

## **Going to Production With the bq2754x**

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*Michael Vega and Ming Yu**PMP - BMS Handheld*

### **ABSTRACT**

This application report presents a strategy for high speed, economical calibration, and production programming of the bq2754x single-cell gas gauge. Flowchart examples are provided, along with step-by-step instructions for preparing a calibration data set that is required when creating the golden data flash image (DFI) that is programmed into all bq2754x at the pack maker production line.

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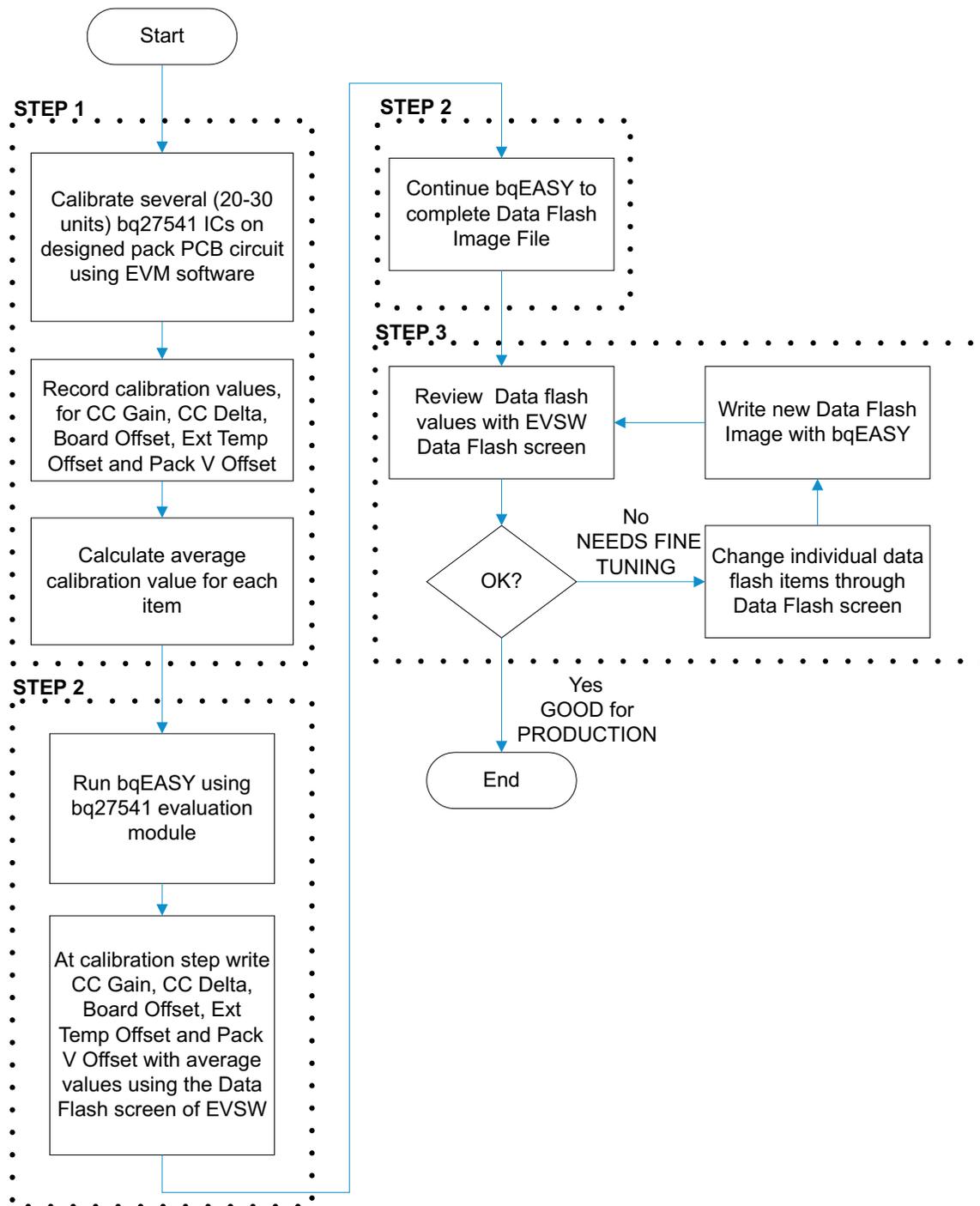
### **Introduction**

The bq2754x gas gauge is built with new technology and a new architecture for both data flash access and calibration. With this new architecture, unit production cost and capital equipment investment can be minimized, as it is no longer necessary to perform a learning cycle on each pack. A single golden DFI file can be used to program each bq2754x in production. Also, the calibration method is quick and simple because most of the calibration routines are built into the firmware of the target device or can be based on average values.

### **Determining Data Flash Constants**

To configure the bq2754x for a given application, the data flash set must be programmed depending on the cell, application system, and charger. The application report entitled *Configuring the bq2754x Data Flash* (SLUA410, SLUA503, neither doc released) gives a detailed description of all the data flash constants that the user can modify. All bq2754x ICs for an application must contain the same data flash.

The golden DFI is a file that contains all flash and is used at the pack PCB production line to program the bq2754x. The DFI is programmed using I<sup>2</sup>C™ communication with the bq2754x using a test platform developed by the customer. Creating the DFI can be summarized with the process depicted in [Figure 1](#).



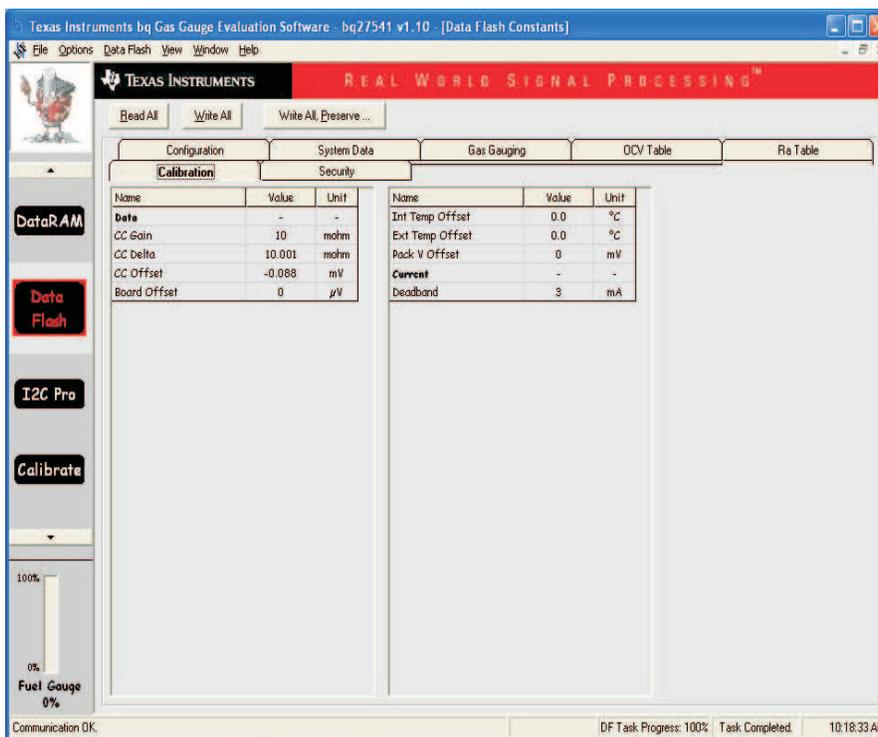
**Figure 1. DFI Creation Flow at Preproduction**

## STEP 1: Characterize the Calibration Process

Devices of bq2754x single-cell gas gauges are quick and easy to calibrate. With the Impedance Track™ devices, most calibration routines have been incorporated into firmware algorithms, which can be initiated with I<sup>2</sup>C commands. The hardware for calibration is also simple. One current source, one voltage source, and one temperature sensor are all that is required. The accuracy of the sources is not important, only their stability. However, accurately calibrated reference measurement equipment must be used for determining the actual arguments to the function.

The user has two strategy choices to follow for calibration. One is to characterize the calibration process and include the characterization results as part of the production DFI; the second is to individually calibrate every printed-circuit board (PCB) with a gauge that goes through the pack manufacturer's production line.

The recommended strategy for bq2754x calibration is to perform the calibration characterization using 20 to 30 final pack PCBs containing the bq2754x IC. All the calibration flash values are to be recorded and averaged among the 20 to 30 samples taken. The average values are the ones to be used when creating the DFI file needed for production. At time of calibration, the I<sup>2</sup>C pins, both ends of the sense resistor, and battery power must be accessible. The calibration consists of performing coulomb counter offset, current gain, board offset, and temperature offset. The Evaluation Software (EVSU) is used to perform all calibration. Using the EVSU allows the user to verify the affected data flash values due to calibration (see [Figure 2](#)).



**Figure 2. bq27541 EVSU Calibration Data Flash Screen**

The voltage calibration is not required for this device given that each IC is calibrated for voltage measurement at the device's final test process by Texas Instruments.

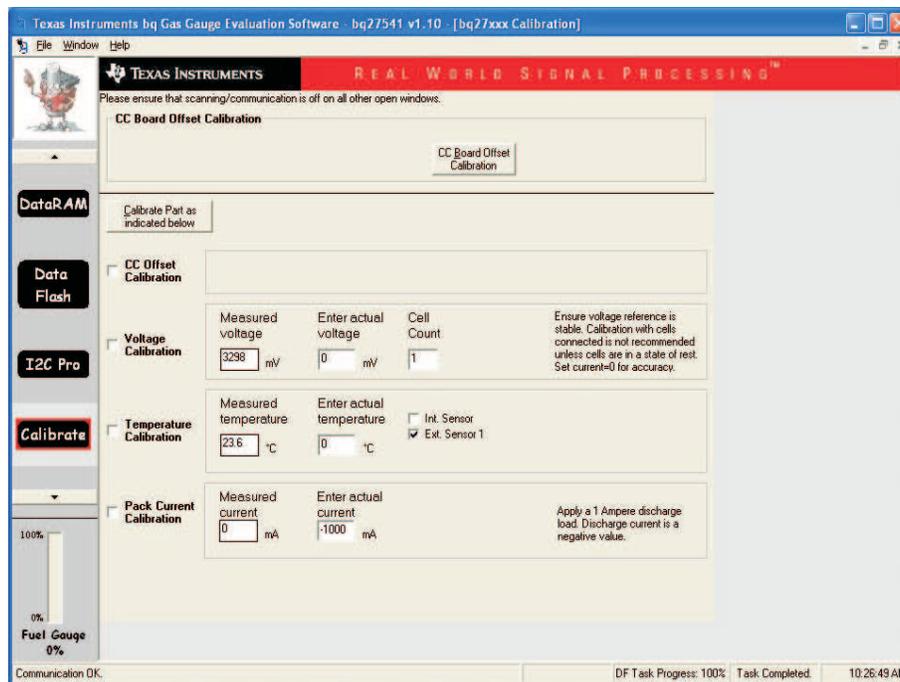
Perform the following calibration tests on each of the system samples:

**CC Offset Calibration** – Select the *CC Offset Calibration* checkbox then click on the *Calibrate Part as indicated below* button and wait for the EVSU to indicate that the calibration is completed. Read back the updated CC Offset data flash value by going to Data Flash screen in EVSU and selecting the Calibration tab. Press Read All button so that all the data is refreshed on screen.

**Temperature Calibration** – Select the *Temperature Calibration* checkbox and have Int. Sensor unchecked and Ext. Sensor 1 checked. Write the actual temperature to which the thermistor is exposed obtained by the reference equipment measurement. Click on the *Calibrate Part as indicated below* button, and wait for the EVSU to indicate that the calibration is completed. Read back and record the Ext Temp Offset value from the Data Flash screen.

**Board Offset Calibration** – Ensure that no current is flowing through the sense resistor (no charge or no discharge occurring). Confirm that all calibration checkboxes are unchecked. Click on CC Board Offset Calibration button, and wait for the EVSW to indicate that the calibration is completed. Read back and record the updated Board Offset data flash value by going to Data Flash screen in EVSW and selecting the Calibration tab. Press Read All button so that all the data is refreshed on screen.

**Pack Current Calibration** – Select the *Pack Current Calibration* checkbox. Write the actual current measured by the meter (negative sign indicates current in discharge direction). Click on the *Calibrate Part as indicated below* button, and wait for the EVSW to indicate that the calibration is completed. Read back and record the updated CC Gain and CC Delta data flash values by going to the Data Flash screen in EVSW and selecting the Calibration tab. Press Read All button so that all the data is refreshed on screen.



**Figure 3. bq27541 EVSW Calibration Screen**

The average CC Gain, CC Delta, Ext Temp Offset, and Board Offset values are entered into the DFI file in Step 2.

## STEP 2: Using bqEASY™ Software for Production Preparation

The bqEASY™ software (see [Figure 4](#)) is a tool embedded within the EVSW that provides detailed instructions and automates processes that, on completion, creates the DFI and ROM (not implemented yet) files that will be used at production to program all bq2754x for a given application.

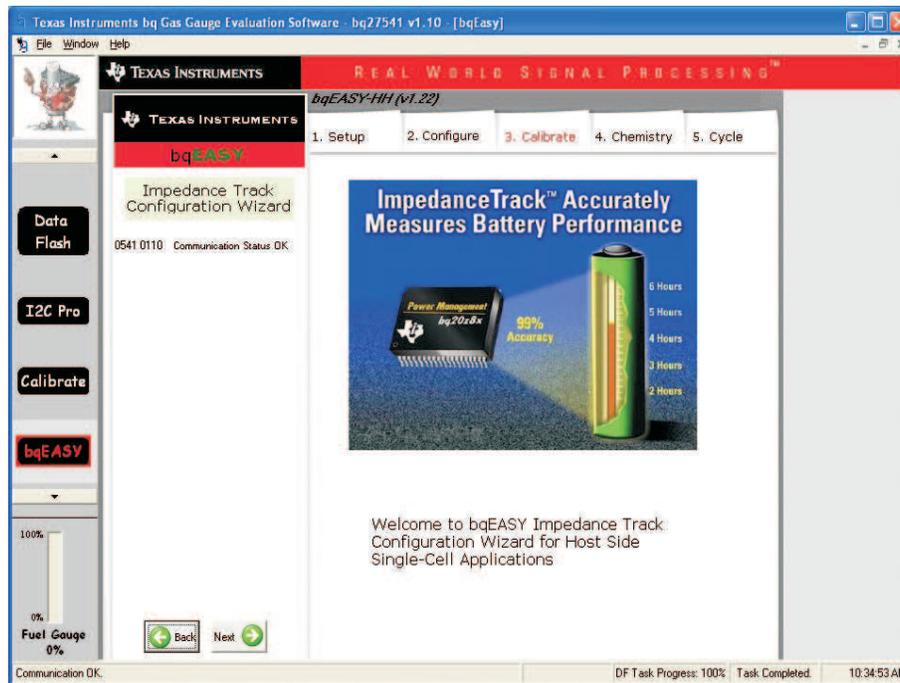
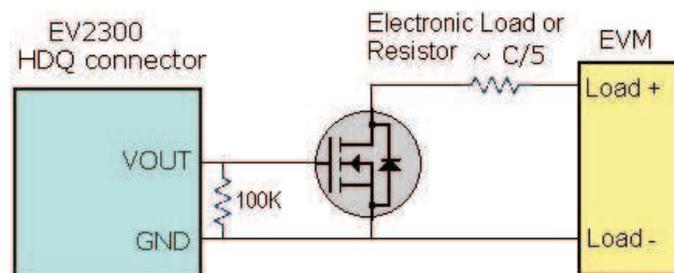


Figure 4. bqEASY™ Screen

The data flash of the bq2754x is configured based on a Q and A session within the Configure section of the bqEASY™ software. The questions involve topics specific to the battery pack, the charger, and the system application.

At the Calibrate session of the bqEASY™ software, it is expected of the user to navigate to the Data Flash section of the EVSW and enter the average calibrations obtained from the process described in the Characterize the Calibration Process section of this document.

The Chemistry session in the bqEASY™ software is a valuable tool that allows the user to select the chemistry of their battery pack from a database. If the user does not know the chemistry of its battery pack, then the bqEASY™ software gives instructions on testing the battery for determining the chemistry. The discharge during the test is automated. For automated discharge, a setup as described in Figure 5 is required. The load must be selected so that it has a C/5 rate when turned on. During automated discharge, the EV2300 board controls when to enable and disable the discharge, allowing the necessary relaxation periods for OCV measurements. Once the chemistry is determined, the data flash of bq27541 is updated so that it contains the proper OCV data that is characteristic of the selected chemistry. Having proper chemistry data is integral for the Impedance Track™ algorithm to perform accurately.



Use N-CH FET with low  $V_{gs}$  or small 5V-coil relay such as OMRON G6RN-1

Figure 5. Load Connection for Automated Discharge

The final session of the bqEASY™ software is for running a learning cycle so that Qmax and the impedance tables are updated. The bqEASY™ software provides step-by-step instructions on how to perform the learning cycle. By having learned Qmax and impedance values, the DFI can be created so that when used to program bq2754x ICs in production, a learning cycle is unnecessary before a device can perform accurate battery fuel gauging as of first cycle in system.

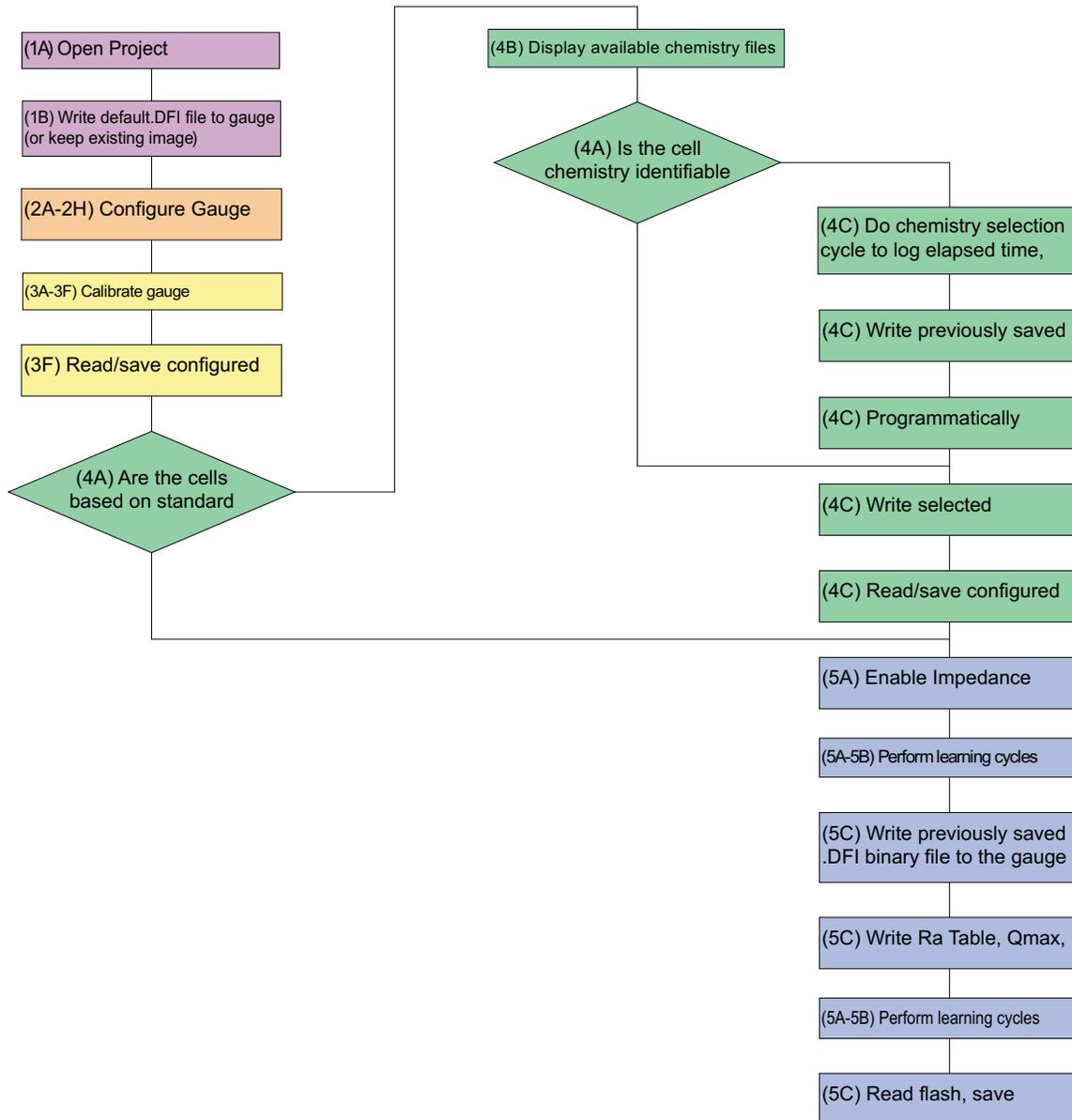


Figure 6. bqEASY™ Process Flowchart

### STEP 3: Data Flash Review

When following the actual steps of the bqEASY™ algorithm, the tool prompts the user to review the data flash constants for advanced configurations that may not have been addressed by the bqEASY™ software. The application report *Configuring the bq2754x Data Flash* (UNPUBLISHED) defines all the bq2754x data flash constants. Use this document for reference when reviewing the data flash configuration against the application needs.

To modify the data flash constants, proceed to the Data Flash screen of the evaluation software, and search for the desired data flash value to be modified and change accordingly.

## STEP 4: Writing the DFI at Production

Pack PCB designers must ensure that the I<sup>2</sup>C lines of bq2754x are accessible at time of writing DFI in production, if the device is intended to be used as a single-wire, communication-enabled device. It is expected that the pack manufacturers add the Write DFI step within their final complete system test that verifies the product to be functional for release to market. The flowcharts in [Figure 8](#), [Figure 9](#), and [Figure 10](#) show the steps that must be followed to write the DFI created with the bqEASY™ software using their own test setup. Test developers can use the flowchart to call I<sup>2</sup>C commands with their test setup and program all the flash of the bq2754x.

If customers develop their own tools to program the DFI and need to set the device to HDQ mode, the following steps are required.

After writing the DFI but before sending the commands to exit ROM mode, send the following commands:

- (a) I2C Command 0x00: Byte 0x16
- (b) I2C Command 0x04: Byte 0x05
- (c) I2C Command 0x64: Byte 0x1B
- (d) I2C Command 0x65: Byte 0x00

Finish the programming process by exiting ROM mode and sending the following commands:

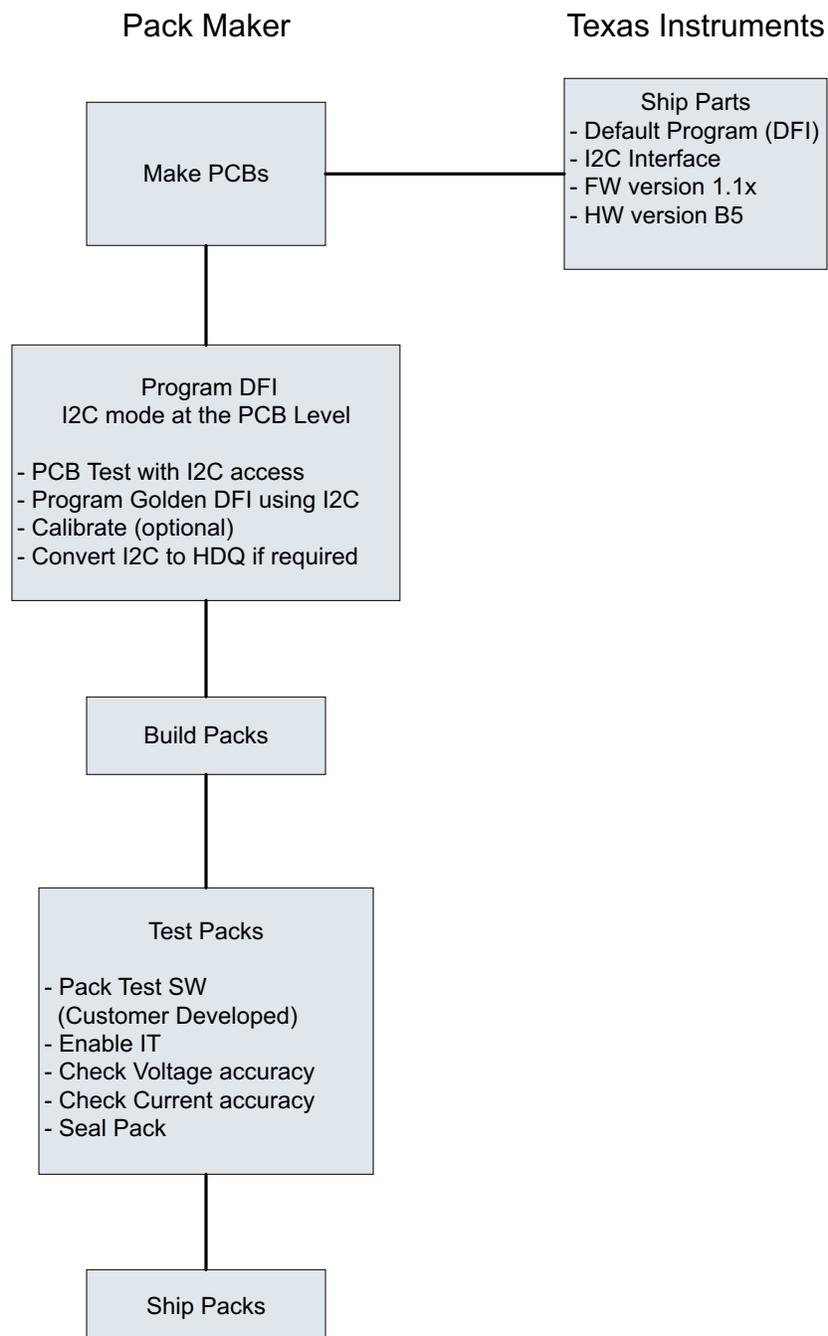
- (a) I2C Command 0x00: Byte 0x0F
- (b) I2C Command 0x64: Byte 0x0F
- (c) I2C Command 0x65: Byte 0x00

Once the DFI writing is complete the pack manufacturer can build the packs and do all necessary pack testing (protection circuit functionality). If customers develops their own tools to program the DFI and need to set the device to HDQ mode, the following steps are required.

On completing all tests, proceed to last step before shipping packs.

The last step of the bq27541 configuration at production is to give the IT ENABLE (0x0021) and SEALED (0x0020) commands. These commands are given by writing the corresponding two-byte data value into the CONTROL register (command 0x00/0x01), using whichever communication protocol the bq27541 has been set to at production.

## 0.1 bq2754x Production Flow



**Figure 7. High Level Production Flow**

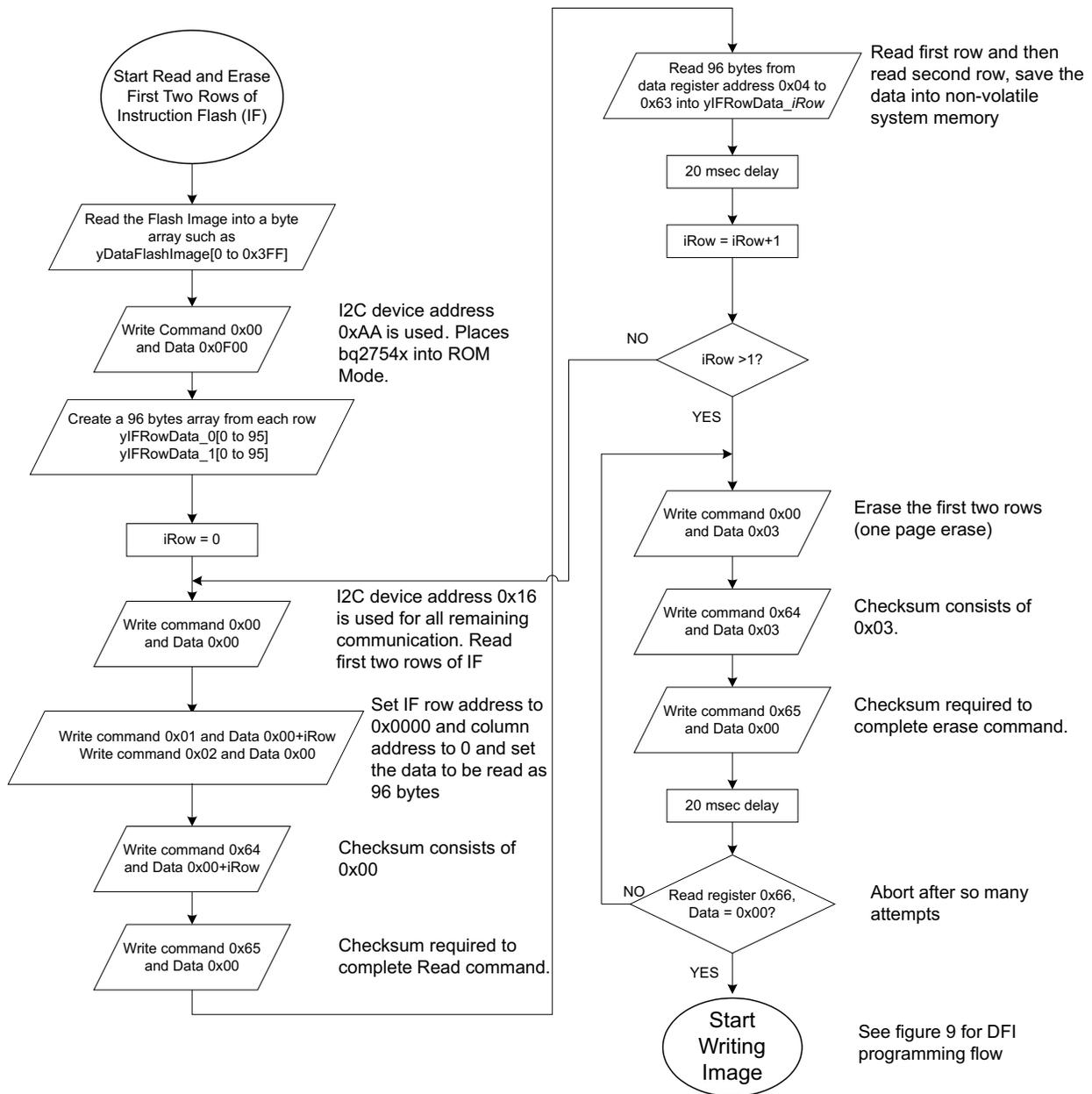


Figure 8. DFI Write Flow

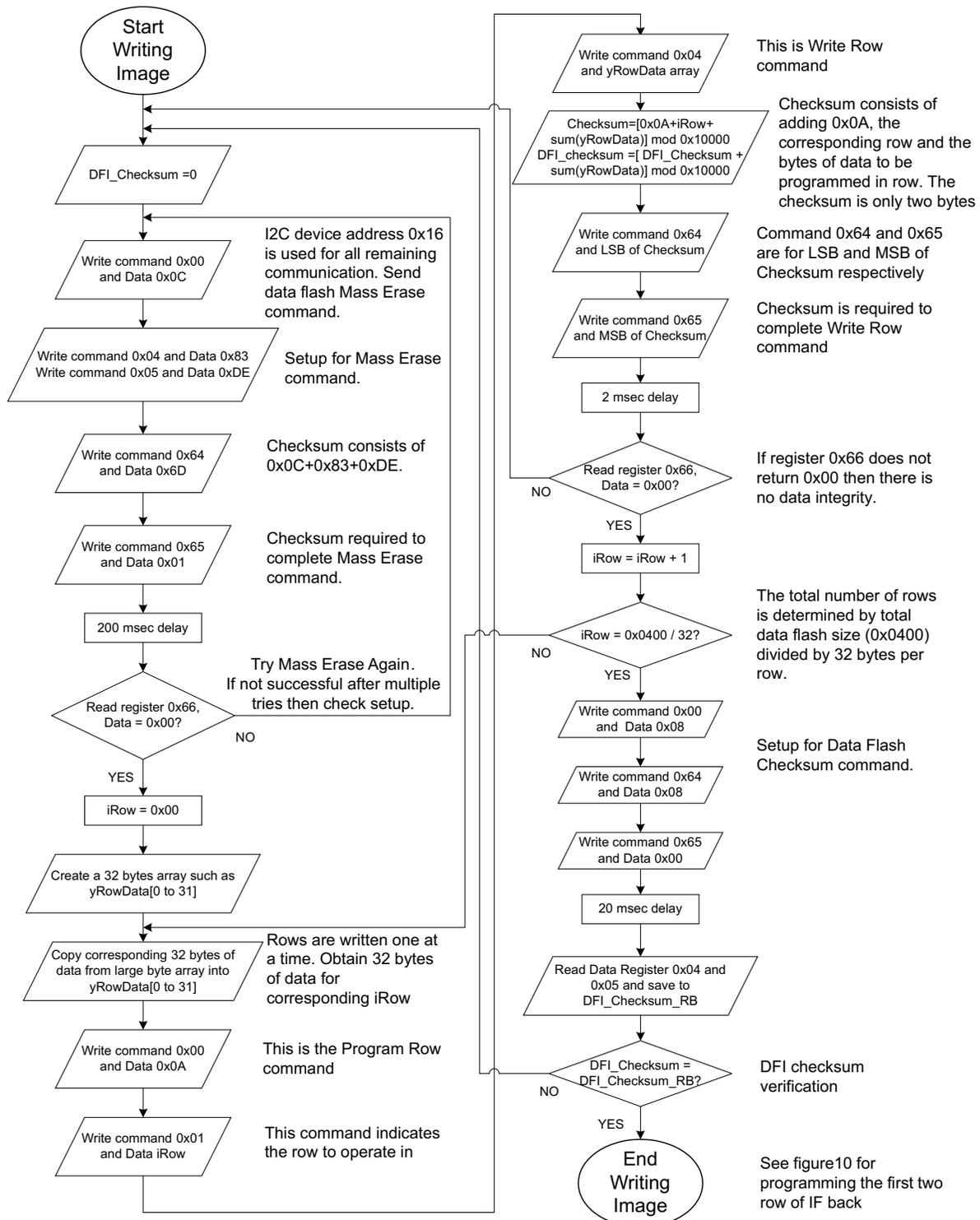


Figure 9. Continuation of DFI Write Flow

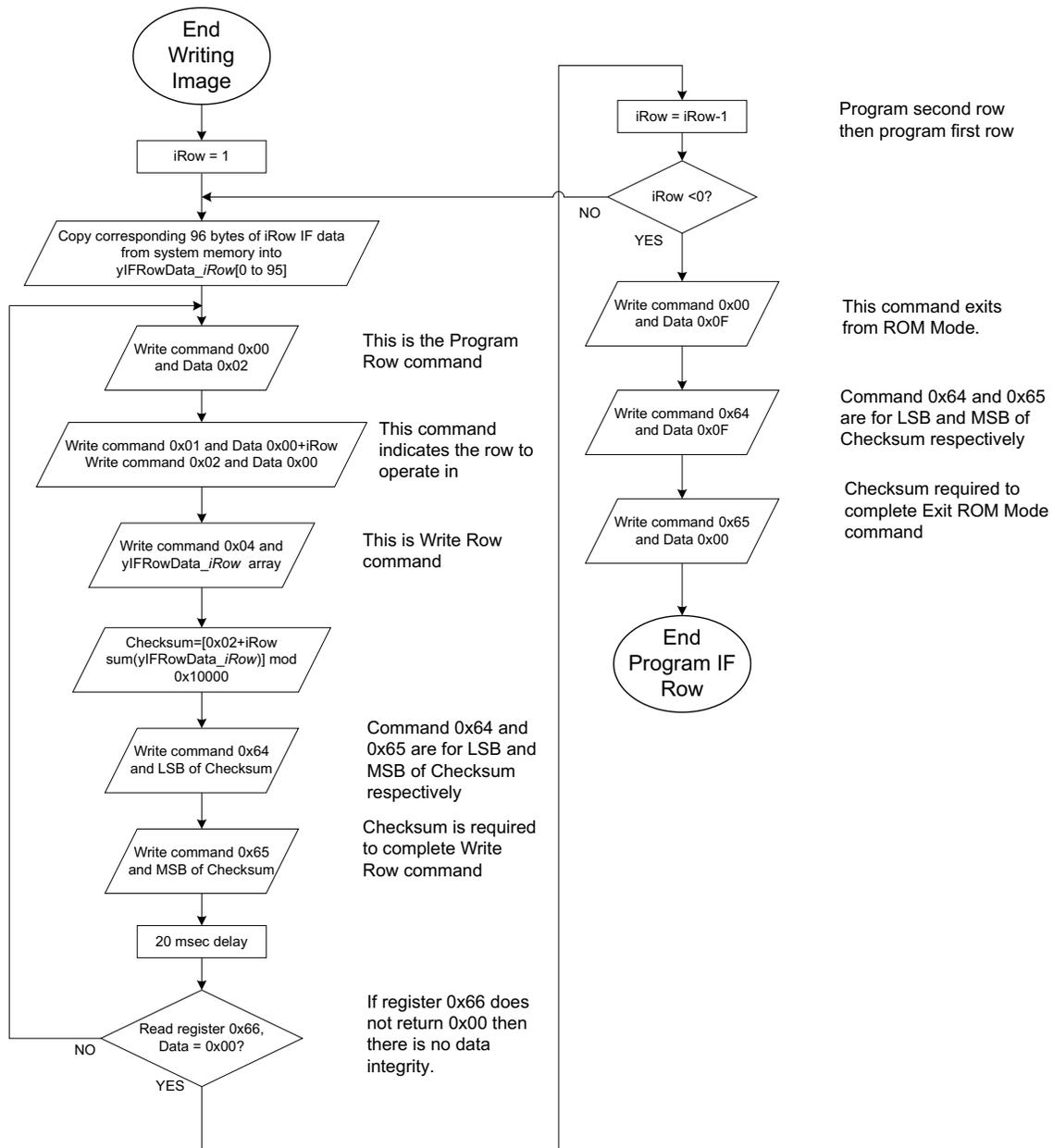


Figure 10. Continuation of DFI Write Flow

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