Battery Pack Production Flow With bq20zXX

Yevgen Barsukov   *Battery Management*

1   Introduction

A battery pack production flow diagram for bq20zXX devices is shown in Figure 1. Each production step shown in the diagram is discussed in detail in this application report.

1.1   Production Flow Diagram

This diagram presents the steps needed for the gas-gauge operation along with optional steps, which are commonly used by battery pack makers, but are not required for gas-gauge operation. The following sections provide detailed description of each step.
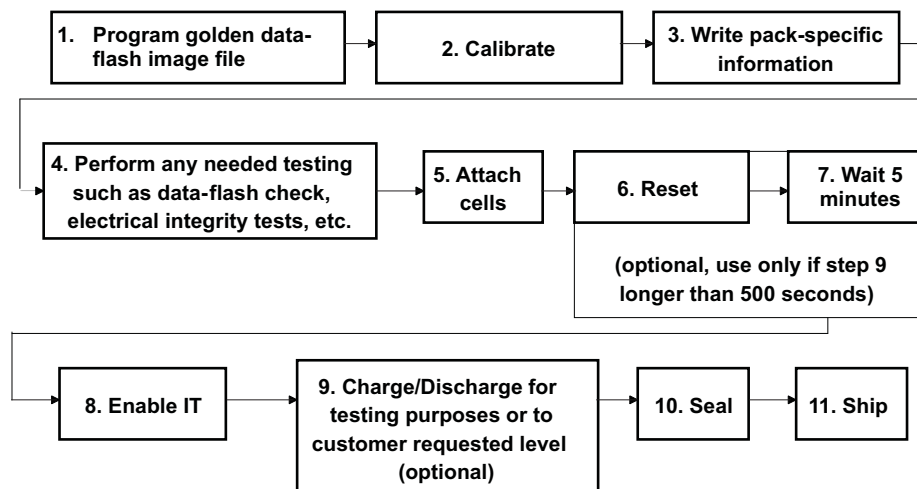

Figure 1. Flow Diagram

2   Detailed Description of Production Steps

2.1   Step 1: Program Golden Data-Flash Image File

A golden data-flash image is prepared during the characterization step as described in application report SLUA380 for the bq20z80 or in application report SLUA379 for the bq20z70/z90. The golden data-flash image contains data-flash settings customized for each particular device, resistance profiles optimized for a given battery, and multichemistry specific data.

Both programming of the data-flash image and calibration can be performed using example software created by Texas Instruments called bqMTester that can be downloaded from the power.ti.com bq20z80 tools and software folder. This software supports up to 12 simultaneous calibrations. It requires the EV2300 SMB interface and a calibration board (stable voltage and current source) per simultaneous calibration which can be purchased from TI or built using the provided schematics.

For a small-size production or test purposes, a single-channel bqTester can be used. It is downloadable from the bq20z80 folder as source file to application report *Using the BQTester Software* (SLUA352). It requires only the EV2300, but the user's own current and voltage source needs to be used. Source code for both these programs can be obtained by request to a local TI sales representative for the user's own modification.

Users can also write their own programs for programming data flash and calibration, as calibration routines are embedded in bq20zXX firmware which makes it easy (for details, see SLUA380 for the bq20z80 or SLUA379 for the bq20z70/z90).

The data-flash image should not be confused with the GG file – the later does not contain multichemistry support data and should not be used in this step. Programming the GG file using EV Software also is much slower than programming the data-flash image using the bqTester method.

If the data-flash image writing is not used, and chemistry is not the default, then chemistry-specific firmware *.senc file should be written prior to writing the GG file. See details on multichemistry support in the application report SLUA372.

2.2 Step 2: Calibration

Perform calibration at the board level before cells are connected. Current flowing through cells can disturb voltage calibration.

The firmware contains calibration routines, which makes this process easy to set up. The test software places the device in calibration mode and sends the true measured values to the device. The procedure is described in detail in SLUA380 for the bq20z80 or SLUA379 for the bq20z70/z90. TI provides bqTester and bqMTester software to automate this procedure (see previous section).

It is important that the voltage is measured with a 1-mV accuracy and that true measured voltage value is sent in a calibration command. Note that the voltage accuracy requirement is higher than in previous devices

Previously used voltage sources can still be used as long as the voltage is measured regularly with a 1-mV accurate voltmeter and the measured value is entered into the calibration program (for example, daily but actual interval depends on observed voltage drift). Only the voltage stability of the source is important, whereas actual voltage value is unimportant as long as it is accurately measured. An example of a voltage and current source that can be used is the calibration board for bqMTester that can be purchased from TI.

The current gain calibration is less critical. It affects only absolute values of gas-gauging (FCC, RemCap) but does not affect relative values (RSOC, Remaining Run Time).

All calibrations take place at the same time, so adding/excluding some calibration does not affect calibration time.

2.3 Step 3: Write Pack-Specific Information

Some examples of pack-specific information are Manufacturing Date, Serial Number, Lot Code, etc.

Writing pack-specific information is accomplished using data-flash access commands as described in detail in SLUA380 for the bq20z80 or SLUA379 for bq20z70/z90.

The bqMTester and bqTester programs write all the foregoing pack-specific information. Free source code can be obtained from TI on request, and more pack-specific data-flash constants can be added to it.

2.4 Step 4: Perform Any Needed Testing Such as Data-Flash Check, Electrical Integrity Tests, etc.

Any test that is performed on other bq20xx family devices can also be performed in this step. There is nothing bq20zXX specific.

Possible tests include:

1. Registers check
2. Data-flash check

3. Electrical checks (turning FETs ON and OFF)
4. Safety check

If turning the FETs ON is needed for some checks, it can be accomplished by using the SMB word write command 46. Word 0006 turns on charge and discharge FETs.

It is not recommended to send the 0021 (IT enable) command to turn ON the FETs at this point of production flow, because it also starts many gas-gauging functions that can read wrong values if cells are not attached. Functions activated include:

- Life Time Data
- Resistance values update
- Qmax values update

2.5 Step 5: Attach Cells

The recommended order of cells attachment is Ground (1N), 1P, 2P, 3P, 4P.

It is recommended that Ground be connected before other cell connections.

After the 1P–4P connection is made, if ground is again disconnected, the voltage measurement digital filter is distorted and wrong voltage readings are reported until the filter settles (up to 5 minutes).

To avoid the possibility of such distortion in case of operator error, a Reset command (0041) can be sent after cells are connected.

The reset (step 6) can be excluded, if after cell connections a handling step that exceeds 5 minutes exists, or if connection of ground first can be guaranteed.

2.6 Reset (Optional)

The purpose of this step is to eliminate possible voltage distortion due to a wrong order of cell connections. This step is optional and can be removed if at least one of the following conditions applies:

- After cell connections, a handling step that exceeds 5 min exists.
- Connection of ground (1N) first can be guaranteed.
- Discharge test in optional step 9 does not exceed 500 seconds (or step 9 is absent), and therefore no resistance is updated prior to shipment.

2.7 Step 7: Wait 5 Minutes (Optional)

Immediately after cell connection, the digital filter needs maximally 5-minutes of settling time to achieve highest voltage measurement accuracy.

If this step is not done (or not provided by handling time until IT is enabled), the first OCV reading after IT enable has a somewhat lower accuracy. The next reading takes place after 35 minutes and high accuracy is recovered. However, if a discharge activity longer than 500 seconds occurs before that time, the resistance update will be less accurate.

This step can be avoided if one of the following conditions apply:

- After cell connections, a handling step that exceeds 5 minutes exists.
- Discharge test in optional step 9 does not exceed 500 seconds (or step 9 is absent), and therefore no resistance is updated prior to shipment.

2.8 Step 8: IT Enable (Command 0021)

The Impedance Track algorithm (IT) is enabled by sending manufacturer access command 0021. This causes the setting of QEN bit in Operation Status. The following processes also are activated:

- Life Time Data update
- Resistance values update
- Qmax values update

The VOK bit in Operation Status also is set if present voltage is in the range of qualified voltages for Qmax update. It is unnecessary that VOK gets set, unless implementing Qmax update during production.

After sending IT enable command, Life Time Data update starts. It is not recommended to do any safety-related tests applying harsh conditions after IT is enabled.

2.9 *Charge/Discharge for Testing Purposes or to Customer Requested Level (optional)*

This step is optional and is not required for the device. Some manufacturers perform this step for their own purposes such as quality control or to bring device to required state of charge.

If this step follows the *IT enable* step, having passed less than 35 minutes and discharge continues for more than 500 seconds, a minimum 5-minute wait is recommended between cell connections and IT enable (step 8).

2.10 *Step 10: Seal*

It is recommended that the user change the default unseal codes in the data flash, so that the seal command prevents unauthorized access (including TI) to data flash and ROM.

Changing the default unseal codes is accomplished in the golden pack by using SMB commands 0x60 and 0x61 prior to creating the data-flash image. Changed values are contained in the data-flash image and copied to all packs in production during step 1.

Note that command 0x60 (like all block read/write commands) has the high byte of each word first. For example, if you want to write codes 0xFDMA 0xMKLR, the block needs to be written as MA FD LR MKX.

Test successful unsealing and accessing ROM during the characterization step before making a data-flash image for production.

3 Possible Alternative Production Order

Some manufacturers perform additional tests that require an alternative order that includes charge/discharge testing prior to enabling IT. In this case, production duration is longer. Such changes are possible as long as the principles outlined in the recommended procedure are followed. One example is given in Figure 2.
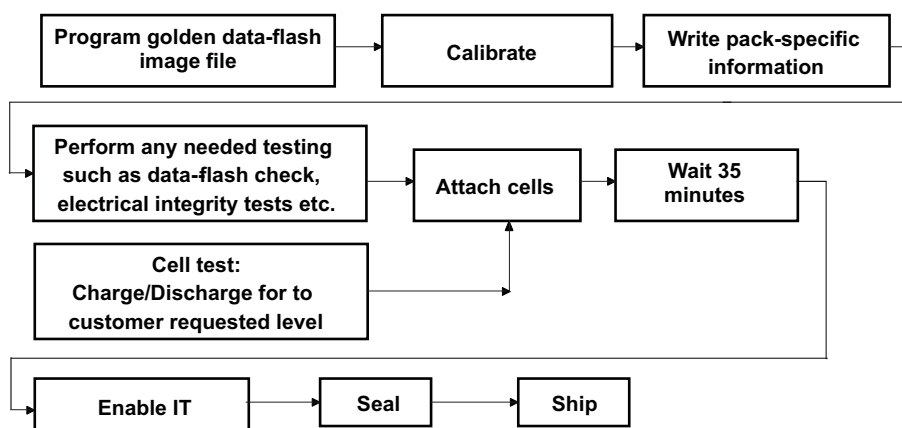

Figure 2. Additional Manufacturers' Charge/Discharge Testing

In this case, the manufacturer undertakes charge/discharge testing at the cell level prior to connecting cells to the PCB. This is acceptable as long as a 35-minute or longer wait period is provided between the charge/discharge and enabling the IT by command 0021.

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