Application Report
SLUA421A–May 2007–Revised September 2007

Quick-Start Guide for bq20zxx Family Gas Gauges

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ABSTRACT

The intent of this application report is to give the user an overview of the design process, how to use the evaluation module and software, and to provide helpful troubleshooting techniques.

Reading the following applications reports before working with Impedance Track™ devices is advisable.

- *Theory and Implementation of Impedance Track™ Battery Fuel-Gauging Algorithm in bq20zxx Product Family* (SLUA364)
- *Impedance Track™ Gas Gauge for Novices* (SLUA375)
- *Exploring the bq20z80 Impedance Track ™Evaluation Kit* (SLUA351)

This document begins with setting up the evaluation module and working with bq Evaluation Software. Several tips for troubleshooting the software connection are included, as well as navigation and what to look for in the different configuration screens.

Step-by-step examples of the following commands/procedures are described as well:

- Pack Reset
- Clearing a Permanent Failure
- Sealing and unsealing a pack
- Updating firmware/chemistry profile
- Data logging during testing

The two comprehensive documents on the Impedance Track™ devices are the *bq20z80 Application Book* (SLUA380) and *bq20z80-V102 + bq29312A Chipset Technical Reference Manual* (SLUU241). The *bq20z80 Application Book* has most of the application reports that have been written on the bq20zxx in a chronological order of designing and testing your system. The *bq20z80-V102 + bq29312A Chipset Technical Reference Manual* has all the manufacture and extended SBS commands for interfacing with the gas gauge. Become familiar with both of these documents prior to developing and debugging your system.

The firmware version is indicated by the –V### behind the part number. When designing your system, use the latest firmware version and review any subsequent changes moving forward. Any literature number referenced in this document can be updated by adding an "A" to the SLxx### or changing an "A" to a "B" for revision 2 of an application report.

This document pertains to all the multicell Impedance Track™ devices; at the time of this publication, the bq20z80, bq20z90, and the bq20z70 devices are released. The bq20z80 is the first generation of hardware, whereas the bq20z90 and bq20z70 are second-generation hardware with the bq20z70 being a subset of the bq20z90 functionality. For example, when looking for information on the bq20z90, look in the bq20z80 product folder. Also, when in the product folder, look at the Application Notes section for all the –v### firmware versions (specifically look in the -v102 product folder for the comprehensive list of individual application notes).

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Windows is a trademark of Windows Corporation.

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1 Getting Started with the bq20zxx Evaluation Module

The first thing to do is load the bq Evaluation Software. This software is included with the EVM on a CD or can be downloaded from the evaluation module product folder (not to be confused with the IC product folder) on the Texas Instruments Web site at www.ti.com. Figure 1 is a screen capture from this page with the software link being: *bqEV-Easy Setup*

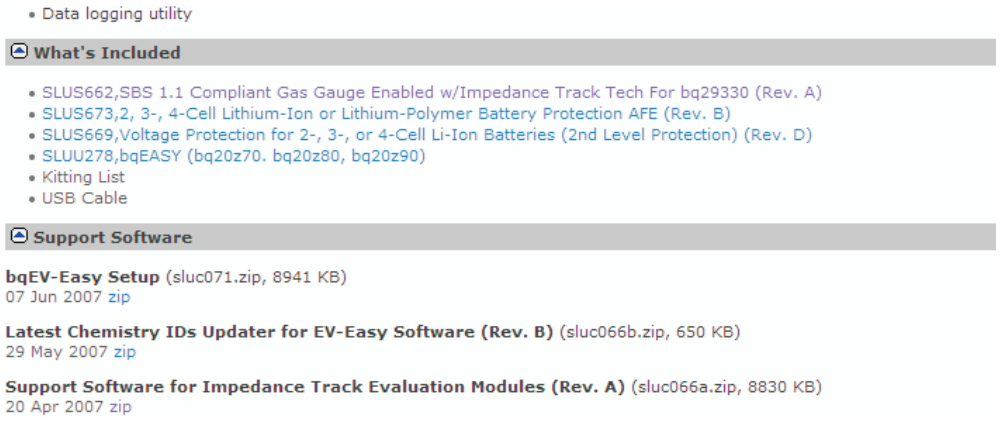


Figure 1. Support Documentation in Evaluation Board Product Folder on ti.com

Driver installation for the EV2300 communication box actually requires that two drivers need to be loaded for proper operation. A good discussion of installing the USB drivers can be found in the application report *Using bqTester Singles Site Software* (SLUA352) in the section entitled "EV2300 Driver to USB Port Association."

To develop familiarity with the bq20zxx EVM, let us simulate a battery stack with resistors and a power supply. You can vary the voltage across these resistors to simulate different states of charge. This configuration is shown in Figure 2 and is described in depth in the application report *Exploring the bq20z70/90 Impedance Track Evaluation Kit* (SLUA396).

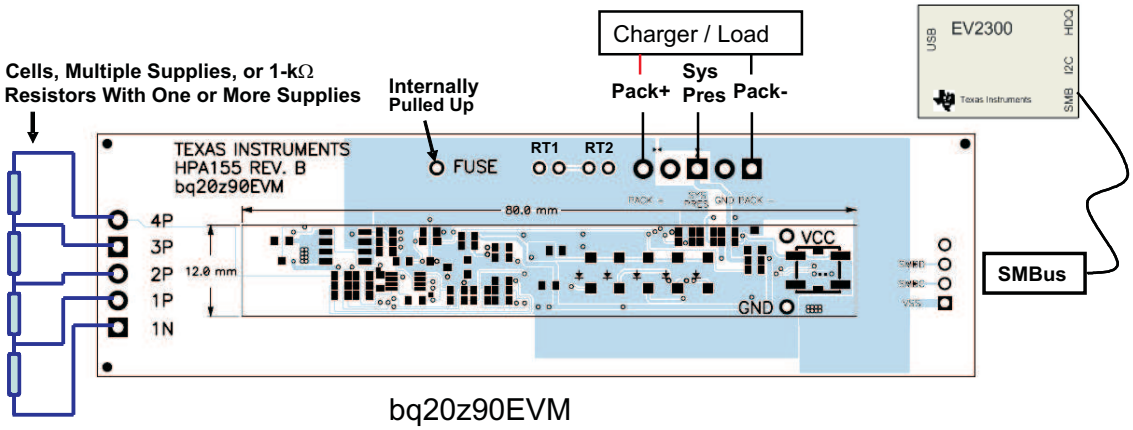


Figure 2. B20z90 EVM

2 Software Communication and Trouble Shooting

When you open the bqEVSW software program, it should automatically recognize the firmware and hardware version. If there is a communication problem, the following screen appears (Figure 3).

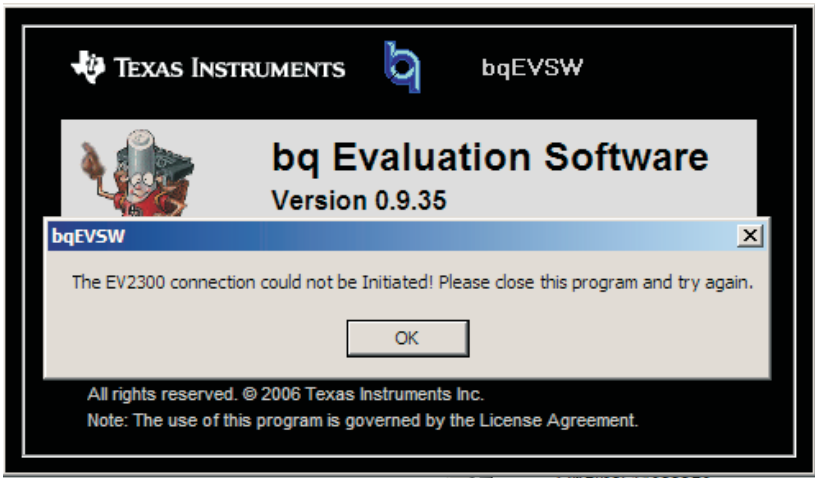


Figure 3. Error Screen When bqEVSW Software Fails to Communicate With EVM

If you press the OK button, then the software asks you to select the device you are using. If you get to this point, however, you will not have proper communication with the EVM. If you proceed and choose one of the devices and firmware revisions, you will eventually be able to open the software window main screen, but it will be grayed out (see Figure 5). Take the following steps if you have communication issues:

- Do you have the EV2300 USB cable connected?
- Have you properly installed both drivers required for proper EV2300 operation?
- Did you *kick start* the EVM by connecting power momentarily to PACK+ and PACK– to simulate a charger insertion?
- Are the SMB lines connected to the EVM (versus I2C or HDQ)?
- Is another instance of the software already running? (Look in Windows™ Task Manager processes.)
- Try restarting your computer if you do not see the *TI USB bq80xx driver* loaded under hardware.

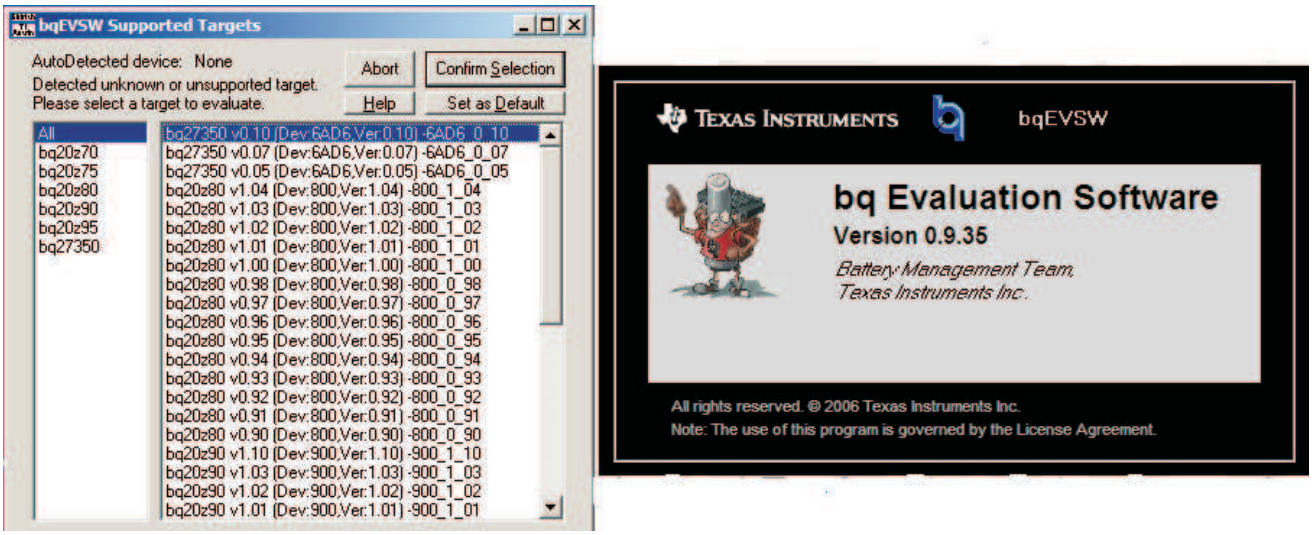


Figure 4. bqEVSW Software Asking With Which Device You Wish to Communicate

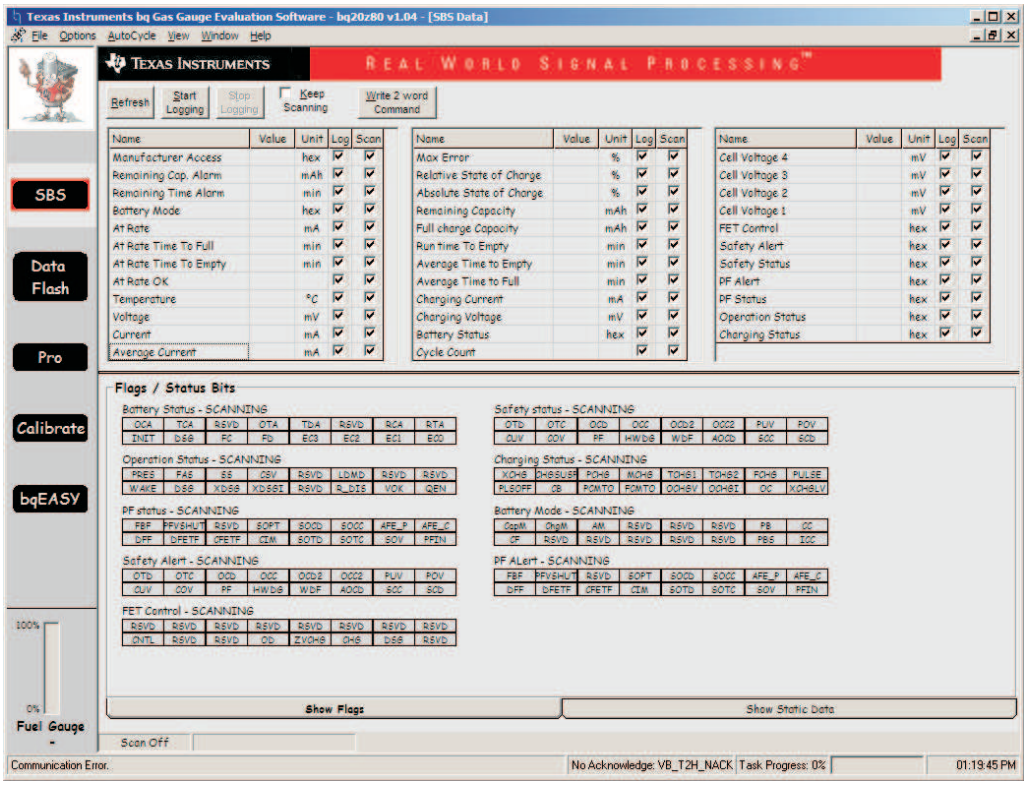


Figure 5. Blank Screen That Appears if bqEVSW Software Is Unable to Communicate With EVM

3 Exploring the Evaluation Software Screens

The SBS screen is first to appear by default. Notice on the left side of the screen the five sections of the software: SBS, Data Flash, Pro, Calibration, and bqEASY.

If everything is working properly, you see a screen similar to Figure 6 with green/orange indicators in the status registers. Also, *Communication OK* appears in the lower left corner. Click on the *Keep Scanning* box at the top of the window. The software continues to update these values throughout your testing process.

The SBS screen shows the standard SMBus information you can read from the pack when it is sealed, as well as showing important status registers on the IC which can only be seen when the pack is unsealed or in full access mode (no FAS or SS bit is set in *Operation Status register*). By default, the IC is configured in full access mode.

Do not issue the seal command unless you are finished with the production flow and have programmed the correct .ROM file of your golden pack. If you do seal the pack, you can issue the unseal command, followed by the full access command. However, if you removed power to the IC, it goes back into sealed mode and you have to repeat this process again to unseal and subsequently move to full access mode. The only way to “reset” the IC to automatically launch in full access mode is to reload the .SENC file with defaults.

Be aware that reloading the .SENC file erases any data flash constants or resistance updates through cycling that you may have made.

An example of how to move from Sealed to Unsealed to Full Access mode can be found in the *Tips and Tricks* section of this application report.

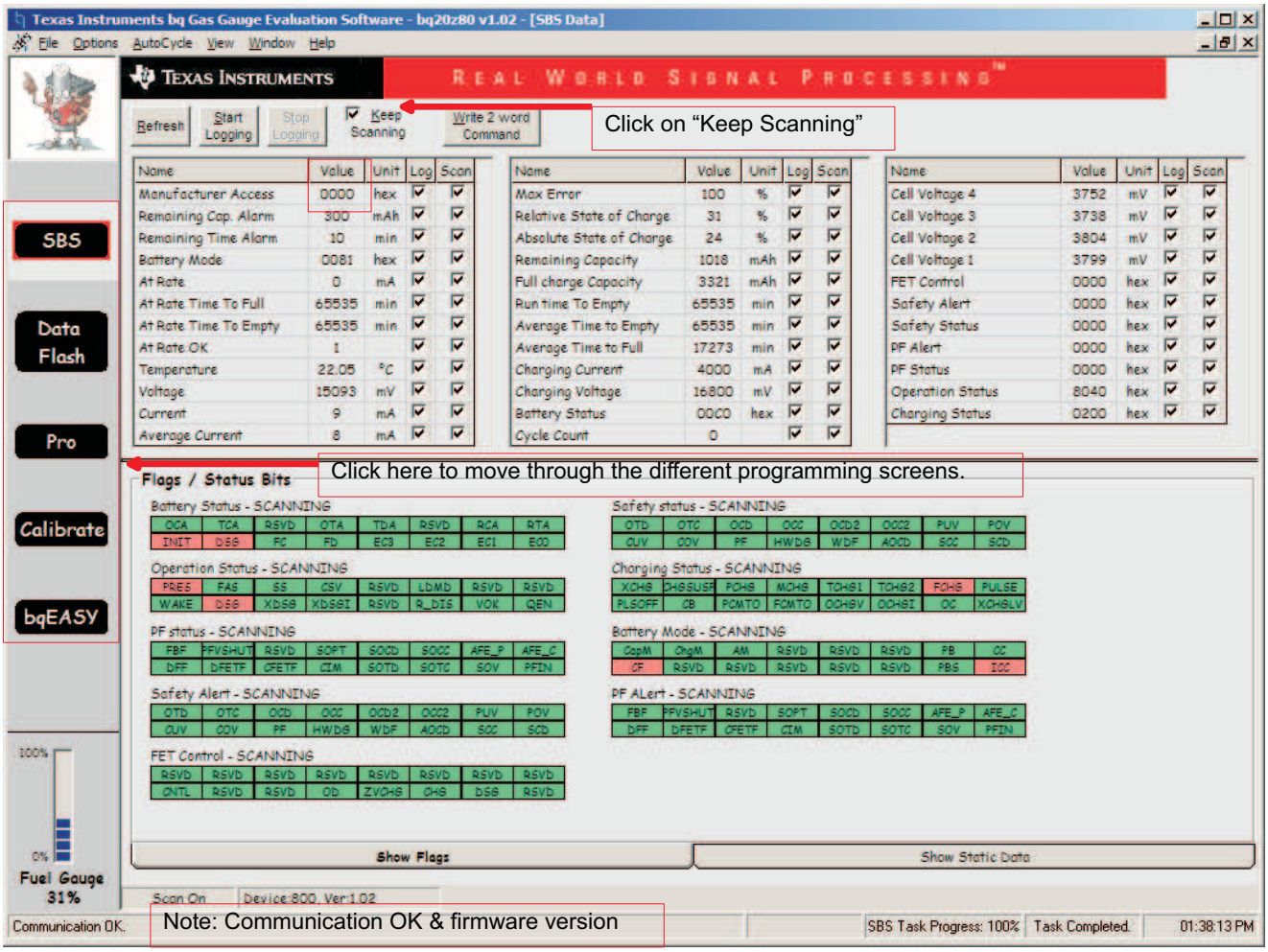


Figure 6. SBS Screen With OK Communication

You can issue Manufacture Access commands from this window Section 3.1 by clicking in the box under *Value*. A warning is displayed saying that the automatic scanning must be disabled in a 2-word write (otherwise, the software issues a command to update its SBS values before you can write the second word).

Another option is to use the *Write 2 word Command* button just to the right of the *Keep Scanning* check box. This sends both words immediately and avoids any issue with software scanning.

For example, this issue arises when writing the Unseal, Permanent Failure, Clear, or Full Access commands. Examples of how to complete these processes are included in the following text.

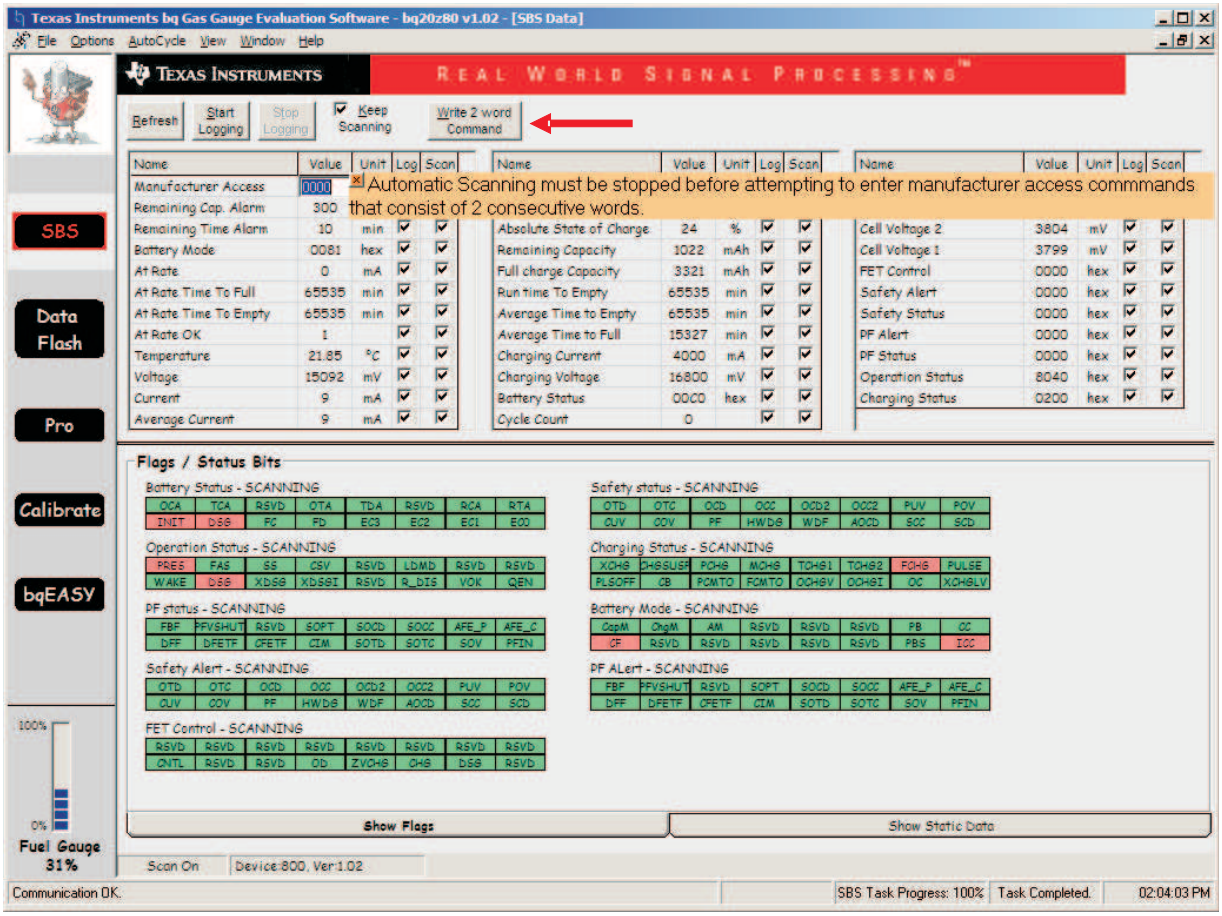


Figure 7. Location of *Write 2 word Command* Button on SBS Screen

3.1 *Reset Example*

Vary the voltage of the power supply (being careful not to exceed maximum voltages), and issue a Manufacture Access RESET command to the bq20zxx. This SMBus Command is 00, Word 0041.

This can be done in two ways. The shortcut is to type 41 into the Manufacture Access Value on the SBS screen. Alternatively, from the PRO screen, you can issue reset command 00, word 0041 from the *Write SMB Word* and press the *Write* button.

You will see the Fuel Gauge reading go to 0% and then return to an estimated capacity based on the open-circuit voltages the gas gauge expects to see.

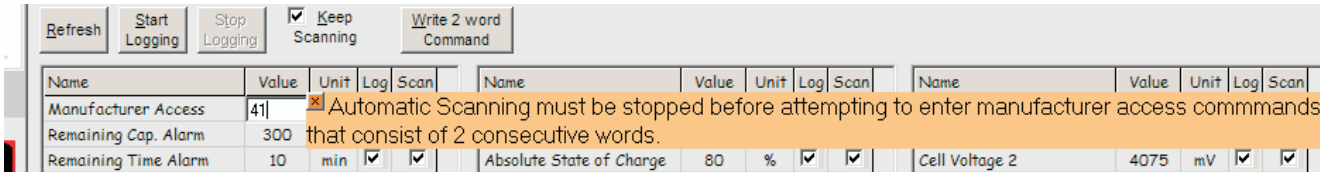


Figure 8. First Method for Sending Manufacture Access Commands

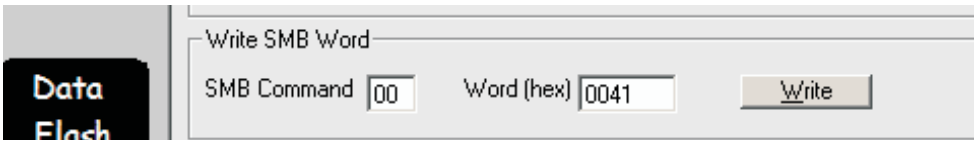
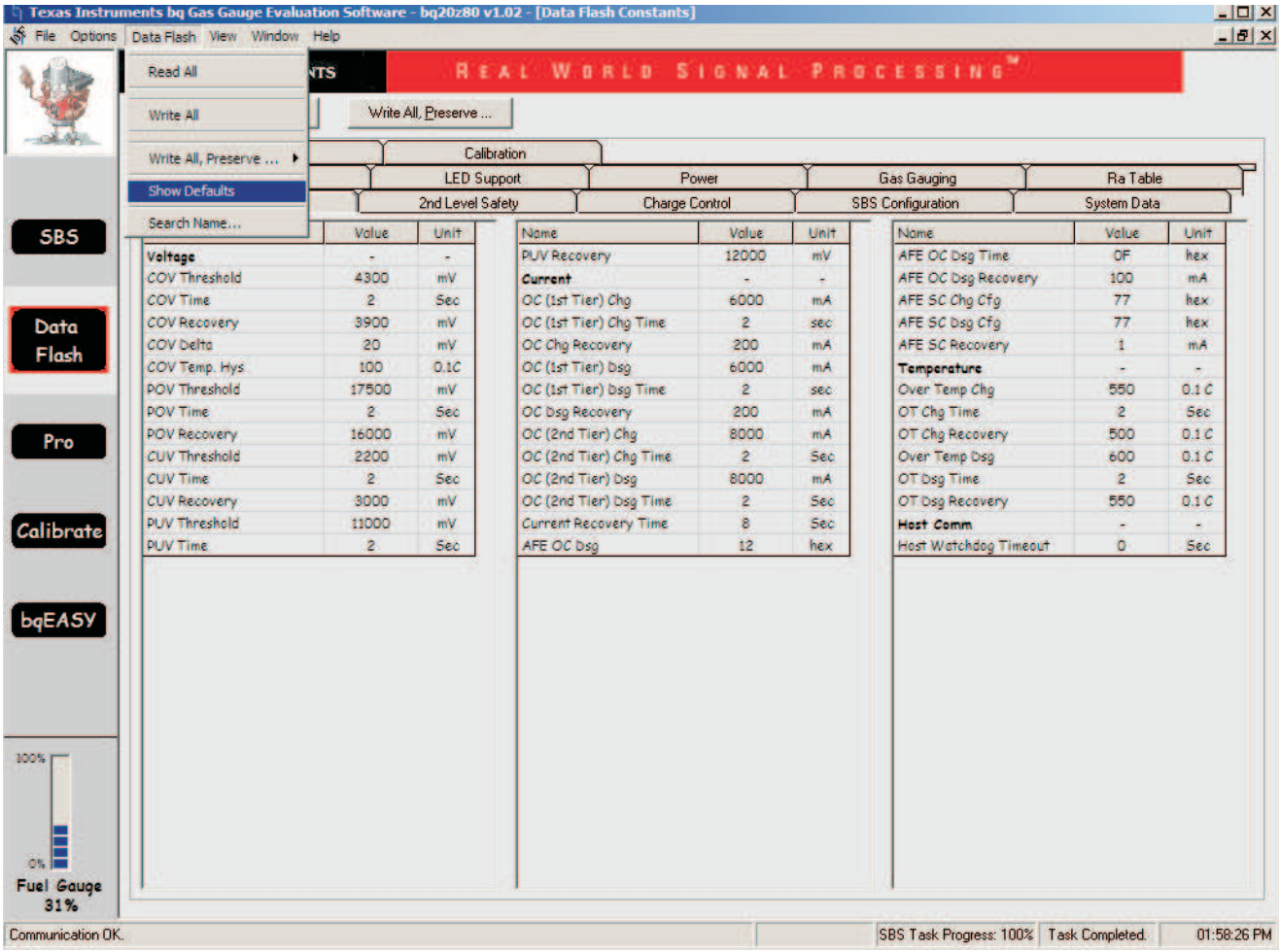


Figure 9. Second Method for Sending Manufacture Access Commands

The Data Flash screen shows all the parameters you can change when designing your system (Figure 10). To begin, load the default values stored that show the configuration of a 4s2p cell pack configuration (four cells stacked in series, and two cells in parallel equaling eight cells total).

Review the following application reports for detailed information on configuring the Data Flash for your particular design:

- *bq20zxx EVM Data Flash Settings for Number of Serial Cells and Pack Capacity* (SLVA208) – this gives a step-by-step tutorial on changing required Data Flash values.
- *Configuring the bq20z90 Dataf Flash* (SLUA405) – is a comprehensive definition resource of all the Data Flash parameters. If you are using the bq20z70 or bq20z80,a similar application report is available for each IC.



Name	Value	Unit
Voltage	-	-
COV Threshold	4300	mV
COV Time	2	Sec
COV Recovery	3900	mV
COV Delta	20	mV
COV Temp. Hys	100	0.1C
POV Threshold	17500	mV
POV Time	2	Sec
POV Recovery	16000	mV
CUV Threshold	2200	mV
CUV Time	2	Sec
CUV Recovery	3000	mV
PUV Threshold	11000	mV
PUV Time	2	Sec

Name	Value	Unit
PUV Recovery	12000	mV
Current	-	-
OC (1st Tier) Chg	6000	mA
OC (1st Tier) Chg Time	2	sec
OC Chg Recovery	200	mA
OC (1st Tier) Dsg	6000	mA
OC (1st Tier) Dsg Time	2	sec
OC Dsg Recovery	200	mA
OC (2nd Tier) Chg	8000	mA
OC (2nd Tier) Chg Time	2	Sec
OC (2nd Tier) Dsg	8000	mA
OC (2nd Tier) Dsg Time	2	Sec
Current Recovery Time	8	Sec
AFE OC Dsg	12	hex

Name	Value	Unit
AFE OC Dsg Time	OF	hex
AFE OC Dsg Recovery	100	mA
AFE SC Chg Cfg	77	hex
AFE SC Dsg Cfg	77	hex
AFE SC Recovery	1	mA
Temperature	-	-
Over Temp Chg	550	0.1 C
OT Chg Time	2	Sec
OT Chg Recovery	500	0.1 C
Over Temp Dsg	600	0.1 C
OT Dsg Time	2	Sec
OT Dsg Recovery	550	0.1 C
Host Comm	-	-
Host Watchdog Timeout	0	Sec

Figure 10. Data Flash Screen in bqEVSW Showing Default Parameters

The Pro screen allows you to communicate with the bq20zxx IC. It is on this screen that you can read and write byte, work, and block information. Also, you can upload a new .SENC file from this screen by following the steps in the application report *Updating Firmware With the bq20zxx and EVM* (SLUA336).

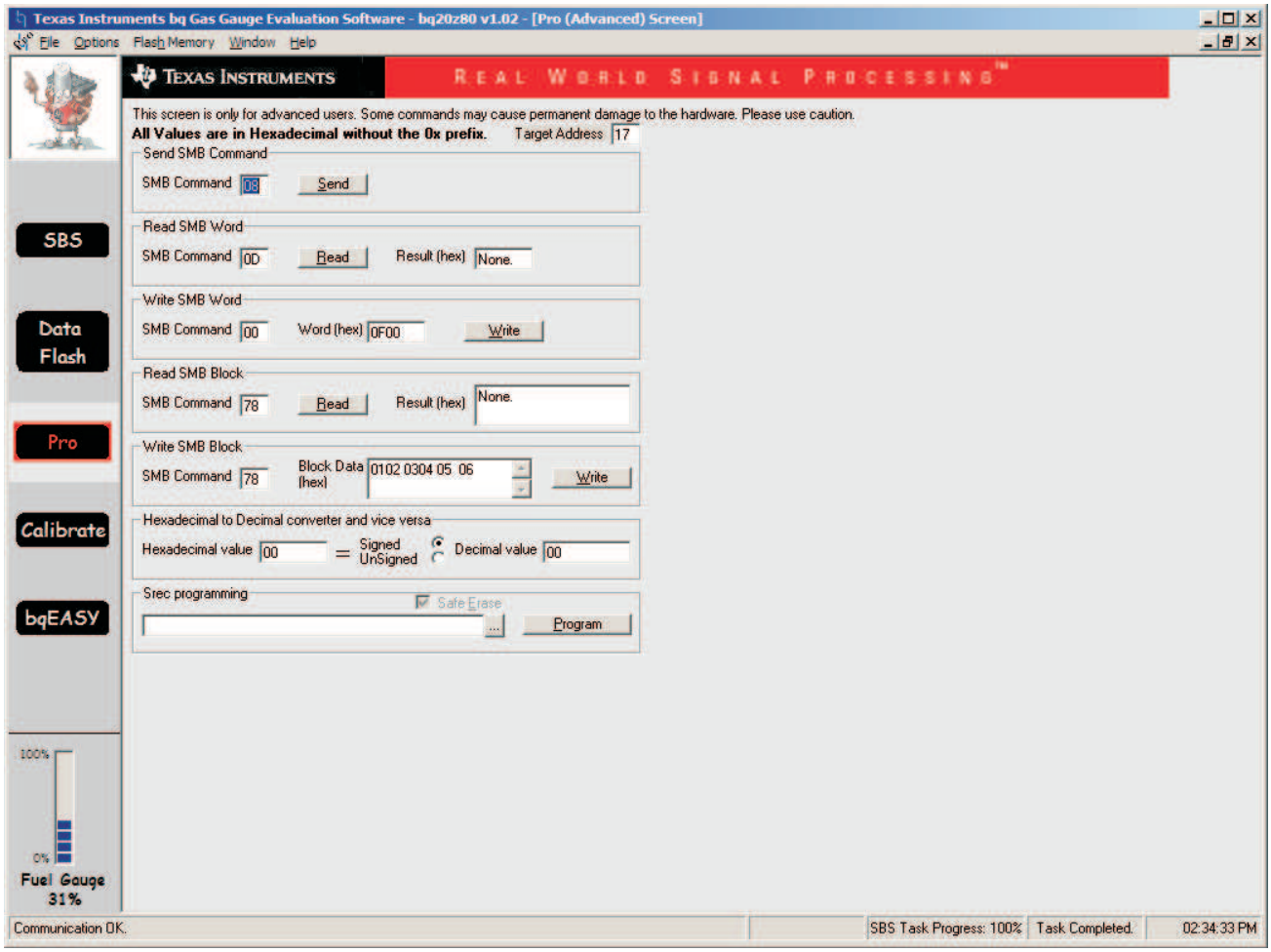


Figure 11. The PRO Screen Allows You to Communicate With the bq20zxx and (Re)Program the .SENC File

The Calibration screen allows you to calibrate the gas gauge voltage, current, temperature, and offsets. Review the *Calibration of bq20zxx Using EV Software* application report for specifics.

The bqEASY screen is a new feature in the bq Evaluation Software. Its purpose is to use a *wizard* to program the Data Flash parameters and to choose the proper battery chemistry and the two cycle tests to create your *Golden Image*. If you are just beginning with Impedance Track™ technology, this is a good way to start.

4 Choosing the Correct Chemistry

For the Impedance Track™ algorithm to work properly, the exact chemistry of the lithium cells needs to be known and the correct .SENC file needs to be loaded.

If you are using the bqEASY design wizard, it asks you to choose the correct chemistry from a list of manufacturers and model numbers, or test for a compatible chemistry using a *4-point test*. Note: success of the 4-point test is contingent on an accurate voltage calibration

The most updated chemistry .SENC files can be found in the *bq20z90-V110 Multiple Li-Ion Chemistries Software* .ZIP link located in the bq20z90 product folder under Tools and Software (Figure 12). (The bq20z70 and bq20z90 devices have a similar .ZIP file.)

The process for updating the .SENC file is outlined in detail in the application report *Updating Firmware With The bq20zxx and EVM.*

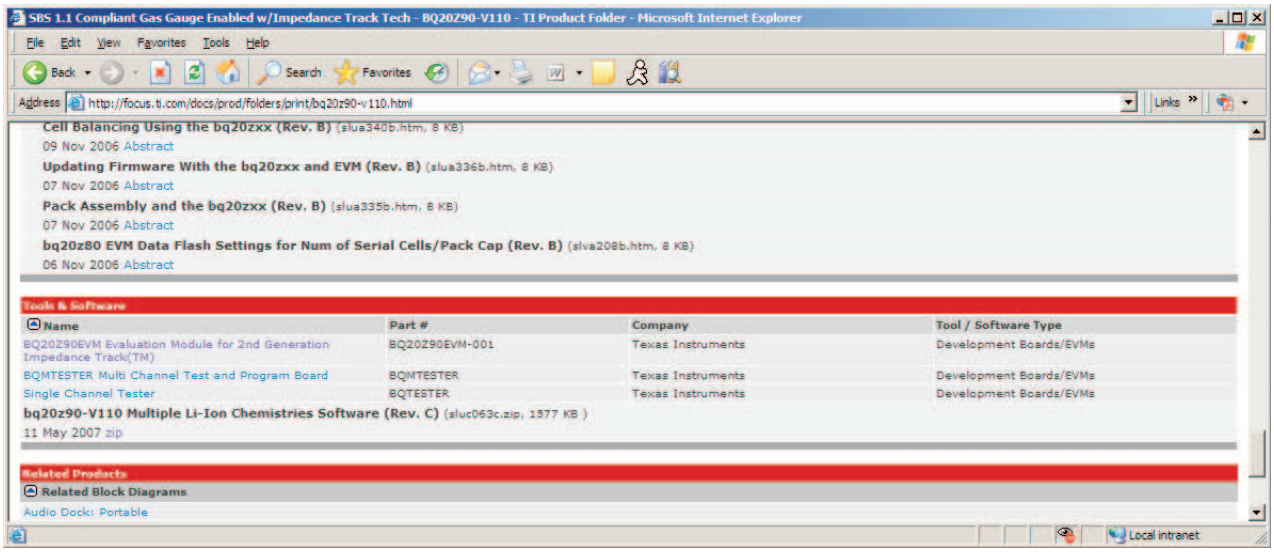


Figure 12. The .ZIP Chemistry File as Seen Under Tools and Software in bq20zxx Product Folder

Within the .ZIP file are different *ID* .SENC files that correspond to different Li-ion battery chemistries. The *chemistry_selection_table.xls* (Figure 14) shows corresponding .SENC files for known chemistries and manufacturer part numbers. Note that in this illustration, a unique chemical ID indicates a different battery chemistry being used.

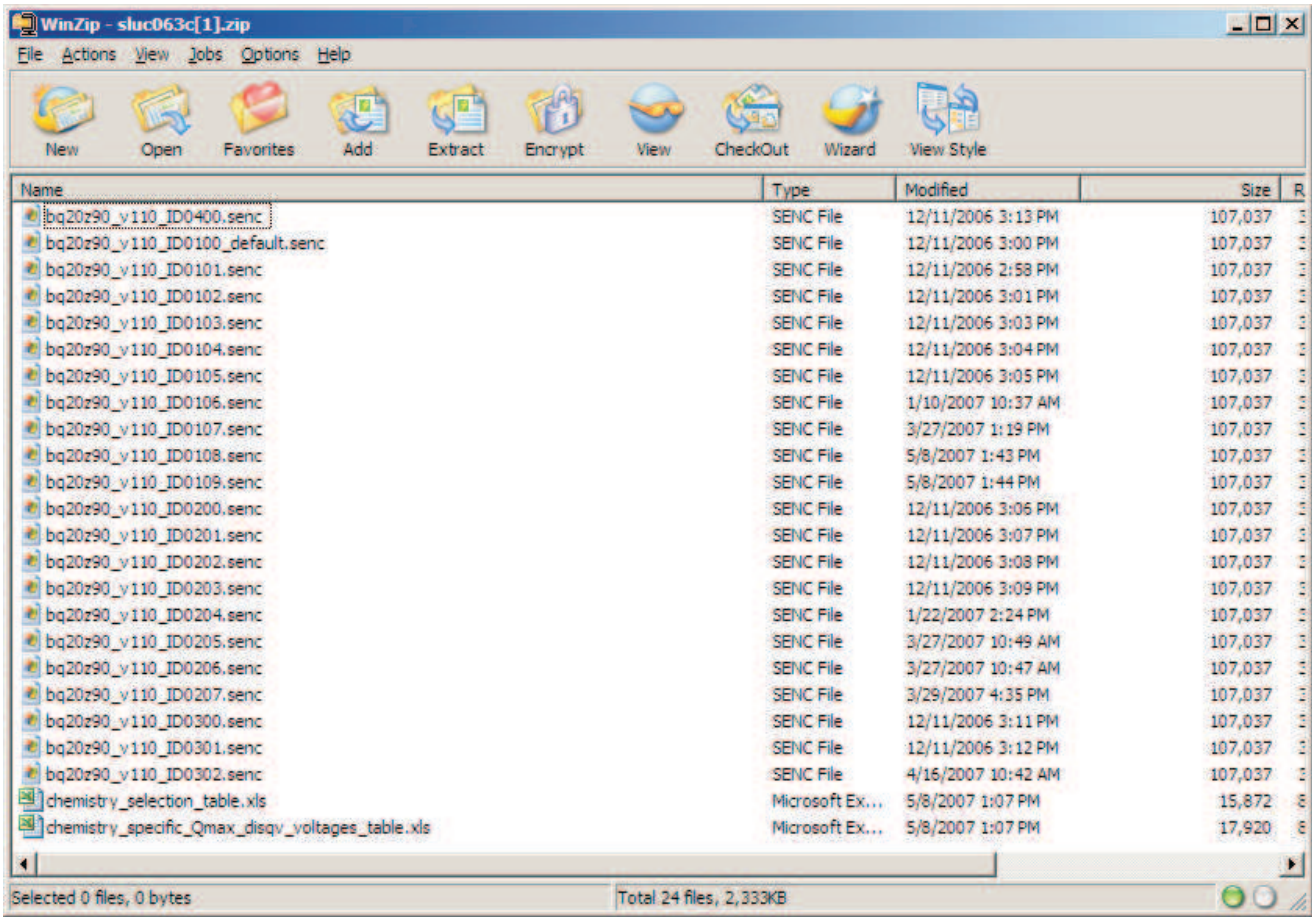
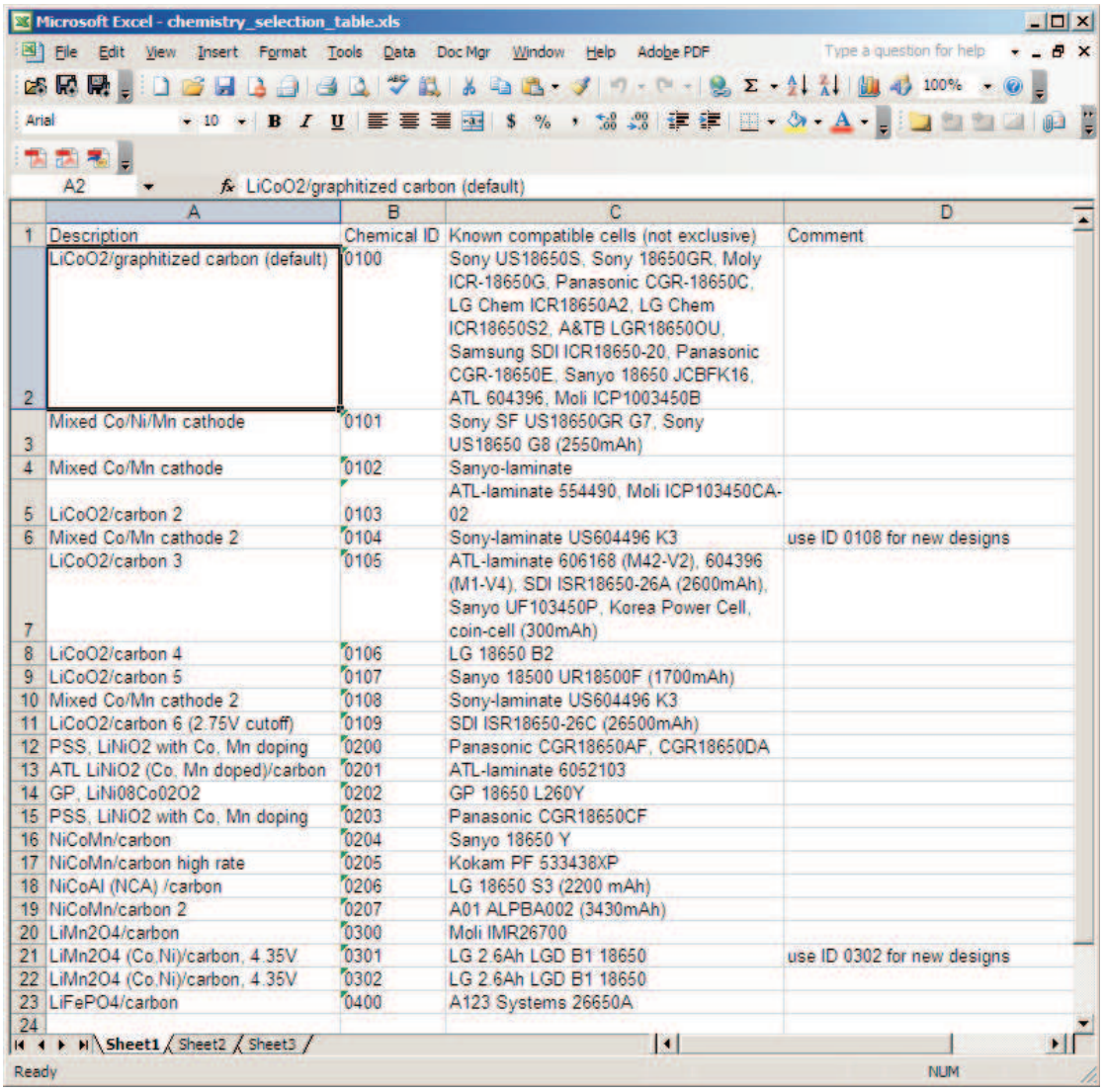


Figure 13. Chemistry .ZIP Contents Located in bq20zxx Product Folder



Microsoft Excel - chemistry_selection_table.xls

File Edit View Insert Format Tools Data Doc Mgr Window Help Adobe PDF

A2 LiCoO2/graphitized carbon (default)

	A	B	C	D
1	Description	Chemical ID	Known compatible cells (not exclusive)	Comment
2	LiCoO2/graphitized carbon (default)	0100	Sony US18650S, Sony 18650GR, Moly ICR-18650G, Panasonic CGR-18650C, LG Chem ICR18650A2, LG Chem ICR18650S2, A&TB LGR18650OU, Samsung SDI ICR18650-20, Panasonic CGR-18650E, Sanyo 18650 JCBFK16, ATL 604396, Moli ICP1003450B	
3	Mixed Co/Ni/Mn cathode	0101	Sony SF US18650GR G7, Sony US18650 G8 (2550mAh)	
4	Mixed Co/Mn cathode	0102	Sanyo-laminate	
5	LiCoO2/carbon 2	0103	ATL-laminate 554490, Moli ICP103450CA-02	
6	Mixed Co/Mn cathode 2	0104	Sony-laminate US604496 K3	use ID 0108 for new designs
7	LiCoO2/carbon 3	0105	ATL-laminate 606168 (M42-V2), 604396 (M1-V4), SDI ISR18650-26A (2600mAh), Sanyo UF103450P, Korea Power Cell, coin-cell (300mAh)	
8	LiCoO2/carbon 4	0106	LG 18650 B2	
9	LiCoO2/carbon 5	0107	Sanyo 18500 UR18500F (1700mAh)	
10	Mixed Co/Mn cathode 2	0108	Sony-laminate US604496 K3	
11	LiCoO2/carbon 6 (2.75V cutoff)	0109	SDI ISR18650-26C (26500mAh)	
12	PSS, LiNiO2 with Co, Mn doping	0200	Panasonic CGR18650AF, CGR18650DA	
13	ATL LiNiO2 (Co, Mn doped)/carbon	0201	ATL-laminate 6052103	
14	GP, LiNi08Co02O2	0202	GP 18650 L260Y	
15	PSS, LiNiO2 with Co, Mn doping	0203	Panasonic CGR18650CF	
16	NiCoMn/carbon	0204	Sanyo 18650 Y	
17	NiCoMn/carbon high rate	0205	Kokam PF 533438XP	
18	NiCoAl (NCA) /carbon	0206	LG 18650 S3 (2200 mAh)	
19	NiCoMn/carbon 2	0207	A01 ALPBA002 (3430mAh)	
20	LiMn2O4/carbon	0300	Moli IMR26700	
21	LiMn2O4 (Co,Ni)/carbon, 4.35V	0301	LG 2.6Ah LGD B1 18650	use ID 0302 for new designs
22	LiMn2O4 (Co,Ni)/carbon, 4.35V	0302	LG 2.6Ah LGD B1 18650	
23	LiFePO4/carbon	0400	A123 Systems 26650A	
24				

Sheet1 Sheet2 Sheet3

Ready NUM

Figure 14. “chemistry_selection_table.xls” From chemistry.zip File.

5 Creating Your Golden Image

One of the major benefits of using the Impedance Track™ technology, aside from highly accurate gas gauging, is a simplified manufacturing process: no charge or discharge cycles are required after being programmed with the golden image file, and the assembling of the pack (a process which can take many hours to charge and discharge).

The different steps in design, preproduction, and production follow.

5.1 Design and Evaluation

1. Install the bqEVSW software and USB drivers for the EV2300 communication box.
2. Connect resistors and power supply to simulate battery pack.
3. Kick-start EVM.
4. Run bqEVSW software.
5. Explore the different features of the software.
6. Load the correct .SENC file corresponding to the chemistry of your battery cells.

7. Program the necessary Data Flash constants specific to your design.
8. Now, connect real battery cells to the EVM. (Note: connect from lowest voltage 1N to highest in order to avoid damage to the analog front-end IC.)
9. Fully charge the cells and let rest for 2 hours.
10. Start Data Logging – both SBS parameters and the .GG gas gauge files
11. Follow the steps outlined in application report *Preparing Optimized Default Flash Constants for Specific Battery Types* (SLUA334). This includes the following steps which basically are:
    - Enable Impedance Track™ algorithm. (See "IT Enable(0x0021)" under Manufacturer Access(0x00) in the *System Control* section of the *bq20z80-V102 + bq29312A Technical Reference Manual* (SLUU241)
    - Discharge the pack to termination voltage and let rest for 5 hours.
    - Repeat.
12. Look for updated resistances and Update Status = 06 in the final .GG file.

    Now that you have a properly cycled pack with updated values, it is time to create the Golden image file that will be programmed into every pack coming off the production line.
13. Export the .GG file and make a few changes (update status and cycle count). Specifics can be found in the *Preparing Optimized Default Flash Constants for Specific Battery Types* (SLUA334) application report.
14. Reload the .SENC file to clear out Data Flash hidden values.
15. Import your changed .GG file.
16. Now you are ready to create the .ROM file to be used to program production packs. The .ROM file is created using the bqTester Single Site or bqMTester (multisite) tester software. See *Using bqTester Single Site Software* application report (SLUA352) and *bqMTester User's Guide* (SLUU238).

6 The .GG File

The purpose of the gas gauge .GG file is to store all the programmable Data Flash parameters, as well as the updated cell resistance profile after doing the 2-cycle tests. Figure 15 shows two .GG files side-by-side. An original (default) .GG file is next to a properly cycled .GG file. Note Update Status, Qmax, and R_a changes.

Note the following items:

1. The Update Status as changed from 0x00 to 0x06. This is what you want.
2. QMAX for the individual cells and pack has been updated. In this case, the capacity at 4400mAh was underestimated.
3. The resistance table has been updated for each of the cells. For example, *Cell0 R_a 0* is 160 (by default) before cycling and has been updated to 139 after cycling.

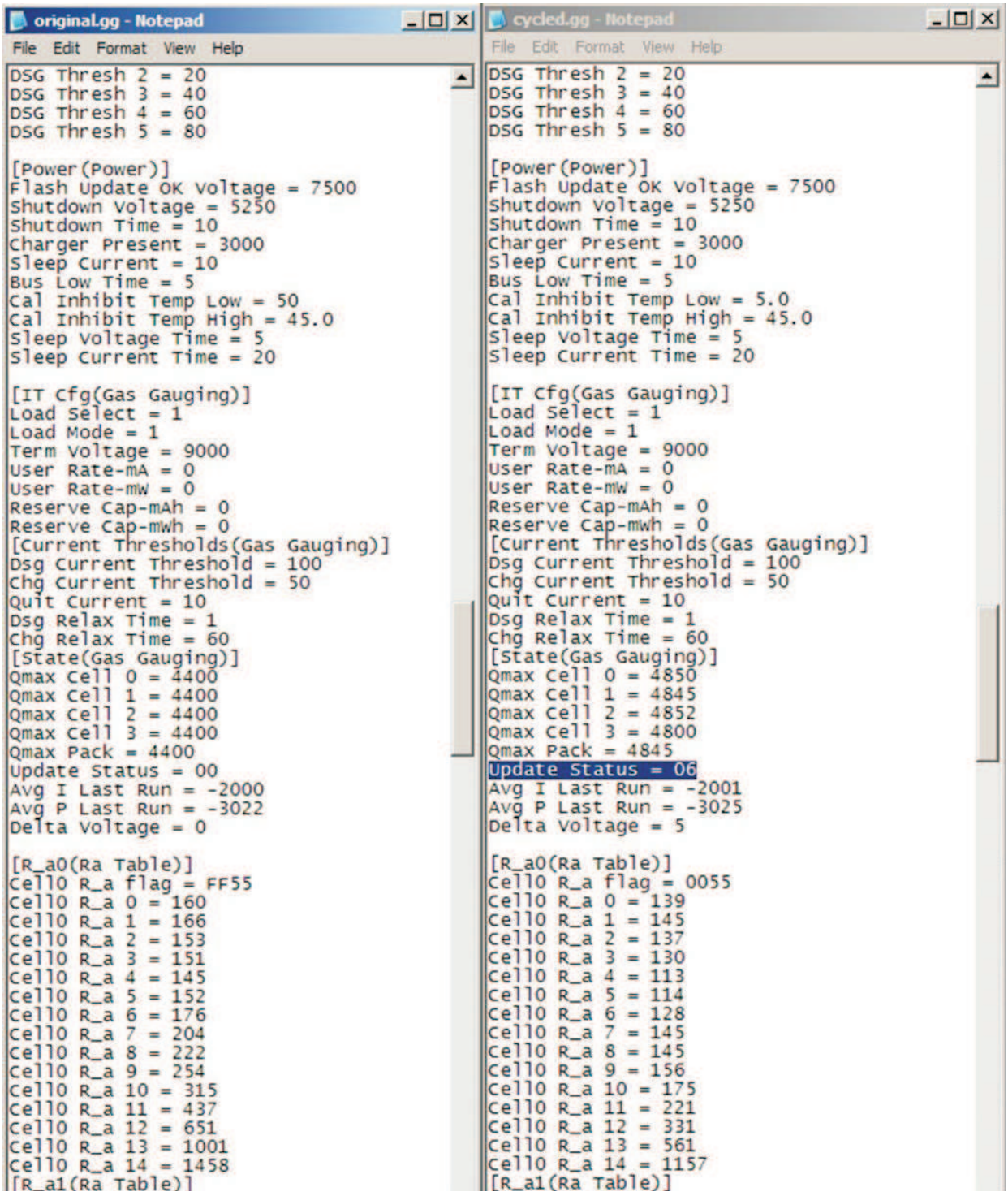


Figure 15. .GG File Diagram

7 Data Logging

While running your charge and discharge tests, log the SBS and .GG gas gauge data. This is accomplished in two steps. The logging of SBS data is found in the SBS screen under FILE, Start Logging. It asks for a file to save the data.

To save the iterations of the .GG file, go to the Data Flash screen and choose OPTIONS, Set AutoExport Filename. A series of .GG files are created in the folder specified throughout testing. Adjust the interval of AutoExport (every 15 minutes is usually acceptable). Finally, click on *AutoExport* to begin saving the .GG files.

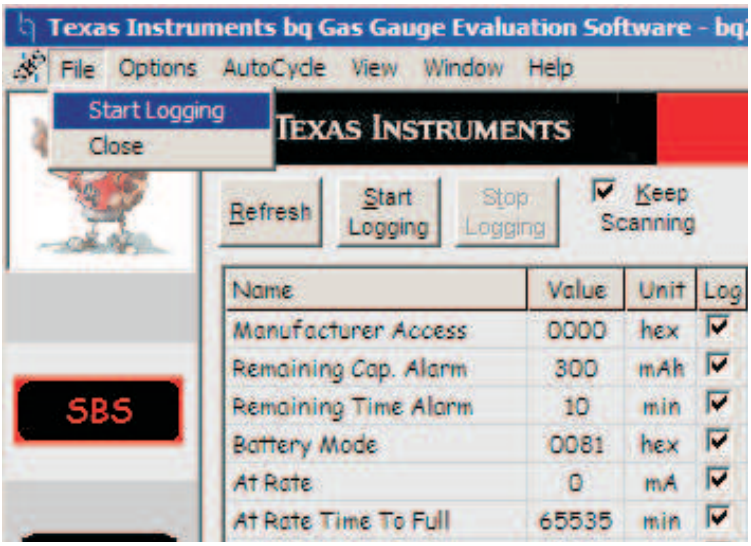


Figure 16. SBS Data Logging Pulldown Menu

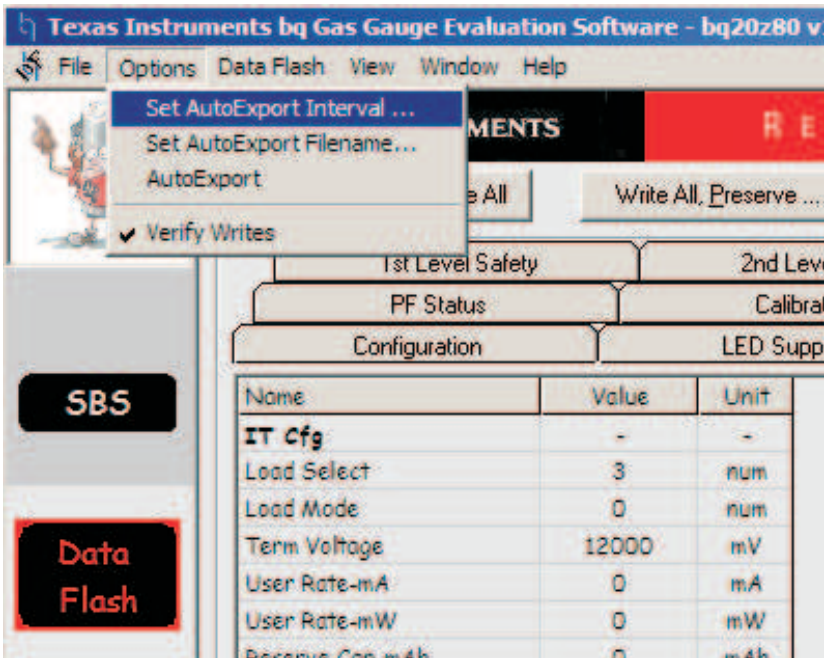


Figure 17. .GG File Logging Pulldown Menu

8 Tips and Tricks

8.1 Right-Click Instant Help

Remembering all the nuances of the Data Flash parameters is impractical. However, after working with the system for a while, many of the parameters will be remembered.

In any case, all of the Data Flash definitions are listed in the bq20zxx Technical Reference Manual. Additionally, you can right-click on any of the parameters, and choose *Help Text* which links you to the appropriate definition directly.

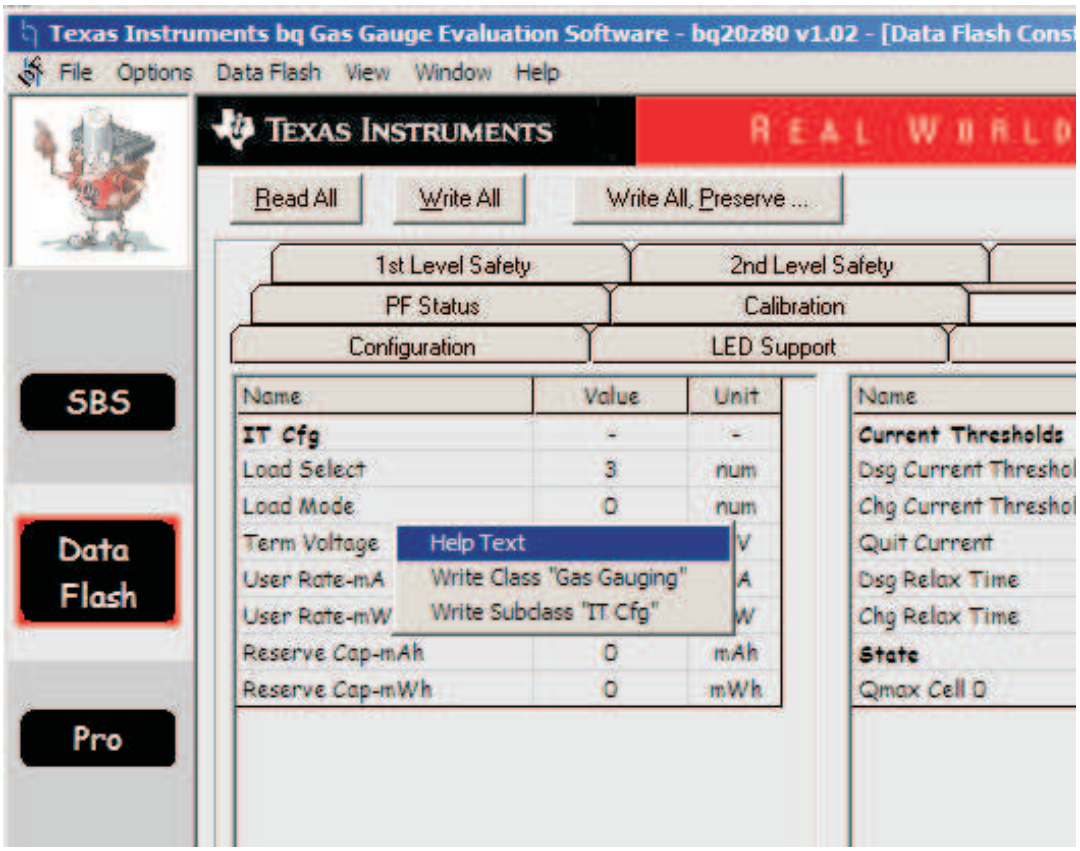


Figure 18. Finding Data Flash Definitions by Right-Clicking and Choosing *Help Text*

8.2 Clearing a Permanent Failure Example

At some point in the design process, you are going to test fault conditions. When that happens, a PF flag is set. The charge and discharge FETs are opened, depending on the fault. To continue testing, you need to reset the IC.

For example, in the Second Level Safety tab, set the SOV time to 3 seconds and SOV Threshold to 18000 mV (Figure 19). Now, raise the voltage across the resistor divider network to 18.1 V. You will see a Safety Alert followed by a Permanent Failure (Figure 20).

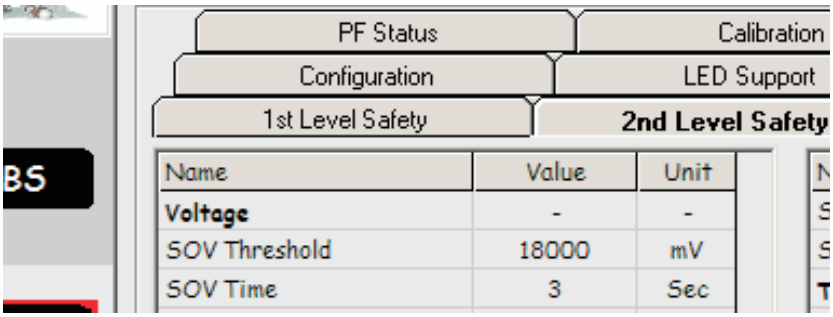


Figure 19. Simulating an Overvoltage Permanent Failure

Set SOV Time to 3 seconds to simulate an overvoltage permanent failure.

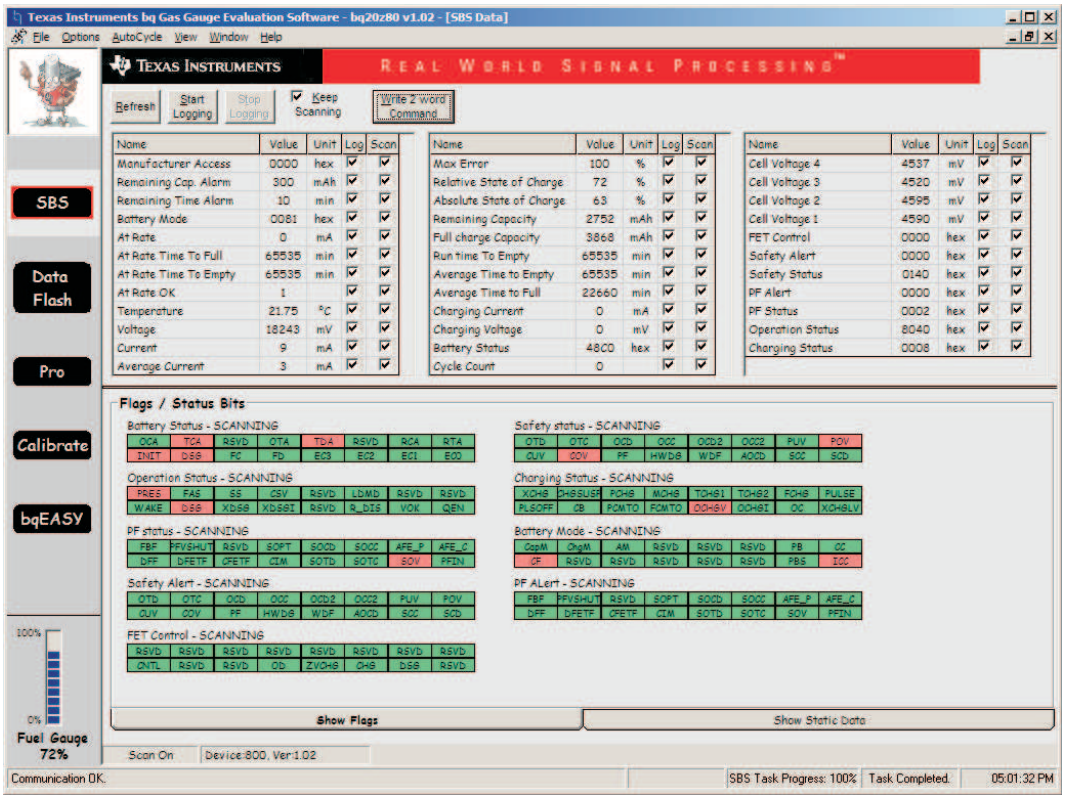


Figure 20. SOV Bit Set in Permanent Failure Status Register

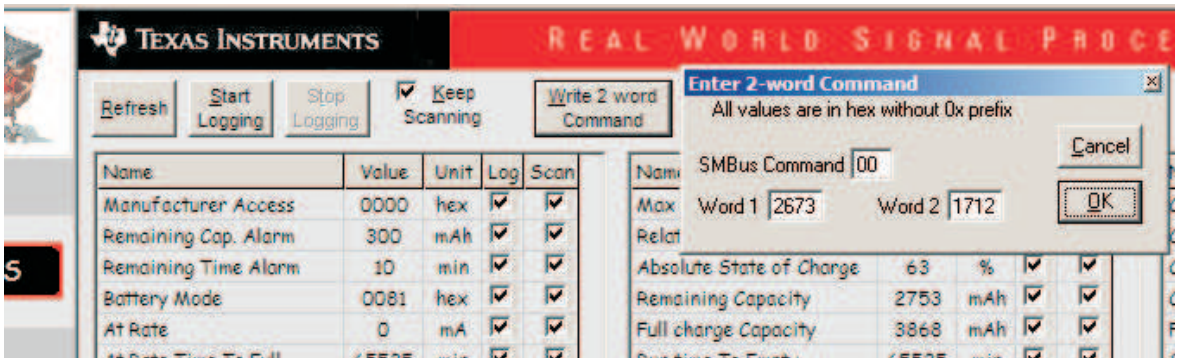


Figure 21. Clearing the Permanent Failure

To clear the Permanent Failure, write the 2 Word Command PFKey (Figure 21).

8.3 Seal and Unseal Process Example

If you seal your battery pack, and later decide you need to unseal it (for example, diagnosing a field failure), perform the following steps.

During production, change the default Unseal and Full Access Keys programmed into the IC. To read the default Unseal and Full Access Key, review the relevant sections in the Technical Reference manual.

By maneuvering to the PRO screen and reading the SMB Block for the Unseal Key (SMB Command 60; Figure 22) and the Full Access Key (SMB Command 61; Figure 23), it is seen in this particular device the default is 0414 3672 and FFFF FFFF by default. (Note the Little Endian representation of the data.)

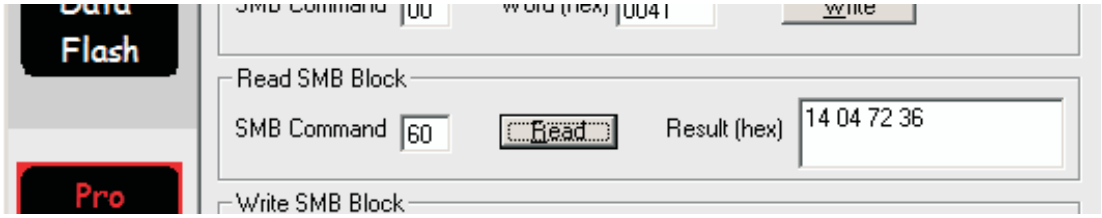


Figure 22. Default Unseal Key

Figure 23. Default Full Access Key

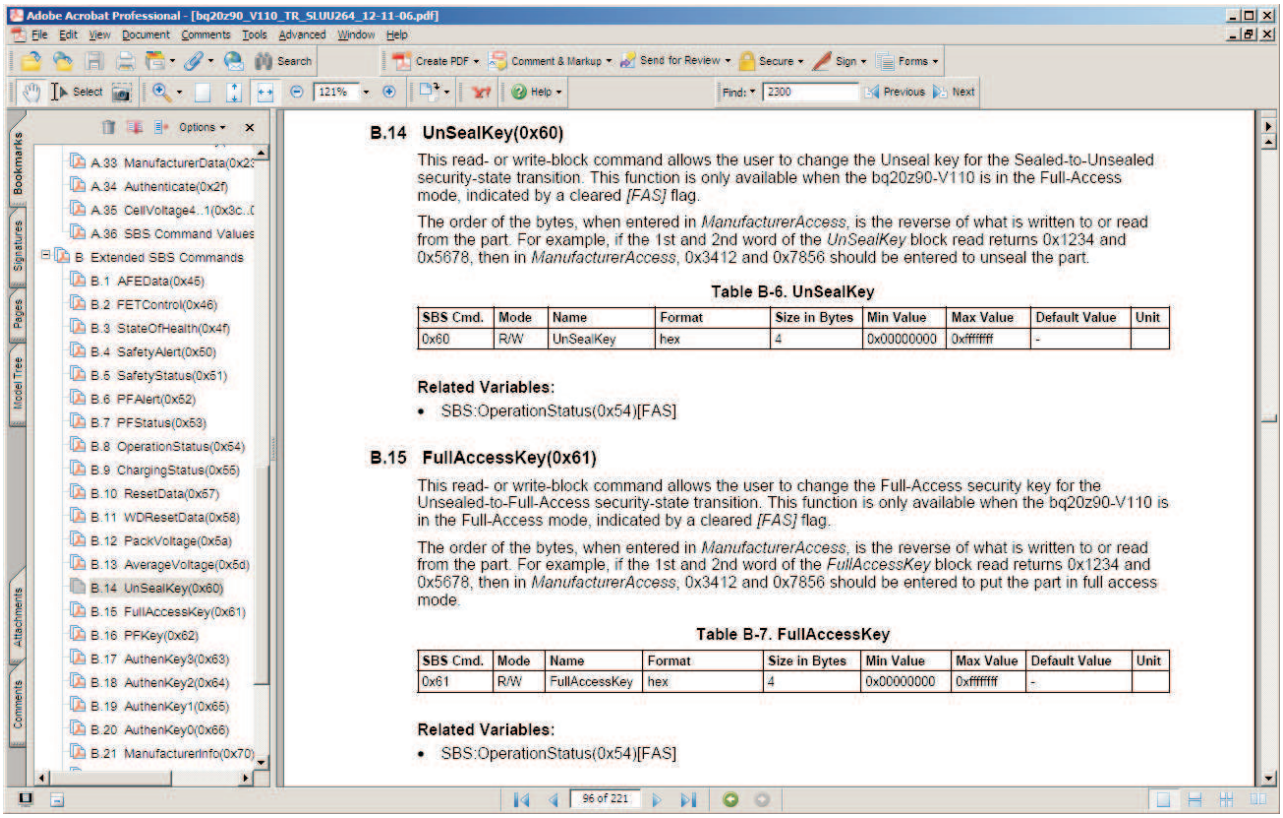


Figure 24. Unseal and Full Access Key Information in Technical Reference Manual

When the IC is sealed and you connect the EV2300 and open the software, you see a screen that looks like Figure 24. Not all the status registers are accessible and are grayed out in the window. To seal the pack, use Manufacture Access 0x0020.

Note: Do not seal your pack until after production.

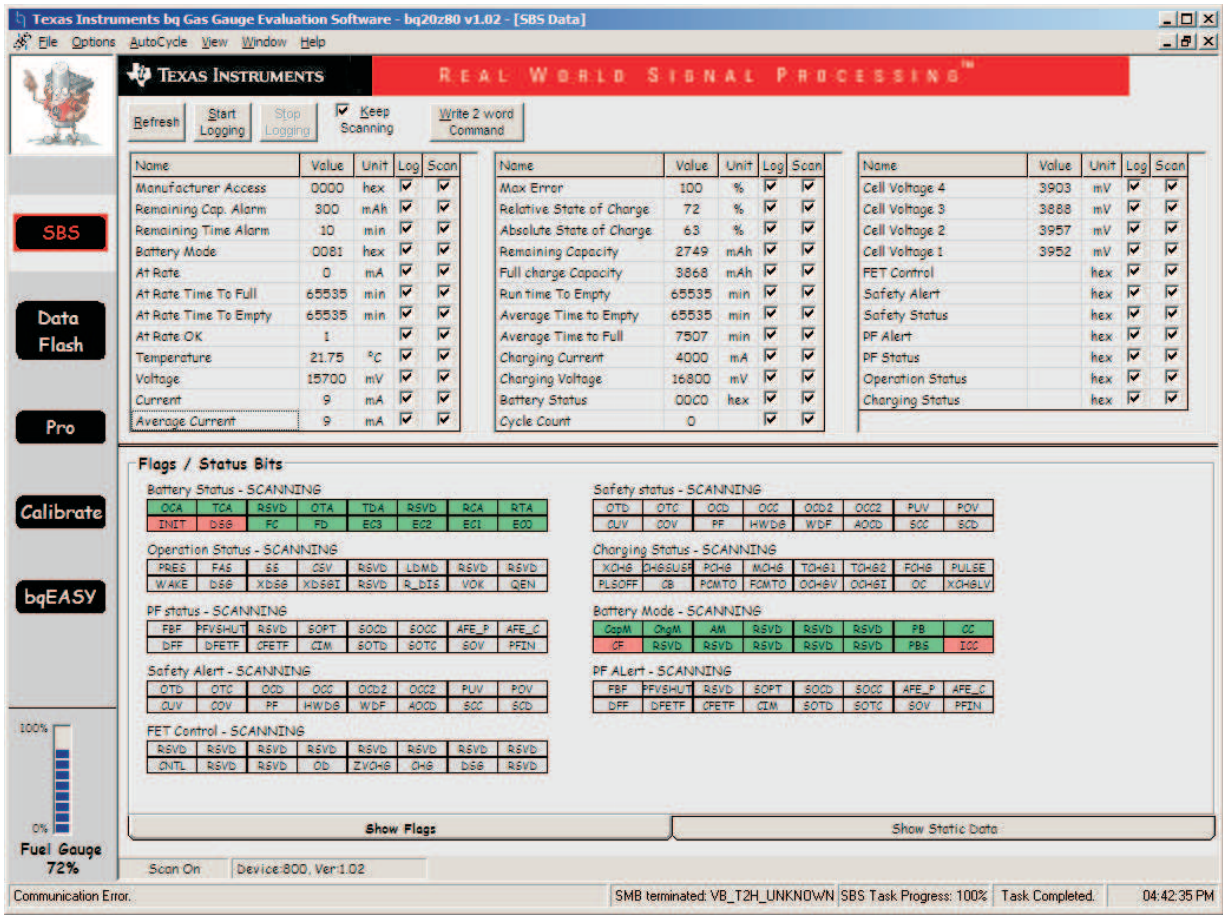


Figure 25. bqEVSW Screen in Sealed Mode

In Sealed mode, the bqEVSW screen has most Status Registers grayed out (Figure 25).

To move from SEALED to UNSEALED mode, write a 2 word Command 00 with the UNSEAL Key.

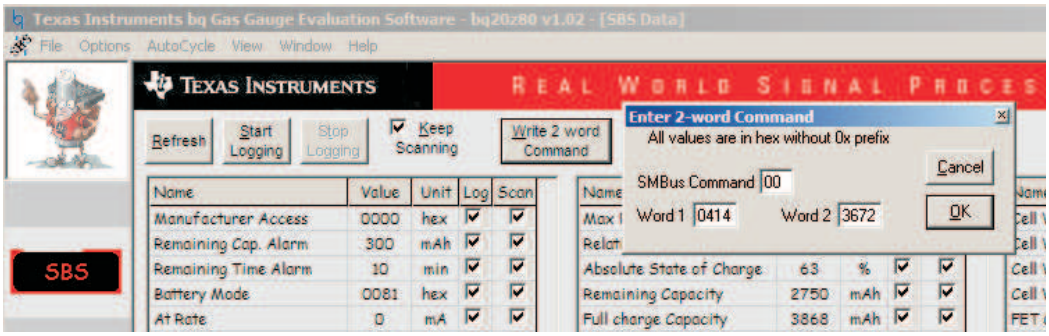


Figure 26. Default Unseal Command Using *Write 2-word Command*

After this command is issued, all the status registers can be read. Note the SS bit (Sealed) is cleared, but the FAS bit (Full Access) is still set. To move from Unsealed to Full Access mode, use the FullAccessKey.

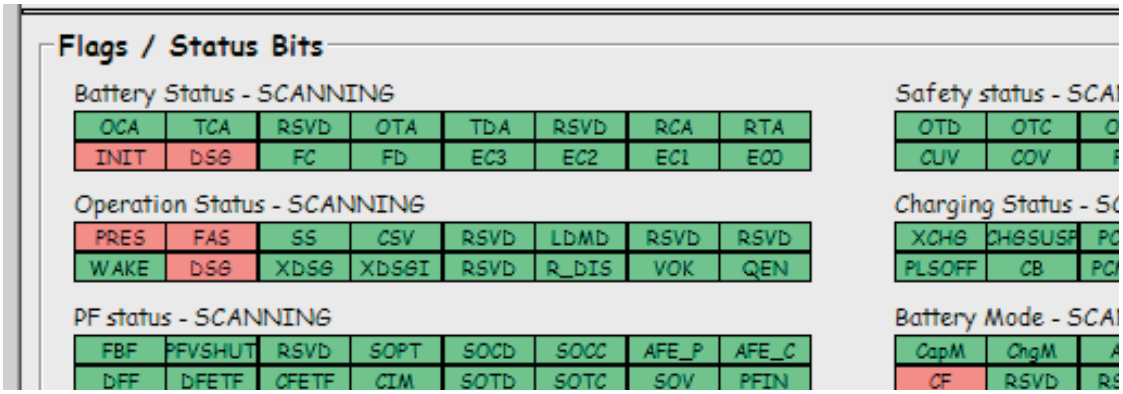


Figure 27. Operation Status Showing Unsealed Mode With Full Access FAS Bit Set

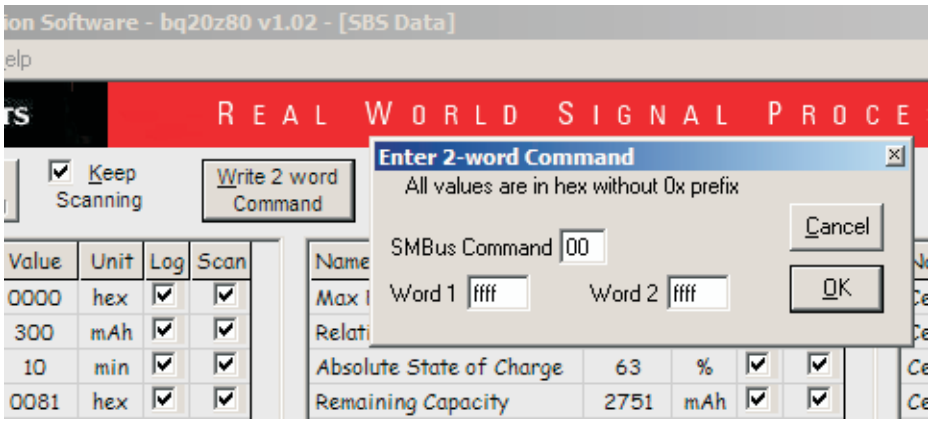


Figure 28. *Write 2 Word Command* to Move From Unsealed to Full Access Mode

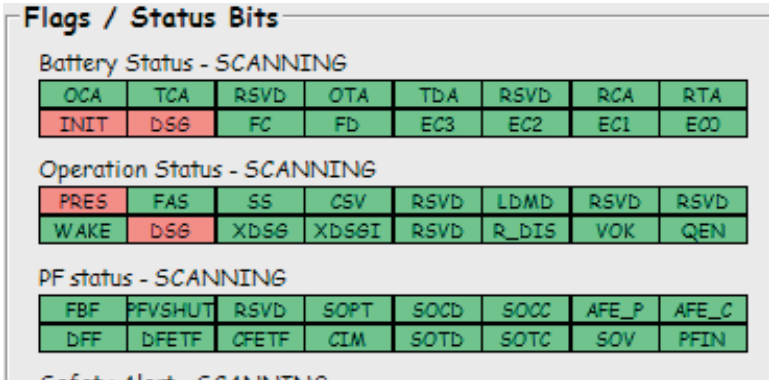


Figure 29. Cleared Flags/Status Bits

After issuing the FullAccess Command, note that the FAS and SS bits are cleared.

8.4 Production Flow

Figure 30 is a block diagram showing the normal production flow of the bq20zxx chipset. A detailed description of all these states is in the application report *Battery Pack Production Flow with bq20zxx*.

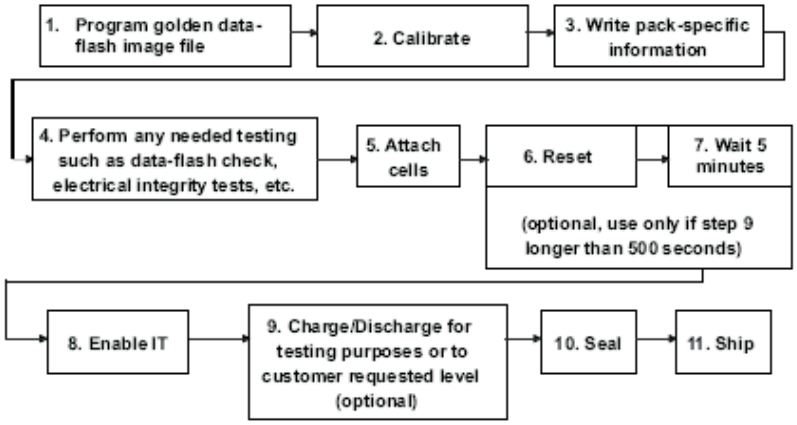


Figure 30. Production Flow Diagram

8.5 SMBus Arbitration

Specifications on SMBus standard protocol can be found at http://smbus.org/specs/. Implementation of bus arbitration is necessary for proper communication from the gas gauge to a host processor. Note that the TI evaluation software does not implement arbitration as it is assumed to be the only device communicated on the SMBus during development or debug.

Appendix A Questions and Answers

A.1 Important Documentation

Each gas gauge chipset has three important documents that are available in each gas gauge IC product folder on the TI Web site:

1. Data sheets of the gauge and the AFE that specify electrical characteristics and provide an overview of the chipset functionality
2. A technical reference manual (TRM) that describes in detail the operation of firmware
3. An application book that is a compilation of all application reports supporting the chipset

A.2 Introduction to the Gas Gauge Circuit

What are the major components of a typical gas gauge circuit?

A typical two- to four-cell Li-ion gas gauge circuit using the bq20z80/bq20z90/bq20z70 chipsets consists of three ICs, the gauge, the analog front end (AFE), and the second-level voltage protector. These ICs control and use a pair of power MOSFETs, a current/coulomb sense resistor, and a chemical fuse to provide gauging and protection of the two- to four-cell Li-ion battery. A block diagram of the circuit is shown in Figure A-1.

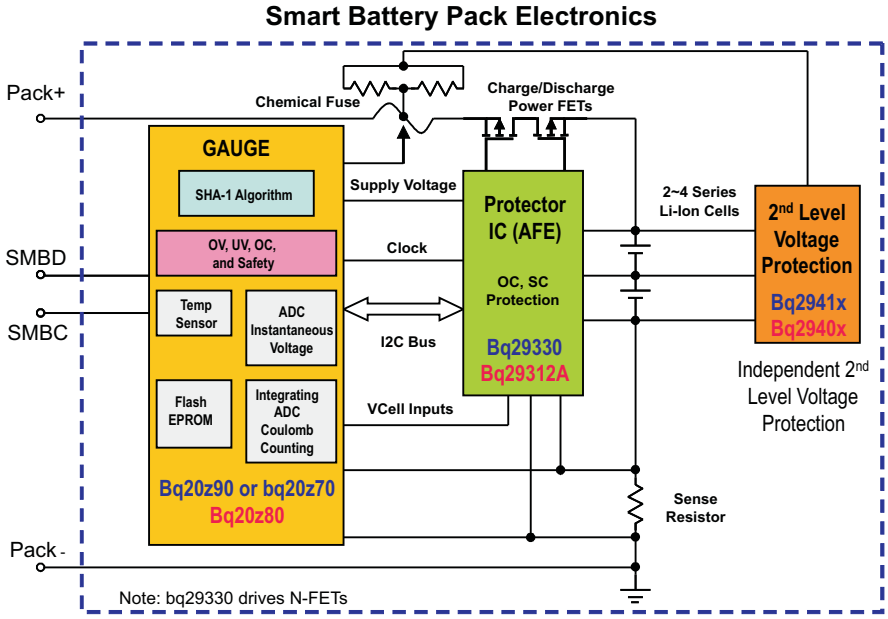


Figure A-1. Block Diagram of Gas Gauge Circuit With bq20zxx Chipsets

What are the functions of each of the ICs?

The flash-based gas gauge IC bq20zxx runs the Impedance Track™ algorithm, TI's latest gas gauging benchmark, off an ultralow power CPU. The gauge incorporates two ADCs, one for measuring instantaneous voltage and temperature, and the other for measuring current and coulomb counting. The AFE is a current-fault protector (hardware level) and a cell voltage multiplexer and level shifter. The AFE provides scaled voltage signals of the battery cells for the gauge to sample and measure. The gauge also measures current, temperature, and coulomb and processes the converted digital values to report to the host through an SMBus. In case of over/undervoltage, overcurrent, short-circuit, and temperature conditions, the chipset initiates protecting actions, typically including shutting off the FETs and raising alarm flags. The gauge can even sense FET failures and whether the fuse is successfully blown when intended. The secondary voltage protector IC provides an independent level of overvoltage protection, which may also blow the fuse to cut current flow when triggered.

A.2.1 Using bqEVSW to Work With Gas Gauge Chipsets

The evaluation software bqEVSW (version 0.9.35 and after) comes with a data flash help system for device bq20z80 v1.02, bq20z70 v110, and bq20z90 v110. Access the Data Flash screen, right-click on any data flash constant, and select Help Text from the pulldown menu. An HTML help document is opened by the default browser. This HTML help document has the same content as section 2, Configuring the bq20z80 Data Flash, in the bq20z80 application report (SLUA380). For bq20z70/z90 devices, see sections 2 and 3 of bq20z70 and bq20z90 application report (SLUA404).

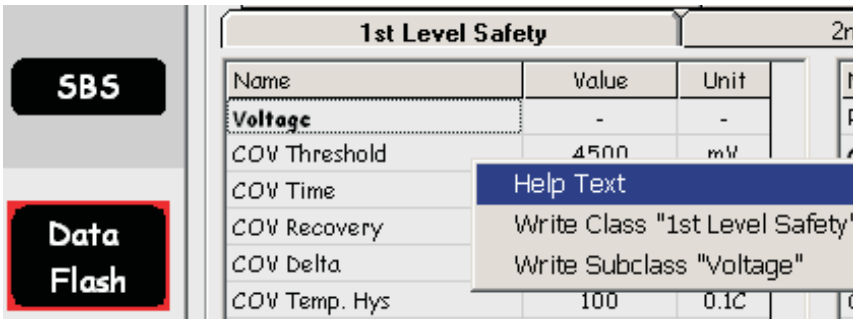


Figure A-2. Using bqEVSW Help System With bq20z80 v1.02 Device

Where are the buttons and how do I use them on the SBS screen?

Depending on the initial configuration of the evaluation software, you may see a few convenient pushbuttons on the SBS screen. These buttons can be enabled by select the pulldown menu View/Display Buttons. Select the *Keep Scanning* checkbox if you wish to have the software scan and display the SBS information of the gas gauge at a frequency set by pulldown menu Options/Set Scan Interval. The default is 2 seconds and setting this value lower is meaningless because the SBS information update interval is approximately 2 seconds. The button *Write 2 word Command* is useful when you wish to write a two-word SMBus command to the gauge. The button stops any SMBus scanning and allows the keys to be sent to the device. For example, to clear the permanent fail (Permanent Fail Clear), you need to write the two-word PFKey with a SMBus command of 0x00.

What is Manufacturer Access (MAC)?

Manufacturer Access (MAC) is simply an alias of the SMBus command 0x00. It includes a number of read- or write-word functions that provide battery-system level data, access to test controls, and security features. MAC facilitates pack test development by providing system data (device type, firmware version, chemistry ID, etc), a means of system control (power mode, seal/unseal, Impedance Track™ enable, LED control, etc), and some extended SBS commands. The two ways to use MAC commands are:

1. In the SBS screen, as shown in the Figure A-3, a single-word MAC command can be achieved by entering the word in the *Value* cell of Manufacturer Access and pressing the *ENTER* key. If writing a two-word MAC command, use the *Write 2 Command Word* button as previously described.

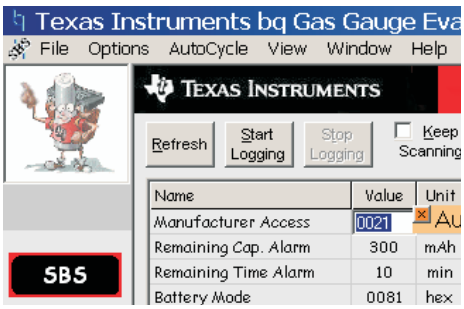


Figure A-3. Writing One-Word MAC Command on SBS Screen

2. On the Pro screen, fill in the command 00 and the input word in the *Write SMB Word* box and press the *Write* button.

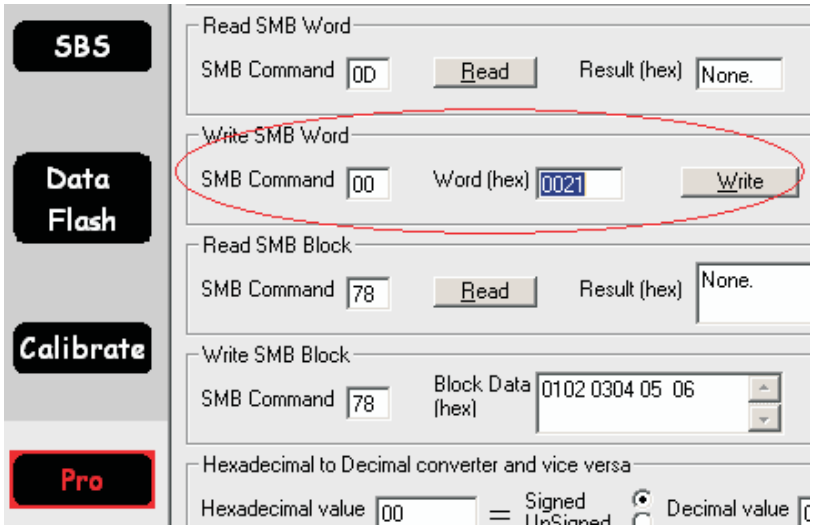


Figure A-4. Writing One-Word MAC Command in the Pro Screen

What is a GG file, and how do I read/import/export it?

GG file refers to files with a .gg extension that are used to store data flash configurations for the Impedance Track™ family gas gauge chipset. To access the data flash, ensure that the circuit board or EVM is powered and connected through the EV2300 box to the computer, and ensure that the gas gauge is awake (see the following relevant information or refer to the technical reference manuals on how to wake up the chipset from shutdown mode). On the Data Flash screen, press the *Read All* button to read all data flash parameters in the gauge. To export it, select the pulldown menu File/Export to save a .gg file to your local disk. The GG file is a text file and can be edited with Notepad or other text editors. A GG file can be imported to a gauge IC with the same device name and firmware version. To import a GG file, select the pulldown menu File/Import on the Data Flash screen, find the file you want to load, and then select *Open* in the dialog window; you must click on *Write All* to complete the import process. The *Write All, Preserve...* button writes all data flash except the calibration values. More information can be found in section 8 of the bq20z70 and bq20z90 application report (SLUA404).

How do I use the bqEVSW to program/flash the gas gauge?

This is described in section 12 of bq20z70 and bq20z90 application report (SLUA404).

How do I collect debug information for TI technical support in case of a technical problem?

A gas gauge is a complicated system and debugging it requires all the information herein described to have the best chance of discovering what occurred. When encountering a problem that you cannot resolve,

1. Take the SBS screen shot, and save it as a BMP or PNG file
2. Read and export the Data Flash GG file
3. Save the .senc file (encrypted srec). In Pro screen, Write word 0f00 to SMB Command 00 (MAC) to put the device in ROM mode; then select from the pulldown menu Flash Memory/Read to File… to save the .senc file. (To exit ROM mode, reapply power to the board, or send 0x08 SMB command.)
4. If the issue is learning- or accuracy-related, the SBS data need to be logged to show the occurrence of the issue, if possible. The SBS log interval should be set to between 2000 ms and 10,000 ms.

Send all this information collected to your TI technical support contact.

A.2.2 Operation of Gas Gauge Circuit

What are the first things to do when evaluating the EVM?

With a new, out-of-the box EVM, the first thing to do is to quickly familiarize yourself with the EVM User's Guide that comes with the package. You need to install the evaluation software, bqEVSW, which also includes the drivers for the USB interface box, the EV2300. Then, connect the power and SMBus according to the instructions in the User's Guide, followed by waking up the chipset by momentarily shorting Pack+ with 4P terminal. Figure A-5 gives a quick reference for the setup, using bq20z90EVM as an example.

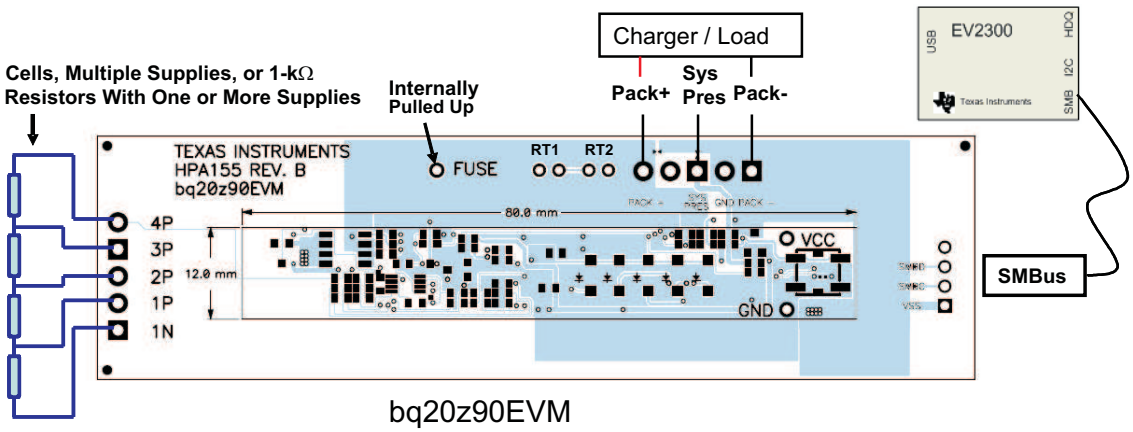


Figure A-5. External Connection Setup for Evaluating bq20z90 EVM

Once the software and hardware are ready, prepare for successful evaluation by following these steps:

1. Calibrate the CC offset and board offset, using the bqEVSW's Calibration screen. Optional for quick evaluation: voltage calibration and current calibration. For Pack Voltage Calibration, connect a power supply across Pack+ and Pack- before calibration. For more information, see the application report *Battery Pack Production Flow With bq20zxx* (SLUA391)
2. Set the Non-Removable/SYS_PRES configuration appropriately because this affects how the chipset recovers from an overcurrent safety condition. If the NR bit in DF:Operation Cfg B is not set, the SYS_PRES terminal on the EVM must be grounded for the FETs to be turned on, and FET safety recovery can only be achieved by disconnecting SYS_PRES from ground and then reconnecting it to ground. If the NR bit in DF:Operation Cfg B is set, the chipset operates in what is known as the Non-Removable configuration. In this case, the FET recovery occurs when the overcurrent safety conditions are cleared.
3. Enable Impedance Track™ (IT) by entering 0x0021 to Manufacturer Access (does not return any value). Figure A-3 shows how to do this. This sets the chipset in normal operating mode; and all gauging/protection functions are activated.

Note: When the gas gauge is loaded with new .senc firmware, the FETs are off by default, and cannot be turned on automatically unless both the IT is enabled and the NR bit and Sys_Pres pin are configured correctly as previously described.

How do I turn on the charge/discharge power FETs?

See the preceding question *What are the first things to do when evaluating the EVM?*.

Why are the FETs always off even with the Impedance Track™ enabled and with no safety flags raised?

One possible reason is that NR (Non-removable) and SYS_PRES have not been configured correctly as previously described. For example, the NR was set to Removable, and the pack went through an overcurrent safety condition that caused both FETs to be off. For a Removable pack to recover from an overcurrent type of fault, even when the fault condition goes away, the pack must still be removed and reinserted into the system. In other words, the SYS_PRES pin in the EVM must be disconnected from ground and then reconnected to ground.

What are the differences among data flash image, gg file, senc file, and log file?

A log file records all SBS information during pack cycling and can be generated by pressing the *Start Logging* button on the SBS screen. Logging options are available from the pulldown menu Options. The relationship of data flash image, gg file, and senc file is described in Figure A-6. The senc file contains the encrypted programming and data flash memories. The data flash image file only contains the encrypted data flash memories. The gg file is a text file that contains user-accessible data flash constants. Data flash image file is used with TI's single site tester and bqMtester in production with an extension of .ROM, and is used in bqEASY with an extension of .DFI.

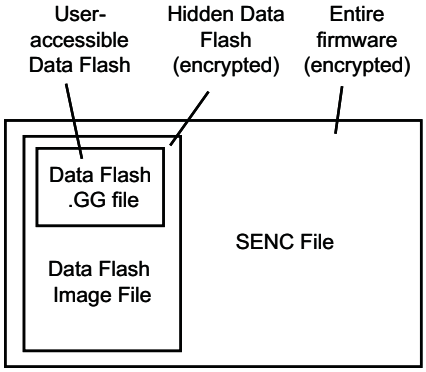
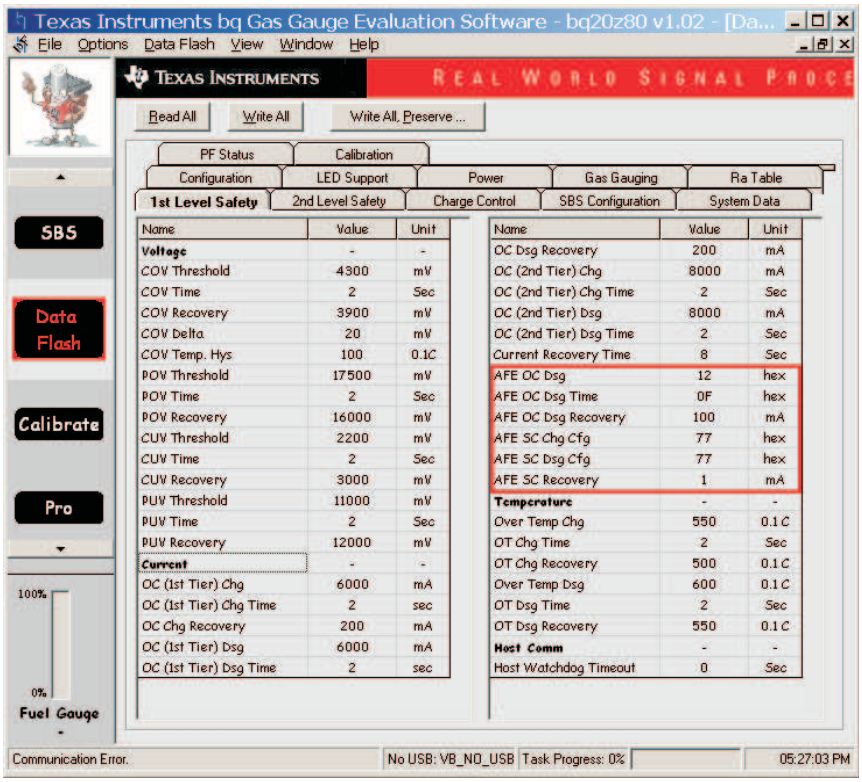


Figure A-6. Relationship of GG file, Data Flash Image File, and senc File.

How do I change the registers in the AFE IC?

AFE register setting is only accessible by the gas gauge IC. User-changeable AFE registers are listed in DF:1st Level Protection as shown in Figure A-7. The three-step procedure to change these registers follows:

1. Perform a *Read All* on the Data Flash screen,
2. Set desired AFE register values by entering them in the *value* field,
3. Reset the gauge by sending word 0x0041 to Manufacturer access (MAC)



Name	Value	Unit
Voltage	-	-
COV Threshold	4300	mV
COV Time	2	Sec
COV Recovery	3900	mV
COV Delta	20	mV
COV Temp. Hys	100	0.1C
POV Threshold	17500	mV
POV Time	2	Sec
POV Recovery	16000	mV
CUV Threshold	2200	mV
CUV Time	2	Sec
CUV Recovery	3000	mV
PUV Threshold	11000	mV
PUV Time	2	Sec
PUV Recovery	12000	mV
Current	-	-
OC (1st Tier) Chg	6000	mA
OC (1st Tier) Chg Time	2	sec
OC Chg Recovery	200	mA
OC (1st Tier) Dsg	6000	mA
OC (1st Tier) Dsg Time	2	sec

Name	Value	Unit
OC Dsg Recovery	200	mA
OC (2nd Tier) Chg	8000	mA
OC (2nd Tier) Chg Time	2	Sec
OC (2nd Tier) Dsg	8000	mA
OC (2nd Tier) Dsg Time	2	Sec
Current Recovery Time	8	Sec
AFE OC Dsg	12	hex
AFE OC Dsg Time	0F	hex
AFE OC Dsg Recovery	100	mA
AFE SC Chg Cfg	77	hex
AFE SC Dsg Cfg	77	hex
AFE SC Recovery	1	mA
Temperature	-	-
Over Temp Chg	550	0.1C
OT Chg Time	2	Sec
OT Chg Recovery	500	0.1C
Over Temp Dsg	600	0.1C
OT Dsg Time	2	Sec
OT Dsg Recovery	550	0.1C
Host Comm	-	-
Host Watchdog Timeout	0	Sec

Figure A-7. Modifying AFE Registers

The last step is necessary because modifying these values in bqEVSW changes the values stored in the memory of the gas gauge IC only. On reset, the gas gauge modifies the AFE user-changeable register settings according to the stored data in the memory during initialization.

Note: Never use SBS command AFEData (0x45) to alter AFE registers. The AFEData command is a read-only command, and writing to it results in unpredictable behaviors.

A.3 Impedance Track™ Algorithm

What is precharge? What is zero-volt charge?

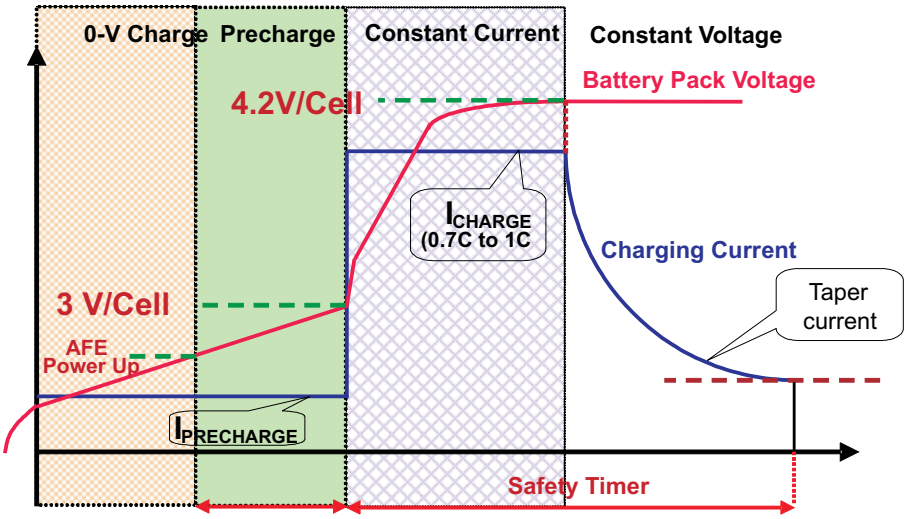


Figure A-8. Precharge and 0-V Charge

Because fast charging a Li-ion cell with a cell voltage of 3 V or less can accelerate the degradation of the cell, a much lower charging current, usually at 1/20 C, is used to charge the battery. This is called Precharge. Zero-volt charging and refers to the action of charging a 0-V battery or a depleted battery. Zero-volt charge is a special case of precharge and usually refers to the situation when the battery or PACK+ voltage is not high enough to power up the AFE. In the bq20zxx gas gauge, once the AFE is up and running, the gas gauge IC derives power from the LDO of the AFE; and the firmware precharge setting in the Operation Config A register immediately takes over the control from the AFE hardware precharge setting.

When are Lifetime data collected and recorded (applies only to bq20z80 and bq20z90 devices)?

Lifetime data provide a range of usage history of the battery, such as maximum/minimum temperature and maximum/minimum current, etc., which is convenient for troubleshooting. The gas gauge records pack Lifetime data only after Impedance Track™ is enabled. If Impedance Track™ is enabled in the final test before safety test, it is recommended to clear Lifetime data before the battery pack is shipped so that the recorded Lifetime data do not include test data. Assuming Impedance Track™ is enabled before the safety test, the steps for clearing Lifetime data are:

1. After safety test, clear Lifetime data by programming/writing default values, followed by a reset (write 0x0041 to MAC command)
2. Because the reset affects open-circuit voltage reading used by the IT algorithm, the pack should not experience any charge/discharge within at least 35 minutes after the reset. This ensures that a reasonably accurate open-circuit voltage reading can be taken

More information can be found in the application report *Battery Pack Production Flow with bq20zxx* (SLUA391).

A.4 Abbreviations

GG	Gas gauge	IT	Impedance Track™
AFE	Analog front end IC	SOC	State of charge
MAC	Manufacturer access	TRM	Technical reference manual
DF	Data flash		

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