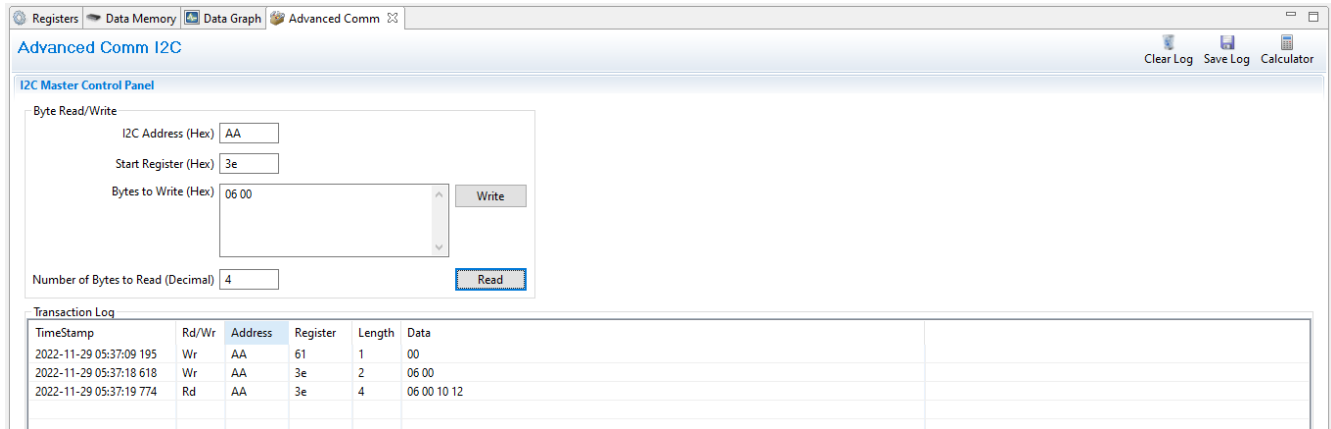
**Figure 1-10. Golden Image Screen**

### 1.3.8 Advanced Comm I<sup>2</sup>C Screen

Press the **Advanced Comm I<sup>2</sup>C** button to select the **Advanced Comm I<sup>2</sup>C** window. This tool provides access to parameters using I<sup>2</sup>C and Manufacturing Access commands. See [Figure 1-11](#) . The transaction log screen shows the history of sent commands.

#### Note

I<sup>2</sup>C commands are sent in Little Endian format.



**Figure 1-11. Advanced Comm I<sup>2</sup>C Screen**

#### Examples:

Reading an I<sup>2</sup>C Command.

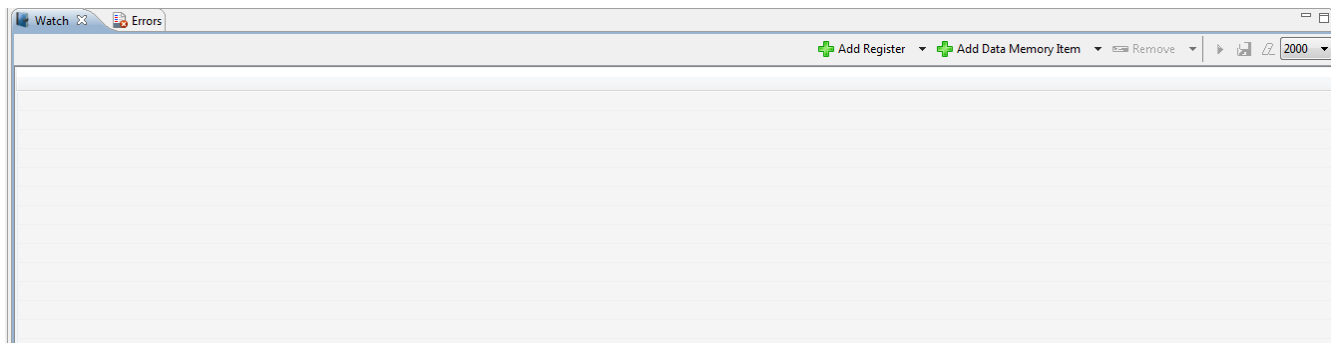
- Read chemical ID (0x 0006).
  - Make sure the device is unsealed
  - Write 0x00 using BlockDataControl() command (0x61) to enable block data flash control. (wr 0x61 0x00)
  - Write to mac address 0x3e Command 0x06 0x00 (see [Figure 1-11](#)).
  - Read 4 bytes.
  - The result returned is 0x10 0x12, which is little endian for chem id 1210.

Sending a MAC *Gauging()* to enable IT via *ManufacturerAccess()*.

- With Impedance Track™ disabled, send *Gauging()* (0x0021) to *ManufacturerAccess()*.
  - Write to mac address 0x3e command 0x21 0x00 (see [Figure 1-11](#)).

### 1.3.9 Watch Screen

This enables monitoring of specific registers and data memory items at user specified time intervals. By clicking the add register or add data memory item, these will be added to the table of values to be tracked.



**Figure 1-12. Watch Screen**

## 1.4 Circuit Module Physical Layouts and Bill of Materials

This section contains the printed-circuit board (PCB) layout, bill of materials, and assembly drawings for the BQ28Z620/BQ294502 circuit modules.

### 1.4.1 Board Layout

This section shows the dimensions, PCB layers (see [Figure 1-13](#) through [Figure 1-18](#)), and assembly drawing for the BQ28Z620 modules.

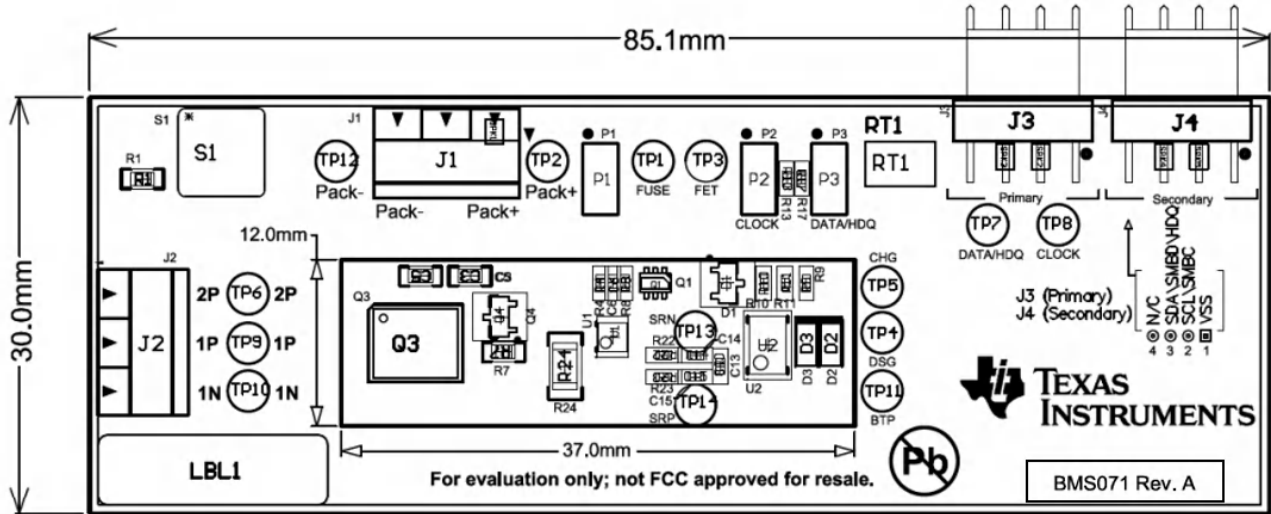


Figure 1-13. Top Silk Screen

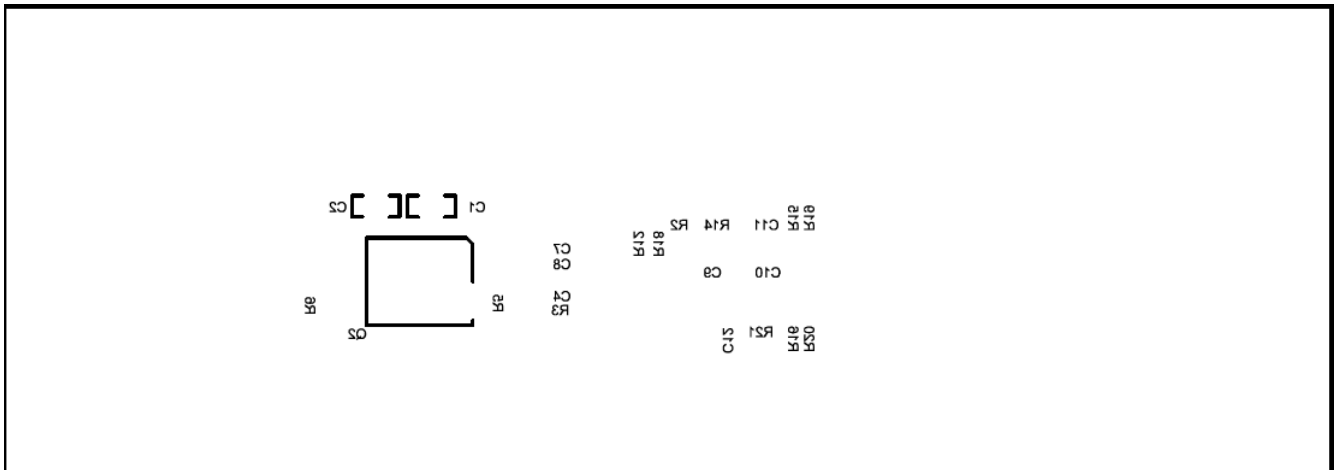
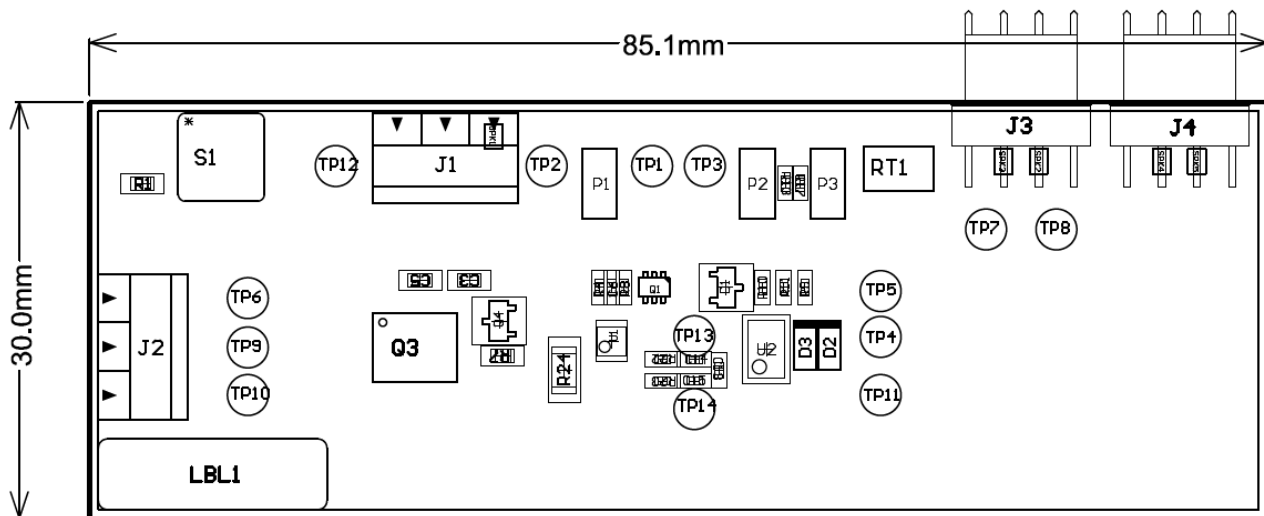
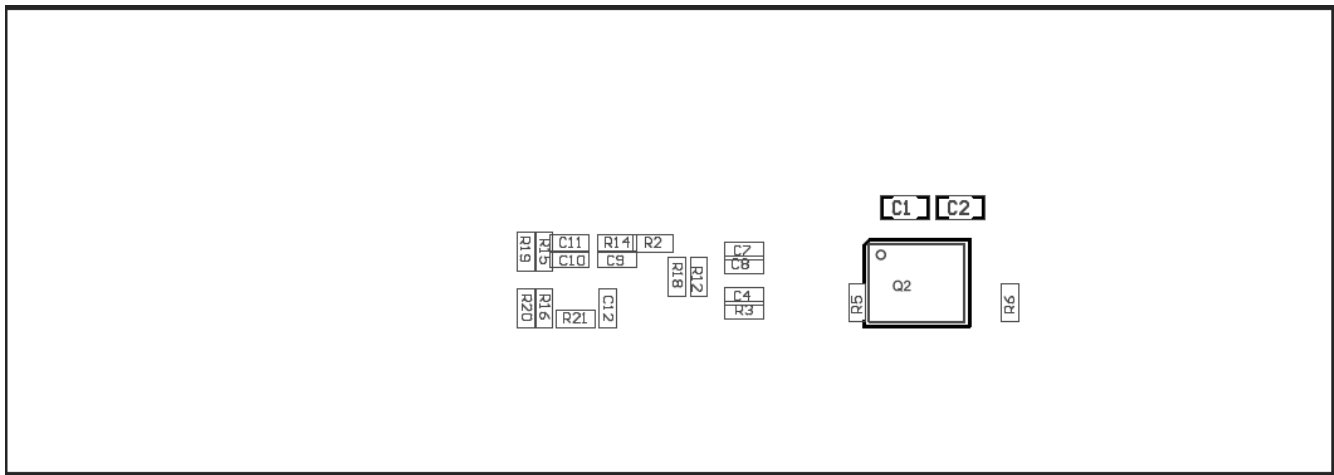


Figure 1-14. Bottom Silk Screen



**Figure 1-15. Top Assembly**



**Figure 1-16. Bottom Assembly**



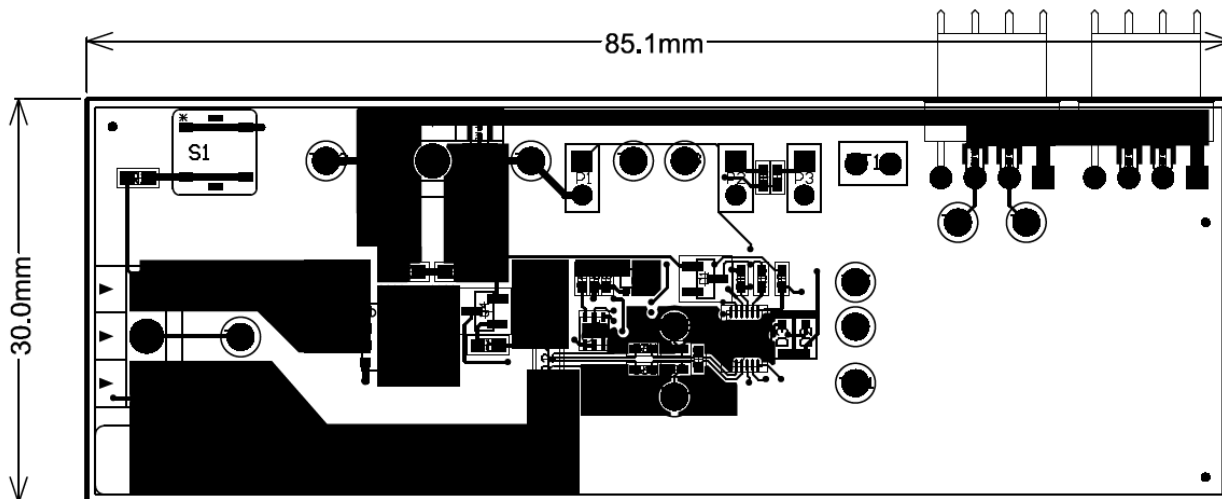


Figure 1-17. Top Layer

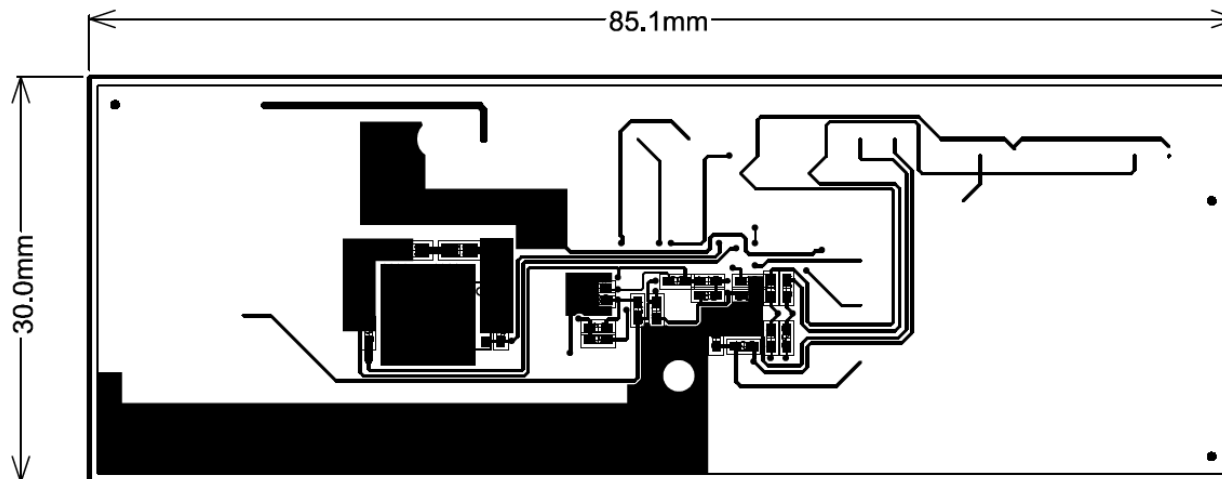


Figure 1-18. Bottom Layer

## 1.4.2 Bill of Materials

### Note

The BQ294502 secondary protector used on this evaluation module has a max OVP of 4.35 V. If higher OVP is needed, please check the BQ2945x family devices.

Qty	Value	Ref Des	Package_Case	Manufacturer	Manufacturer Part No
1	BMS071	!PCB1	24146	Krypton Solutions	KS 24146
4	0.1 $\mu$ F	C1, C2, C3, C5	0603	Samsung Electro-Mechanics	CL10B104KB8NNNL
6	0.1 $\mu$ F	C4, C6, C7, C8, C10, C13	0402	Murata Electronics North America	GRM155R71C104KA88D
1	1.0 $\mu$ F	C9	0402	Samsung Electro-Mechanics America, Inc.	CL05A105K05NNND
1	2.2 $\mu$ F	C11	0402	TDK Corporation	C1005X5R1E225K050BC
1	Single (Standard) - 75V	D1	SOT-23-3	Diodes Inc	BAS16-7-F
2	Single (Zener) - 5.6V	D2, D3	SOD-323F	ON Semiconductor	MM3Z5V6C
2	Black 3 Pin Female R/A	J1, J2	3.5mm 16-28 AWG	On Shore Technology Inc	ED555/3DS
1	1 X 4 R/A Shrouded - 1 Wall	J3	0.1	Molex Inc	22-05-3041
3	1 x 2	P1, P2, P3	0.1	Samtec Inc	HTSW-102-07-G-S
1	MOSFET N-CH 30V	Q1	6-TSSOP	Vishay Siliconix	SI1416EDH-T1-GE3
2	MOSFET N-Channel	Q2, Q3	8-SON	Texas Instruments	CSD16412Q5A
1	MOSFET N-Channel, 6pF	Q4	SOT-23-3	Micro Commercial Co	2N7002K-T1-E3
1	1.00K	R1	0603	Yageo	RC0603FR-071KL
8	100 Ohm	R2, R15, R16, R18, R19, R20, R22, R23	0402	Yageo	RC0402FR-07100R
3	1.00k ohm	R3, R4, R12	0402	Vishay Dale	CRCW04021K00FKE D
2	10.0M	R5, R6	0402	Vishay Dale	CRCW040210M0FKE D
1	10.0K	R7	0603	Yageo	RC0603FR-0710KL
1	100k ohm	R8	0402	Yageo	RC0402FR-07100KL
4	5.10K	R9, R10, R13, R17	0402	Yageo	RC0402FR-075K1L
1	10.0 Ohm	R11	0402	Yageo	RC0402FR-0710RL
1	4.99 ohm	R14	0402	KOA Speer Electronics, Inc.	RK73H1ETTP4R99F
1	0.001	R24	1206	Stackpole	CSNL1206FT1L00
1	10.0K ohm	RT1	P2.54 3.7 mm W x 17 mm L x 2.4 mm H	Semitec	103AT-2-

1	PB SPST-NO Off-Mom	S1	4.90mm x 4.90mm	Panasonic Electronic Components	EVQ-PLHA15
10	Test Loop - Black	TP1, TP3, TP4, TP5, TP7, TP8, TP10, TP12, TP13, TP14	0.040	Keystone Electronics	5001
3	Test Loop - Red	TP2, TP6, TP9	0.040	Keystone Electronics	5000
1	BQ294502DRV	U1	6-SON	Texas Instruments	BQ294502DRV
1	BQ28Z620DRZ	U2	DRZ0012A	Texas Instruments	BQ28Z620DRZ
1	4 wire cable(black/white/brown/red)	W1	L18	Krypton Solutions	I2C_SMB_CABLE CBL002

### 1.4.3 Schematic

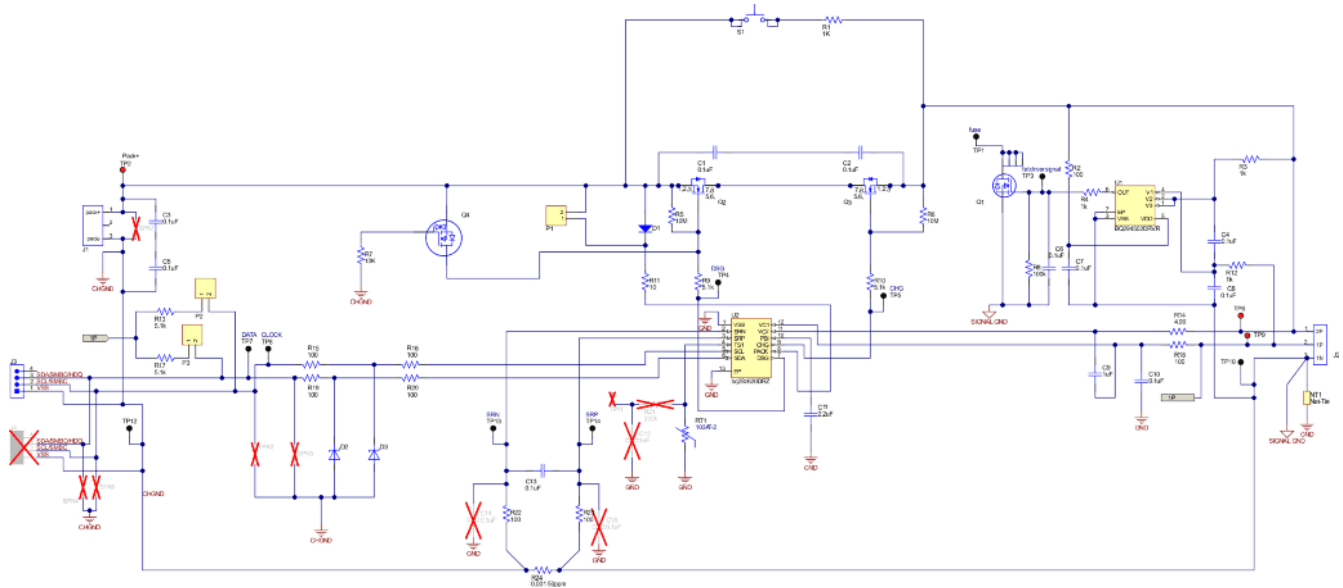


Figure 1-19. Schematic

### 1.4.4 Testing Fuse-Blowing Circuit

To prevent the loss of board functionality during the fuse-blowing test, the actual chemical fuse is not provided in the circuit. FET Q1 drives TP1 low if a fuse-blow condition occurs; thus, monitoring TP1 can be used to test this condition.

## 2 Revision History

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

Date	Revision	Notes
March 2023	*	Initial Release

## 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 semiconductor 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/llds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/llds/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

ンスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 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/llds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/llds/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, INDEMNITY 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2023, Texas Instruments Incorporated



## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](http://ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025