Application Report

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Start Guide for the BQ27546-G1

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ABSTRACT

The bq27546 is a flash based battery gauge that uses TI's patented impedance track technology for predicting the remaining capacity of battery amongst other functionalities. This documents helps users walk through the process of setting up the gauge, identifying a chemical id, performing a learning cycle and creating a golden file ready for production.

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1 Introduction

For first time users, the complexity of the impedance track algorithm might seem overwhelming, but in actuality, setting up the gauge and getting it fully functional is a straight forward and simple process. This start guide is geared towards the first time user to facilitate coming up to speed and getting the gauge fully functional.

2 Gauge set up and Golden file generation

The processes of getting the gauge fully functional are summarized below with elaborate details following thereafter:

1. Set up the EVM following the instructions listed in the EVM User Guide.
2. Make sure the gauge has the most up-to-date G1 firmware on the chip which is 0546_2_01(your board will come with this firmware already loaded).
3. Perform voltage, current and temperature calibration as described in the evm user guide if using your board. If using the EVM, there will be no need for calibration as the EVM already comes factory-calibrated.

4. Identify your chem id and program the identified chem id on the gauge
5. Configure the data flash for your specific application.
6. Perform a learning cycle.
7. Extract the golden file
8. Evaluate the accuracy of the gauge.

2.1 EVM set up

For EVM setup, you need a power supply or charger, a second power supply or battery, an electronic load, an EV2300 or EV2400, bqstudio software and the necessary connecting cables. Please see the EVM user guide here for step by step details on getting the board set up as shown in Figure 1. Connect jumpers to J3 and J4 for 10k pull ups on the I2C SDA and SCL lines, place a jumper on pin 1 and 2 of J6 (ON) to ensure the chip is powered on .

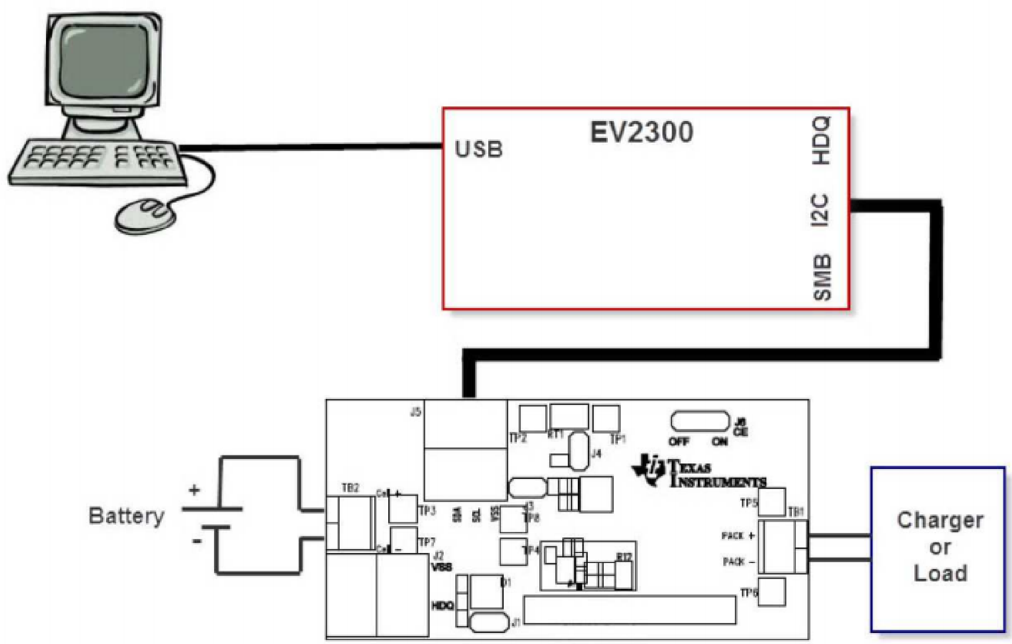

Figure 6. bq27546 Circuit Module Connection to Cell and System Load or Charger

Figure 1. EVM set-up

2.2 Verify the firmware is most recent

Upon startup of bqstudio, the device should be automatically detected. If that isn’t the case, and a screen as seen in Figure 2 appears, then you need to check to make sure your device is properly powered on and that your gauge IC isn't damaged. Also, check to make sure you are connected to the I2C port on the EV2300 and on the EVM.

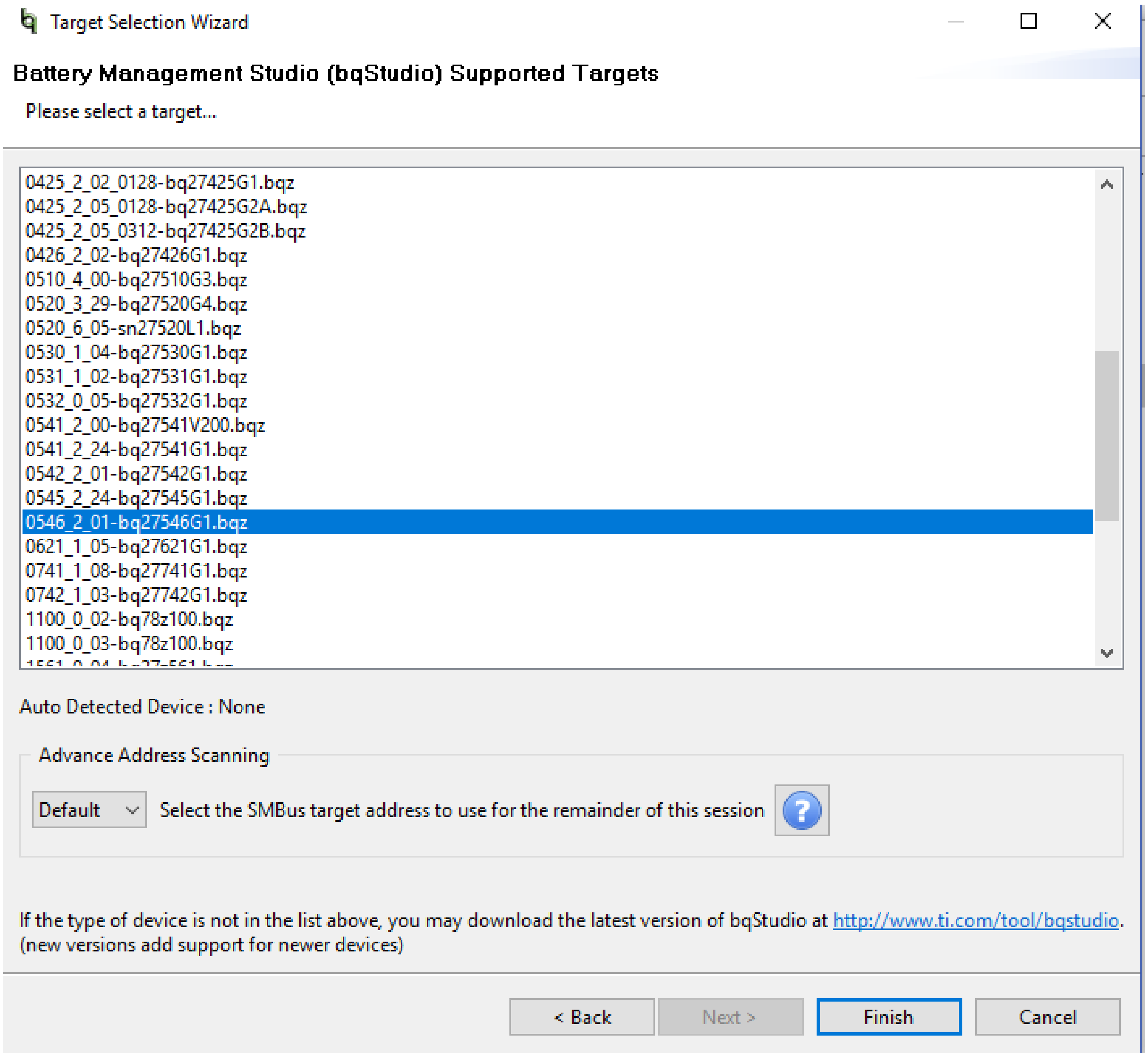

Figure 2. Non-auto detection of device firmware by bqstudio

If the device is auto detected upon booting your screen will look like Figure 3.

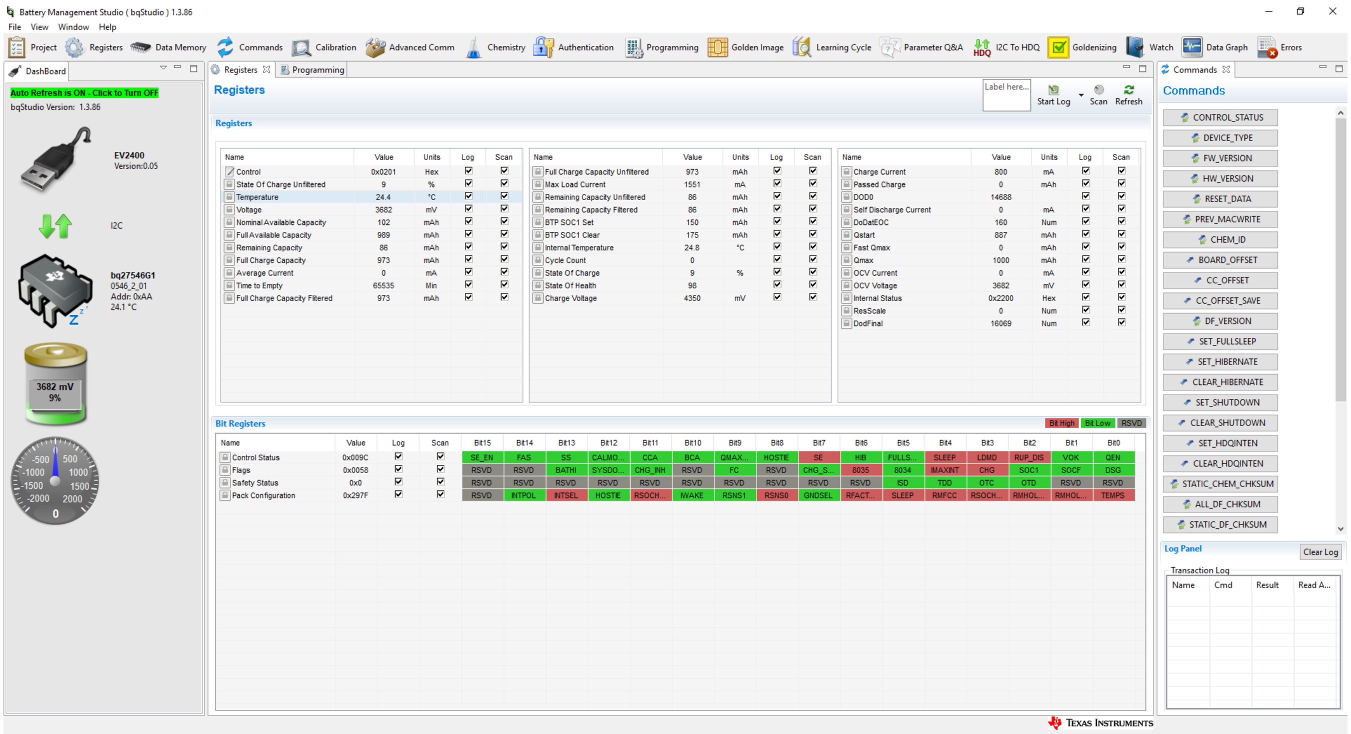

Figure 3. Auto Detected Device

If you need to update the firmware on the device, the process of updating the firmware is as follows:

- - Select gauge from the device type as shown in Figure 2 . Then select the 0546_2_01-bq27546G1.bqz from the next window that pops up.
- - Then go to the programming window as shown in Figure 4 and browse to where the srec is stored on your computer. Select it, and then hit the program button. This process will update the firmware on the chip.

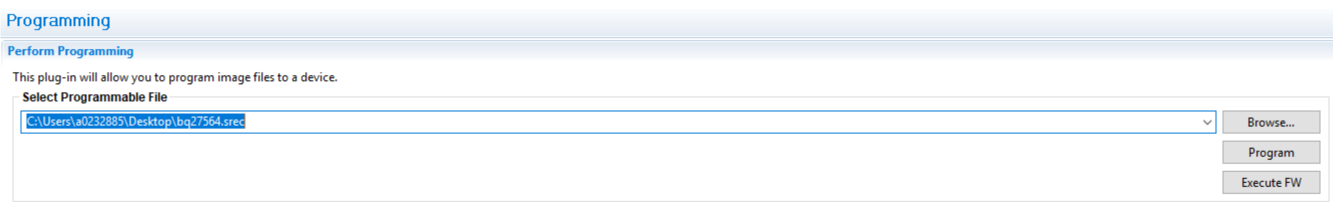

Figure 4. Programming the firmware on the gauge using bqstudio

2.3 *Calibrate Voltage, Current, Temperature, CC and Board Offset.*

The EVM user guide (section 9) contains the description of how to calibrate the voltage, current and temperature measurements as well as the offsets. If you are using your own boards, then calibration is required. If there is a need to avoid calibrating each board, 20 boards should be calibrated and the average of each of the calibration parameters obtained should be programmed in the corresponding section of the gauge data flash. It is easier to make edits to the gauge parameters using the gg file rather than making edits via bqstudio. You can extract a gg file by clicking the data memory section of bqstudio and then click export button and then save the file to a desired location. See Figure 5. A gg file can also be programmed on the device by clicking the import button. . The evm board already comes pre-calibrated so if running tests on an EVM, there is no need to perform calibration.

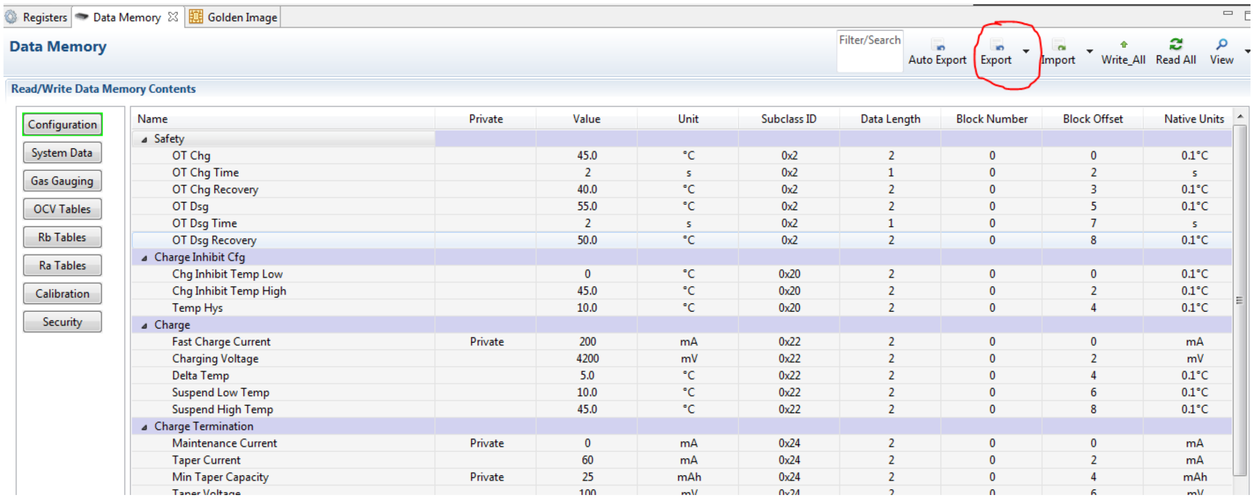

Figure 5. Exporting a gg file.

2.4 Chem id Identification and programming

The chem id is a look up table which the gauge uses for determination of state of charge during initialization. The gauge also uses this table as part of the IT algorithm to predict remaining capacity. This table consists of the open circuit voltage profile of the battery as well as the resistance profile of the battery which is split up into grid points that corresponds to different state of charges. Both the OCV and resistance tables have the temperature dependent components which aids gauge performance at different temperatures. It is important that the chem id programmed on the gauge was either generated by TI for that battery or a close match to an existing chem id in TI data base for batteries has been identified using our online chem id identification tool- gpcchem. The chem id identification requires running a relax-discharge-relax (rel-dis-rel) test while logging data using the gauge's GUI (bqstudio) and then using gpc chem tool with the logged data to identify a close match. If there is no match, then the cells have to be sent to TI for characterization and chem id generation. Contact a local field applications engineer if cells have to be sent to TI. Once a chem id has been identified or created, it has to be programmed on the fuel gauge. You can select the new found chem id and program it using the chemistry plug-in of bqstudio as shown in Figure 6 below. Note that if an incorrect chem id is used, learning cycle may never successfully complete and state of charge prediction will never be accurate.

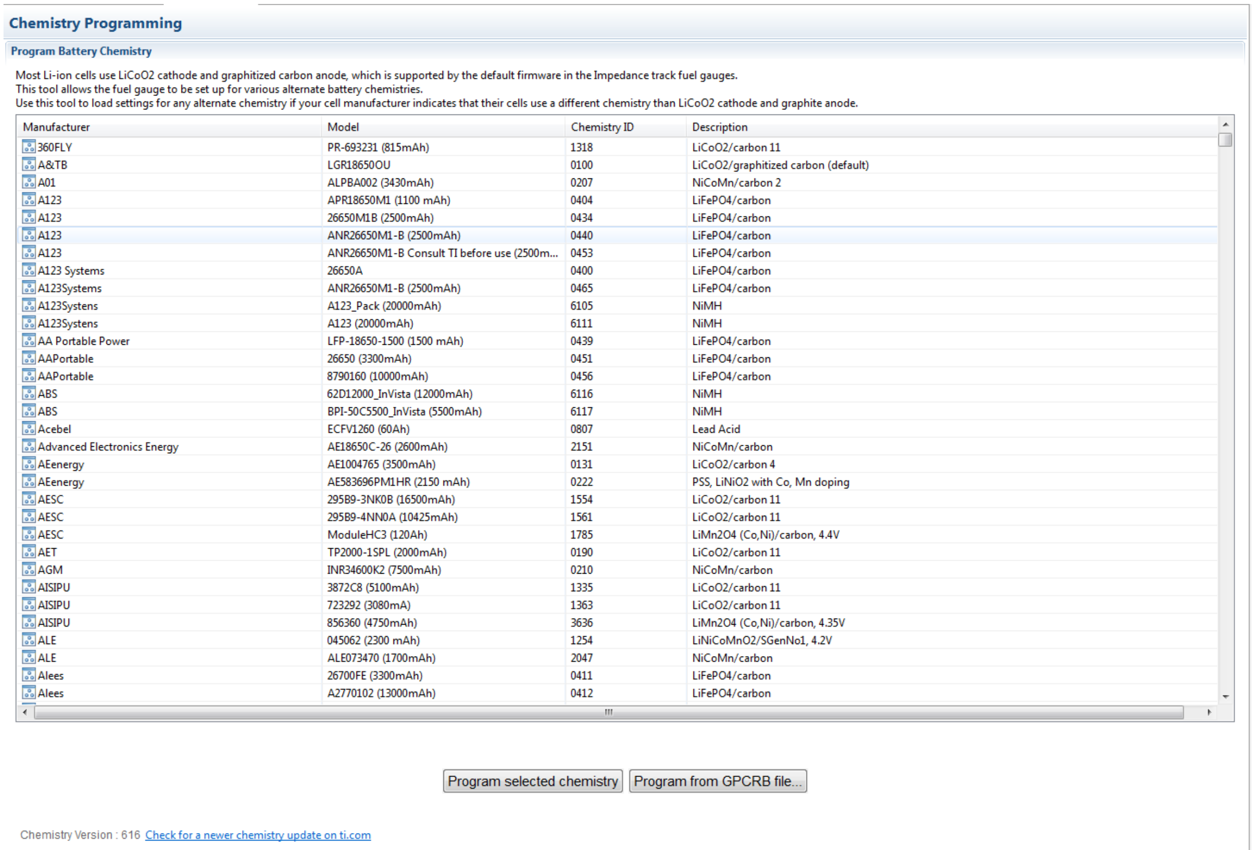

Figure 6. Chem id programming

2.5 Configuration of the data flash for your specific application

In order to have learning cycle successfully complete, certain parameters in the data memory of the gauge need to be configured specific to the application and the battery typ. At a minimum, these parameters are design capacity, taper current, discharge (dsg) current threshold, charge (chg) current threshold, quit current, and terminate voltage. You can search for these parameters in data memory by typing in the filter/search box as seen in Figure 7:

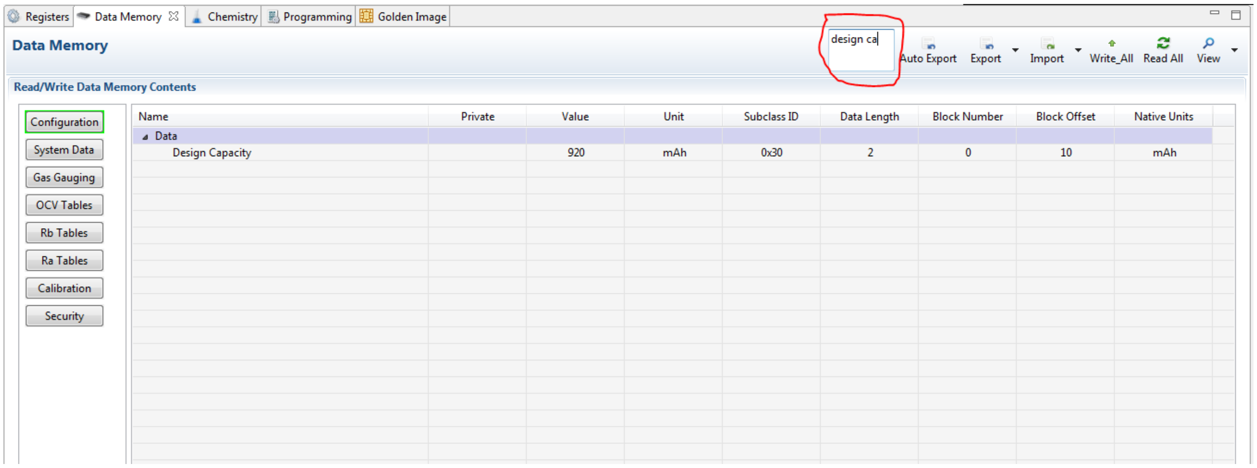

Figure 7. Searching for a parameter in data memory

Design Capacity

The design capacity should be set to the value specified in the cell manufacturer's data sheet as the nominal capacity. If there are n cells in parallel, the design capacity will be n x nominal capacity of 1cell

Taper Current

Most battery chargers have a +/-10% error in taper current threshold at which point the charger cuts off charging. It is very important to set the taper current programmed in the data flash of the gauge slightly higher than the taper current threshold of the charger. This will ensure that the gauge detects the battery is fully charged before the charger cuts off charge. For example, if your charger taper current is 50mA, it is recommended to set the taper current in data flash greater than 50mA. A good value to use will be 70mA. Also, it is recommended that the taper current should be less than C/10 to ensure that the battery gets properly fully charged.

Discharge (Dsg) Current Threshold

This is the current threshold above which the gauge detects that it is in discharge mode. It is an unsigned integer as the gauge has the ability to detect the direction of current flow. This value should be set lower than the charge termination taper current. In the previous example, if charge termination taper current is set to 70mA, a good value for discharge current threshold is 45mA

Charge Current Threshold

This is the current above which the gauge detects that it is in charge mode. This value should be set lower than the charge termination taper current as well. As with the previous example, a good value for charge current threshold would be 40mA.

Quit Current Threshold

This is the threshold that determines that the gauge is in relax mode. This mode is very important because this is where the gauge takes OCV readings which are used for Qmax calculations. It is recommended that the quit current be less than C/20 and must be less than the discharge and charge current threshold. In the previous example mentioned, a good value to use will be 10mA.

Terminate Voltage

This is the voltage where the gauge should detect that the battery is at 0% SOC. For learning cycle purposes, this should be set to the minimum voltage of the battery as specified in the manufacturer's data sheet. After learning cycle is completed, this value can be adjusted upwards if there is a need for the gauge to report 0% at a higher voltage.

2.6 Learning Cycle

The learning cycle is needed for the gauge to update the total chemical capacity (Qmax) and the resistance (Ra) tables of the cell in data flash. It is also needed for the update status which the gauge controls to indicate that the learning cycle has been completed. Before the learning cycle is started, extract a gg file and start logging the registers by clicking the start log button in the register window as shown in Figure 8and save the file at a desired location. The purpose of the log file is for debug purposes in case learning isn't successful. It will enable the understanding of the failure.

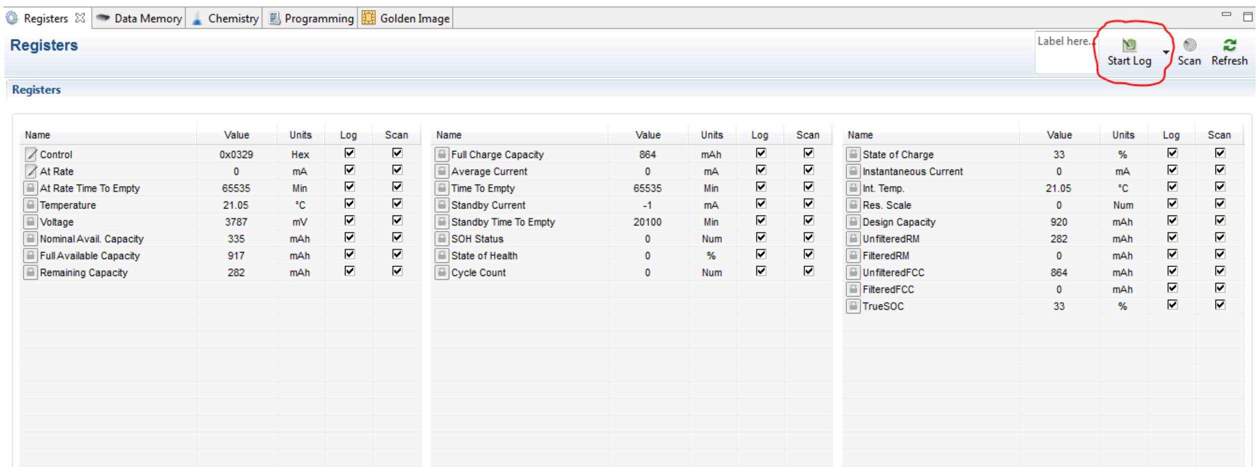

Figure 8. Logging the registers

The learning cycle as seen in Figure 9 is as follows:

1. Enable impedance track (0x21), issue a reset command (0x41). Update status will go from 00 to 04.
2. Discharge the cell to empty and let it relax for 5 hours.
3. Charge the cells to full ensuring that the current goes below taper current and fc bit gets set, then let it relax for two hours. Qmax updates at this point and update status goes to 05. At least 90% of the cells design capacity has to go into the battery for qmax to learn. The learning cycle must be done at room temperature.
4. Discharge the cells to empty using the typical discharge rate of your application. It must be between c/5 to c/10 rate otherwise learning will fail. Resistance tables will get updated during this discharge cycle.
5. Let the cells relax for 5 hours. Update status would have changed to 06 before the end of relaxation indicating learning cycle was successful. If Update status is not 06 at the end of learning, go back to step 3 and repeat the process one more time.

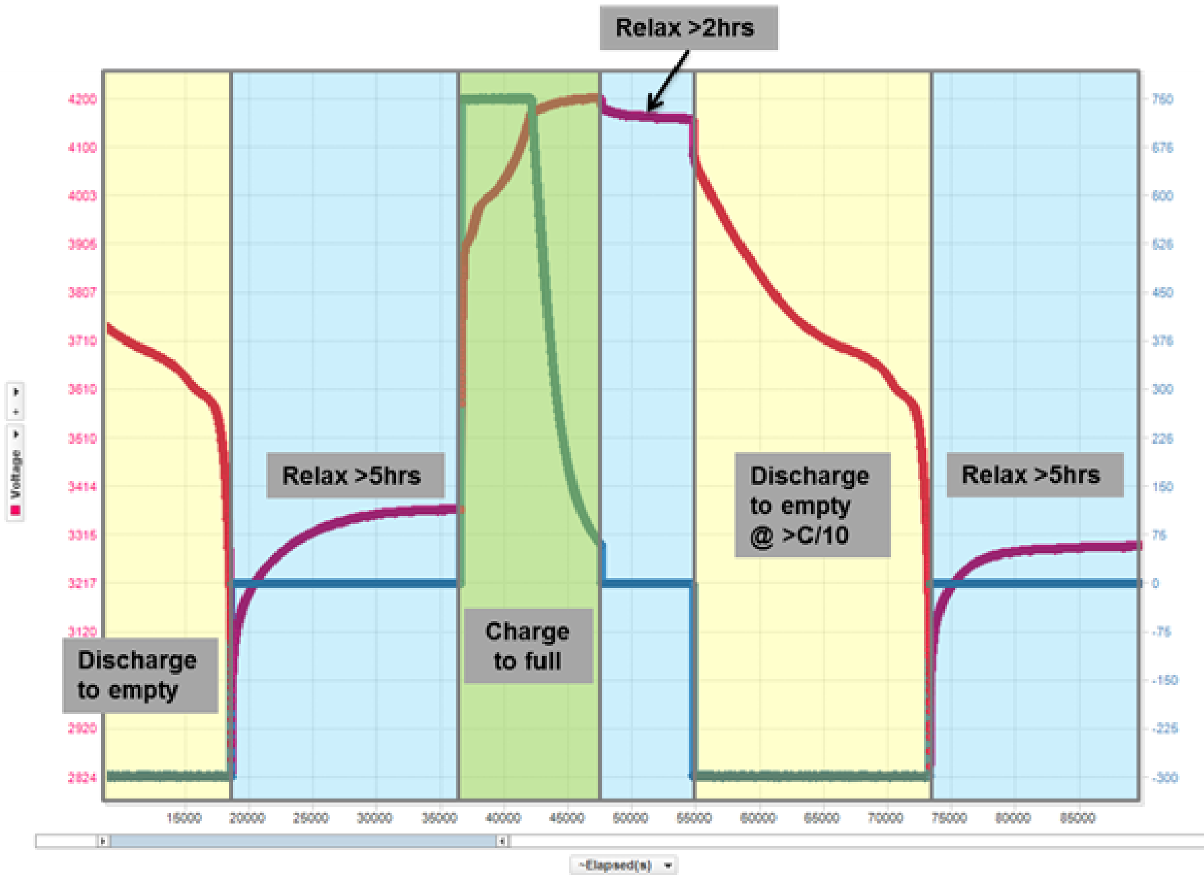

Figure 9. Learning cycle.

2.7 Extract the golden file

The golden file can be extracted by clicking the golden image tab and then clicking the create image files button if one of the srec , bqfs or dffs field box is checked. see Figure 10The srec and bqfs both contain the instruction flash (IF) and dataflash (DF) while the DFFS contains just the data flash content which is why it is a smaller in size than either of the aforementioned files and is the preferred file format for in-system gauge programming.

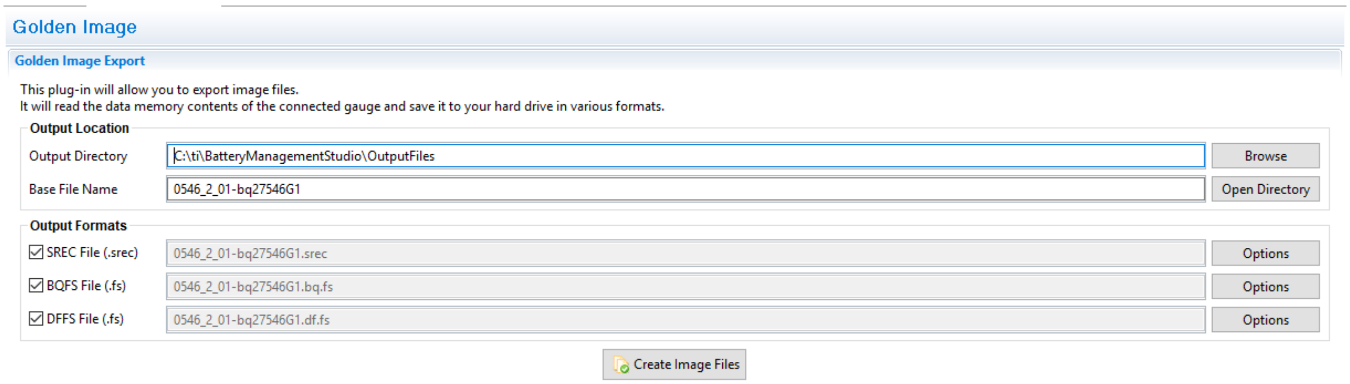

Figure 10. Extracting the golden image

2.8 *Evaluate for accuracy.*

Cycle the gauge one more time to evaluate for accuracy. Follow the blog here to perform gauging accuracy calculations

3 Summary

In summary, the process of setting up the gauge, while may be lengthy, is a very straight forward and simple process. If this guide is followed step by step, the gauge will be fully functional and configured in less than a week.

4 References

- bq27546 EVM With Pack Side, Single-Cell Impedance Track™ Technology Evaluation Module User Guide
- Technical Reference Manual SLUUB74
- How accurate is your battery fuel gauge part 2/2

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265