User's Guide

BQ27Z746EVM Impedance Track™ Battery Gas Gauge and Protection Solution for 1-Series Cell Li-ion Battery Packs

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ABSTRACT

The BQ27Z746EVM comes with the BQ27Z746 integrated gas gauge and protection IC with external high-side protection N-Channel FETs. This user's guide will walk you through the following tasks:

- Connect the necessary components together to power up the EVM
- Installation of the necessary Texas Instruments software tools
- Bring up the EVM for a basic chemistry and accuracy cycle check
- Evaluate the functionality of the BQ27Z746 solution under different charge and discharge conditions

The latest Windows®-based PC software can be downloaded from the product folder on the Texas Instruments website. Use the Texas Instruments web search for Battery Management Studio on www.ti.com.

Table of Contents

List of Figures

List of Tables

1 Trademarks

Impedance Track™ is a trademark of Texas Instruments.
I2C™ is a trademark of NXP.
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2 Features

- Complete evaluation system for the BQ27Z746 gas gauge and protection with Impedance Track™ technology
- Populated circuit module for quick setup
- Personal computer (PC) software and interface board for easy evaluation
- Software that allows configuring and data logging for system analysis

2.1 Kit Contents

- BQ27Z746 circuit module (BMS047)

This EVM is used for the evaluation of the BQ27Z746. Visit the product web folder at www.ti.com to properly configure the BQ27Z746.

3 BQ27Z746-Based Circuit Module

The BQ27Z746 based circuit module is an example solution of a BQ27Z746 circuit for battery management. The circuit module incorporates a BQ27Z746 battery gas gauge and protection integrated circuit (IC) with external sense resistor to accurately predict the capacity of a 1-series Li-ion cell. In addition, it includes external N-channel FETs for high-side battery protection.

3.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- Direct cell connection to the battery pack (J1): BAT+, BAT–
- Direct system connection for charging and discharging (J2): PACK+, PACK–
- I2C™ communications via external EV2400 to Windows-based PC USB port (J11): SDA, SCL, VSS
- Cell voltage sensing outputs (J7): BAT_SP, BAT_SN,

3.2 Pin Descriptions

Table 3-1. Pin Descriptions

Pin Name	Description
PACK+	Pack positive terminal
PACK–	Pack negative terminal
BAT+	Battery positive terminal and BQ2980 bypass path
BAT–	Battery negative terminal
SDA	External I^2C communication data line
SCL	External I^2C communication clock line
VSS	Device ground
BAT_SP	Cell sensing positive output terminal
BAT_SN	Cell sensing negative output terminal

4 Circuit Module Physical Layout, Bill of Materials, and Schematic

This section contains the board layout, bill of materials, and schematic for the BQ27Z746 circuit module.

4.1 Board Layout

This section shows the printed-circuit board (PCB) layers (Figure 4-2 through Figure 4-4), and assembly drawing for the BQ27Z746 module.

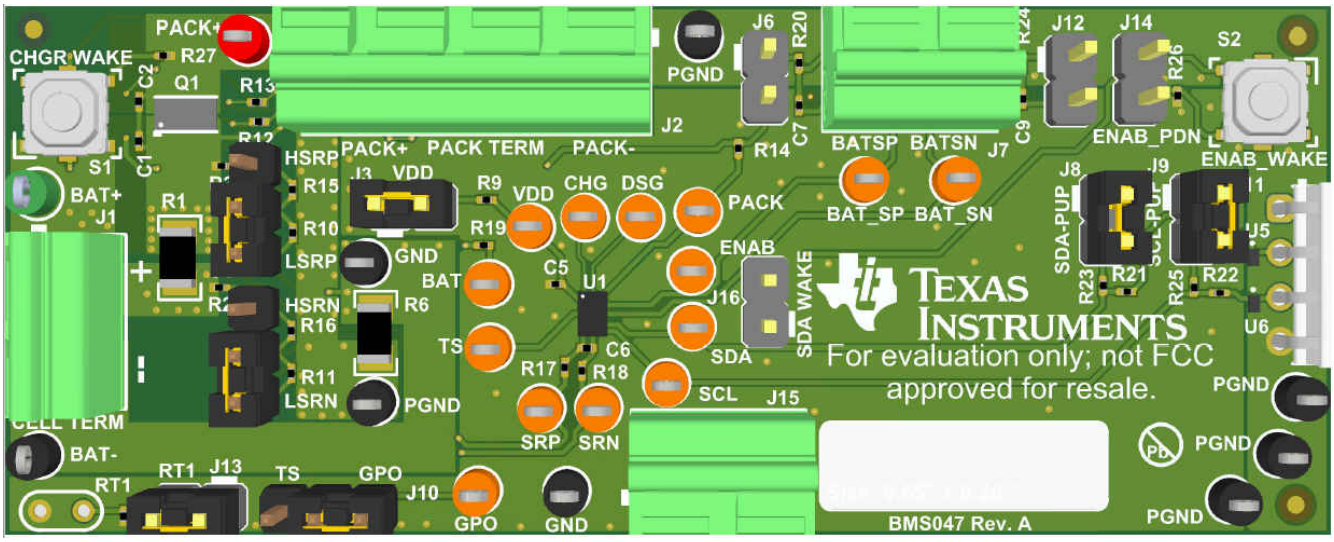

Figure 4-1. EVM Image

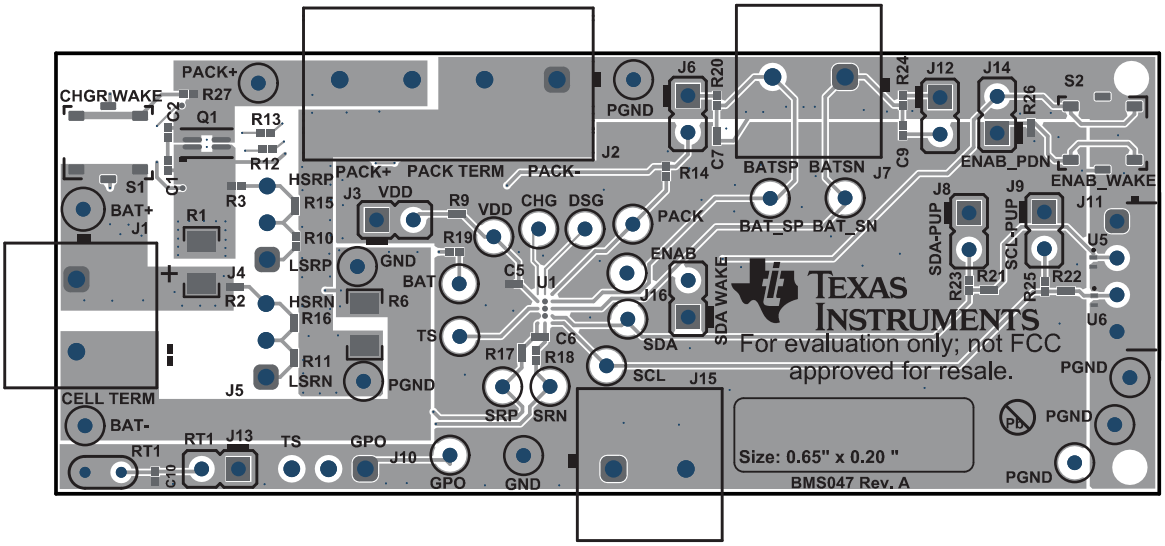

Figure 4-2. Top Layer Composite

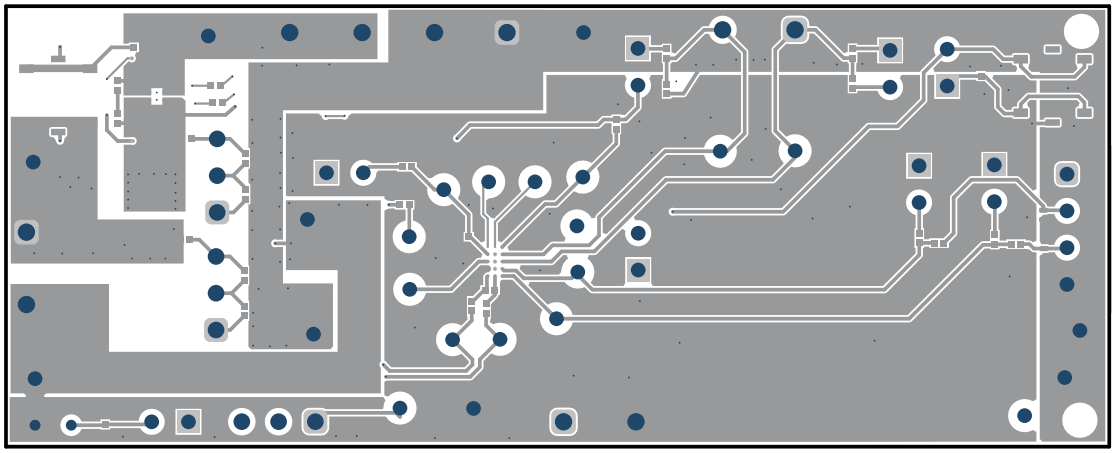

Figure 4-3. Top Layer

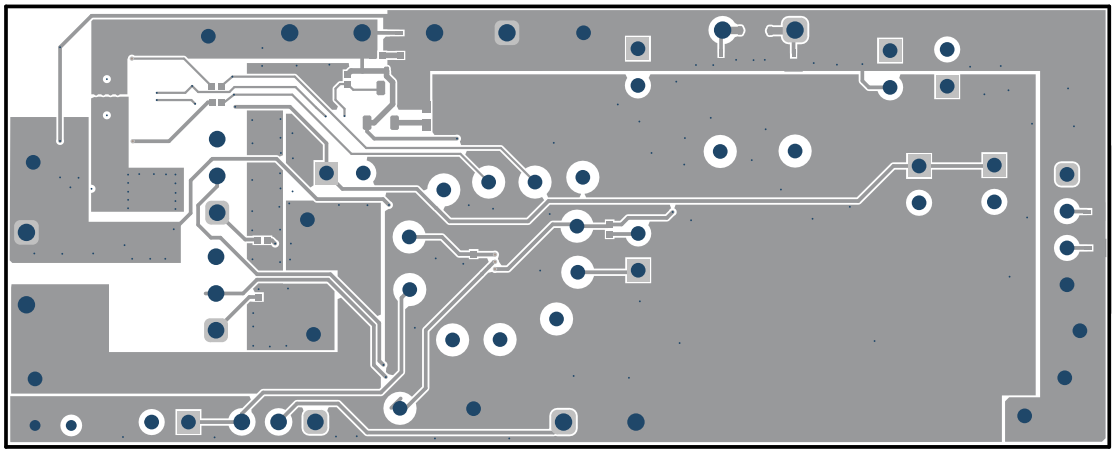

Figure 4-4. Bottom Layer

4.2 Schematic

This section contains the schematic of the different (PCB) components.

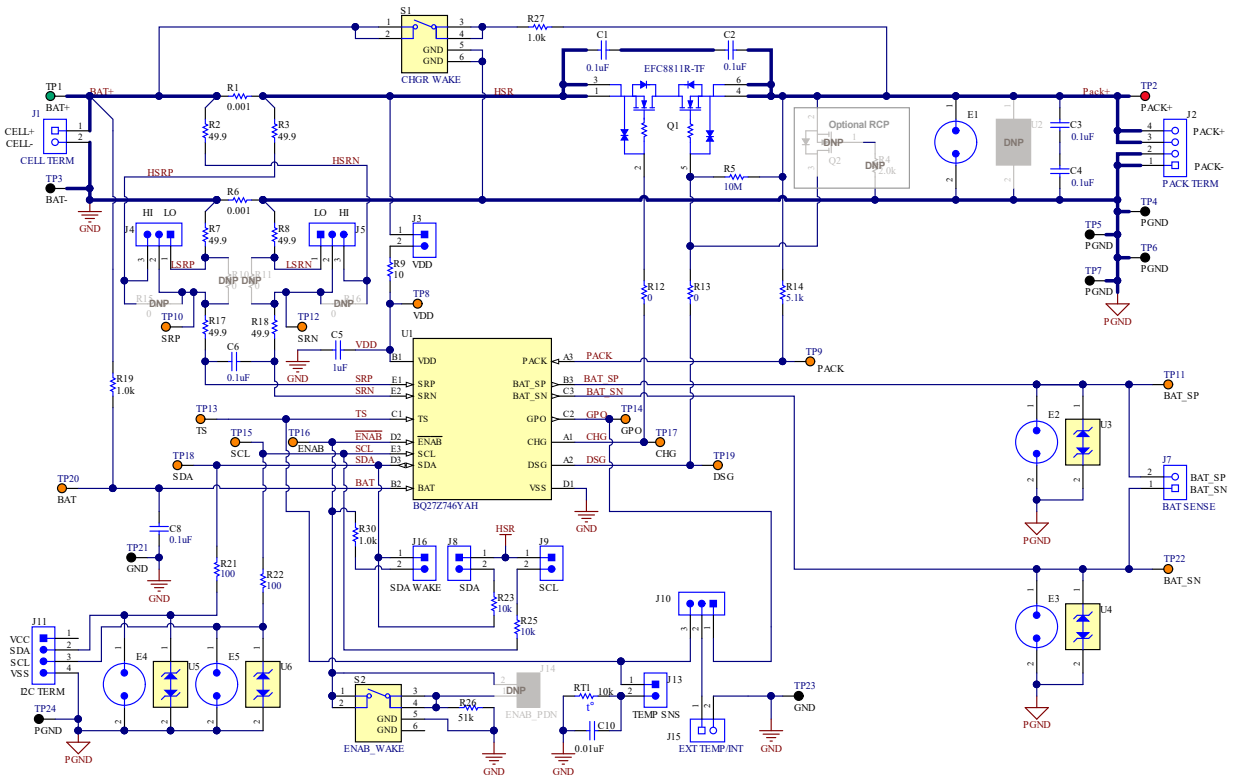

Figure 4-5. BQ27Z746 Reference Schematic

4.3 Bill of Materials

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
PCB1	1		Printed Circuit Board		BMS047	Any
C1, C2, C3, C4	4	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X5R, 0201	0201	GRM033R61E104KE14J	MuRata
C5	1	1uF	CAP, CERM, 1 uF, 10 V,+/- 20%, X5R, 0201	0201	GRM033R61A105ME15D	MuRata
C6, C8	2	0.1uF	CAP, CERM, 0.1 uF, 16 V,+/- 10%, X7R, 0201	0201	GRM033Z71C104KE14D	MuRata
C10	1	0.01uF	CAP, CERM, 0.01 uF, 10 V, +/- 10%, X5R, 0201	0201	GRM033R61A103KA01D	MuRata
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J1, J7, J15	3		Terminal Block, 5mm, 2x1, R/A, TH	Terminal Block, 5mm, 2x1, R/A, TH	1792863	Phoenix Contact
J2	1		Terminal Block, 5mm, 4x1, R/A, TH	Terminal Block, 5mm, 4x1, R/A, TH	1792889	Phoenix Contact
J3, J8, J9, J13, J16	5		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54 mm, 2x1, TH	GBC02SAAN	Sullins Connector Solutions
J4, J5, J10	3		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J11	1		Header, 2.54mm, 4x1, R/A, Tin, TH	Header, 2.54mm, 4x1, R/A, TH	640455-4	TE Connectivity
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
Q1	1		Power MOSFET for 1 Cell Lithium-ion Battery Protection 12V, 3.2mOhm, 27A, Dual N-Channel, SMD	1.77x3.54mm	EFC8811R-TF	ON Semiconductor
R1, R6	2	0.001	RES, 0.001, 1%, 1 W, AEC-Q200 Grade 0, 1206	1206	CSNL1206FT1L00	Stackpole Electronics Inc
R2, R3, R7, R8, R17, R18	6	49.9	RES, 49.9, 1%, 0.05 W, 0201	0201	CRCW020149R9FKED	Vishay-Dale
R5	1	10Meg	RES, 10 M, 5%, 0.05 W, 0201	0201	RC0201JR-0710ML	Yageo America
R9	1	10	RES, 10, 5%, 0.05 W, 0201	0201	RC0201JR-0710RL	Yageo America
R12, R13	2	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale
R14	1	5.1k	RES, 5.1 k, 5%, 0.05 W, 0201	0201	RC0201JR-075K1L	Yageo America
R19, R27, R30	3	1.0k	RES, 1.0 k, 5%, 0.05 W, 0201	0201	RC0201JR-7D1KL	Yageo America
R21, R22	2	100	RES, 100, 1%, 0.05 W, 0201	0201	CRCW0201100RFKED	Vishay-Semiconductor
R23, R25	2	10k	RES, 10 k, 5%, 0.05 W, 0201	0201	RC0201JR-7D10KL	Yageo America
R26	1	51k	RES, 51 k, 5%, 0.05 W, 0201	0201	RC0201JR-7D51KL	Yageo America
RT1	1	10k	Thermistor NTC, 10.0k ohm, 1%,		103AT-4-70261	SEMITEC Corporation

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
S1, S2	2		Switch, SPST-NO, Off-Mom, 0.02 A, 15 VDC, SMD	4.9x4.9mm	EVQ-PLHA15	Panasonic
SH-J1, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8	7	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1	1		Test Point, Miniature, Green, TH	Green Miniature Testpoint	5116	Keystone
TP2	1		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP3, TP4, TP5, TP6, TP7, TP21, TP23, TP24	8		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP22	14		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
U1	1		Impedance Track!" Battery Gas Gauge and Protection Solution for 1-Series Cell Li-Ion Battery Packs, YAH0015 (DSBGA-15)	YAH0015	BQ27Z746YAH	Texas Instruments
U3, U4, U5, U6	4		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYR	Texas Instruments
C7, C9	0	0.1uF	CAP, CERM, 0.1 uF, 16 V,+/-10%, X7R, 0201	0201	GRM033Z71C104KE14D	MuRata
J6, J12, J14	0		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54 mm, 2x1, TH	GBC02SAAN	Sullins Connector Solutions
Q2	0	60V	MOSFET, N-CH, 60 V, 0.17 A, SOT-23	SOT-23	2N7002-7-F	Diodes Inc.
Q3	0		23V 30A Common-Drain Dual N-Channel MOSFET	AlphaDFN3.2x2.1_10	AOCA36136E	Alpha and Omega Semiconductor
R4	0	2.0k	RES, 2.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K00JNED	Vishay-Dale
R10, R11, R15, R16, R28, R29	0	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale
R20, R24	0	1.0k	RES, 1.0 k, 5%, 0.05 W, 0201	0201	RC0201JR-7D1KL	Yageo America
U2	0		Single-Channel ESD in 0402 Package With 10pF Capacitance and 6V Breakdown, DPY0002A (X1SON-2)	DPY0002A	TPD1E10B06DPYR	Texas Instruments

4.4 BQ27Z746 Circuits Module Performance Specification Summary

This section summarizes the performance specifications of the BQ27Z746 circuit module.

Table 4-2. Performance Specification Summary

BQ27Z746 Specification	Min	Typ	Max	Units
Input voltage Pack+ to Pack–	-12	3.6	24	V
Input voltage Bat+ to Bat–	-0.3	3.6	6	V
Hardware Protection Specification				
Overvoltage protection	4.300	4.460	5.000	V
Undervoltage protection	2.000	2.500	3.000	V
Overcurrent in charge	-22	-9	-1	mV(1)
Overcurrent in discharge	1	9	22	mV(1)

(1) Based on 1-mΩ sense resistor.

5 EVM Hardware and Software Setup

This section describes the installation of the BQ27Z746EVM PC software, and how to connect the different components of the EVM.

5.1 System Requirements

The bqStudio software requires Windows 7 or later. Using earlier versions of Windows operating system may not work with the USB driver support.

5.2 Software Installation

Find the latest software version of bqStudio on http://www.ti.com/tool/bqStudio. Search for the BQ27Z746 part number to get to the tool folder for the device. Following these steps to install the BQ27Z746 bqStudio software.

1. Before starting this procedure, make sure the external EV2400 is not connected to the personal computer (PC) through the USB cable.
2. Open the archive containing the installation package and copy its contents into a temporary directory.
3. Rename any previous BatteryManagementStudio folder by adding a version to the end.
4. Open the bqStudio installer file that was downloaded from the TI website.
5. Follow the instructions on-screen until completing the software installation.
6. Before launching the evaluation software, connect the EV2400 USB cable to the computer and I^2C port to the EVM board (J11).
7. For the EV2400, the driver should be installed along with the bqStudio software installation.

6 Troubleshooting Unexpected Dialog Boxes

The user that is downloading the files must be logged in as the administrator. The driver is not signed, so the administrator must allow installation of unsigned drivers in the operating system. If using Windows 7, install the software with administrator privileges.

7 Hardware Connection

The BQ27Z746 with integrated protection evaluation module requires three hardware connections: the cell(s), the I^{2}C communication (EV2400), and the system load/charger.

7.1 Connecting the BQ27Z746 Circuit Module to a Battery Pack

Figure 7-1 shows how to connect the BQ27Z746 circuit module to the battery, personal computer (PC), and a system load/charger.

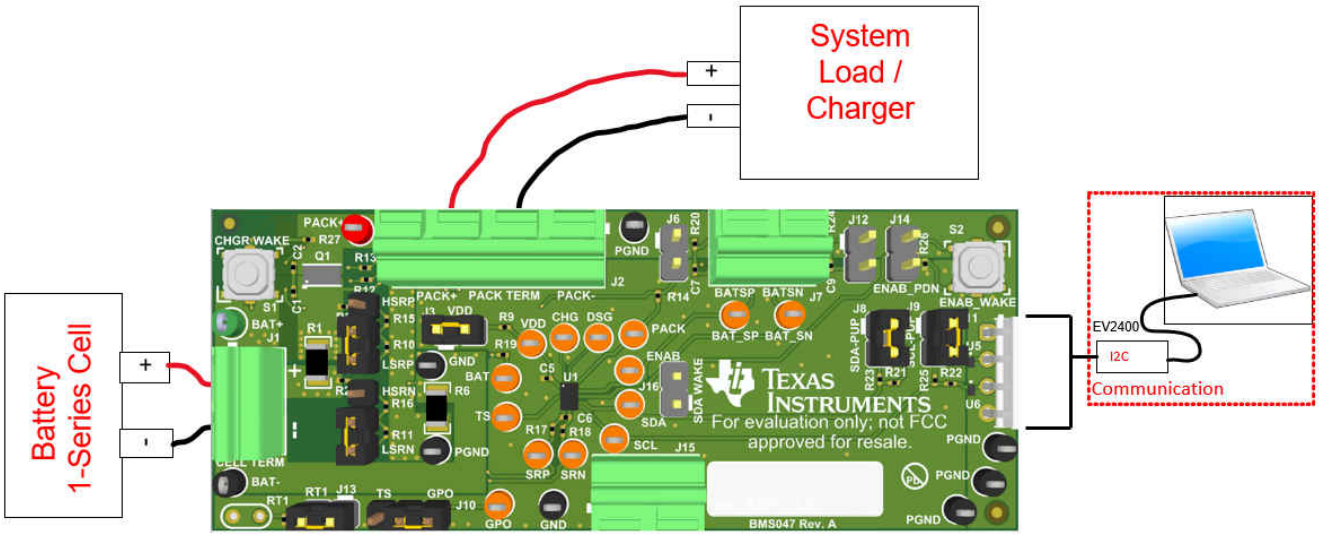

Figure 7-1. Connect the BQ27Z746 Circuit Module to a 1SxP

7.2 EVM Jumpers Description

The following section describes the critical jumpers and their purpose on this board:

1. **J3 - LDO Regulator Input (VDD):** This jumper ties the BQ27Z746 VDD pin to the cell+. This jumper is intended to be able to install a shunt resistor/ammeter to monitor device current consumption under various operating conditions. The shunt needs to be installed for normal operation.
2. **J9 - I^2C Clock Pullup (SCL):** This jumper applies a 10-kΩ pullup resistor on the I^2C communication line. When using a communication device without external pullup, install this shunt. If attaching an EV2400 and/or debug sniffer which contains unremovable pullups, these jumpers can be removed.
3. **J8 - I^2C Data Pullup (SDA):** This jumper applies a 10-kΩ pullup resistor on the I^2C communication line. When using a communication device without external pullup, install this shunt. If attaching an EV2400 and/or debug sniffer which contains unremovable pullups, these jumpers can be removed.
4. **J5 - Current Sense Resistor Negative Input (SRN):** This jumper selects high-side or low-side current sensing for the SRN pin of the BQ27Z746. Install this shunt in the "LO" position for low-side current sensing or "HI" position for high-side current sensing. This shunt must be in the same position on both J4 and J5 jumpers.
5. **J4 - Current Sense Resistor Positive Input (SRP):** This jumper selects high-side or low-side current sensing for the SRP pin of the BQ27Z746. Install this shunt in the "LO" position for low-side current sensing or "HI" position for high-side current sensing. This shunt must be in the same position on both J4 and J5 jumpers.
6. **J10 - External Temperature Sensor (TS/GPO):** This jumper ties the TS pin or GPO pin to an external temperature sensor (NTC) through terminal J15. Install this shunt in the "TS" position to connect the TS pin to an external temperature sensor and remove the shunt for jumper J13 or install this shunt in the "GPO" position to connect the GPO pin to an external temperature sensor.
7. **J13 - Onboard Temperature Sensor (TS):** This jumper ties the TS pin to an onboard temperature sensor (NTC). Install this shunt for normal operation when using the default TS pin for temperature sensing.
8. **J16 - External Enable (ENAB):** This jumper ties the ENAB pin to the SDA pin to provide a system side wakeup or exit from SHUTDOWN option for pin limited battery pack connectors without requiring a charger be connected to exit SHUTDOWN.

8 Operation

This section details the operation of the BQ27Z746 bqStudio software.

8.1 Starting the Program

Run bqStudio from the desktop. The window consists of a tools panel at the top, and other child windows that can be hidden, docked in various positions or allowed to float as separate windows. When bqStudio first starts up the *Gauge Dashboard* window, the Registers window, and *Data Memory* window should be seen in the main window. *Registers, Data Memory, Commands*, and other windows can be added to the main window by clicking on the corresponding icon in the tools panel at the top of the main window. Data should appear initially in the *Gauge Dashboard, Registers* and *Data Memory* sections. The **Refresh** (single time scan) or the **Scan** (continuous scan) buttons can be clicked in order to update the data in the *Registers* and *Data Memory* windows. Continuous scan is enabled when the *Scan* checkbox is highlighted green and disabled when the *Scan* checkbox is not highlighted. The continuous scanning interval can be set with the *stopwatch* icon next to the **Scan** button. When the *stopwatch* icon is clicked, a drop-down menu appears and the desired scanning interval can be selected. The scan interval value shows up next to the *stopwatch* icon.

bqStudio provides a logging function which logs selected Data Registers last received from the BQ27Z746. To enable this function, click **Start Log**. The default elapsed interval is 4000 milliseconds. To change this interval, go to Window, select Preferences, choose Registers, and change Scan/Log Interval from 4000 to 1000 milliseconds. There is no need to log faster than 1 second as the gas gauge does not update the registers faster than 1 second.

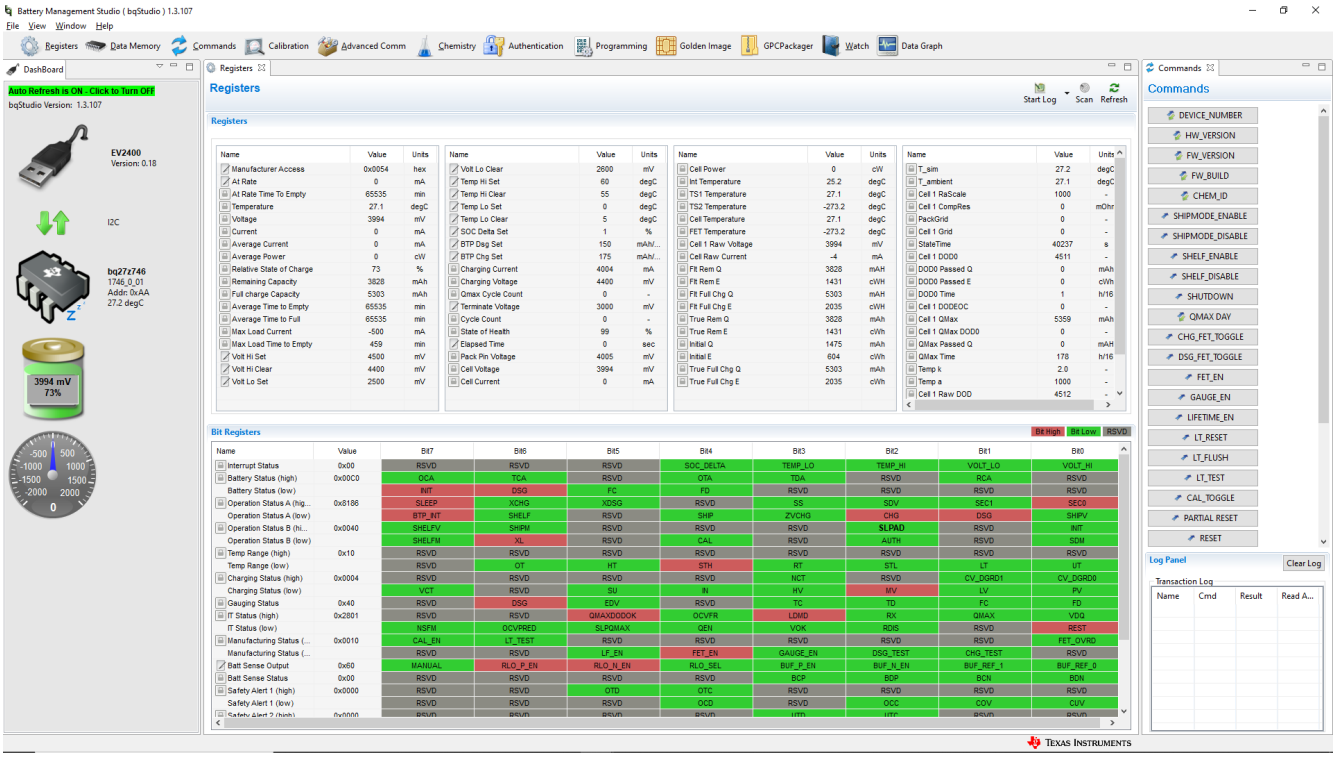

Figure 8-1. Registers Screen

Figure 8-1 shows the main bqStudio window. Additional Flag and Control Status data can be viewed at the bottom of the registers window.

8.2 Setting Programmable BQ27Z746 Options

The BQ27Z746 comes configured per the default settings detailed in the BQ27Z746 data sheet. Ensure that the settings are correctly changed to match the pack and application for the BQ27Z746 solution being evaluated.

Note

The correct setting of these options is essential for best performance. Configure these settings using the *Data Memory* window seen in the main bqStudio window (Figure 8-2).

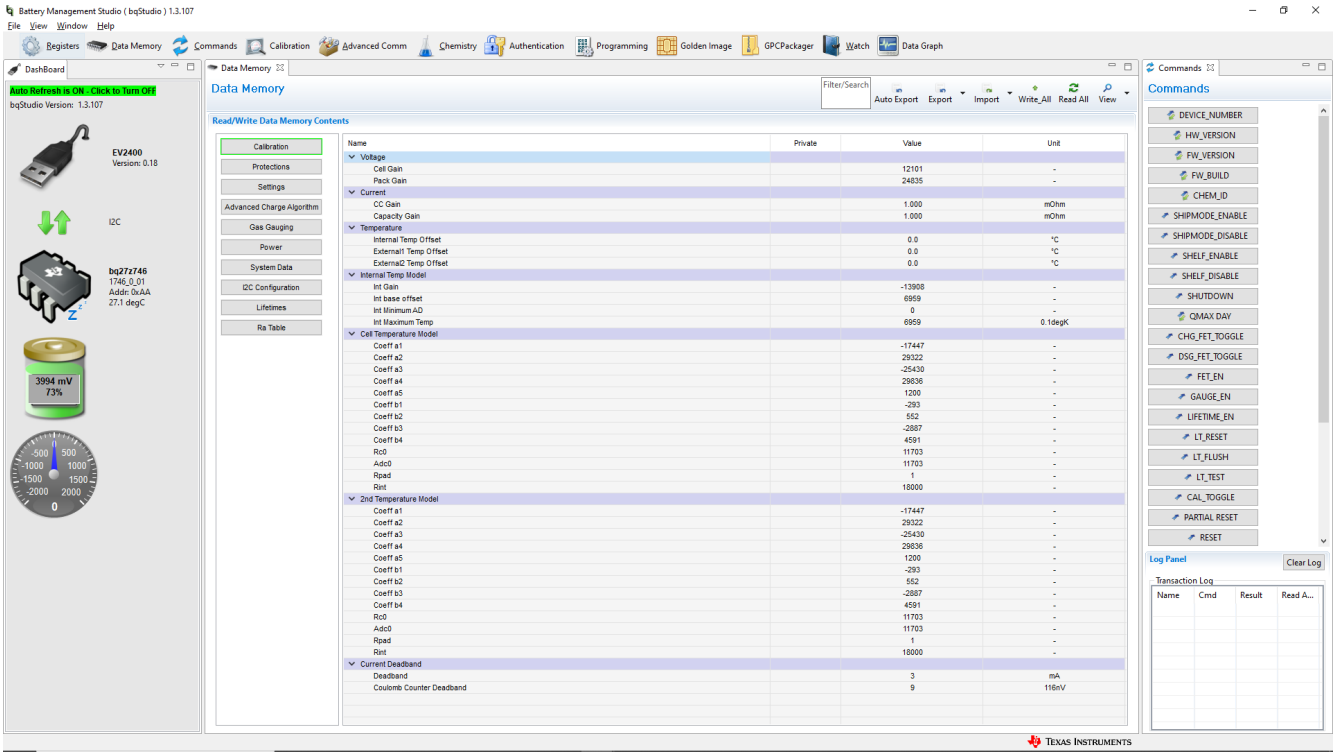

Figure 8-2. Data Memory Screen

To read all of the data from the BQ27Z746, click the **Read All** button in the *Data Memory* window. 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 Figure 8-2 to export and import .gg.csv files. The auto export button enables gg files to be exported periodically at intervals. This feature is useful when debugging issues with the gauge. A write command is necessary if a .gg.csv file is imported to ensure that all changes made on the .gg.csv file are affected on the gauge. Use the read command to read back all of the data written to the gauge to verify the changes were made. 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 the file, which bqStudio rejects. Make sure to use a text editor like notepad or similar to edit a .gg.csv file.

8.2.1 Important Data Memory Parameters to Change

This section outlines the minimal critical settings that should be changed for even a basic evaluation. A short description is included which can be used as a recommendation on how to set the parameter value. Additional updates are needed for a production setting.

1. ***[Gas Gauging][State][Qmax Cell 1]:*** Update this value to the default design capacity of the battery being used. It represents the full unloaded chemical capacity of the cell. This value is updated by the gauge when proper learning is performed and in the field over the life of the battery.
2. ***[Gas Gauging][IT Cfg][Term Voltage]:*** Set this value to the minimum value of the end system when the absolute 0% state of charge should be reported. For normal Li-ion cells this value should range between 3.2 V to 2.75 V. It is recommended this value is not set above 3.4 V.
3. ***[Gas Gauging][Advanced Charge Algorithm][Charge Term Taper Current]:*** Set this value to slightly above the capabilities of your charger to taper to. A recommended value is C/20 where C is the default capacity of the cell. For example, a battery with 1000-mAh capacity should have a taper current of around 50 mA.
4. ***[Gas Gauging][Advanced Charge Algorithm][Low/Standard/High/Rec Temp Charging][Voltage]:*** Update this parameter to the maximum charging voltage of the battery to be used. For a typical Li-Ion battery this value is between 4.45 V to 4.2 V.
5. **ChemID:** It is important that the correct ChemID is updated for the best accuracy. Refer to Section 8.3 on how to update the chemistry in the device. If your cell is not included in the chemistry list, it is possible to run a match on the battery by following the steps at the following link: http://www.ti.com/tool/gpcchem. For basic testing, if the correct chemistry is unknown it is important to chose a chemistry ID with the same maximum charging voltage as the intended cell. The recommended IDs for common charging voltages are as follows:
   - 4.2 V (ID 1202)
   - 4.35 V (ID 3230)
   - 4.4 V (ID 3142)

8.3 Setting the Chemistry

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.
- Press **Program Selected Chemistry** to update the chemistry in the device.

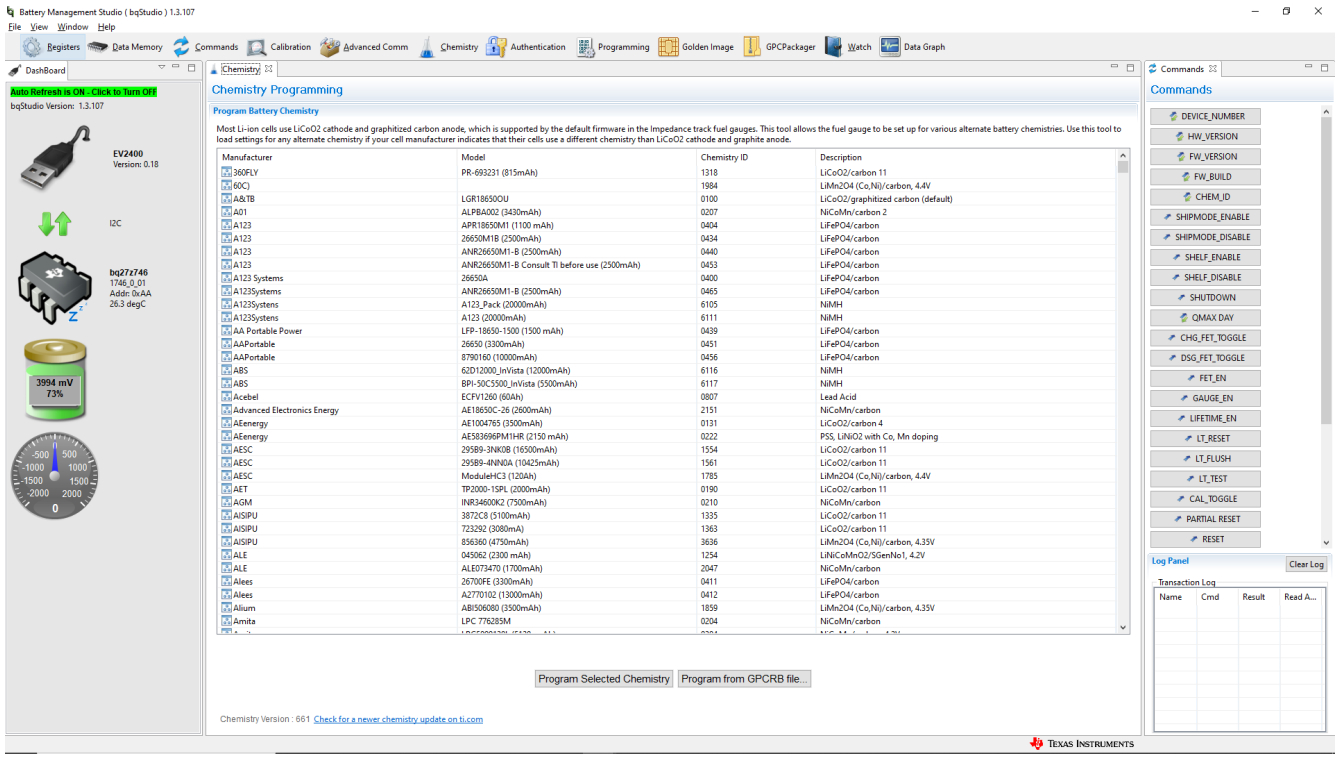

Figure 8-3. Chemistry Screen

9 Related Documentation from Texas Instruments

Updated documents also can be obtained through the TI website at www.ti.com.

1. Texas Instruments Data sheet: *BQ27Z746 System-Side Impedance Track™ Fuel Gauge with Integrated Sense Resistor*, SLUSDW2
2. Texas Instruments Technical Reference Manual: *BQ27Z746 Technical Reference Manual*, SLUUCA6

10 Revision History

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

DATE	REVISION	NOTES
October 2021	*	Initial Release

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