bqEASY™ for bq27505 Impedance Track™ Devices

Texas Instruments advanced fuel gauges, that employ the Impedance Track™ algorithm, offer an unmatched array of features and benefits. Sometimes, the multiple configuration settings can make it challenging to begin the evaluation process. In addition, determining the correct chemistry model and producing the final *golden image* file can be time consuming. The bqEASY™ software is designed to simplify the process of configuring, calibrating, selecting chemistry, and performing the charge-discharge learning cycles using the step-by-step procedural interface.

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1 Introduction

Evaluating the complex configuration options of the Texas Instruments advanced fuel gauges can be simplified by using the bqEASY™ software. The bqEASY™ software procedure provides detailed configuring, calibrating, and chemistry selection instructions, and works within the Evaluation Software (EVSW). The discharge portion of the chemistry and learning cycles can be performed automatically with the use of an additional circuit connected between the target device or Evaluation Module (EVM) and the EV2300. When the automated processes complete, a final *golden image* is generated that can be used in production application programming for all devices.

2 Software Installation

Software installation requires that the latest EVSW be installed from the TI Web site in the Product Web folder or EVM tool folder, for the specific part.

To install the software:

1. Ensure that the EV2300 is **not** connected to the computer, prior to software installation.
2. Go to the TI Web site and get the latest EVSW if not already obtained. As previously described, this can be found on the TI Web site in the *bq27505* Product Web folder (Tools & Software section) or EVM tool folder (Support Software section) (see Figure 1) . As an example, go to the *bq27505-J2* product folder *Tools & Software* at http://focus.ti.com/docs/prod/folders/print/bq27505-j2.html.

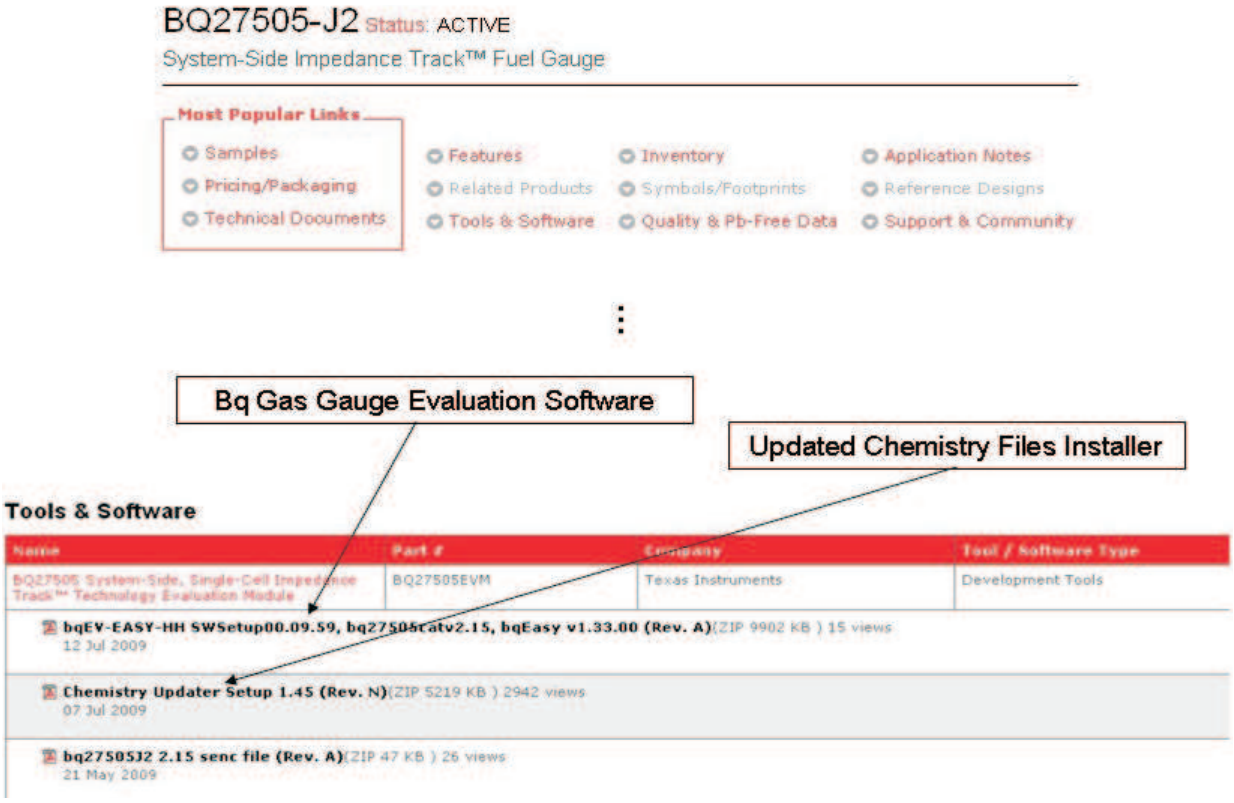

Figure 1. TI bq27505 Web Product Folder

3. Install the EVSW using the Installer screen-displayed instructions. For additional assistance with EVSW installation, see the *Quick-Start Guide for bq27505 Family Gas Gauges* (SLUA515). This document can also be found in the EVM tool folder for the product being used.
4. Once the EVSW is installed, verify its functionality by setting up the EV2300 and a known bq27505 module. Ensure that the computer, EV2300, and bq27505 module all are operating normally and that communication to the module is functioning. For additional assistance help, refer to *Quick-Start Guide for bq27505 Family Gas Gauges* (SLUA515).

5. Because chemistry files are added to the device TI Web site Product Web folder often, check the Web folder page for updates. A self-extracting installer is available for updating the chemistry file. Install these updates if they exist in the Web site folder.
6. Start the bq Gas Gauge Evaluation Software using the menu commands **Start** → **Programs** → **Texas Instruments** → **bq Evaluation Software**.
7. To access the bqEASY™ procedures, click the **bqEASY** button in the left column (below the **Calibrate** button) in the EVSW (Figure 2).

Figure 2. bqEASY™ Procedure Software

3 Program Navigation and Flowchart

The operation sequence of the bqEASY™ software can be understood by reviewing the procedure flowchart in Figure 3. Start a new project and follow the procedure steps. Use the **Next** button, or click the top dialog tabs and left subsection labels to move among the bqEASY™ dialogs. Some operations must be completed in sequence because of data dependencies, or to implement the required steps. TI recommends following the prescribed sequence, initially.

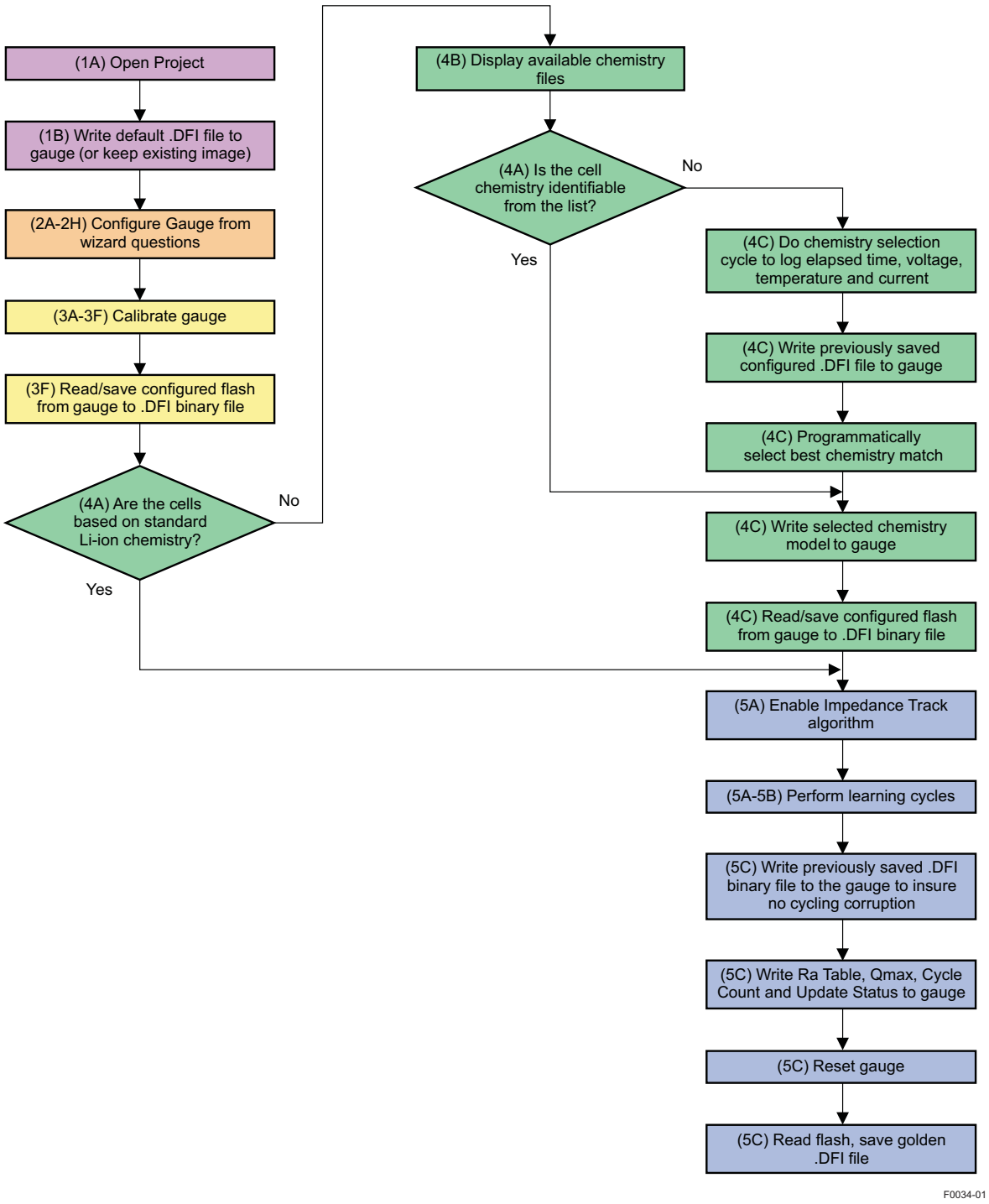

Figure 3. bqEASY™ Process Flowchart

4 Configuration Procedures

These configuration procedures can be used to set up parameters without navigating through the entire EVSW user interface:

- Gas Gauge configuration using default or custom data
- Chemistry data installation using available bqEASY™ chemistries

To configure the gas gauge using default or custom data:

1. Start the EVSW (**start** → **Programs** → **Texas Instruments** → **bq Evaluation Software**) and click the **bqEASY** button in the left column (below the **Calibrate** button) in the user interface.
2. Click the **2. Configure** dialog tab at the top of bqEASY™ tabs. Note, the first dialog tab can be skipped.
3. Answer all questions or leave defaults for the **2. Configure** dialog tab. Be sure to click OK at the bottom of each **2. Configure** dialog to ensure that a completion checkmark displays for each page
4. On dialog **2H**, when clicking the **OK** button, the software asks if the user wants to write the information to the data flash memory. Click **Yes** to write the information to the data flash.

The Gas Gauge module now has the data flash configured with the information entered in **2. Configure** bqEASY™ dialogs.

To install chemistry data using available bqEASY™ chemistries:

1. Start the EVSW (**start** → **Programs** → **Texas Instruments** → **bq Evaluation Software**) and click the **bqEASY** button in the left column (below the **Calibrate** button) in the user interface.
2. Click the **4. Chemistry** dialog tab at the top of bqEASY™ tabs. Note, the initial three dialog tabs can be skipped.
3. Select **Use Default Chemistry**, or click **Enable Chemistry Selection** and select the correct chemistry from the list.
4. If the proper chemistry is not found, check the device EVM tool folder on the TI Web site for any new Chemistry file updates as described in the Software Installation section and identified in Figure 1.

5 bqEASY™ Data Files

The bqEASY™ software uses several file types to configure a fuel gauge:

The software configures all data flash locations on the Gas Gauge module that deal with chemistry functions. No other data flash locations are modified.

- ***.ENCR (Data Flash Files)—**default data-flash definition files found in the *...\bq_Evaluation_Software* folder. An ENCR file is a copy of the entire data-flash from a fresh Gas Gauge prior to any data-flash updates by the user or the Gas Gauge. These files are unique for every version of each TI fuel gauge product. If working with a newer version fuel gauge and an older version of the bqEASY™ software, the correct file may not be present in the software. This requires a new version of the EVSW with the bqEASY™ software. Navigate to the TI Web site in the EVM tool folder for the device being used, and download the latest version, or contact TI. For the bqEASY™ software, the ENCR files act as a dictionary to look up the address for a given data-flash location. For EVSW, the define window display parameters including address, display formulas, and data types. An error message displays if the correct .ENCR data flash file cannot be found.
- ***.CHEM (Chemistry Files)—**read-only files found in the *...\bq_Evaluation_Software\Plugins\Chemistry* application folder. When a new Li-ion battery chemistry is developed, a new Impedance Track™ model is required to define the chemical model. During automated chemistry selection, each of these files is scanned to select the best match with the recorded data. If working with a newly developed chemistry, it is possible that an acceptable match may not be found. If this is the case, check for updated bqEASY™ software or Chemistry files on the TI Web site in the EVM tool folder for the part being used.

- ***.DFI (Data-Flash Image Files)—**binary images of the fuel gauge data-flash with modified values based on the application. Because of the binary format, it is easy to transfer them to and from a gauge. Each fuel gauge model and firmware version has a unique read-only .DFI which is found in the *...\bq_Evaluation_Software\Plugins\Device_Defaults* folder of the application. During the bqEASY™ process, intermediate versions of .DFI files are recorded with current updated data to prevent data corruption. The final output of bqEASY™ is a .DFI file which is called the *golden image* and used to program production units. This output file is placed in the *...\bq_Evaluation _Software\Plugins\Projects* folder.
- ***.EZY (bqEASY™ Project Files)—**read/write text files which record header information regarding a project, answers to the wizard questions, and status regarding the completion stages (red completion checkmarks in Figure 15). The files are stored in the *...\bq_Evaluation_Software\Plugins\Projects* folder.

6 Completion Checkmarks

As the bqEASY™ questions and tasks are completed, completion checkmarks display in two places—along the task list on the left and on the top dialog tabs. A checkmark on a top dialog tab displays only after all category tasks are completed.

Completion marks are saved in the *.EZY bqEASY™ project text file. When a completed or partially completed project file is opened, the user is given the option to erase the checkmarks.

Note: Completion checkmarks for Categories (dialog tabs) and Tasks (above the **Back** and **Next** buttons)

7 Device Detection

The bqEASY™ software is designed to work with a fuel gauge present and already communicating with the Evaluation Software (EVSW), using the EV2300 USB interface. When the Evaluation software is started, it reads the device type and displays it on the upper title block. For example, in Figure 4, the bqEASY™ software detected a bq27505 that is running version 2.15 of the firmware. This information is used by the bqEASY™ software to select the correct default data-flash image (***.DFI**) and data-flash configuration file (*.ENCR) for this device. To ensure that the device has not changed, the bqEASY™ software also checks the device type each time the user clicks the **bqEASY** button. If the correct files are not found, first check the TI Web site in the EVM tool folder for the part being used, and download the latest version of EVSW (see Figure 1) with bqEASY™ support. If that does not help, then contact TI.

The major procedure areas in the bqEASY™ software are:

1. **Setup**

   Step 1A helps the user to continue with an existing project file or start a new one. A new project is given a project file with the *.EZY filename extension.

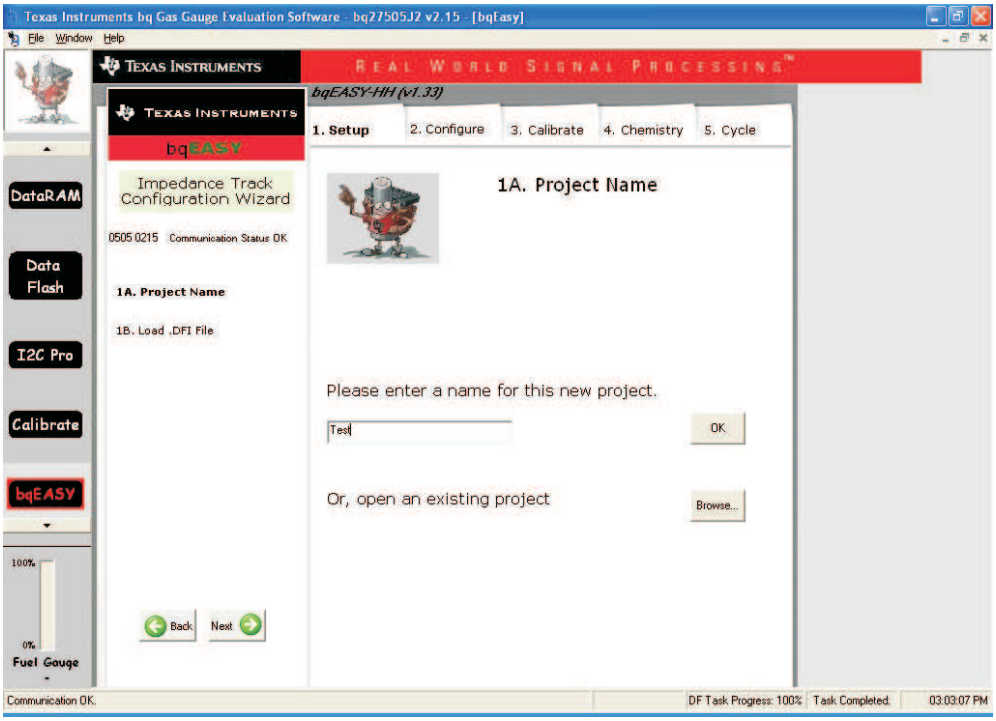

Figure 4. Project Name

Step 1B optionally loads the default data-flash image for the detected device. If starting from a *known* new device, this step can be skipped. Also, this screen can be used to select any customer-created data-flash image so that the gauge can be used for evaluation based on learned data from another device.

Figure 5. Load DFI File

2. **Configure**

This is a sequence of dialogs used to collect information about the battery pack application that enables automatic configuration of the most critical data-flash parameters.

Section 2A - The questions in this section are to determine cell characteristics that lead to the nominal capacity of the battery. The nominal capacity is used to give the Impedance Track™ algorithm a good starting point but it eventually learns the actual capacity of the battery through test.

Figure 6. Questions Pertaining to Cell Characteristics

Section 2B -This section covers understanding the charger characteristics. Answering these questions allows setting the data flash so that charge termination is detected by the gauge before the charger terminates during taper current and also establishes temperature thresholds during charge activity.

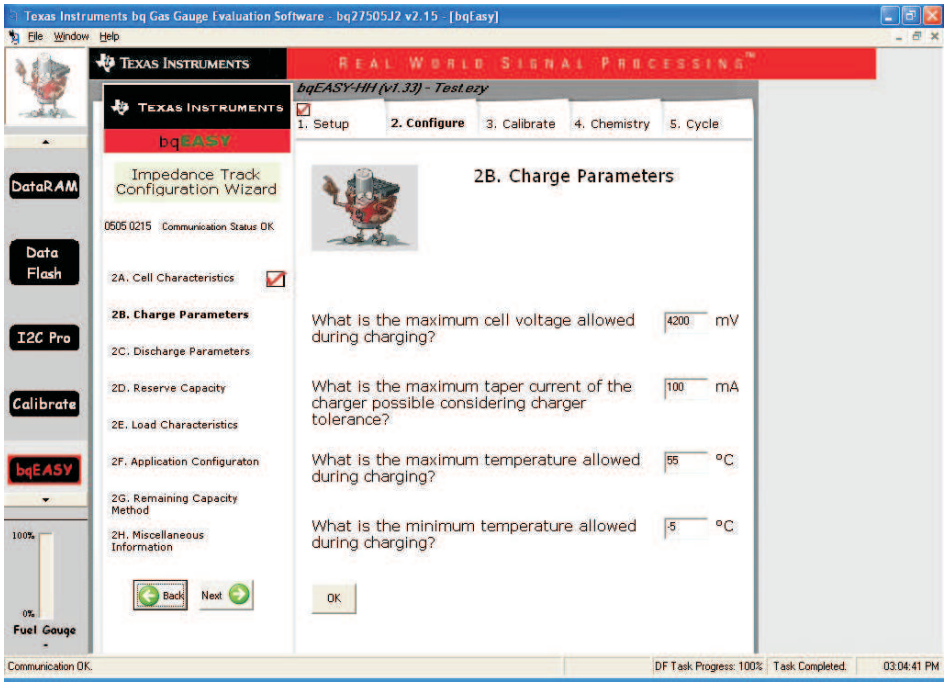

Figure 7. Questions Pertaining to Charge

Section 2C - These questions establish application system requirements. From these questions, the data flash is programmed to the voltage to which the gauge reports 0% for State of Charge along with a few alarms that are available in the gauge.

Figure 8. Questions Pertaining to System Requirements

Section 2D - The reserve capacity is used to allow the gauge to calculate 0% for State of Charge based on allowing the selected amount of reserve capacity to be left unused. Reserve capacity can be set in terms of charge (mAh) or energy (mWh).

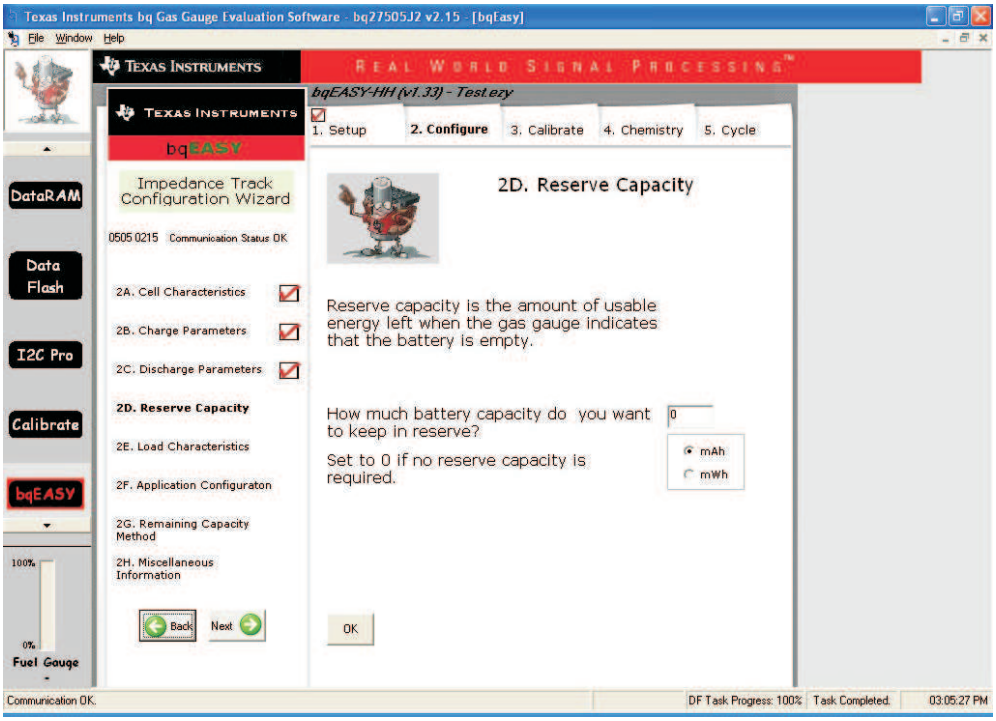

Figure 9. Reserve Capacity

Section 2E - Select the type of load that the system represents. For example, a typical application can be a constant-power type.

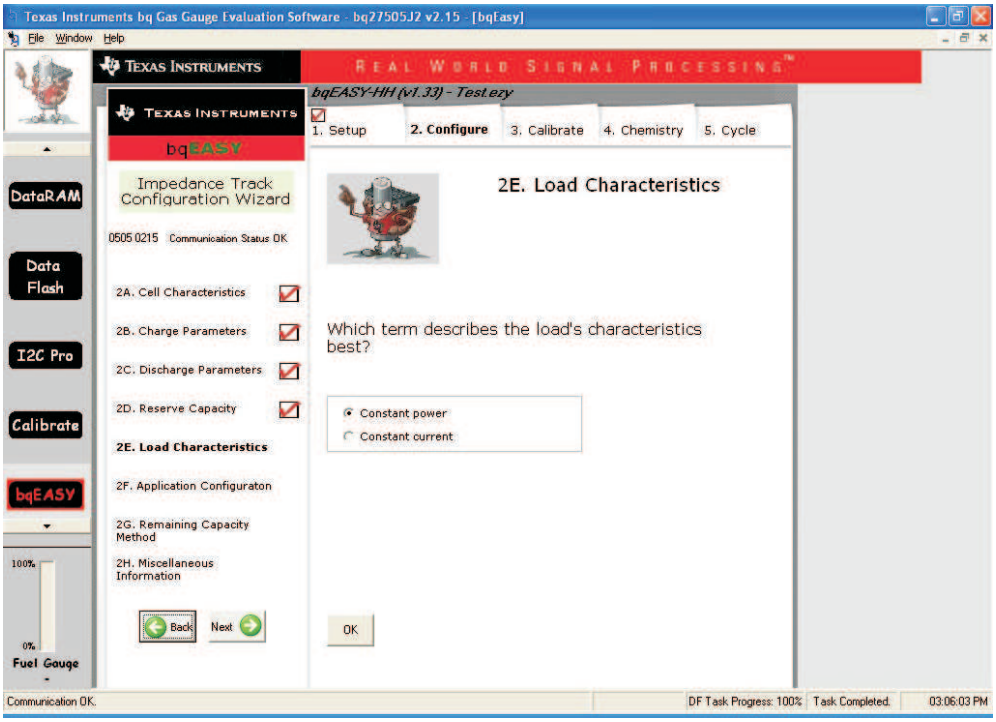

Figure 10. Load Characteristics

Section 2F - Selects the use for BAT_GD and BAT_LOW pins. The BAT_GD pin operates based on the Pin-Function Code (PFC) selected.

Figure 11. Application Configuration

Section 2G - In this section, select the first option if the system load is stable, or select the second option if the system load is dynamic as such with a GSM-type mobile phone.

Figure 12. Remaining Capacity Method

Section 2H- This section is used to set up the State of Health (SOH), the State of Charge Interrupt (SOC_INT), and thermistor parameters.

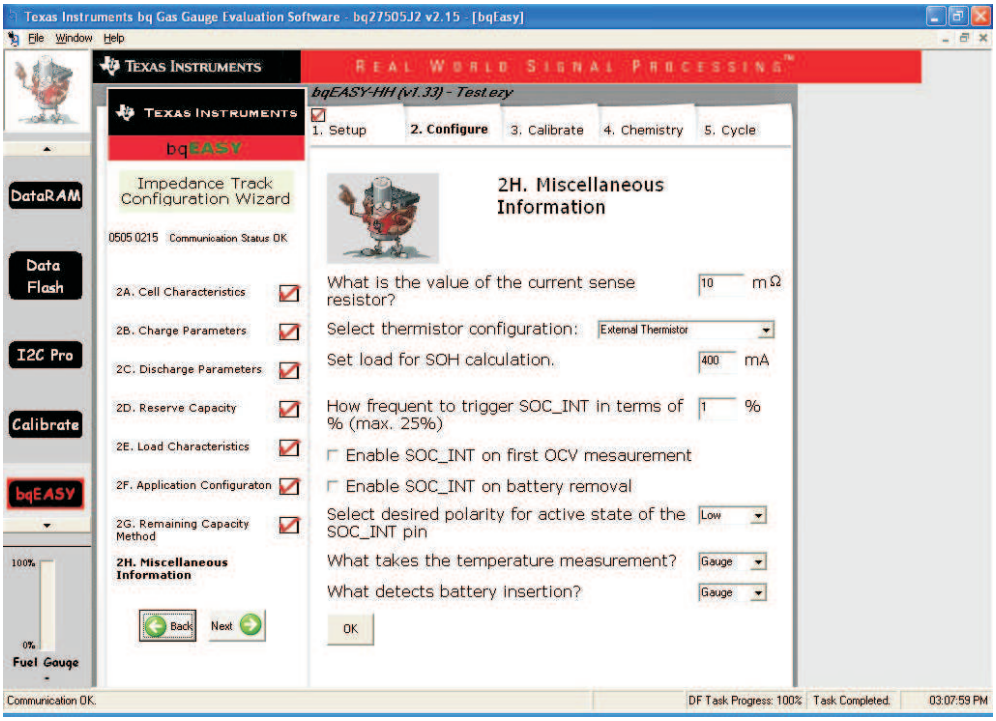

Figure 13. Miscellaneous Information

3. **Calibrate**

To proceed with automatic chemistry selection or *golden image* unit learning cycles, the Impedance Track™ fuel gauge must be accurately calibrated. The bq™ dialogs ask the user to use the bqEASY™ calibration window for this purpose.

With the Impedance Track™ devices, most calibration routines can be incorporated into firmware algorithms, which can be initiated with communication commands. The hardware necessary for calibration is simple. One current source, one voltage source, and one temperature sensor are required. The source stability is important; the accuracy is a secondary concern.

However, accurately calibrated reference measurement equipment must be used for determining the actual arguments to the function. For periodic voltage measurement, a digital voltmeter with better than a 1-mV accuracy is required. The recommended strategy for bq27505 calibration is to perform the calibration using 20-to-30 final application systems containing the bq27505 IC. All the calibration flash values are recorded and averaged among the 20-to-30 samples. The average values are used when creating the DFI file needed for production.

At the time of calibration, access is required to the communication pins, both ends of the sense resistor, and battery power. The calibration process has to be completed in EVSW Calibrate dialog. The calibration consists of performing Coulomb Counter Offset Calibration, Voltage Calibration, Temperature Calibration, Pack Current Calibration, and CC Board Offset Calibration, one at a time. The EVSW is used to perform all calibrations as is shown in Figure 14. Each calibration has to be completed separately.

After the calibration is completed, click the close window control **X** in the upper right corner of the calibration window to close it.

CAUTION

The Calibration window ***must be closed*** after the calibration completes. Otherwise, it interferes with the bqEASY™ learning cycle.

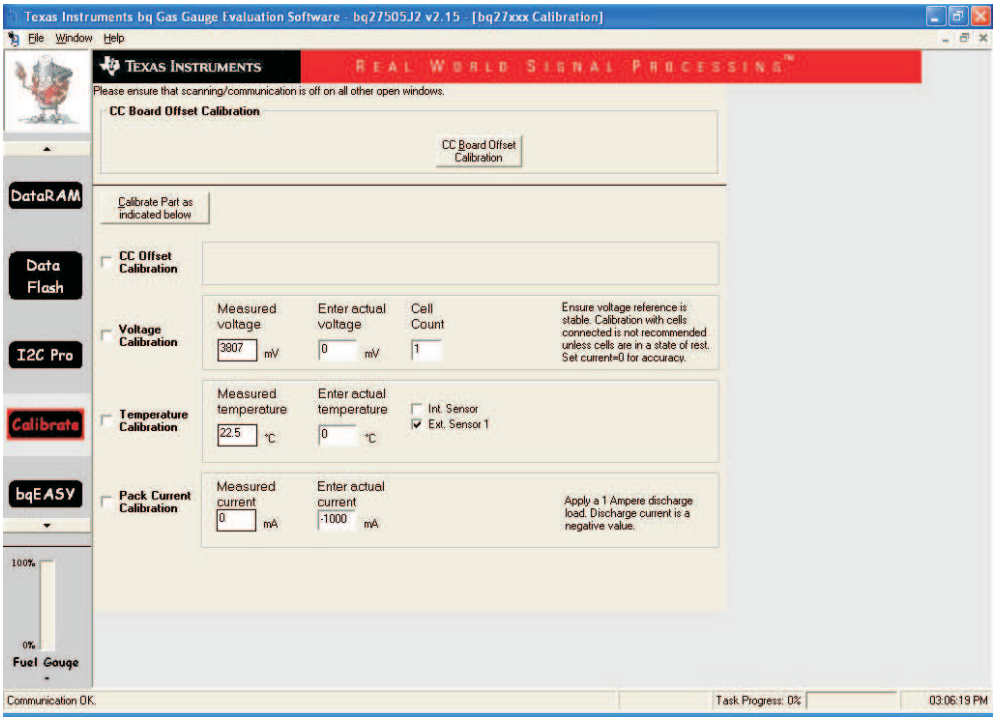

Figure 14. EVSW Calibration Window

Section 3F - Once done with the calibration, the user must review all the data flash values that have been programmed. After reviewing and modifying the data flash if necessary, then select Read DFI button so that the program can extract a temporary data-flash image that can be used before creating the golden DFI after learning has occurred. This screen can be used at any time to extract a DFI of the device connected to the software. The resulting DFI can be found under C:\Program Files\Texas Instruments\bq Evaluation Software\Plugins\Projects and is named by the project name appended with the device type and firmware, and appended with the term "CONFIGURED.dfi". Based on Figure 15, the dfi file name that results from a read DFI is "Test_0505_0215_CONFIGURED.dfi.

Figure 15. Read DFI

4. **Chemistry**

Section 4A - Select No if you do not wish to alter the chemistry files. If you need to select a chemistry type or test for it, then select Yes.

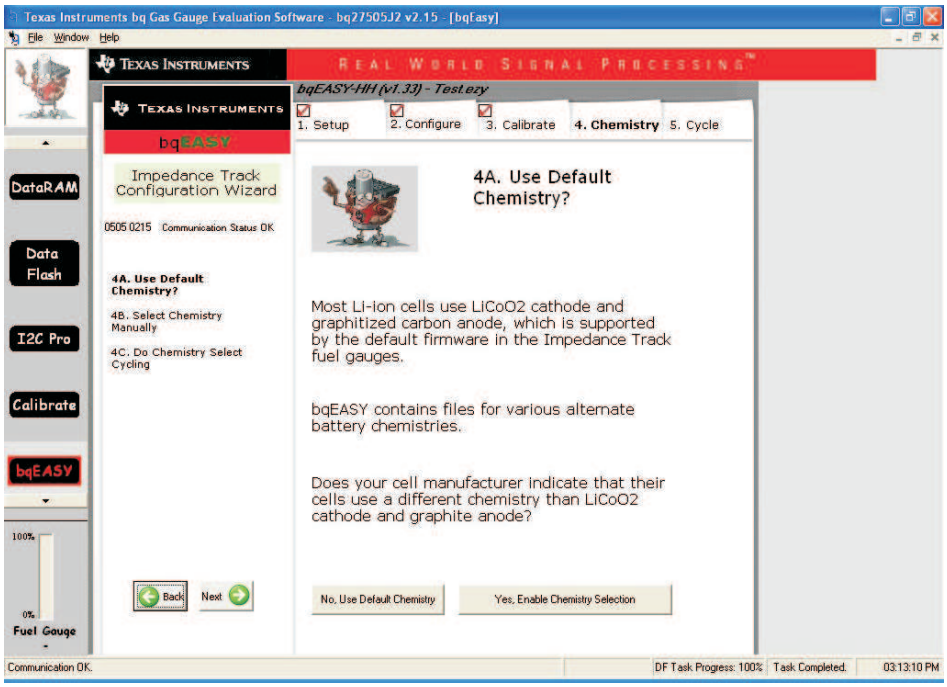

Figure 16. Default Chemistry

The choices presented in **4B Chemistry** section are based on files in the *\Chemistry* folder of the bqEASY™ application. The latest files are available for downloading from the TI Web site.

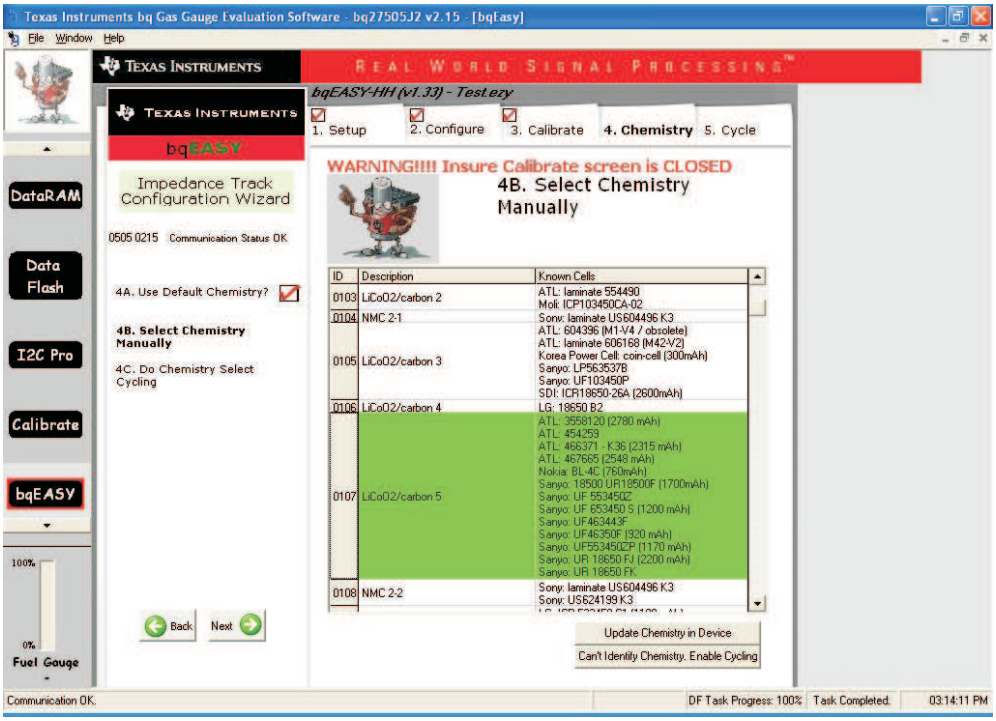

Figure 17. Chemistry Manual Selection

Automation of the chemistry-selection cycle is made possible using a simple load and switch as depicted in Figure 19. The switch can be implemented with a low V_{GS}-threshold FET or a small relay such as the OMICRON G6RN-1 with a 5-Vdc coil. Multiple 2N7000 FETs can be paralleled if nothing else is available. The load can be a power resistor or an electronic load set to a discharge rate of C/5.

Hint: Follow the bqEASY™ dialog instructions exactly to prevent errors.

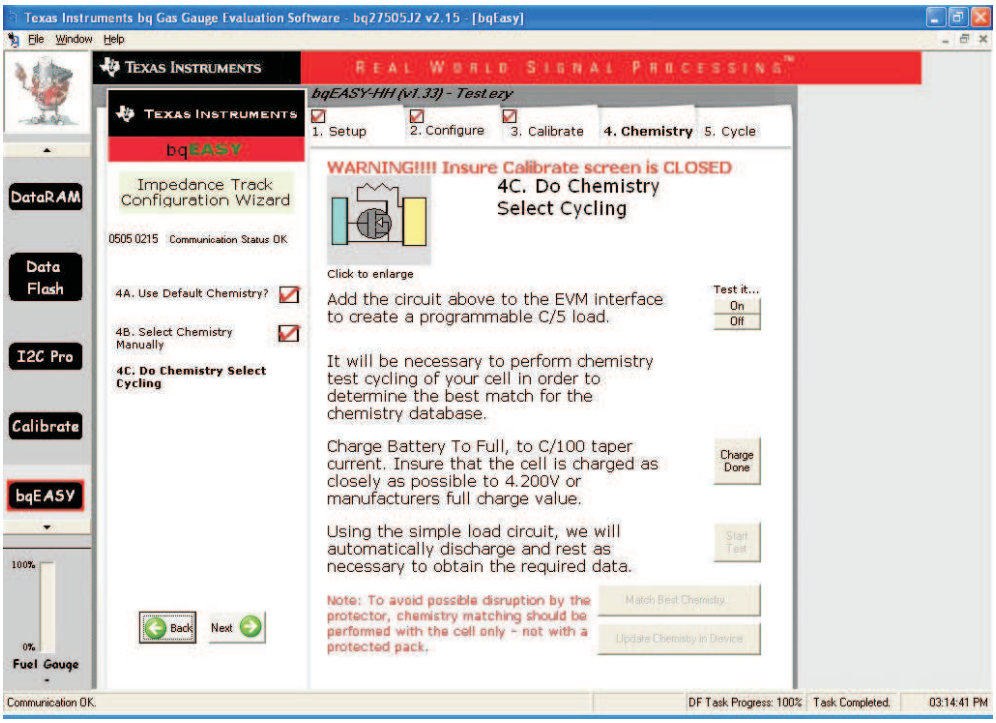

Figure 18. Chemistry Cycling Test

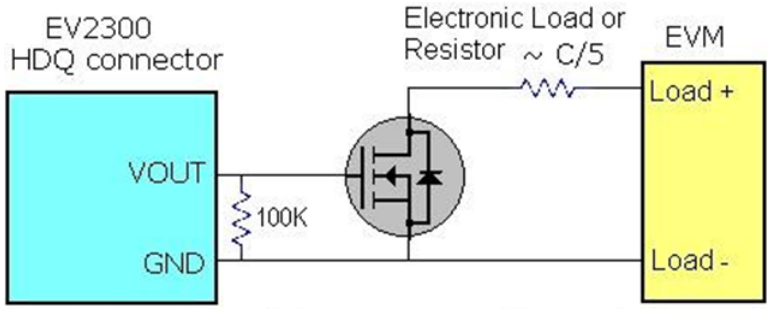

Figure 19. Example Load

CAUTION

The cell ***must be fully charged*** to C/100 taper current. Ensure that the cell is charged as closely as possible to 4.2 V (+/-5 mV), or to the manufacturer's full charge value.

5. **Cycle**

When preparing for mass production, cell learning is required, but only on one *golden* pack. The chemical information learned from one pack can be transferred to all production units, prior to calibration. Doing this correctly requires a series of charge and discharge cycles. The discharge part can be automated with the bqEASY™ software if the simple load circuit for the chemistry selection is available; follow the bqEASY™ dialog instructions as shown in Figure 20. The bqEASY™ software provides two ways to complete the learning cycle.

The first method is to use the bqEASY™ software semi-automatically to complete the learning cycle. This includes:

- Auto-discharge the cell and auto-relax
- Manual initialize the Impedance Track™ devices
- Manual charge the cell to full and manual wait
- Auto-discharge to empty and auto-wait

Another way to complete the cycle is to complete the foregoing steps 1 to 4 manually.

The second method does not involve a constant voltage check by the bqEASY™ software and can be used with data logging without any interference.

If doing the learning cycle manually, you must ensure that all discharges are done until the battery voltage reaches 2.9 V. This is independent of the expected termination voltage for the end-application system. The purpose for the learning cycle in this step is to learn the impedance of the cell throughout the total cell capacity rather than the useable capacity when powering the application system.

When charging, ensure that the charge continues until the FC bit in the Flags register is set. To achieve this, ensure that the Taper Current data-flash register value is programmed with a current threshold approximately 10 mA above the maximum expected current termination threshold for the charger being used.

Ensure that the relaxation time after a discharge is at least 5 hours and after a charge at least 2 hours. Note that this requirement is only for this specific learning cycle process and not for any other learning cycle done once a golden file has been achieved.

Figure 20. bqEASY™ Learning Cycle

Section 5B - Once a valid learning cycle is completed, a golden DFI is created. The bqEASY™ program confirms that the learning cycle is successful by testing against the Update Status register. If the bqEASY™ software was not used for the learning cycle, the user can still create a golden DFI at this section but must still go to section 3F and do a Read DFI before proceeding with the golden DFI creation. The golden DFI is located under C:\Program Files\Texas Instruments\bq Evaluation Software\Plugins\Projects and has a filename similar to the DFI obtained in section 3F but it does have the term "GOLDEN.dfi" rather than "CONFIGURED.dfi". Based on this example, the golden DFI has the filename of Test_0505_0215_GOLDEN.dfi.

Figure 21. Update Golden DFI

A device that has gone completely through the bqEASY™ process including the learning and golden DFI creation, is left in an after-customer, production-line status. This means that the gauge is configured such that it is ready to operate within the application but requires receiving the IT Enable (0x0021) command at the Control register.

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