User's Guide

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

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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.

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-kΩ 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. 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. 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.

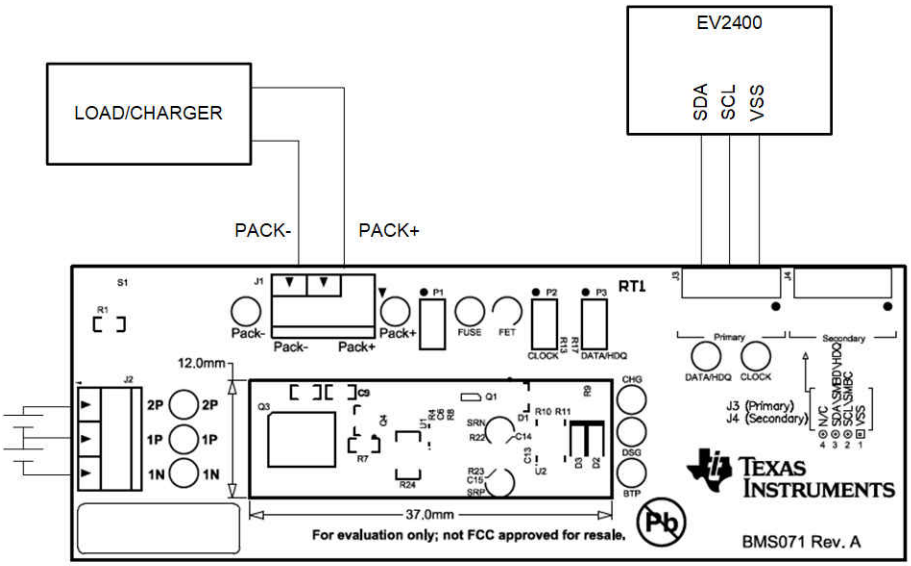


Figure 1-1. BQ28Z620 Circuit Module Connection to Cells and System Load or Charger

- 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 × 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.

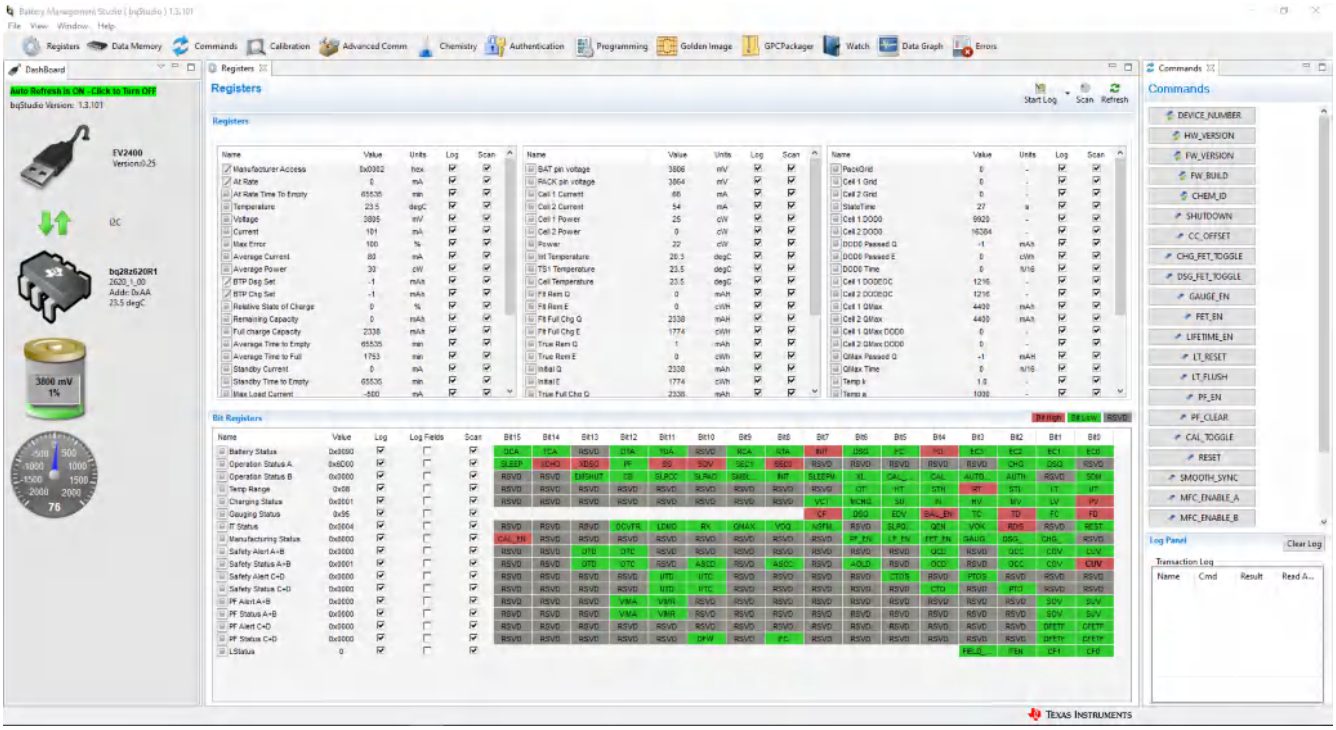


Figure 1-3. Registers Screen

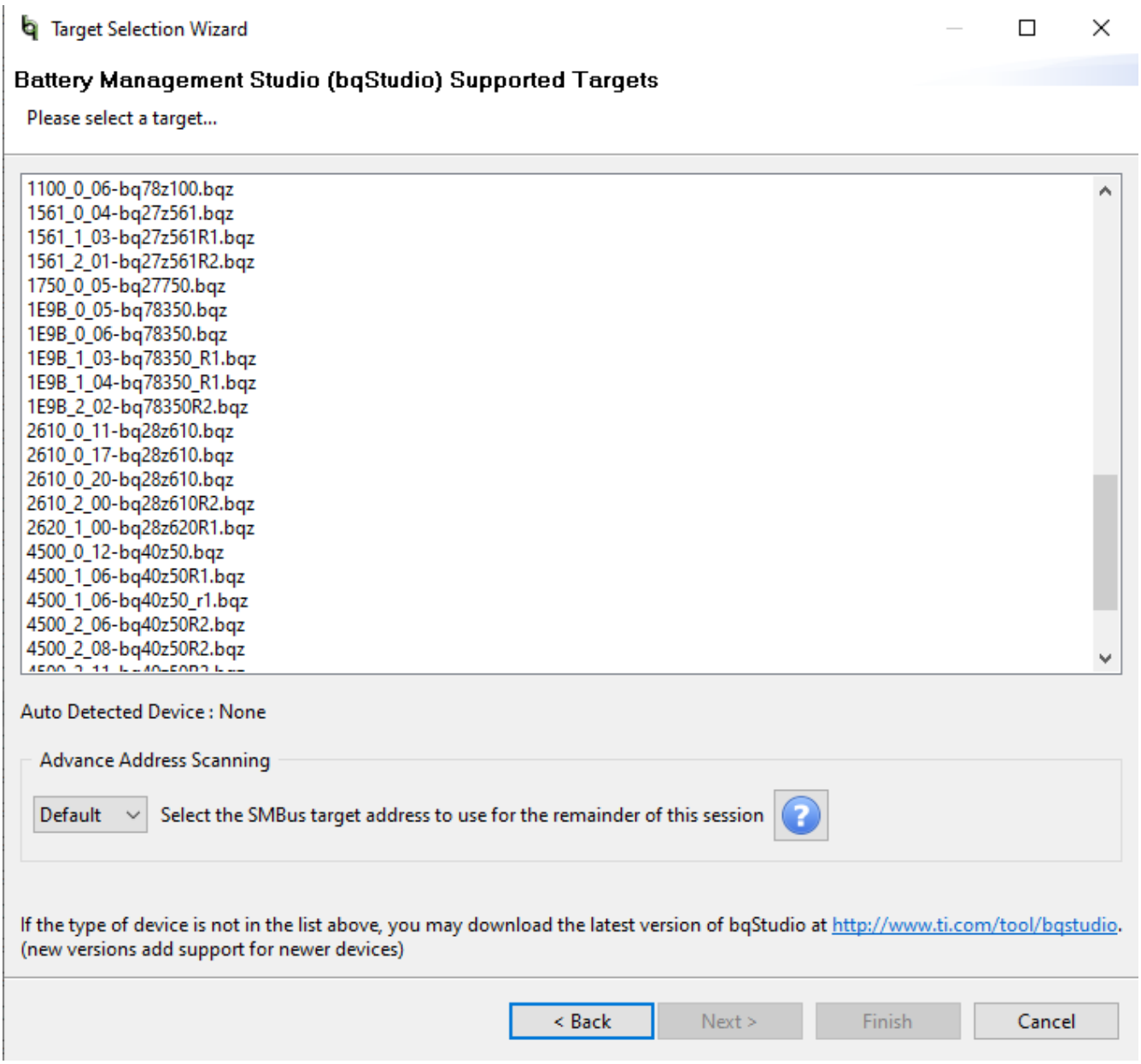


Figure 1-4. Battery Management Studio Supported Targets

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.

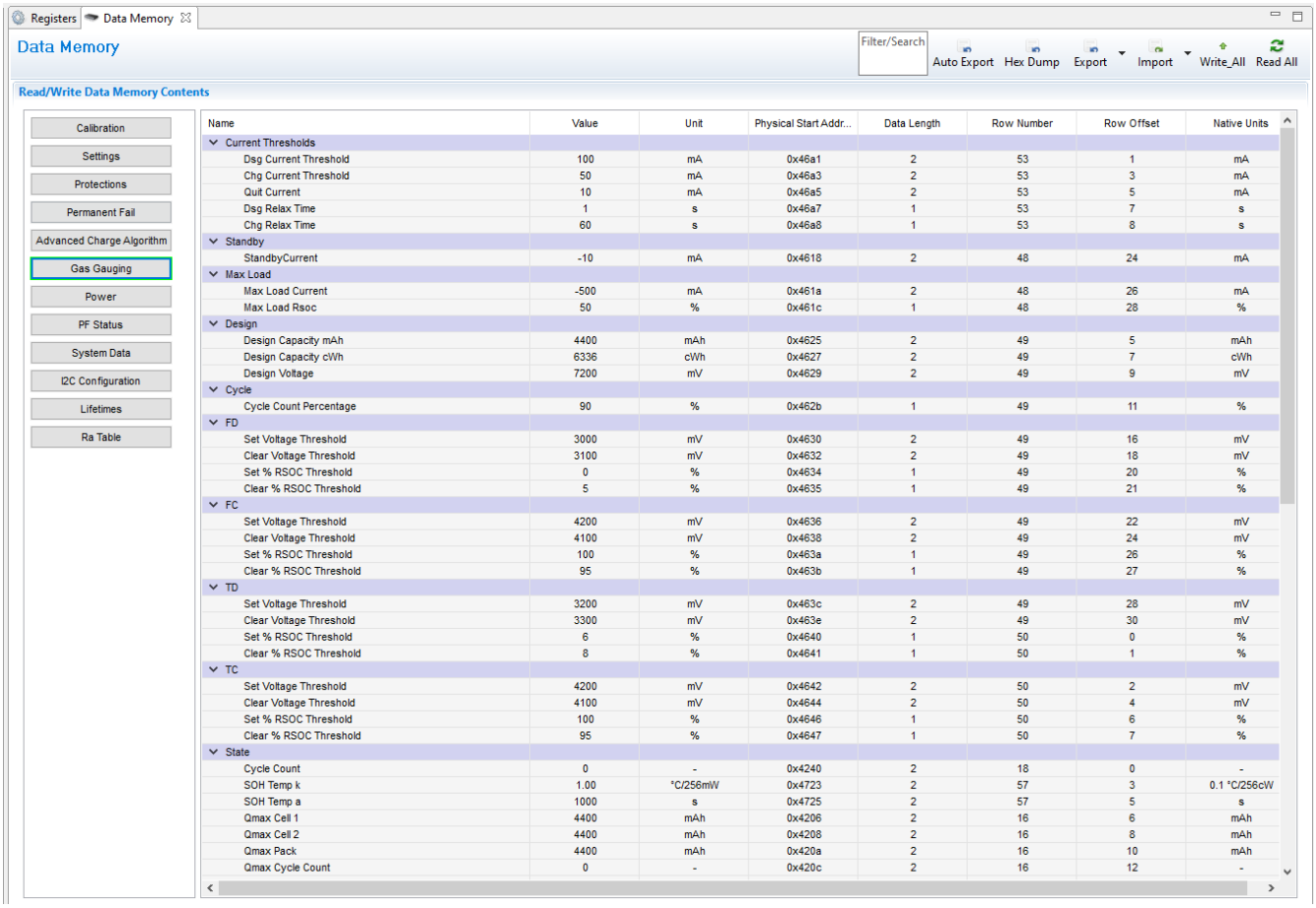
The Battery Management Studio program provides a logging function which logs all the values of the parameters in the Register section if running the program in “Show basic view mode”. In order to selectively choose the parameters of Register section that are scanned and logged, the user needs to set 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
Current Thresholds							
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
Standby							
StandbyCurrent	-10	mA	0x4618	2	48	24	mA
Max Load							
Max Load Current	-500	mA	0x461a	2	48	26	mA
Max Load Rsoc	50	%	0x461c	1	48	28	%
Design							
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
Cycle							
Cycle Count Percentage	90	%	0x462b	1	49	11	%
FD							
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	%
FC							
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	%
TD							
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	%
TC							
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	%
State							
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.

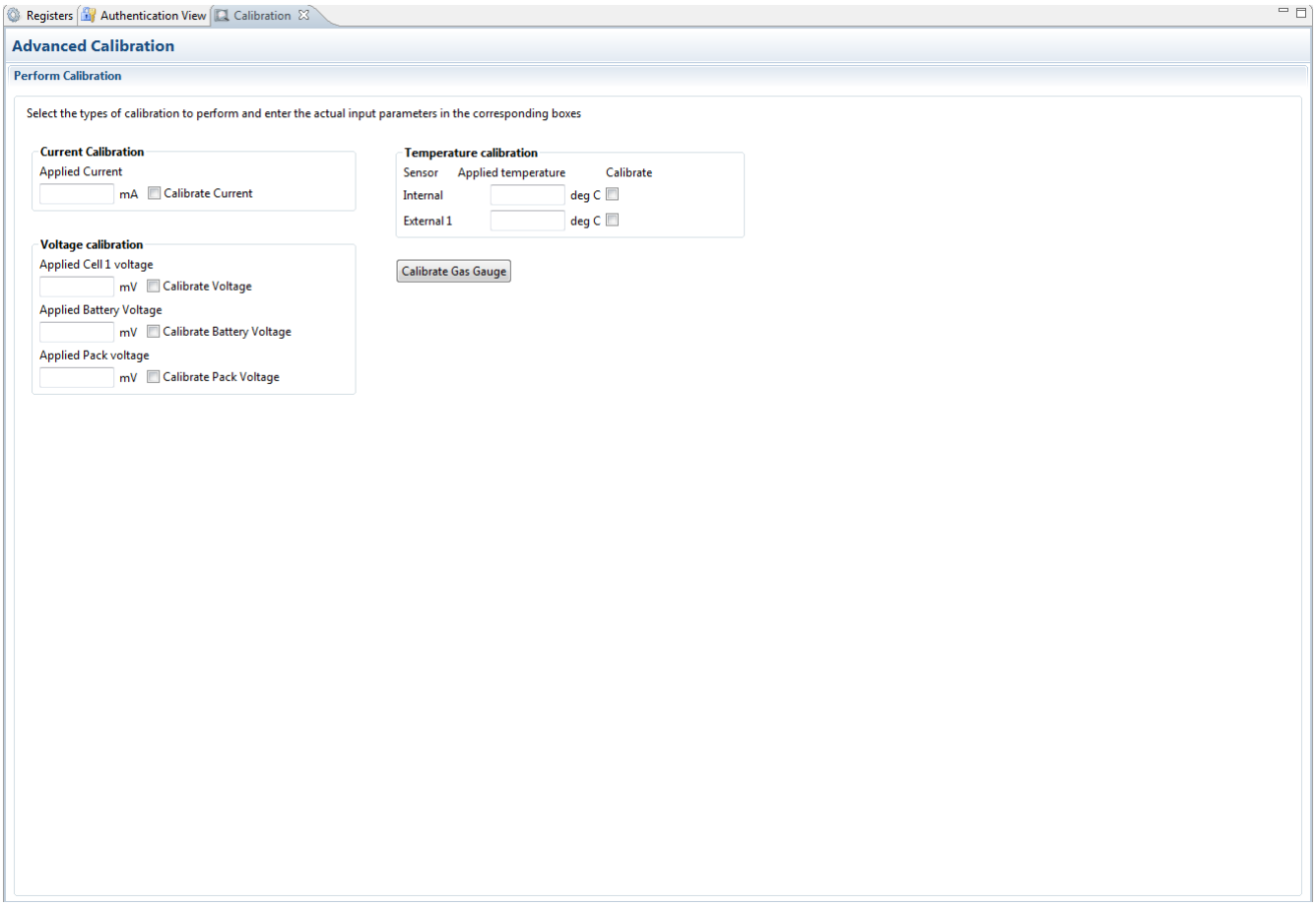


Figure 1-6. Calibration Screen

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.

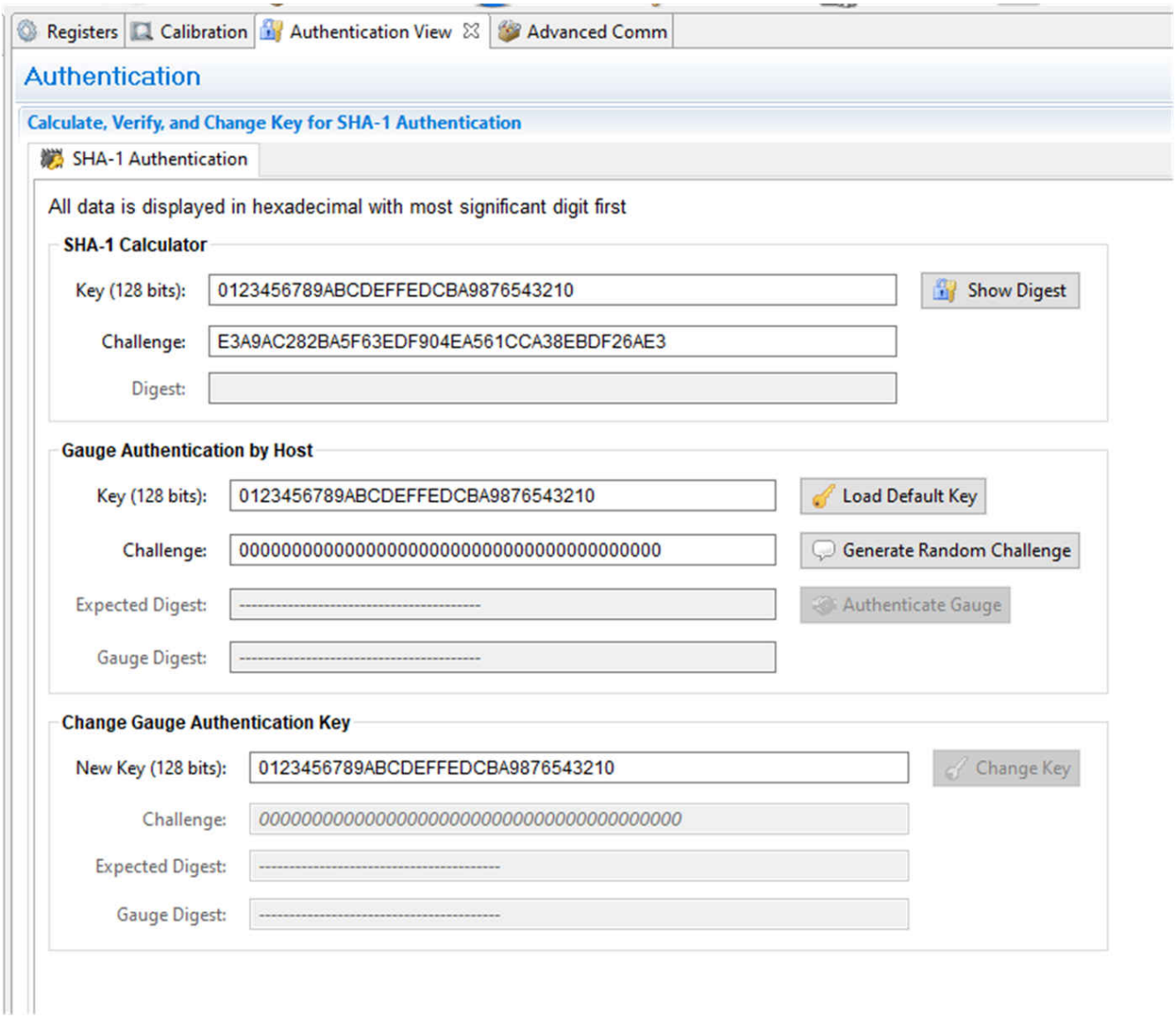


Figure 1-7. Authentication Screen

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.

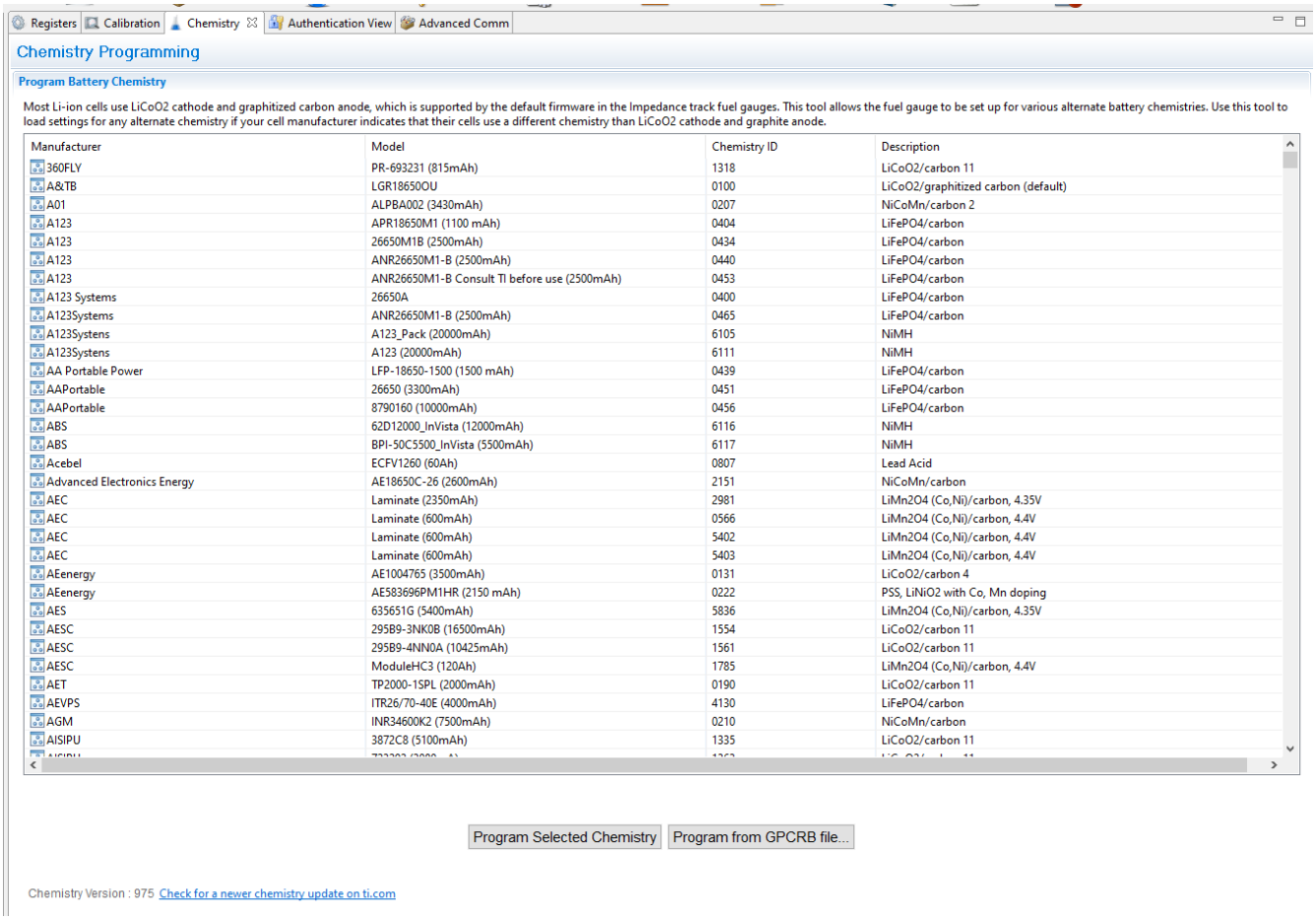


Figure 1-8. Chemistry Screen

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.

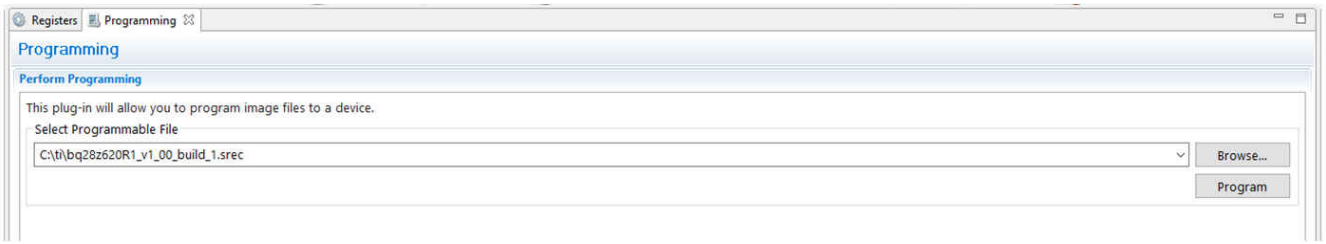


Figure 1-9. Programming Screen

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.

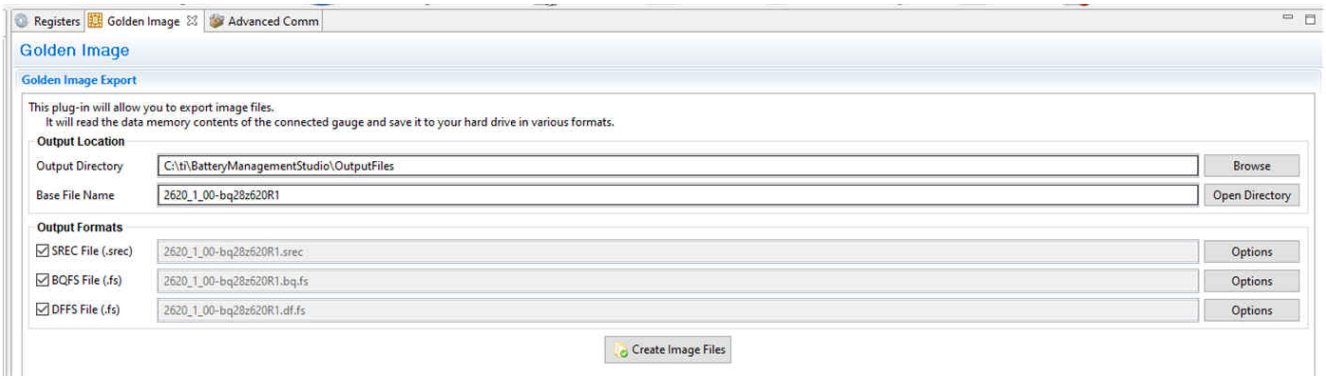


Figure 1-10. Golden Image Screen

1.3.8 Advanced Comm I²C Screen

Press the **Advanced Comm I2C** button to select the **Advanced Comm I2C** window. This tool provides access to parameters using I²C and Manufacturing Access commands. See Figure 1-11 . The transaction log screen shows the history of sent commands.

Note

I²C commands are sent in Little Endian format.

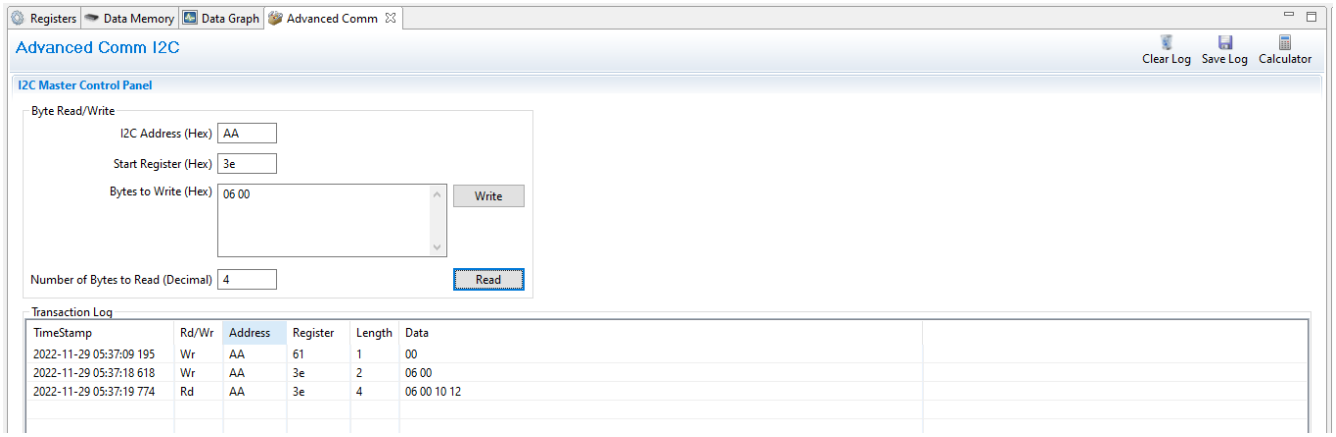


Figure 1-11. Advanced Comm I²C Screen

Examples:

Reading an I²C 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.

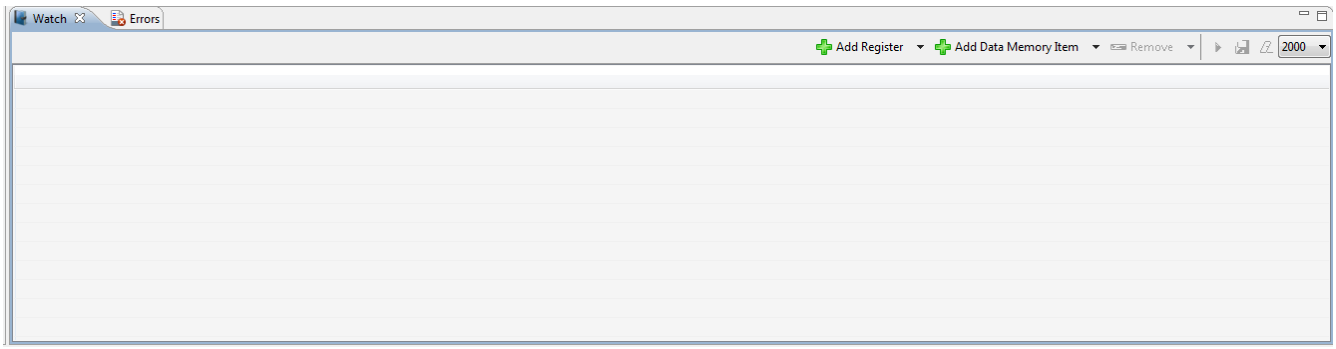


Figure 1-12. Watch Screen

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.

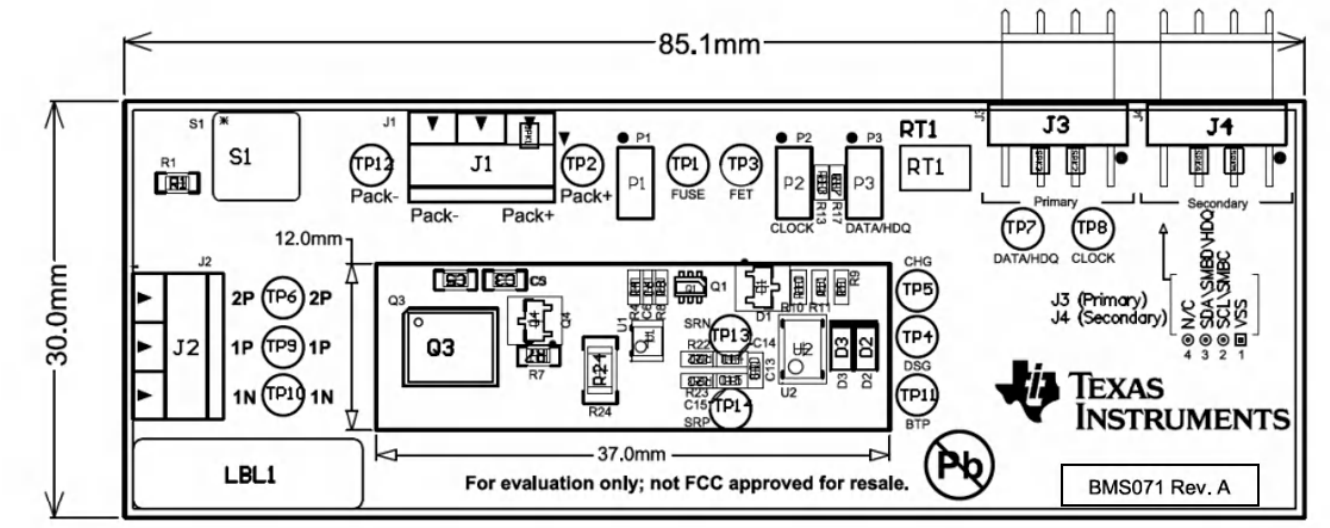


Figure 1-13. Top Silk Screen

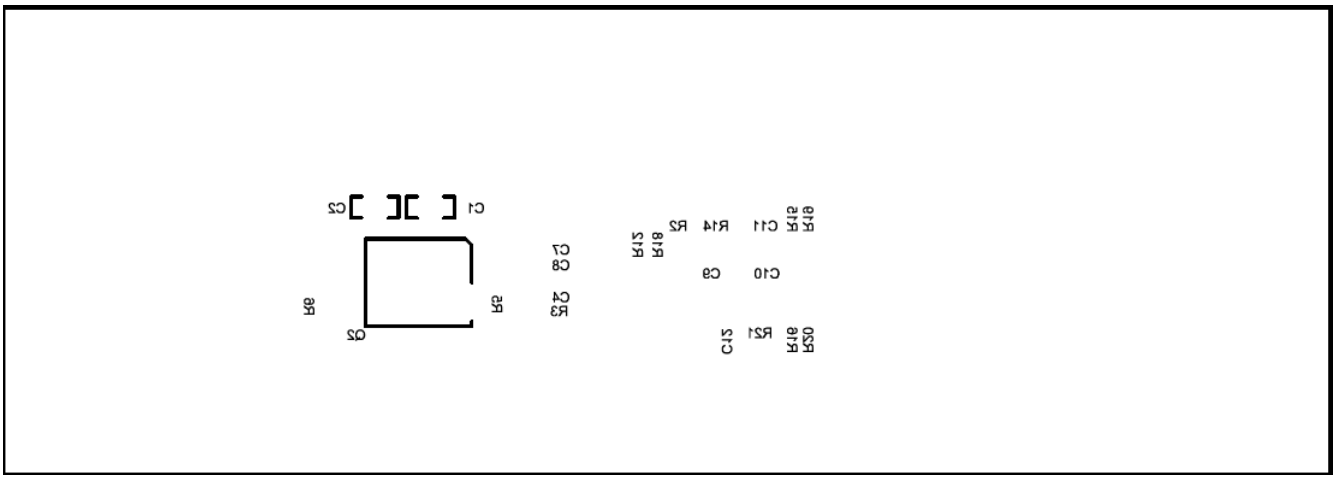


Figure 1-14. Bottom Silk Screen

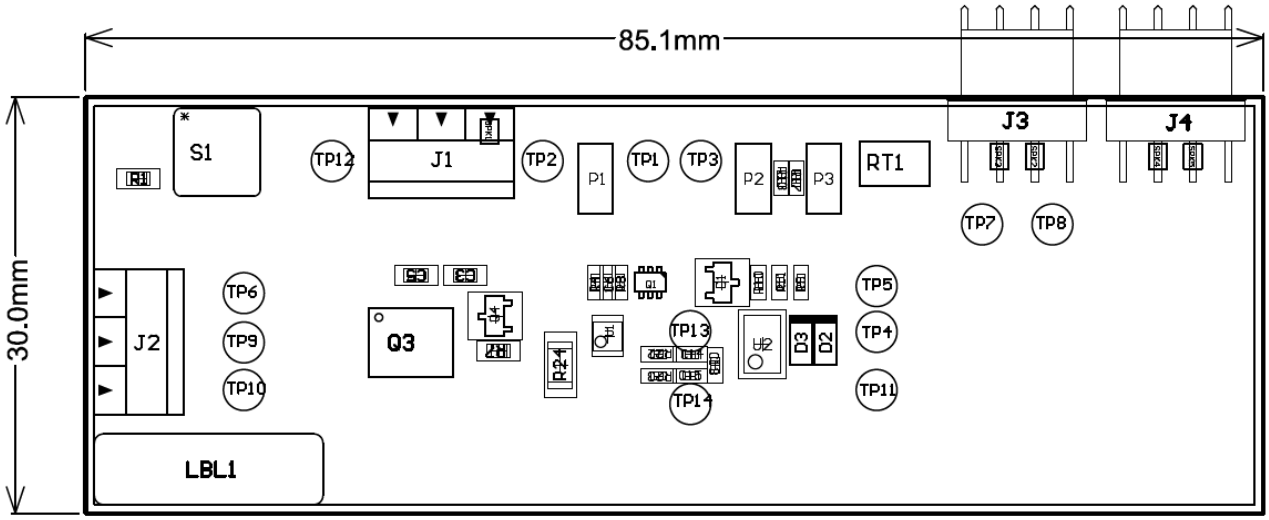


Figure 1-15. Top Assembly

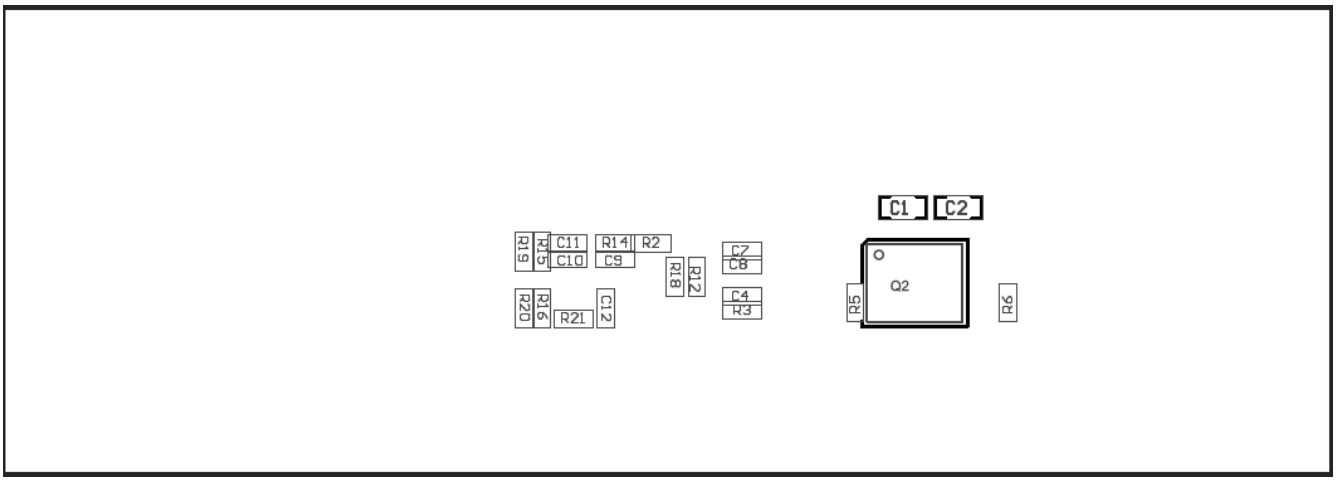


Figure 1-16. Bottom Assembly

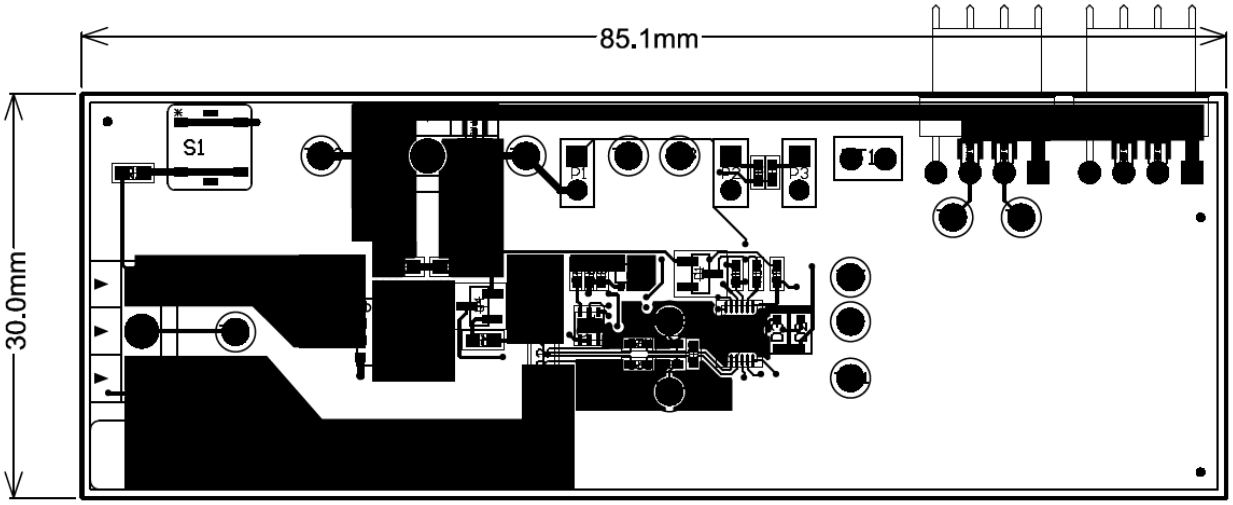


Figure 1-17. Top Layer

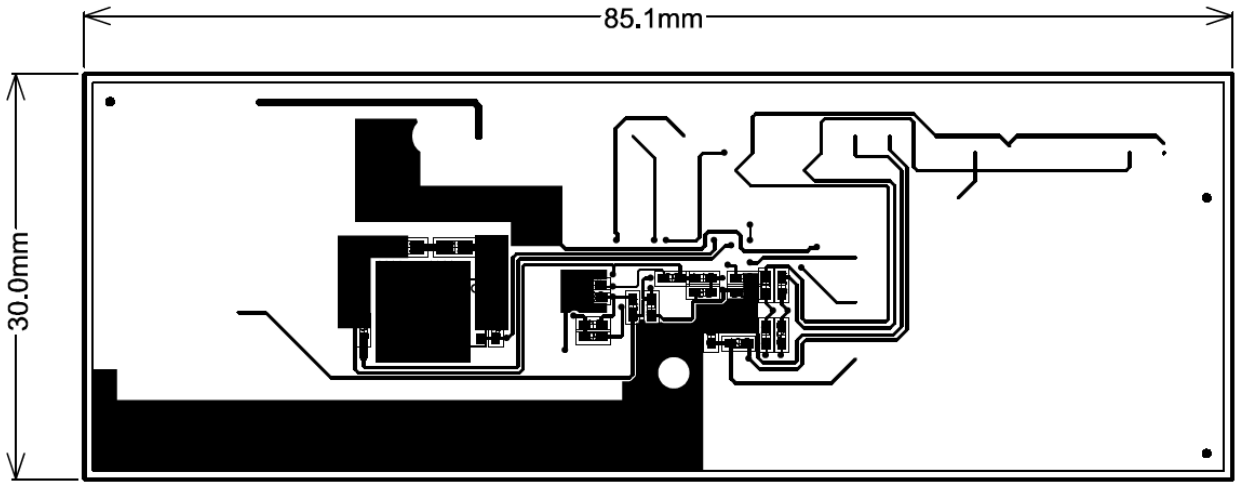


Figure 1-18. Bottom Layer

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 BQ2945'x family devices.

Qty	Value	Ref Des	Package_Case	Manufacturer	Manufacturer Part No
1	BMS071	!PCB1	24146	Krypton Solutions	KS 24146
4	0.1µF	C1, C2, C3, C5	0603	Samsung Electro-Mechanics	CL10B104KB8NNNL
6	0.1µF	C4, C6, C7, C8, C10, C13	0402	Murata Electronics North America	GRM155R71C104KA88D
1	1.0µF	C9	0402	Samsung Electro-Mechanics America, Inc.	CL05A105KO5NNND
1	2.2µF	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	CRCW04021K00FKED
2	10.0M	R5, R6	0402	Vishay Dale	CRCW040210M0FKED
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

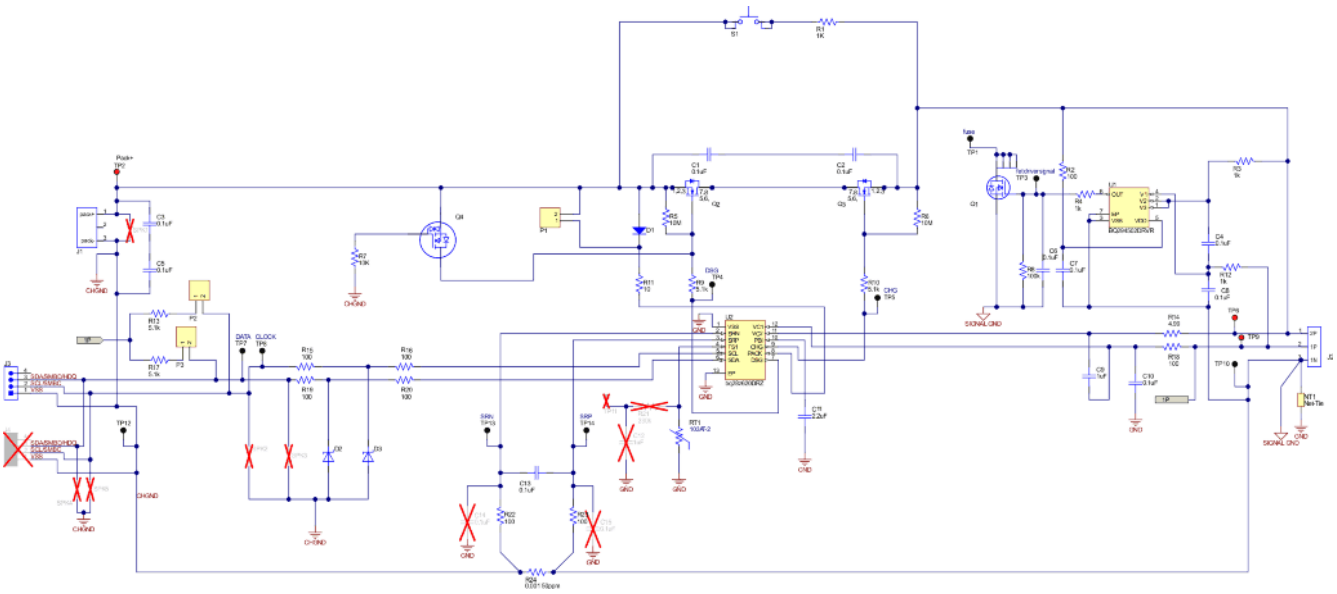


Figure 1-19. Schematic

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

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