Using the bq35100 with Li-Primary Based Applications

TEXAS INSTRUMENTS

0.1 Why bq35100 ?

The BQ35100 is an accurate low power battery gauge that extends the life of primary batteries through accurate gauging. The gauge offers support for Lithium Thionyl Chloride chemistries with an EOS(end of service) algorithm which only consumes 0.35 uA of current as well as support for Lithium Manganese Dioxide chemistries with an SOH(state of health) algorithm which only consumes .06 uA of current. The device itself only needs to be powered long enough to record voltage, current, and temperature measurements used for computing parameters in SOH and EOS mode. These parameters, for instance, state of health and or impedance can be recorded based on user defined triggering of the GE pin which controls the devices power state. The user can obtain the results of EOS and SOH algorithms via an I2C bus, or use the ALERT output on the gauge as an interrupt to the host system. Additionally, the gauge algorithms support seamless replacement of old batteries and use an SHA-1 authentication to help prevent counterfeit battery usage. This gauge is best suited for use in products such as smoke alarms, flow meters, door access controllers, and similar devices for early fault detection and to maximize runtime.

0.2 Hardware

- EV2400 (Used for communicating over I2C with the BQ35100 IC)
- Power Supply (This can be a battery or power supply, the board is powered from this)
- USB 2.0 Type A to Type B (Connect EV2400 to your PC) I2C data cable (Connect EV2400 to board)

0.3 Software

- bqStudio Software (Program to interface with IC)
- EV2400 Firmware (Firmware for the 2400 must be updated in order to be used)

0.4 EV2400 Setup

- Connect usb from EV2400 to computer and connect data cable from EV2400 to I2C port on the board.
- Connect your EV2400 to your PC and navigate to http://www.ti.com/tool/EV2400 .
- Download the firmware and execute it in order to update your EV2400.

0.5 bqStudio Setup

- Navigate to http://www.ti.com/tool/BQSTUDIO and install the software.

0.6 Board Setup

- Place Jumpers across ALERT/PULL-UP
- Place Jumpers across GE/PULL-UP (Toggling this turns the device on and off)
- For one cell place jumpers across bottom two “1s”.
- For multi-cell you will need to place jumpers on the top two 2-4s pins on J2.
- Following this place pins on J3 indicating the number of cells you have.
- Connect your battery across BAT+ and BAT-
- Connect data cable on J1 to the I2C port on your EV2400.

0.7 Loading Board Firmware (Optional)

- If your board does not come loaded with firmware or you wish to change it. Navigate to the Programming tab at the top.
- Select your .srec file and press PROGRAM. Once programming has finished press Execute FW. See "Programming" image in the Graphics section for reference.

0.8 Starting bqStudio

- Turn on your power supply and make sure you have jumped the GE pin.
- Upon launching bqStudio the software should auto detect the IC you are using. See "Start Screen" in the Graphics section for reference.
- You can use the SCAN button to continuously sample the visible parameters or use REFRESH at your discretion.

0.9 Using bqStudio

1. Press UNSEAL in the Commands tab. Check SEC1 and SEC0 in the Bit Registers window to see that SEC1 is green and SEC0 is red. (10) which means that the device has been unsealed

2. Press RESET in the Commands tab.

3. Press CAL_TOGGLE in the Commands tab.

4. If you are using a pack with more than one cell in series, navigate to the gas gauging tab within the Data Memory tab. Make sure to enter your series cell count and write it the data flash prior to calibration. See "Series Cell Count" in the Graphics section for reference.

5. Navigate to the calibration tab at the top.

6. Check the “calibrate voltage” box and enter the measured voltage. You may get an error related to scanning in which navigate back to the Registers tab and turn scanning off. Once voltage calibration is finished uncheck the box next to it.

7. Repeat this procedure for the current and the temperature.

8. Finally, check Calibrate CC Offset and calibrate.

9. In the Command tab press CAL_TOGGLE so that CalMode in the Bit Registers is Green indicating 0 which is off.

0.10 Cell Chemistry

- Navigate to the Chemistry tab.
- When selecting the Chem ID, primary cell IDs are listed as 6xxx. If you cannot find your specific model contact Texas Instruments on model generation.
- Select the chemistry you are using and press Program selected chemistry. See "Cell Chemistry" in the Graphics section for reference.

0.11 Entering Into SOH Mode

This mode is used for tracking capacity of batteries where the capacity decreases steadily with no sharp increases in internal impedance. Moreover this is characteristic of Lithium Manganese Dioxide chemistries.

1. Press UNSEAL in the COMMAND tab. Check SEC1 and SEC0

2. Press NEW_BATTERY in the Commands tab.

3. Navigate to the Data Memory tab.

4. In the Data Memory tab press on the Configuration button.

5. From here press on “Operation Config A”.

6. Observe the values of Bit1 (GMSEL1) and Bit0(GMSEL0). To be in SOH mode we need the values to be as such GMSEL1 = 0 =green and GMSEL0 = 1 = red. Press on GMSEL0 so that it turns red and changes what mode we are in and save. Reference the "GM Select" image in the Graphics section for where you should be when changing GM Sel.(NOTE: In the referenced image the operating mode is set to EOS)

7. We are now in SOH mode.

8. Navigate to Gas Gauging in the sidebar. Here are variables the user can modify as needed. Here you can enter the series cell count, etc.

9. Once you SOH decrease it will not increase so you will need to press NEW_BATTERY each time you wish to use a new cell.

0.11.1 SOH Mode Fundamentals

SOH mode takes in the battery voltage and temperature. The gauge uses these two values and references them to the OCV lookup table in order to determine the SOH. One important variable to adjust in the Gas Gauging sidebar is the” Sate of Health Max Delta”. This variable determines by how much you SOH can change with every cycle of the GE pin. If you plan on sampling very frequently and reading the voltage lower values will work. However, if your delta value is low and the voltage drops very suddenly you will not observe a change immediately but rather it will take multiple cycles to catch up to the new voltage.

0.11.2 Using SOH Mode

Once you have followed the above steps, using SOH mode is simple. Have your battery connected to the gauge and simply cycle the GE pin in order to get updated values of SOH after you have finished loading and the battery’s open circuit voltage has relaxed back up. It is essential to wait for the battery’s open circuit voltage to relax up in order to get accurate SOH readings. Make sure to press NEW_BATTERY if you are inserting a new cell.

0.12 Entering Into EOS Mode

EOS is used for devices where the overall capacity doesn't decrease steadily with time but rather drops off sharply at the end of its life due to a sharp increase in impedance. Moreover this is characteristic of Lithium Thionyl Chloride chemistries. Reference the "Battery Impedance at EOS" graph on the Graphics page to see a characteristic curve of impedance increasing at EOS.

1. Press UNSEAL in the COMMAND tab. Check SEC1 and SEC0

2. Press NEW_BATTERY in the Commands tab.

3. Navigate to the Data Memory tab.

4. In the Data Memory tab press on the Configuration button.

5. From here press on "Operation Config A".

6. Observe the values of Bit1 (GMSEL1) and Bit0(GMSEL0). To be in EOS mode we need the values to be as such GMSEL1 = 1=red and GMSEL0 = 0 = green. Press on GMSEL1 so that it turns red and changes what mode we are in and save.

7. We are now in EOS mode.

8. Navigate to the EOSData tab, here there are important variables the user can modify which will be subsequently discussed.

0.12.1 EOS Mode Fundamentals

EOS mode works by tracking the internal impedance of your battery with a short trend and long trend average. The gauge looks for a sharp increase in the short trend average when compared to the long trend average. The EOS Trent Detection average is the % increase of the short trend average in relation to the long trend average. Once the equation below is satisfied an EOS condition is set in the Battery Alert register. Reference the "EOS Usage" diagram on the Graphics page for a flowchart on using the mode.

Short Trend Average > Long Trend Average * (1 + EOS Trent Detection/ 100)

0.12.2 Using EOS Mode

One important parameter to consider is the EOS Detection Pulse Count Thrshd. This threshold is the number of Gauge_Start and Gauge_Stop cycles you must perform before your device will begin calculating the short trend and long trend averages for EOS detection. Adjust this value in accordance with how many times you will cycle your device. Modify the trent detection value based on how sharp of a decline your battery exhibits during EOS. Additionally make sure to adjust your cell terminate value under the Gas Gauging tab. Values for the impedance and SOH become available after the G_DONE bit is set to 1. Reference the "EOS Usage" diagram in the Graphics section for a flowchart on using the mode as well as the "EOS Parameters" image in the Graphics section for modifiable parameters.

0.13 When is my battery empty?

When using EOS or SOH mode it is important to understand when a battery is dead. In general, a battery is considered dead when the relaxed open circuit voltage is at or below the terminate voltage. In SOH mode the decline towards this voltage is easy to see with each successive discharge bringing the relaxed voltage closer to the terminate voltage. Towards the end of a batteries life in SOH mode, the voltage will begin to dip to or below the terminate voltage and relax up to subsequently lower values with successive discharges. With EOS mode, the sharp increase in impedance signals that the battery is close to being unusable and the battery is said to be completely depleted when the voltage drops below the terminate voltage. This change happens rapidly and the battery itself becomes unusable very quickly.

1 Golden Image

Once you have calibrated, loaded the chemistry, and made sure your gauge is operating as you would like. You can extract a "golden image" file which is essentially an image of the flash memory that you can load into additional gauges so that you do not have to perform setup steps repeatedly. The "xxx.srec" file you extract can be used to program gauges as described in the "Loading Board Firmware Section". In order to extract the "xxx.srec" simply press "Create Image Files". See the 'Golden Image" image in the Graphics section for further reference.

1.1 Trademarks

All trademarks are the property of their respective owners.

2 Advanced Programming

In the advanced programming tab you can send I2C commands to the gauge to read and write data. See the "Advanced Communications" image in the Graphics section for an example of requesting the voltage.

3 Related Documentation

For information regarding sending I2C commands to your device see the Using I2C Communications Manual .

For more detailed information about the BQ35100 see the Technical Reference Manual.

For more information about the EV2400 see the EV2400 EVM Interface Board manual.

3.1 Trademarks

All other trademarks are the property of their respective owners.

1 Programming

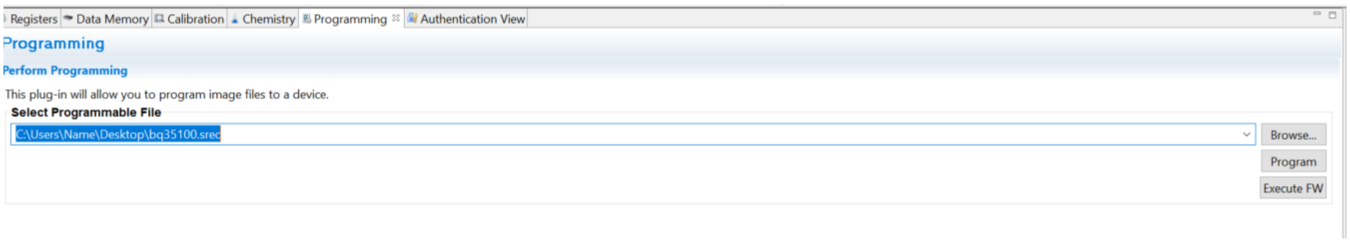

Figure 1. Programming xxx.srec file

2 Start Screen

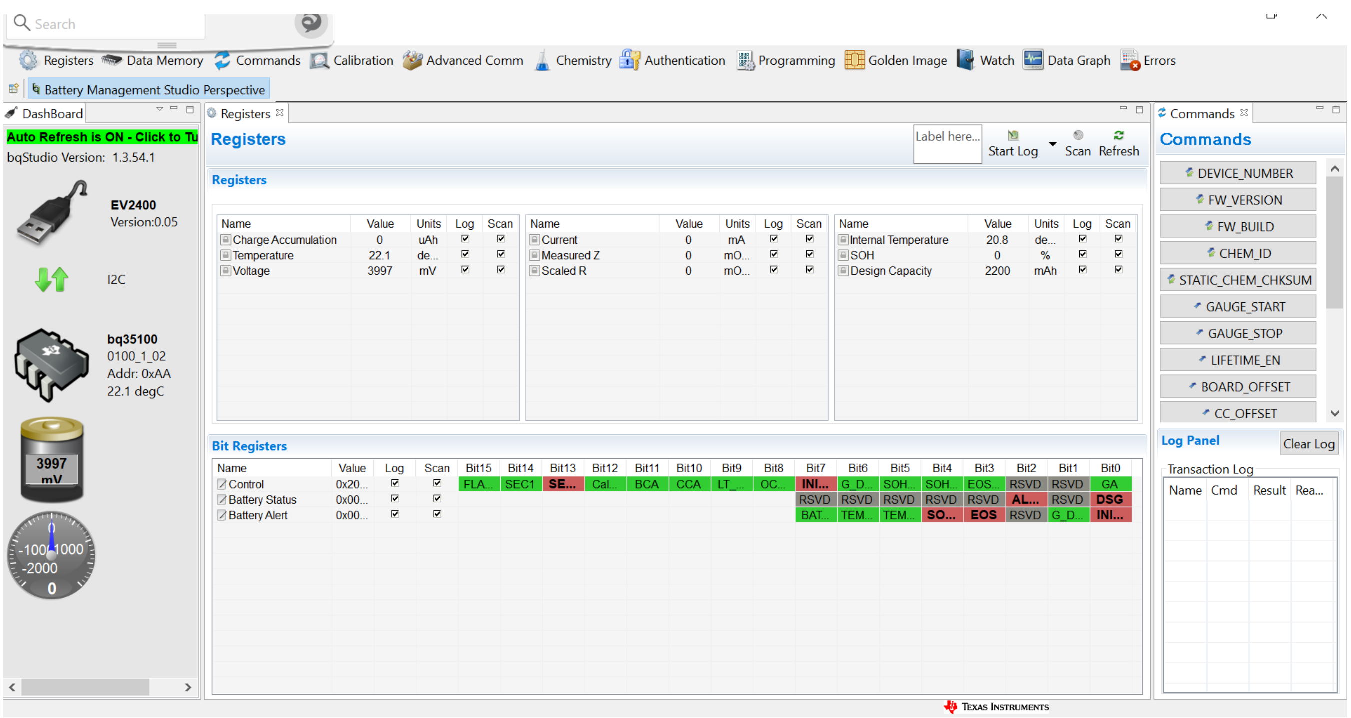

Figure 2. Start Screen

3 Series Cell Count

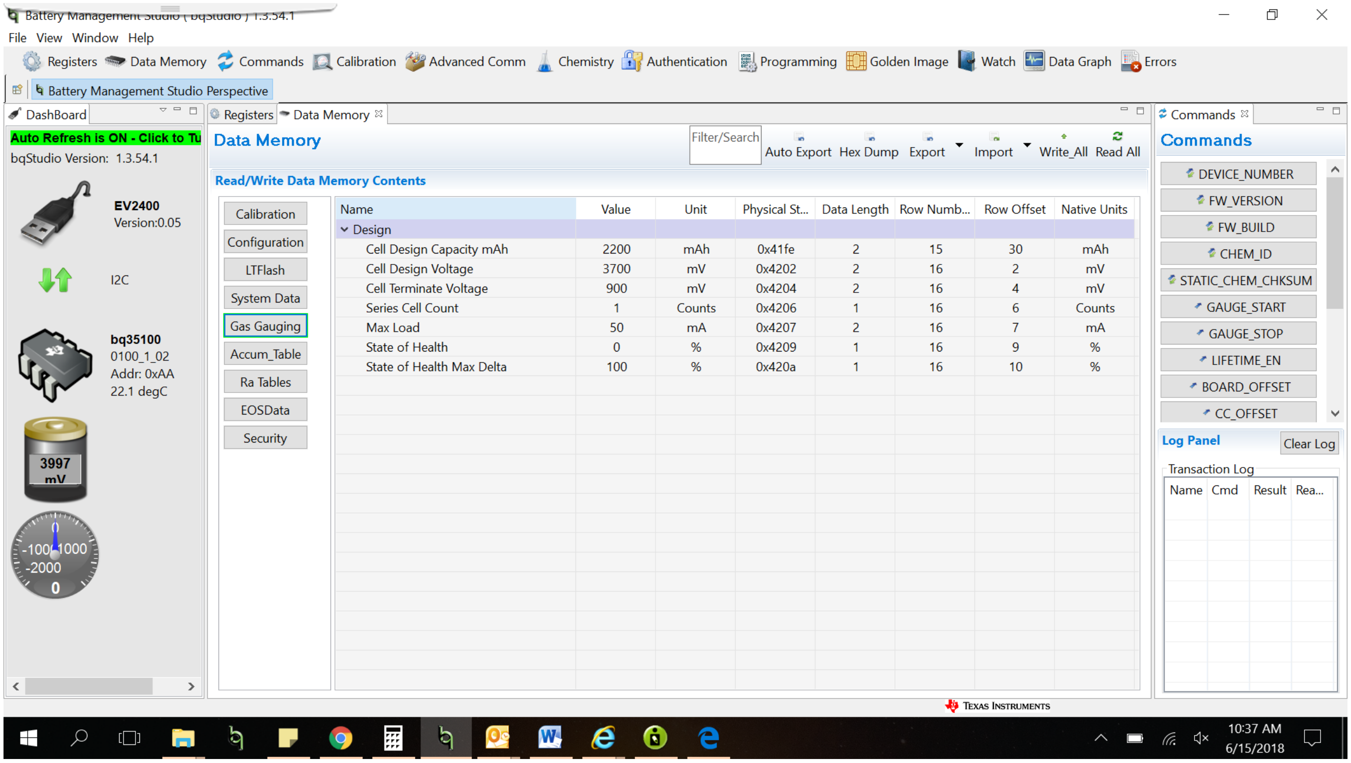

Figure 3. Modifying series cell count in data flash

4 Calibration

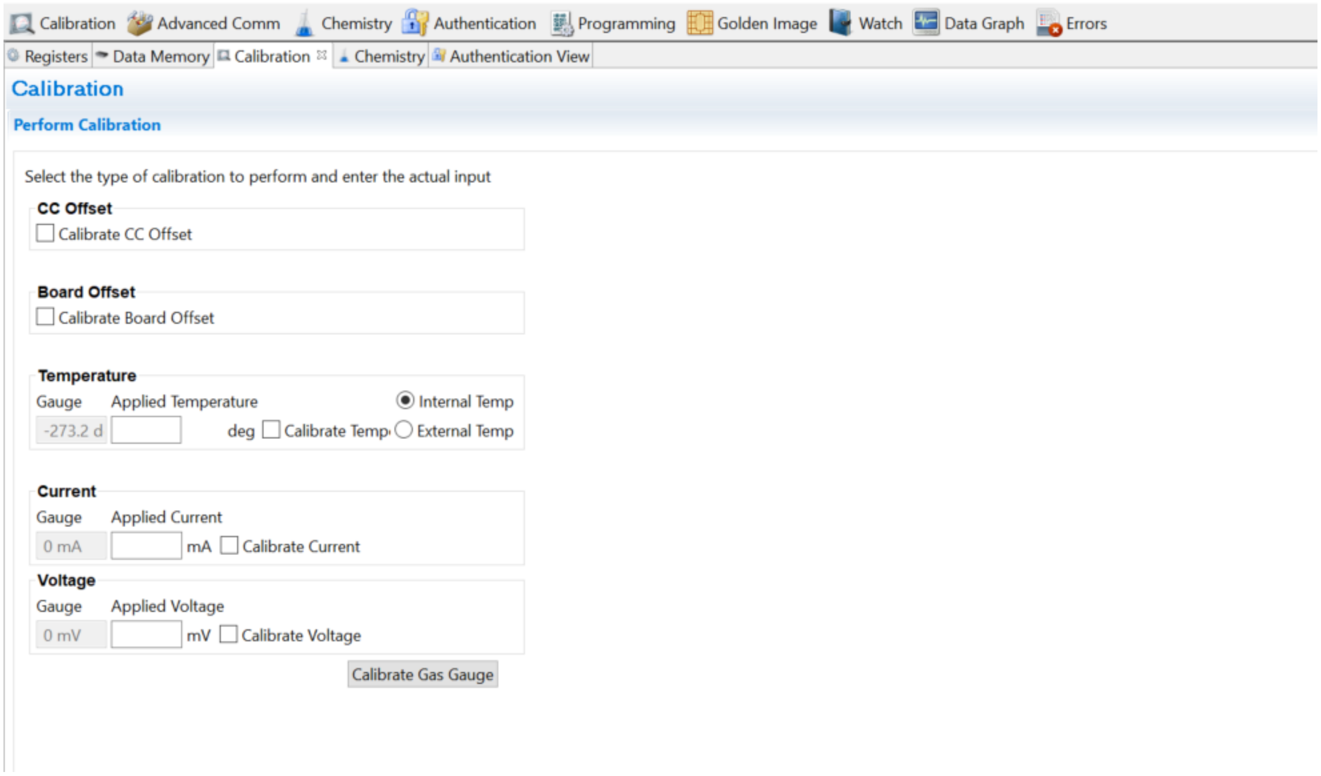

Figure 4. Calibration Screen

5 Cell Chemistry

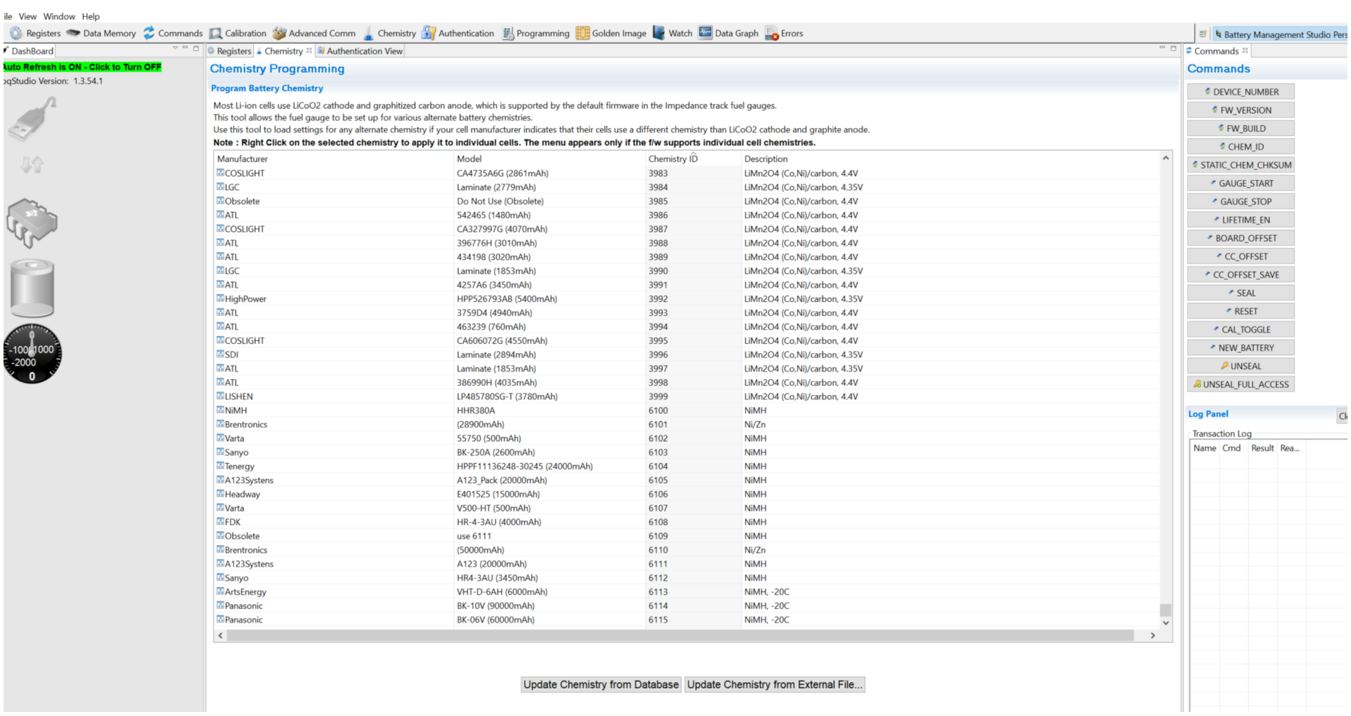

Figure 5. Chemistry Programming Screen

6 GM Select

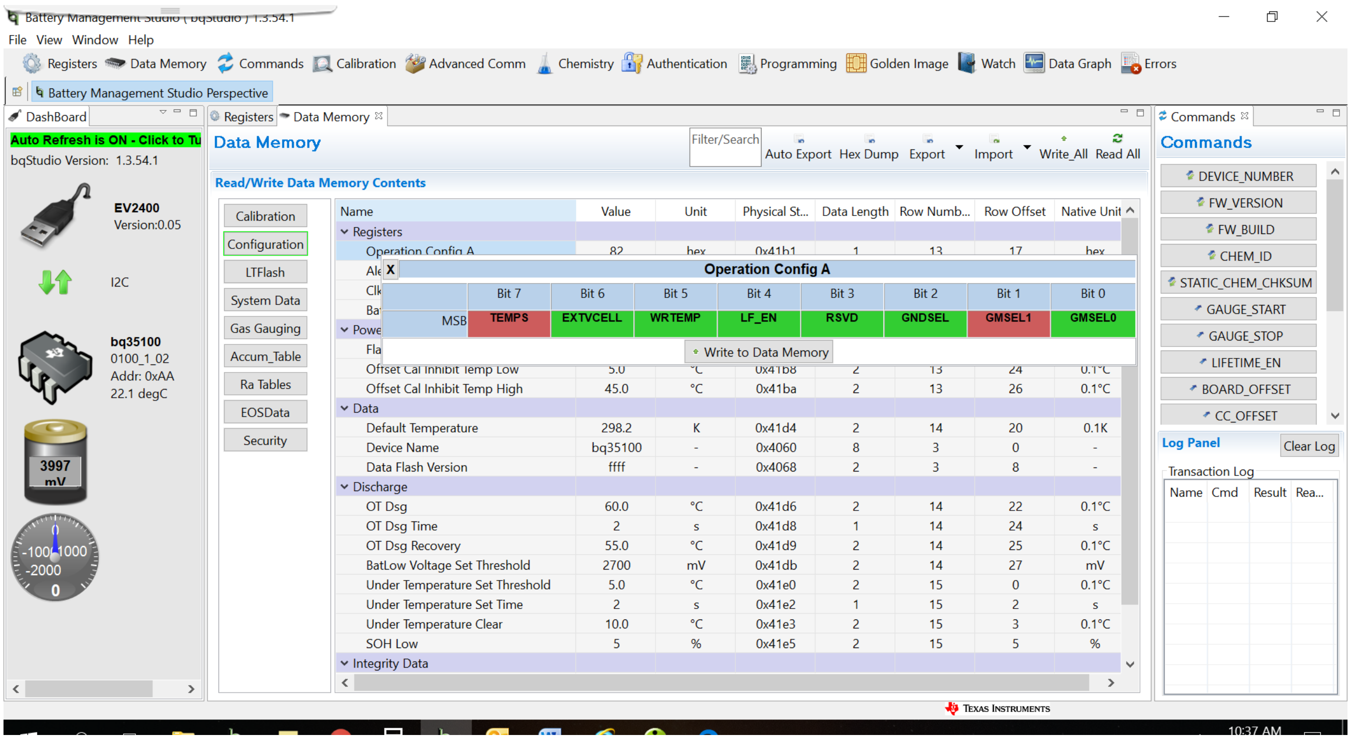

Figure 6. GM select is toggled to change operating modes in this image the operating mode is set to EOS

7 SOH Usage

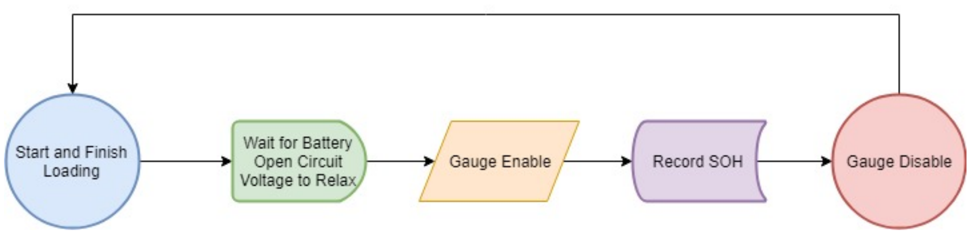

Figure 7. SOH Mode Usage Diagram

8 EOS Parameters

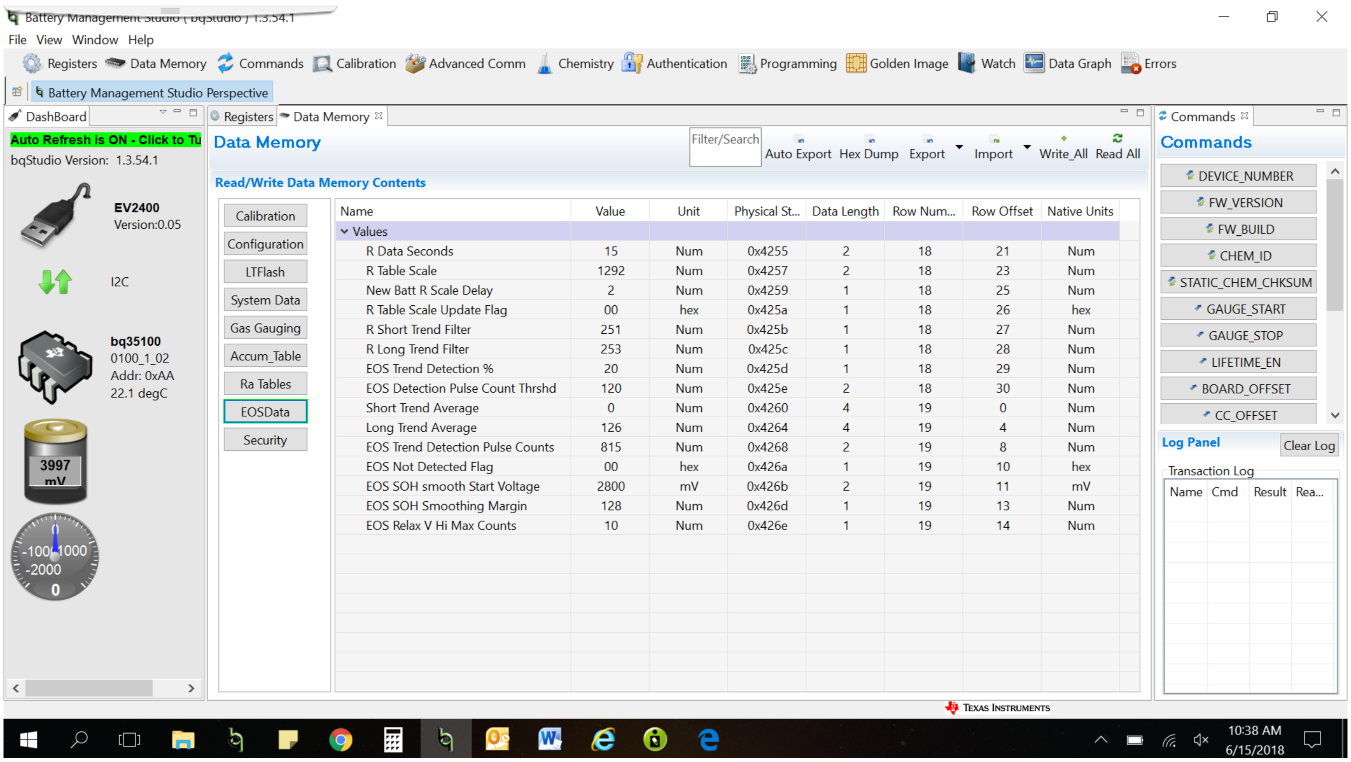

Figure 8. EOS parameters that can be modified

9 EOS Usage

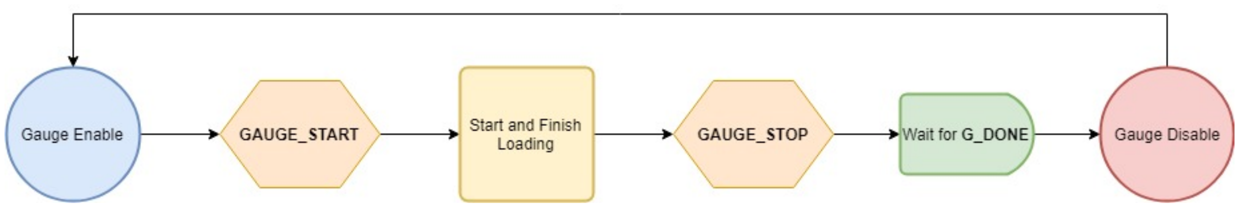

Figure 9. EOS Mode Usage Diagram

10 Battery Impedance at EOS

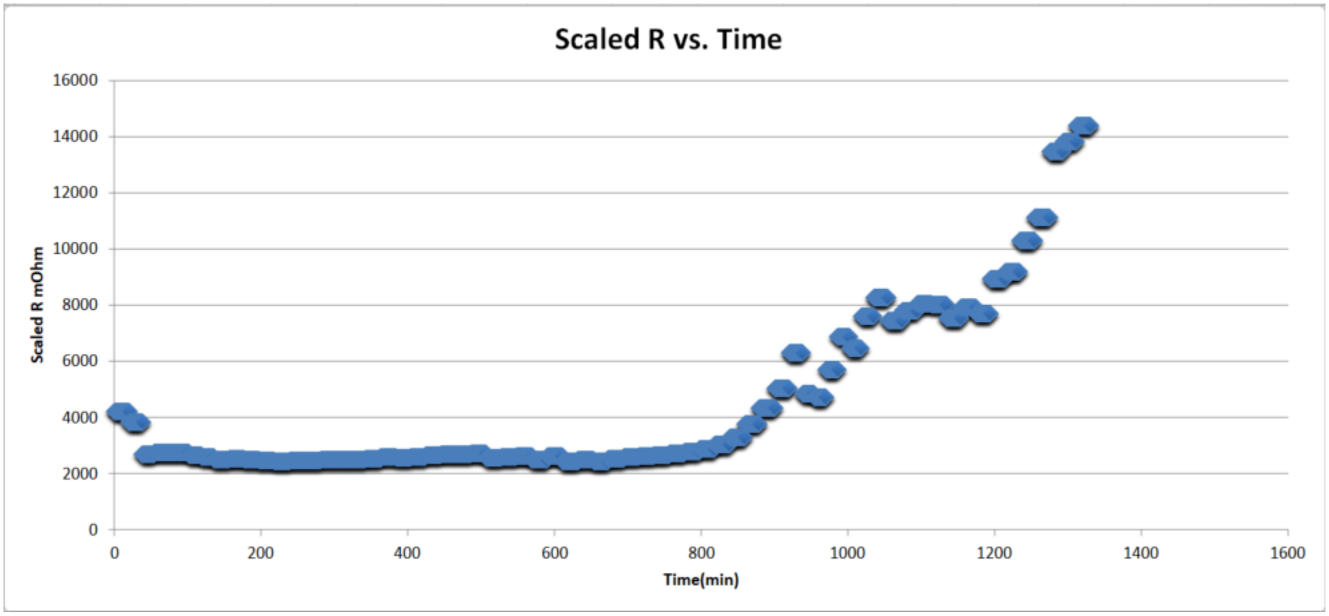

Figure 10. Scaled-R increasing at EOS

11 Golden Image

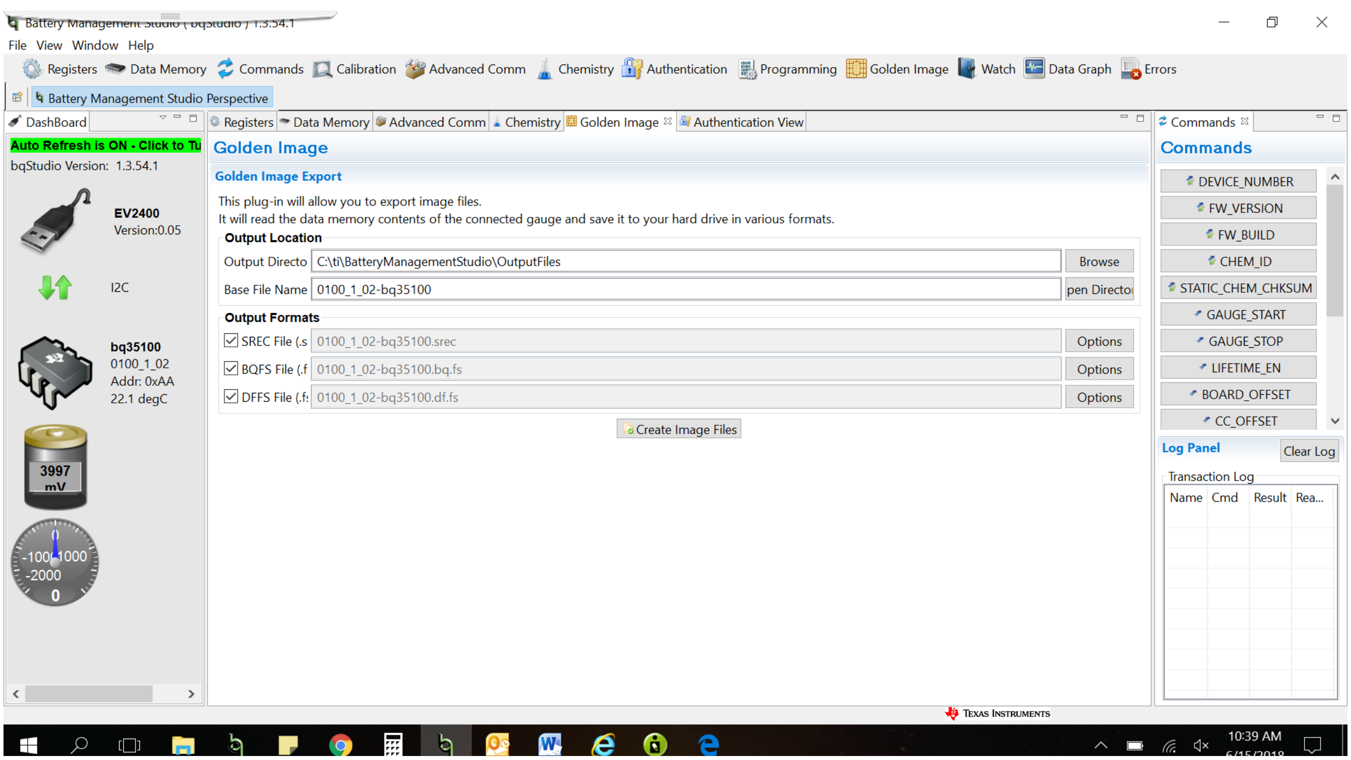

Figure 11. Golden image extraction

12 Advanced Communications

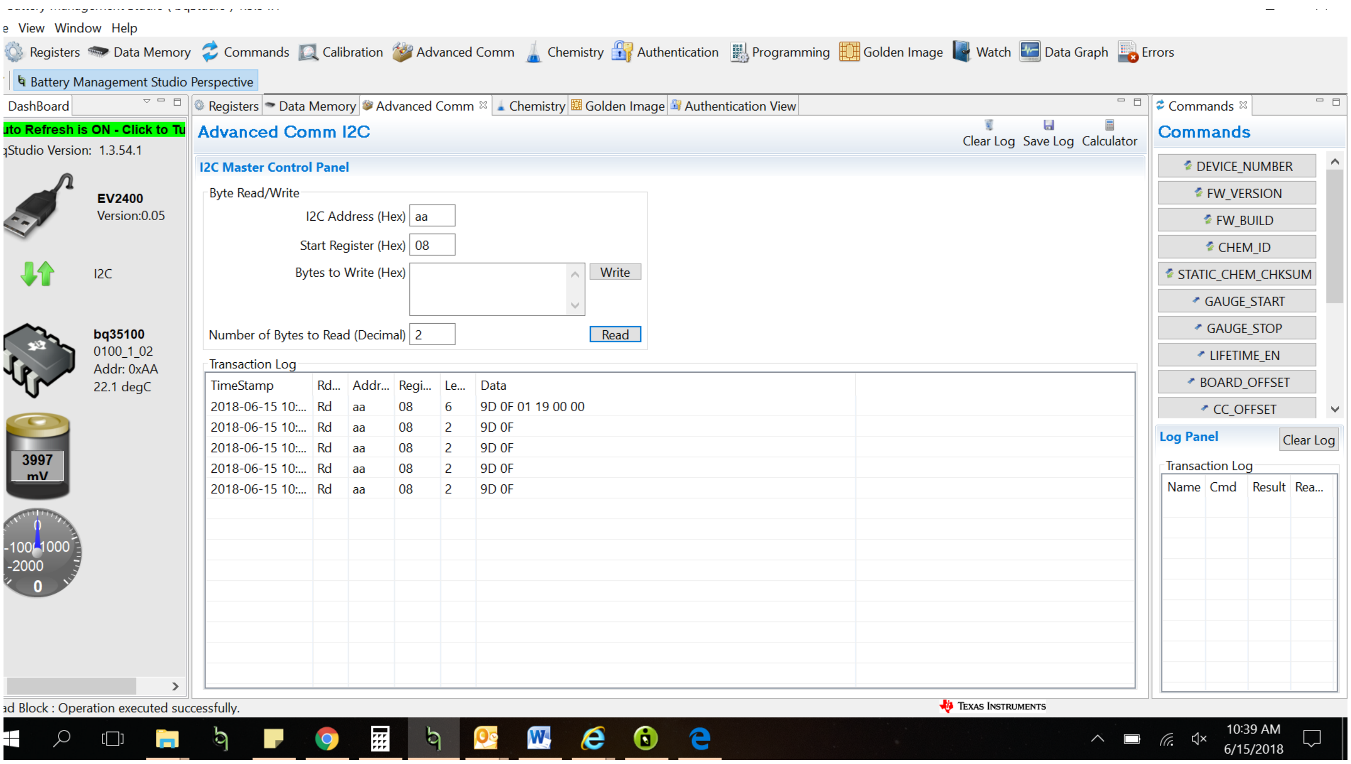

Figure 12. Reading the register 0x08 which is voltage

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