User's Guide

Golden GG Maker and Resistance Temperature Compensation Optimizer

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ABSTRACT

This user's guide is provided as a simple guide for the GPC Golden GG Maker tool. This document includes a summary of the tool, requirements, how to submit data, and examples of each. This guide also describes how to obtain the required log files and GG file.

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1 Trademarks

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2 Tool Summary

Gauging Parameter Calculator (GPC) Resistance Temperature Compensation and Golden GG maker tool helps the battery designer to optimize low temperature accuracy of an Impedance Track battery gauge.

The need to optimize resistance temperature compensation arises due to differences in temperature distribution in the cells during steady-state, constant temperature lab test, where the default compensation parameters are obtained, and during cell heating caused by discharge in an actual system where heating and cooling of the cells are inhomogeneous. This results in somewhat different relationship between cell impedance and temperature readings of the temperature sensor, which can be taken into account using this tool.

Resistance temperature compensation parameters can be optimized for gauges that use two exponent temperature compensation (Rb). If you are not sure if your gauge supports two exponent Rbs, you can submit a GG file exported from you firmware with this package to the tool, and the tool will give an error message if two exponent Rbs are not supported.

While Ra and Qmax parameters can be learned by the gauge automatically through performing a traditional optimization cycle, this tool also allows to obtain thermal model parameters that do not update in some Impedance Tracking gauges (single cell gauges), which help with high rate tests accuracy.

It also provides Ra0_charge value (helps to reach 100% SOC during charge more accurately).

In addition, this tool can utilize the log file from the optimization cycle if some problems with learning Qmax and Ra have been observed, or to obtain all golden GG parameters by using Arbin or Maccor testers on a bare cell without using an actual EVM.

The tool requires two log files of a charge / relaxation / discharge /relaxation test performed under load and heat exchange conditions similar to an actual device, or ideally inside the actual device. Log files are recorded at room temperature and low temperature starting conditions.

They can be created with various test equipment such as Maccor or Arbin battery testers or by using logging capabilities of TI's EV Software (EVSW) or Battery Management Studio (bqStudio) software with an evaluation board connected through USB.

This tool also requires a gauge parameter file exported from your gauge EVM or device PCB using EVSW or bqStudio after chosen chemical ID data has been programmed. This file will be used to detect present firmware properties that affect the parameters, and will be returned after Ra tables, Qmax, and thermal parameters have been populated with new values.

This guide describes how to obtain the required log files and GG file.

3 Required Data

The GPC tool requires a single .zip file containing one configuration file, two data files at room and low temperatures and one configuration parameters file (gg file) as input. The name of the .zip file is not important. The .zip file should contain following files:

- config.txt
- roomtemp.csv
- lowtemp.csv
- gg.csv

3.1 Configuration File (1 Each)

The configuration file is a text file named config.txt and is an ASCII text dictionary containing the following information:

- ProcessingType = 4 <Determines the type of tool used. Value should be 4 for Resistance Temperature Compensation Optimizer and Golden GG Maker tool>
- ChemID = <Chemical ID selected or released for your cell. Selection can be performed using GPC: Chemical ID selection tool>
- NumCellSeries = <Number series cells for which voltage data in the log are reported. Note that if your battery pack has 3 series cells, but your log file is for a single-cell voltage as is recommended, this value should be 1>
- VoltageColumn = <Zero-based column number for the voltage data in your data logs>
- CurrentColumn = <Zero-based column number for the current data in your data logs>
- TemperatureColumn = <Zero-based column number for the temperature data in your data logs>
- ElapsedTimeColumn = <Zero-based column number for the elapsed time data in your data logs>

Typical settings are:

ProcessingType=4

ChemID=3514

NumCellSeries=1

ElapsedTimeColumn=0

VoltageColumn=6

CurrentColumn=4

TemperatureColumn=1

3.2 Data Log File

3.2.1 Test Setup

This tool can calculate RbL and thermal model parameters. For optimal results, two separate test setups are recommmended. It is possible to use only one setup but this will not create the best results for both RbL and thermal model parameters.

For convenience, the TI tool chain (gauge EVM + EV2400 or EV2500 + bqStudio on a PC) together with the cell can be used to collect the log file for this tool. bqStudio can log all registers of the gauge, including current, voltage and temperature and this log file is compatible with this tool.

It is not mandatory using the TI tool chain - any lab setup which can produce the required log file can be used instead.

3.2.2

To perform the low temperature test, it is necessary to place either the device or the thermal box with the EVM and the cell into the thermal chamber, and set its temperature to 0°C or other low temperature you would like to optimize for. It is not recommended to use a bare cell or open EVM-cell combination, because the thermal chamber fan is blowing directly at it and will cause a very different thermal environment from the actual device. The cell will have much less self-heating, resulting in shorter run-time (impedance increases with lower temperature) and less accurate gauging parameters.

If the device is not available, discharge and charge can be performed using external battery test equipment such as Arbin or Maccor, or even current/voltage regulated power supply and electronic load commonly found in electronics labs. If battery test equipment is used, logging will be provided by the equipment. If power supply/ electronic load are used, logging needs to be done using your gauge EVM connected to EV2400 and performed by bqStudio.

Placement of the thermistor is very important both for calculating battery resistance temperature compensation parameters, Ra tables, and for thermal parameters. If you are using EVM for logging, you can unsolder the thermistor connected to the EVM and solder it to longer wires, so the thermistor can be placed directly at the cell surface and taped tightly to it. It is also recommended that the thermistor would be “underneath” the cell and not directly exposed to the air and possibly blowing fan, because it would measure more of air temperature than the cell temperature. If you are using a thermocouple from Maccor and Arbin, it should also be attached directly to the cell surface. Placing the cell in a thermal box (with the thermistor inside the box) also helps to read actual cell temperature.

3.2.3 Test Procedure

The required test consists of the following steps for 25°C and your target lower temperature:

1. The charging is performed at room temperature. Optional: If the cell was at a different temperature before, let it relax for 2 hr at room temperature prior to the test.
2. Charge using CC/CV charging to full using taper current as in your actual charger, for example C/20. Use nominal CC charge rate and CV voltage. If another charging method is specified by the cell maker, this other method can be used. If you are charging in a device, using the device charger is the best.
3. Let the battery relax for 2 hrs to reach full equilibrium open circuit voltage (OCV). If in a device, shut down the device during this period to avoid low current discharge.
4. Set discharge test temperature (first 25°C, than 0°C or other low temperature of your choice).
5. Wait for 1 hr until pack reaches thermal equilibrium and cell temperature will stop changing. If temperature did not stabilize (can happen for larger systems) use more time.
6. Discharge the battery at system typical high rate until the minimal voltage, as specified by the cell manufacturer, is reached. If you are discharging in a device, discharging to device minimum voltage is acceptable. This can either be a constant current or constant power load.
   a. For best RbL values: Discharge the battery at the following rates, depending on temperature, until the minimal voltage, as specified by the cell

      manufacturer, is reached.:

      C/5 for T >= 0°C

      C/7 for T < 0°C and >= -10°C

      C/10 for T < -10°C and >= -20°C

      C/15 for T < -20°C
   b. For best thermal model parameters: Discharge the battery with a typical high rate for your device until the minimum voltage for your device. The goal is that the battery heats up as it would in your device.
   c. If you want to combine RbL and thermal model parameter calculations in one test setup: Use the test setup for thermal model parameters (3.2.1 step 6.b) and discharge the battery with a medium load so that there is self-heating between 5°C and 10°C. This rate needs to be above a C/10 rate and the temperature cannot exceed 20degC.

Note

For the best gauging results, please complete at least two tests, one following the instructions detailed in 6.a and another following 6.b. This will allow for the gauge to have the ideal RbL and thermal model parameters.

If 6.a and 6.b are completed, there is no need to complete 6.c. Only use 6.c if only one test can be completed for the GPCRB input.

7. Verify that temperature during low temperature discharge does not exceed 20°C. If it does, rerun the test at a reduced rate to reduce self-heating.
8. Let the battery relax for 5 hrs to reach full equilibrium OCV. If in a device, shut down the device during this period to avoid low current discharge. Go to step 1, and repeat all steps with temperature set to 0°C in step 4).

The resulting room temperature log is exemplified in Figure 3-1. Low temperature log should have similar shape of the curves, but discharge would start at a lower temperature. :

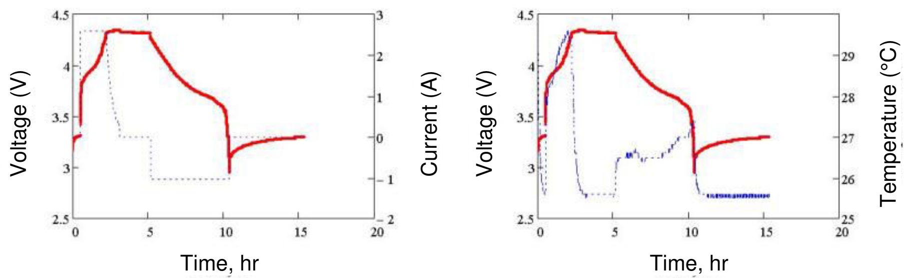

Figure 3-1. Voltage Current and Temperature Profiles of the Room Temperature Test Required for Golden GG Creation

Data logging should store data into a file containing the following columns, in a coma-separated (CSV), tab separated, or space separated format:

- Time (in seconds elapsed)
- Voltage (in millivolts)
- Current (in milliamps where discharge current is negative)
- Cell temperature (measured by a thermistor attached to the surface of the cell, in degrees Celsius). One decimal place is acceptable.

If the original data format is not one of the supported formats (for example Microsoft® Excel®), the data file must be saved as .csv. Any text that is not part of data-columns, such as the log file header generated by bqStudio or EV Software, as well as empty lines should be removed from the file prior to submission. One row of column names can remain, (the tool will skip it), as long as it has just one name per column. An easy recording method utilizes TI's bqStudio software utility called GPC Packager that reads data directly from a TI fuel-gauge.

Values of current in ampere and voltage in volts are acceptable, the tool will auto detect it and use the correct scale factor.

The columns can be in any order since the column positions are defined in the config.txt file.

However, both room temperature and low temperature logs should have the same column positions for t,V,I,T values. The log file can have some other data columns that are not used in this tool (no need to remove them), as long as the size of the zip file prepared for submission does not exceed 2MB. Note that since it is a compressed file, you can sometime squeeze it some more by utilizing different compression settings in your archiver program.

The sampling interval can be from 5 to 100 seconds.

The initial charging portion needed for Ra0_charge calculation. Relaxation data is required both before and after the discharge.

Precision of the measurements is important. In particular, current measurement should be better than 0.1% of range accuracy, and for voltage measurement 1 mV at room temperature. 16-bit ADC is recommended.

The room data log should be renamed as: **roomtemp.csv**, and low temperature log as **lowtemp.csv** prior to submission of the package, regardless of actual text format.

3.3 Gauge Configuration (GG) File

GG files are commonly exported by the EV Software (*.gg) or by bqStudio (*.gg.cvs). You can use either format, depending if the gauging IC you are using is an older one supported by EV Software or a newer one supported by bqStudio.

To create the GG file for the tool, please follow these steps:

1. Program chosen chem ID
2. Export <name>.gg file or <name>.gg.csv file
3. Rename the file regardless of format to gg.csv

When the processing is complete, the tool will create gg_out.csv which will be the same file, except Ra, Qmax, Ra0_ch, and thermal parameters will be replaced with newly calculated values, and Ra flags and update status will be set to indicate a completed optimization cycle.

- If the 6.a and 6.b test procedure was used, program the chemdat file produced by the 6.a file for the RbL table, then the 6.b gg_out.csv for the thermal model and other parameters.
- If the 6.c test procedure was used, program the chemdat file and gg_out file from this test.

3.4 Examples

3.4.1 Config.txt File

ProcessingType=4

ChemID=3514

NumCellSeries=1

ElapsedTimeColumn=0

VoltageColumn=6

CurrentColumn=4

TemperatureColumn=1

3.4.2 Excerpted Example Data Log

In the following excerpt, the columns are:

```
elapsed time (sec), voltage (mV), current (mA), temperature (C)
20.02833  2975.308     0       28.95893
30.04369  2974.984     0       28.88429
40.05915  2975.308     0       28.91459
50.09006  2974.984     0       28.73499
60.13664  2975.308     0       28.74904
70.20198  3008.069    99.9098  28.89834
80.20158  3023.314    99.9098  28.77718
90.23994  3300.643  1300.396   28.79125
100.2554  3360.975  1300.396   28.79125
110.2708  3404.115  1300.221   28.58133
120.2859  3439.146  1300.572   28.59754
```

4 Data Submission

The zip file created as previously described needs to be submitted to the GPC tool through the web-interface here:

https://www.ti.com/powercalculator/docs/gpc/gpcUpload.tsp

After processing, an E-mail with a report is sent to the E-mail address you will provide when logging in.

Report contains optimized values of Qmax, Ra table, Ra0_charge, and thermal parameters.

If any format or other errors are present, they will be reflected in the report.

The file containing optimized resistance temperature compensation parameters will be attached. It will be called chemdat12_<chem ID>, if you used Battery Management Studio to generate your GG file, or <chem ID>.chem, if you used EV Software. You should use the same tool you used to export the GG file to program the parameters into the gauge by clicking on the “Chemistry” icon and choosing “Update chemistry from external file”. It will assure correct chemical ID as well as optimized temperature correction coefficients.

In addition, the original GG file populated with the new values of the parameters generated by the tool will be attached to the report with the name gg_out.csv.

Prior to programming of this GG file into the gauge, please make sure that chemdat12 or *.chem file is programmed as previously described. The actual format of the GG file will be the same as your original file, not necessarily csv. Please rename it using the original naming convention as <name>.gg or <name>.gg.csv prior to using EV Software or Battery Management Studio to program it into your gauge. After programming, the gauge is ready for exporting of the golden image, that can be programmed into other ICs as part of production.

4.1 Example Report

```
Resistance temperature compensation optimizer, rev3.57

Optimized Impedance Track parameters:

Qmax,mAh : 5222

Ra table normalized to 25C, uncompressed, unscaled

DOD,% Ra,mOhm

  0         113
 11.11      59
 22.22      62
 33.33      64
 44.44      64
 55.56      61
 66.67      68
 77.78      75
 80.95      80
 84.13      85
 87.3       95
 90.48      133
 93.65      196
 96.83      346
 100        843

Ra0_ch, mOhm : 113    This value is already included in Ra table

Thermal parameters:

Temp a 212
Temp k 0.5
Res Relax Time 178

Optimized resistance temperature compensation parameters saved in chemdat12


All GG values updated and saved in gg_out.csv
```

5 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from September 30, 2015 to January 31, 2026 (from Revision * (September 2015) to Revision A (January 2026))	Page
• Clarified Test Procedure	1
• Updated Example Report	9