bqEASY™ for Single Cell 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.

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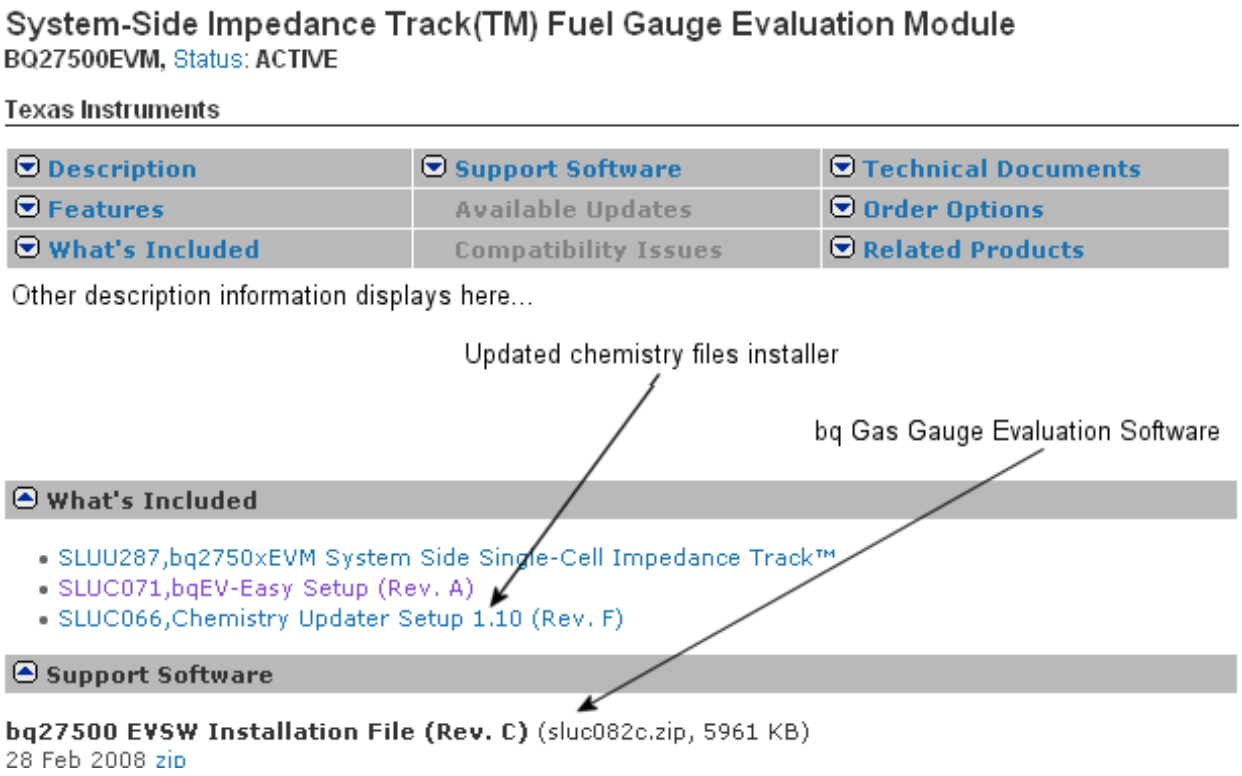
2 Software Installation

Software installation requires that the latest EVSW be installed from the TI Internet in the EVM tool folder, for the specific part. In this document, the *bq275xx* EVM tool folder is referenced, but any EVM tool folder that supports bqEASY can be used.

To install the software:

1. Ensure that the EV2300 is **not** connected to the computer, prior to software installation.
2. Go to the TI Internet and get the latest EVSW if not already done. As described above, this can be found on the TI Internet in the EVM tool folder Support Software section (see Figure 1) for the part being used. As an example, go to the *bq27500EVM* folder *Support Software* at http://focus.ti.com/docs/toolsw/folders/print/bq27500evm.html.

Figure 1. TI Internet bq27500EVM Product Folder



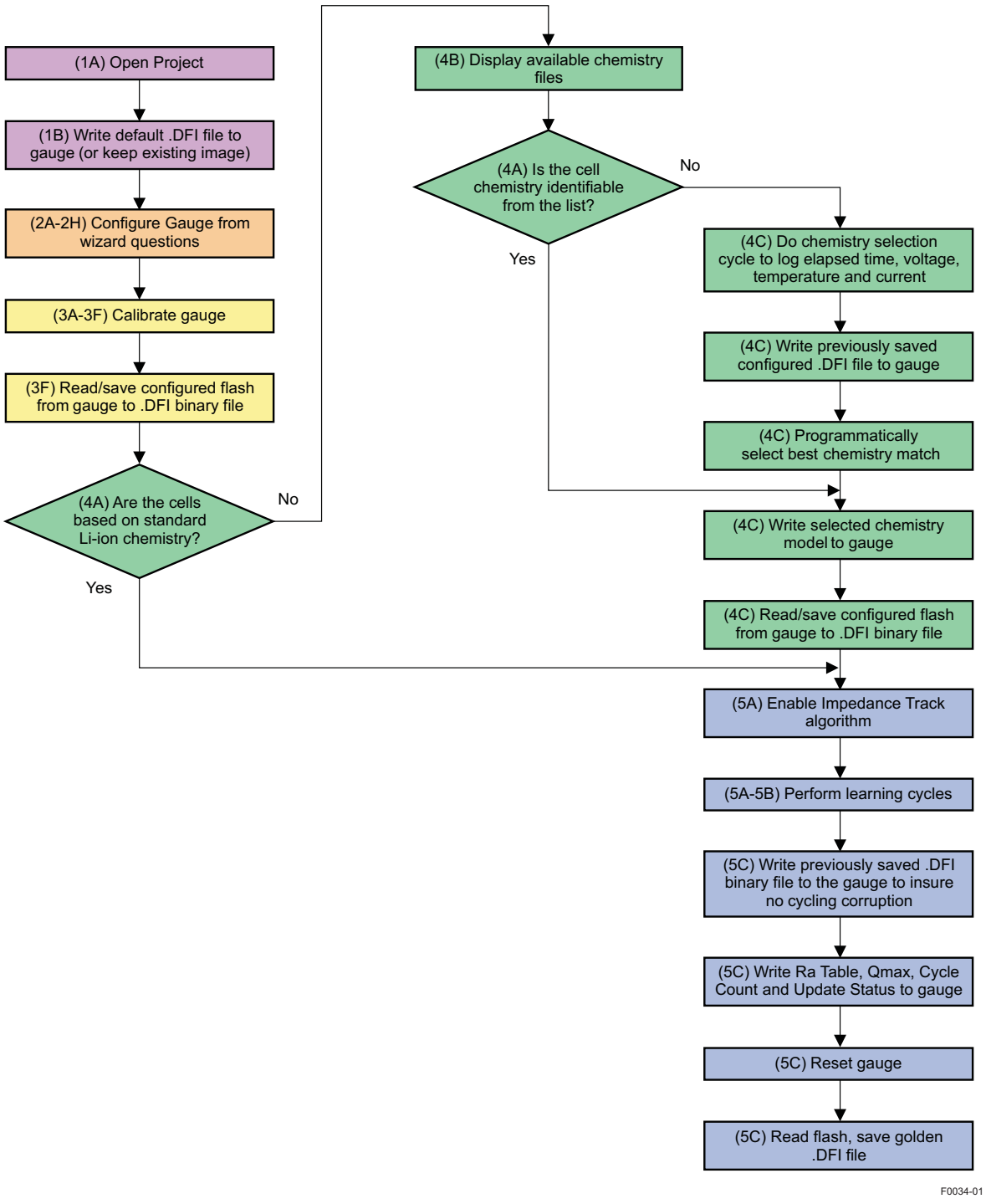
3. Install the EVSW using the Installer screen-displayed instructions. For additional assistance with EVSW installation, see the *Quick Start Guide for bq2750x Family Gas Gauges* (SLUA448). This document can also be found in the EVM tool folder (see Figure 1) for the product being used.
4. Once the EVSW is installed, verify its functionality by setting up the EV2300 and a known bq275xx module. Ensure that the computer, EV2300, and bq275XX module all are operating normally and that communication to the module is functioning. For additional assistance help, refer to *Quick Start Guide for bq2750x Family Gas Gauges* (SLUA448).
5. Because chemistry files are added to the device Internet EVM tool folder often, check this Internet page for updates. A self-extracting installer is available for updating the chemistry file. Install these updates if they exist in the Internet 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 **Calibrate**) in the EVSW (Figure 2).

Figure 2. bqEASY Procedure Software

3 Program Navigation and Flowchart

The operation sequence of bqEASY 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 sub-section 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 **Calibrate**) 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 check mark (Figure 4) 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 **Calibrate**) 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 Internet site for any new Chemistry file updates as described in the Software Installationsection and identified in Figure 1.

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

5 bqEASY Data Files

bqEASY uses several file types to configure a fuel gauge:

- ***.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 bqEASY, the correct file may not be present in the software. This requires a new version of the EVSW with bqEASY. Navigate to the TI Internet in the EVM tool folder for the device being used, and download the latest version, or contact TI. For bqEASY, 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 will not be found. If this is the case, check for updated bqEASY software or Chemistry files on the TI Internet 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 the 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 check marks in Figure 4). The files are stored in the *...\bq_Evaluation_Software\Plugins\Projects* folder.

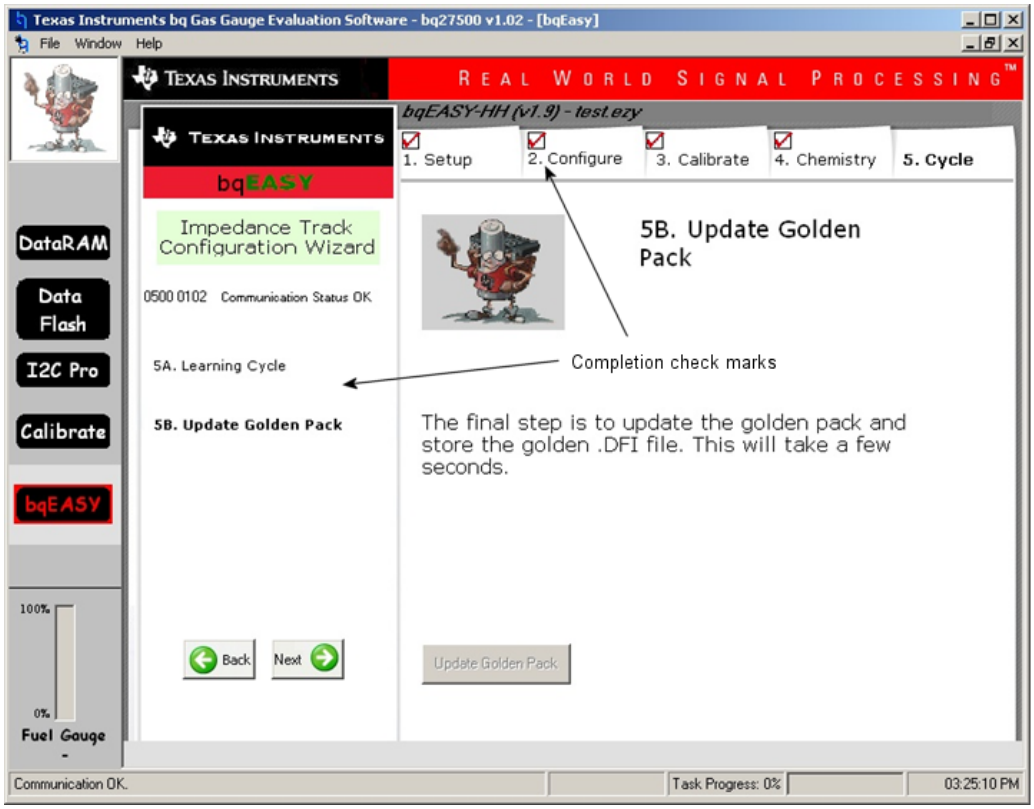
6 Completion Checkmarks

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. For example, in Figure 4, all of the **Setup** tasks and **Configure** 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)

Figure 4. Process Completion Checkmarks



7 Device Detection

The bqEASY 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 bq27500 that is running version 1.02 of the firmware. This information is used by bqEASY 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, bqEASY also checks the device type each time the user clicks the **bqEASY** button. If the correct files are not found, first check the TI Internet 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 bqEASY 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.

   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.

2. **Configure**

   A sequence of dialogs used to collect information about the battery pack application that enable automatic configuration of the most critical data-flash parameters.

3. **Calibrate**

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

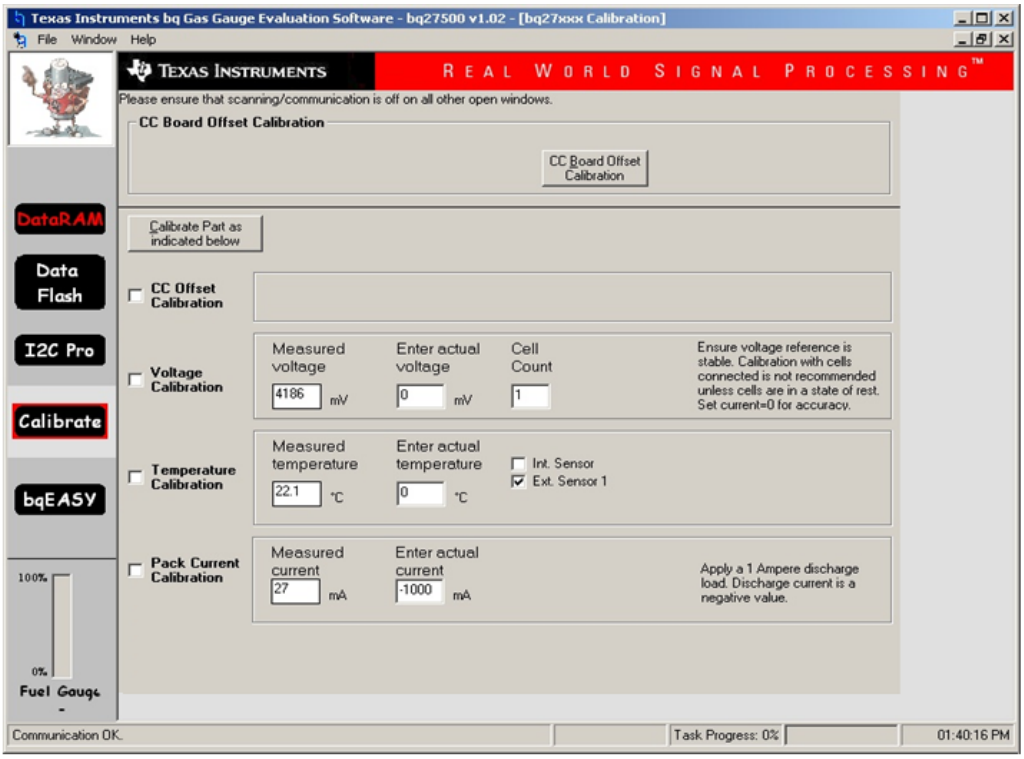
   However, accurately calibrated reference measurement equipment should be used for determining the actual arguments to the function. For periodic voltage measurement, a digital voltmeter with better than a 1-mV accuracy is required. The recommended strategy for bq27500/1 calibration is to perform the calibration using 20 to 30 final application systems containing the bq27500/1 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 is shown in Figure 5. Each calibratino has to be completed seperately.

   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 5. EVSW Calibration Window



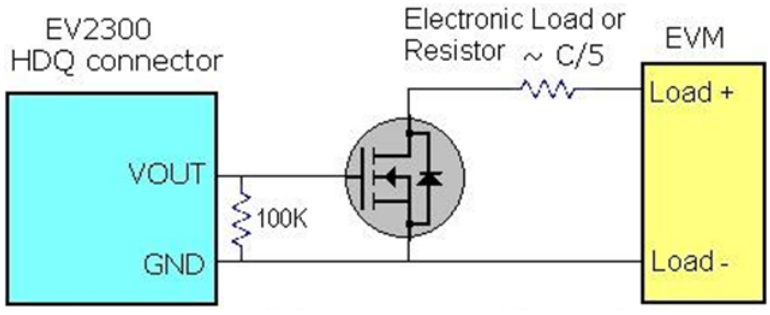
4. **Chemistry**

   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 Texas Instruments Internet site.

   Automation of the chemistry-selection cycle is made possible using a simple load and switch as depicted in Figure 6. 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 6. Example Load



CAUTION

The cell ***must be fully charged*** to C/100 taper current. Insure that the cell is charged as closely as possible to 4.2V (+/-5mV), or to the manufacture'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 bqEASY if the simple load circuit for the chemistry selection is available, follow the bqEASY dialog instructions as shown in Figure 7. The bqEASY provides two ways to complete the learning cycle.

The first method is to use bqEASY semi-automatically to complete leaning cycle. This includes:

- auto-discharge the cell and auto-relax,
- manual initialize the Impedance Track,
- manual charge the cell to full and manul wait,
- Auto-discharge to empty and auto-wait.

Another way to complete the cycle is to complete above step 1 to 4 manually.

The second method does not involve a constant voltage check by bqEASY, and can be used with datalogging without any interference.

Figure 7. EVSW Learning Cycle Window

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