Simple Guide to GPC Golden GG Maker Tool

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.

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1 Tool Summary

The Gauging Parameter Calculator (GPC) Golden GG Maker is a math calculation tool that helps the battery designer to refine the impedance track battery gauge parameters for a given battery.

While Ra and Qmax parameters can be learned by the gauge automatically through performing traditional optimization cycle, this tool also allows the user to obtain thermal model parameters that do not update in single cell (handheld) gauges, which help with high-rate test's accuracy. The tool also provides Ra0_charge value (helps to accurately reach 100% SOC during charge), which does not self update and is not yet available in older chem IDs. In addition, this tool can utilize the log file from 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 a log file of a charge/relaxation then discharge/relaxation test performed under load and heat exchange conditions similar to actual device, or ideally inside the actual device.

This log that can be created with various test equipment such as Maccor or Arbin battery testers or by using the 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 the chosen chemical ID data has been programmed. This file is used to detect present firmware properties that affect the parameters, and is returned after Ra tables, Qmax, and thermal parameters have been populated with new values.

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

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2 Required Data

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

- config.txt
- sysrate_rel_dis_rel.csv
- gg.csv

2.1 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 = 3 <Determines the type of tool used. Value should be 3 for 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=3
ChemID=3514
NumCellSeries=1
ElapsedTimeColumn=0
VoltageColumn=6
CurrentColumn=4
TemperatureColumn=1
```

2.2 Data Log File

2.2.1 Test Setup

Best results are achieved if the actual device is available. In this case, logging can be performed by soldering wires to the I2C or HDQ outputs of your gauge PCB inside the device and to EV2400 inputs, while bqStudio is recording the logged data. The device should be discharged at typical high load (not extreme high load).

If the device is not yet available, as it is often the case, testing can be performed with a bare battery. It is recommended to place the battery into a “thermal box” which emulates the heat exchange behavior of the actual device by slowing down heat transport from the battery to the air.

Placing the battery on an open desktop or inside a thermal chamber where a fan is blowing directly at it will cause a thermal environment very different from the actual device. The battery 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 common in electronics labs current/voltage regulated power supply and electronic load. 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.

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Placement of the thermistor is very important both for calculating battery Ra tables and for thermal parameters. If you are using EVM for logging, 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 the thermistor be placed “underneath” the cell and not directly exposed to the air and possibly a fan, because it would measure more of the 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 temperatures.

2.2.2 Test Procedure

The required test consists of the following steps:

1. Test 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, use that method. If you are charging in a device, using a device charger is the best.
3. Let the battery relax for 2 hrs to reach full equilibrium open circuit voltage (OCV). If the battery is in a device, shut down the device during this period to avoid low current discharge.
4. 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 the device minimum voltage is acceptable.
5. Let the battery relax for 5 hrs to reach full equilibrium open circuit voltage (OCV). If the battery is in a device, shut down the device during this period to avoid low current discharge.

The result is exemplified in Figure 1:

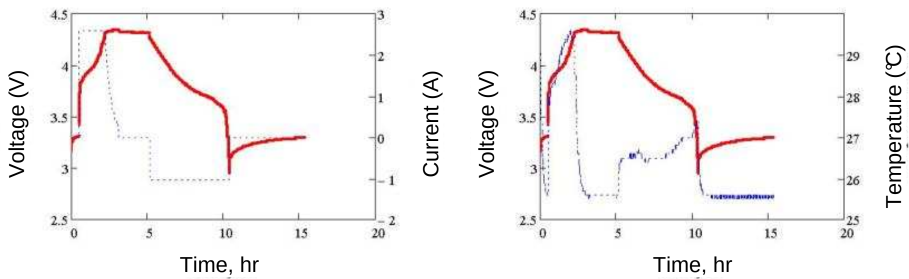

Figure 1. Voltage Current and Temperature Profiles of the Test Required for Golden GG Creation

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.

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The columns can be in any order since the column positions are defined in the config.txt file. 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 sometimes squeeze it some more by utilizing different compression settings in your archiver program.

The sampling interval can be from 5 to 100 s.

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

The 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 data log should be renamed as: **sysrate_rel_dis_rel.csv** prior to submission of the file, regardless of actual text format.

2.3 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.

2.4 Examples

2.4.1 Config.txt File

```
ProcessingType=3
ChemID=3514
NumCellSeries=1
ElapsedTimeColumn=0
VoltageColumn=6
CurrentColumn=4
TemperatureColumn=1
```


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2.4.2 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

3 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.

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 the correct chemical ID is programmed. 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 bqStudio 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.

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3.1 Example Report

```
Optimized Impedance Track Parameters tool, rev=1.1

Optimized Impedance Track parameters:

Qmax, mAh : 5609

Ra table normalized to 25C, uncompressed, unscaled

DOD, %      Ra,mOhm

0           43
11.11       55
22.22    63
33.33       74
44.44       70
55.56       60
66.67       70
77.78       75
80.95       74
84.13       71
87.3        76
90.48       95
93.65    143
96.83       241
100         352

Ra0_ch, mOhm : 115    This firmware is not explicitly supporting Ra0_ch, FCC drop could occur at
low temperatures if used

Thermal parameters:

T Time Constant    318
T Rise    31

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


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