

Support of Multiple Chemistries

Battery Management

1.1 Introduction

Impedance Track™ devices rely on a fixed open circuit voltage (OCV) table to determine the state of dcharge (SOC), where OCV (SOC) dependence is defined by cell chemistry. Impedance Track™ devices come preprogrammed to support the most common Li-Ion cells with LiCoO₂ cathode and graphitized carbon anode. However, multiple other chemistries are grouped under Li-Ion; two examples of which are Co/Mn oxide cathode cells and Ni/Co/Mn cathode cells. Therefore, Impedance Track™ devices are designed with the ability to be programmed with any Li-Ion chemistry OCV table. The process of selecting the correct chemistry OCV table for a particular cell and the specifics of correctly programming this information during production are described in this document.

1.2 Selection of correct chemistry

1.2.1 Chemistry Selection Table

Chemistries that are presently supported are listed in the [Table 1-1](#) which can be found on the TI web site, www.ti.com, in the Tools & Software folder of the corresponding Impedance Track™ based device. Below is an example of the table format, which contains a sample of the data available. In the future more entries will be added to the web based table as additional chemistries are identified.

Table 1-1. Chemistry Selection Table

Description	Chemical ID	Known compatible cells (not exclusive)
LiCoO ₂ /graphitized carbon (default)	0100	Sony US18650S, Sony 18650GR, Moly ICR-18650G, Panasonic CGR-18650C, LG Chem ICR18650A2, LG Chem ICR18650S2, A&TB LGR18650OU, Samsung SDI ICR18650-20
Co/Ni/Mn cathode	0101	Sony SF US18650GR
Hybrid Co/Mn oxide cathode	0102	Sanyo-laminate
LiCoO ₂ ATL	0103	ATL-laminate 554490

1.2.2 Firmware support for different chemistries

The firmware required to support the various chemistries is identical; therefore, no firmware upgrades are required when programming new chemistries into the data-flash (DF) of the corresponding Impedance Track™ based device. As an added feature, the Chemical ID of presently programmed OCV data can be checked using TI's EV Software. This is accomplished by entering 0008 into the Manufacturer Access field in the SBS screen and pressing <enter>. The Chemical ID is then reported back in the Manufacturer Access field. Note that scanning should be enabled.

1.2.3 Methods to identify chemistry of a particular cell:

1. Ask the manufacturer. If the use of standard LiCoO₂ can be assured then the default database with ID 0100 can be used without any changes.
2. Search for the cell part number, in the "Known Compatible Cells" column of the Chemistry Selection table provided by TI. If found, then the corresponding chemistry ID can be used
3. In manufacturer information, search for a "Description" entry similar to that found in the Chemistry Selection table provided by TI. If a similar description is found, then the corresponding chemistry ID

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can be used.

4. If none of the above applies, then a chemistry selection test can be run to help select the best possible fit. It should be noted that this is the most time consuming option, which requires common charge/discharge test equipment such as a Maccor or Arbin tester. However, it provides the highest confidence in chemical data-base selection process. The chemistry selection test procedure is described in the Addendum “Chemistry Compatibility Check”.

1.2.4 Preproduction testing with nondefault chemistry

Preproduction testing, using a nondefault chemistry, is the same as when using the default chemistry, with one exception—a new firmware file (*.senc) containing OCV table specific for a particular chemistry has to be programmed into the pack first. Firmware files for selected chemistry ID’s can be download from the production folder of corresponding Impedance Track™ based device under power.ti.com (see the source files for application note [SLUA372](#)). Programming of the firmware file using TI’s EV Software is described in the chapter *Updating Firmware With The bq20z80 and EVM* ([SLUA336](#)).

After the correct firmware file is programmed, the normal production process may proceed using the steps described in *Basic Pack Assembly* ([SLAU386](#)). Note that prior to production a relaxation/discharge/relaxation test should be done to acquire optimized parameters to be used. This process is described in the chapter *Preparing Optimized Default Flash Constants For Specific Battery Types* ([SLUA336](#)).

1.2.5 Preparing optimized data-flash constants with nondefault chemistry

With the exception of preparing the data flash image file, the production process with nondefault chemistries is the same as with default chemistries, see *Production Flow with bq20x80* ([SLUA385](#)) and *Data Flash Programming and Calibrating the bq20z80 Family of Gas Guages* ([SLUA355](#)).

The additional steps required to prepare the data-flash image file are outlined below.

1. Using an Impedance Track™ based device programmed with the corresponding chemistry specific firmware file (*.senc), complete the Battery Pack assembly steps, as outlined in *Basic Pack Assembly* ([SLAU386](#)). Key steps include: setting basic flash constants for a given pack configuration; calibrating the pack; connecting System Present to ground; and enabling IT. It is also important to correctly set the parameters specific to the number of serial cells used. This is described in *bq20z80 EVM Data Flash Settings for Number of Serial Cells and Pack Capacity* ([SLVA208](#)).
2. Input an initial estimate for Qmax Cell 0, Qmax Cell 1, Qmax Cell 2, Qmax Cell 3 and Qmax Pack using the value specified in the battery manufacturer data sheet. For example, if single-cell data-sheet capacity is 2400 mAh and 3 parallel cells are used, set each value to 2400 \times 3 = 7200 mAh.
3. Charge the pack to full.
4. Let the pack relax for 2 hours.
5. Discharge the pack to the minimum system-acceptable voltage (should be the same as DF:Term Voltage) at the typical application rate. Note that the exact rate is not critical.
6. Let the pack relax for 5 hours.
7. Repeat steps 3 through 6 two times to achieve the maximum accuracy. Using the Data Flash screen in the EVSW, verify that “Update Status”, under the Gas Gauging tab, reads 06. If not, then repeat the cycle.
8. Use the EVSW to export the (.gg) file.
9. Open the (.gg) file with an application like Notepad and manually change the [IT Cfg(Gas Gauging)] “Update Status” to 02 and the [Data(SBS Configuration)] “Cycle Count” to 0. Save and close the (.gg) file
10. Reprogram the pack with a fresh firmware (*.senc) file with selected chemistry ID, to clear all hidden constants and set the correct chemistry specific table.
11. Use the Data Flash screen in the EVSW to import the modified (.gg) file, saved in step 9.
12. In the Data Flash screen of the EVSW click “Write All”.
13. In the Pro screen of the EVSW, send the reset command (0x0041).

The golden pack is now ready to have its data flash read into a binary file, as described in Section 3 of the application note titled *Data Flash Programming and Calibrating the bq20z80 Family of Gas Gauges (SLUA355)*.

Note that as an alternative option, small volume production facilities can use TI's single-channel prototype data-flash writing and calibration software called "bqTester". The single site bqTester software can be downloaded directly from the TI web site (see [SLUA352](#)). Note that care must be taken to ensure that the correct firmware version is inputted into the bqTester.ini file. For example for bq20z80-v102 set: DEV_VER_REV=800.1.02.

1.3 Chemistry Selection Test

1.3.1 Setup

- Use a single cell, or an assembled battery pack without any electronics connected. This is to avoid any current draw and is important because this test takes an extended amount of time and has long inactivity periods
- Measure the voltage at a single cell (even if a battery pack is used)
- Current measurement accuracy is important. The current offset should be calibrated to better than 1-mA accuracy
- Voltage measurement accuracy is equally important and should be accurate to 1mV (should be checked with a 0.1-mV accurate digital voltmeter)
- Configure a thermal chamber to 25°C. Note that testing at 0°C and 50°C are also required in order to create a database, but not for compatibility check
- Voltage, current and temperature data should be collected with 10sec - 100 sec intervals continuously during the test. The resulting file is used in the chemistry selection tool. Plain text files or excel spreadsheets are acceptable formats

1.3.2 Automated Test (can be set up using Maccor or Arbin battery testers):

1. Charge the cell to full using the CC/CV method and terminate the charge when taper current reaches C/100. This state of charge corresponds to full chemical capacity. Note that using the C/100 taper current is critical to ensuring an absolutely fully charged cell.
2. Turn off the current (make sure actual current is below 1 mA) and wait 5 hours for full cell relaxation. If dV/dt smoothed over 100 seconds is available, wait can be terminated before 5 hours if dV/dt < 1 μV/sec. This method helps speed up testing
3. Discharge at C/20 rate for 1 hour, then go to step 2. If voltage goes below 3 V, go to step 4.
4. Turn off current (make sure actual current is below 1 mA) and wait 5 hours for full relaxation. If dV/dt smoothed over 100 sec is available, wait can be terminated before 5 hours if dV/dt < 1 μV/sec. This method helps speed up testing. Check voltage after relaxation is terminated. If V < 3 V, exit test otherwise proceed to step 5.
5. Discharge at C/60 rate for 30 min, or until V < 2.7 V, go to step 4.

Data obtained in this test is used in a MathCad tool provided by TI. For database purposes, additional data at 0°C and 50°C is needed.

1.3.3 Using the MathCad tool to select battery chemistry

To use the chemistry selection tool, MathCad 2001i or higher is needed.

Download the chemistry selection worksheet "chemselect.mcd" from the Tools & Software folder of the corresponding Impedance Track™ based device and then follow these steps to verify battery chemistry:

1. Remove the charge portion of the data-file acquired in the above testing
2. Place the file in the same directory as the "chemselect.mcd" file
3. The chemistry selection file "chemselect.mcd"
4. Assign columns to reflect your file format:

```

Common      time  tn:=0  voltage vn:=2  temper  ttn:=100  curr  in:=1
assignment in
data-file:

```

Change the column numbers for time (tn), voltage (vn), temperature (ttn) and current (in). If temperature column is not available, set ttn:=100 and set correct chamber temperature in °C in the following section:

```

Temperature used in simulation of  T:=25
voltage if no temperature is      Tpress:=T . 10
present in file. Set ttn=100 if not
temperature info present

```

5. Enter your file name into data-loading section. You can try running the program with included example data-file "tIV_example.dat."

```

Data import:  Plain text  A:=READPRN("tIV_example.dat"
load tVIT file  Excel
+              A:= some_excel_fle.xls 

```

If the file is in excel format, then right-click on the section to the right labeled "Excel" line, and click "enable evaluation". If the file is in plain-text format, leave this section disabled. Note that regardless, the file should not include any text headers, only data!

6. Scroll to the bottom of document and click anywhere to place the cursor below all lines. Press F9 to execute all calculations.
7. Read out the chemical ID best suited for your battery:

```

Best          bestchem = 103
Chemistry ID

```

8. Analyze the reported error for best chemistry (on the top of the matrix). If it does not exceed 3%, this chemical ID firmware can be used with your chemistry:

```

Error % ID          1.96682    103
                    3.937942   100
maxerr =           9.521751    101
                    17.384558   102

```

In this example, the max error is 1.96% for chemical ID 103 where anything below 3% is acceptable. Therefore, the firmware file (*.senc) for chemical ID 103, should be downloaded and used.

If "maxerr" for all chemical ID's exceeds 3% a new chemical table must be created. To help facilitate this, repeat the "Automated test" for the additional required temperatures of 0°C and 50°C. Then contact Texas Instrument support at <http://www-k.ext.ti.com/sc/technical-support/product-information-centers.htm> or the local sales representative. Using this data TI will create a new chemical database. Alternatively the cells may be sent directly to TI for evaluation/characterization but this process will take longer

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