

# TI *Live!* BATTERY MANAGEMENT SYSTEMS SEMINAR

JACKSON DIGIOVANNA

DESIGNING WITH TI GAUGES USING  
TI'S TOOL CHAIN

# Agenda

- What is part of TI's gauge toolchain
- The gauge EVM
- The EV2400 I2C/HDQ/SMBus adapter
- BQStudio features
  - Review different BQStudio pages
- How to setup and modify BQStudio features
- Gauge parameter calculator (GPC) tools
  - GPCCHEM
  - GPCCEDV
  - GPCRA0 and GPCRB

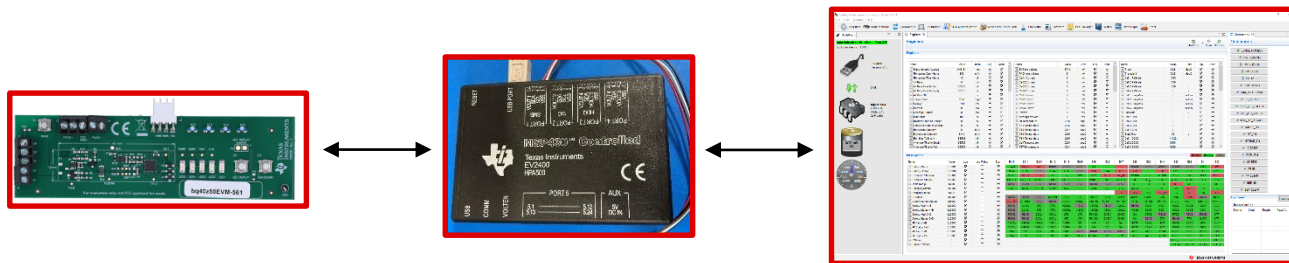
# What is part of TI's gauge toolchain

There are 3 main components to setup TI battery gauges

- EVM or custom gauge PCB
- EV2400 to debug, log, and program the gauge
- BQStudio software to interface with the EV2400

Online tools to help optimize the gauge performance

- GPCCHEM
- GPCRB
- GPCRA0
- GPCCEDV



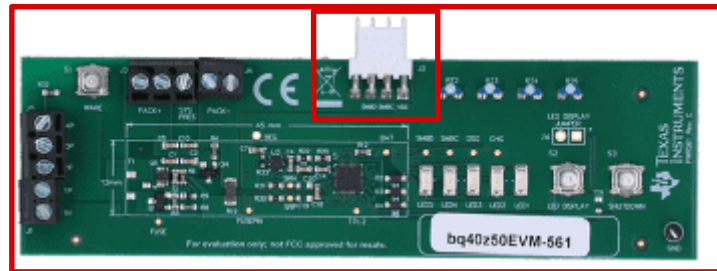
# Why is TI's gauge toolchain important?

- Minimizes the time/effort needed to take a BMS from development to production.
- Allows a highly configurable gauge to be designed into a custom solution in an efficient and easy to use process.

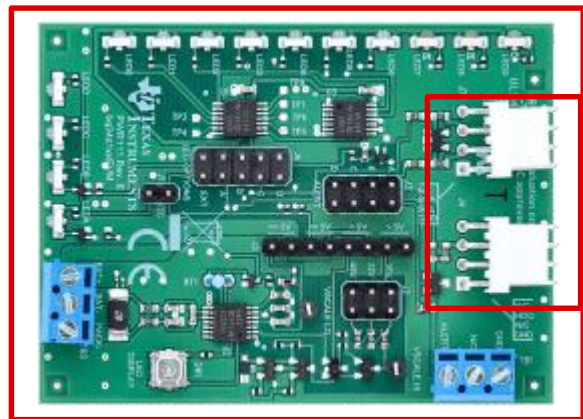
# The gauge EVM

The evaluation module (EVM) is designed for bench testing a specific gauge's feature set

- Contains common components for using the part and for evaluation of the features
- Provides reference schematic and layout for new designs



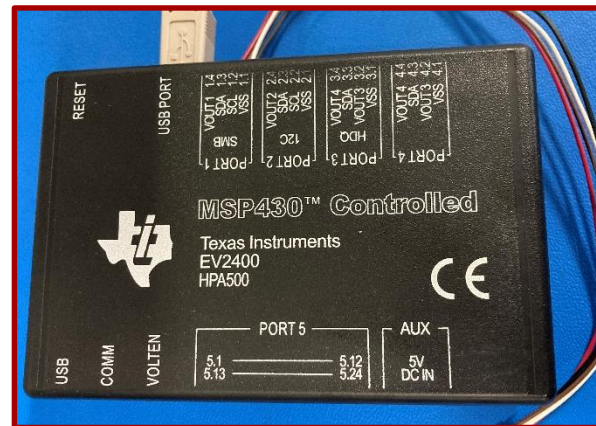
BQ40Z50EVM



BQ34Z100EVM

# The EV2400 adapter

- The EV2400 is the hardware piece to interface between the computer with BQStudio and the gauge EVM
- Features include:
  - Adjustable communication rate (100 KHz or 400 KHz)
  - I2C, SMBus, and HDQ support
  - Firmware updates for new features and upgrades
- Multiple EV2400s can be connected to the same computer with multiple instances of BQStudio for running tests in parallel



# BQStudio features

The main functions for BQStudio include:

- Data logging for debug and online tools
- Golden file creation and programming
- Calibration for current, voltage, and temperature

The screenshot displays the BQStudio software interface for a BQ40Z50-R4 battery management IC. The main window is titled "Registers" and is divided into several sections:

- Registers:** A table listing various system parameters such as BAT pin voltage, PACK pin voltage, Cell 1 Current, Cell 2 Current, Cell 3 Current, Cell 4 Current, Cell 1 Power, Cell 2 Power, Cell 3 Power, Cell 4 Power, Average Current, Voltage, Current, State Error, Relative State of Charge, Absolute State of Charge, Remaining Capacity, Full charge Capacity, Run time To Empty, Average Time To Full, and FET Temperature. Each entry includes a name, value, units, and a scan status.
- Bit Registers:** A table listing bit registers such as Battery Mode, Battery Status, Operation Status A, Operation Status B, Temp Range, Charging Status, Discharging Status, I<sub>C</sub> Status, Manufacturing Status, Safety Alert A+B, Safety Status A+B, Safety Alert C-D, I<sub>PF</sub> Alert A+B, I<sub>PF</sub> Status A+B, I<sub>PF</sub> Alert C-D, I<sub>PF</sub> Status C-D, L>Status, and Bounce Status. Each entry includes a name, value, and a scan status.
- Commands:** A list of commands such as DEVICE\_NUMBER, HW\_VERSION, FW\_VERSION, FW\_BUILD, CHEM\_ID, SHUTDOWN, I<sub>W</sub>SH\_SHUTDOWN, CC\_OFFSET, PCHS\_FET\_TOGGLE, CHS\_FET\_TOGGLE, DSG\_FET\_TOGGLE, GAUGE\_EN, FET\_EN, LIFETIME\_EN, LT\_RESET, LT\_FLUSH, LT\_TEST, PF\_CLEAR, PF\_EN, BBR\_CLEAR, and BBR\_FLUSH.

The interface also includes a dashboard on the left with icons for EV4000, USB, BQ40Z50-R4, and a battery status indicator showing 3781 mV and 8% charge. The bottom right corner features the Texas Instruments logo.

BQStudio main register page  
(BQ40Z50-R4)

# Getting from development to production Using BQStudio

## BQStudio

Program  
ChemID

Write  
config  
settings

Calibrate  
(optional)

Run  
learning  
cycles

Export  
golden  
image





# BQStudio chemistry page

Selecting the proper chemistry ID:

- Select the chemistry with the same model number
- Program the chem ID recommended by GPCCHEM

Update the chemistry database and program GPCRB files

Registers Chemistry

## Chemistry Programming

### Program Battery Chemistry

Most Li-ion cells use LiCoO<sub>2</sub> cathode and graphitized carbon anode, which is supported by the default firmware in the Impedance track fuel gauges. This tool allows the fuel gauge to be set up for various alternate battery chemistries. Use this tool to load settings for any alternate chemistry if your cell manufacturer indicates that their cells use a different chemistry than LiCoO<sub>2</sub> cathode and graphite anode.

Include chemistry IDs that do not support Turbo Mode 2

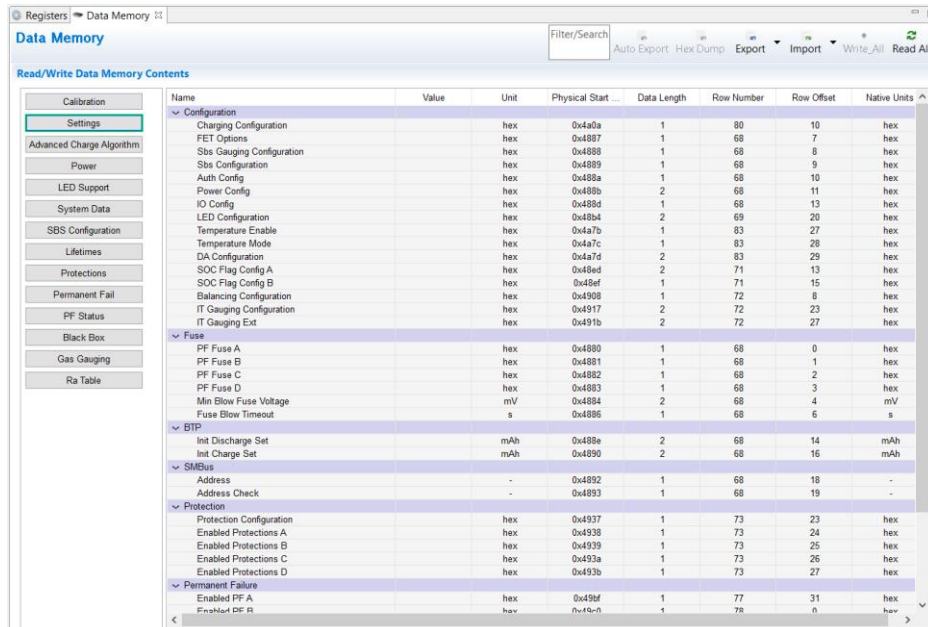
Manufacturer	Model	Chemistry ID	Description
360FLY	PR-693231 (815mAh)	1318	LiCoO <sub>2</sub> /carbon 11
A123	26650M1B (2500mAh)	0434	LiFePO <sub>4</sub> /carbon
A123	ANR26650M1-B Consult TI before ...	0453	LiFePO <sub>4</sub> /carbon
A123Systems	ANR26650M1-B (2500mAh)	0465	LiFePO <sub>4</sub> /carbon
AA Portable Power	LFP-18650-1500 (1500 mAh)	0439	LiFePO <sub>4</sub> /carbon
Acebel	ECFV1260 (60Ah)	0807	Lead Acid
Advanced Electronics Energy	AE18650C-26 (2600mAh)	2151	NiCoMn/carbon
AESC	295B9-3NK0B (16500mAh)	1554	LiCoO <sub>2</sub> /carbon 11
AESC	295B9-4NN0A (10425mAh)	1561	LiCoO <sub>2</sub> /carbon 11
AISIPU	3872C8 (5100mAh)	1335	LiCoO <sub>2</sub> /carbon 11
AISIPU	723292 (3080mA)	1363	LiCoO <sub>2</sub> /carbon 11
AISIPU	856360 (4750mAh)	3636	LiMn <sub>2</sub> O <sub>4</sub> (Co,Ni)/carbon, 4.35V
ALE	045062 (2300 mAh)	1254	LiNiCoMnO <sub>2</sub> /SGenNo1, 4.2V
ALE	ALE073470 (1700mAh)	2047	NiCoMn/carbon

Program Selected Chemistry Program from GPCRB file...

Chemistry Version : 975 [Check for a newer chemistry update on ti.com](#)

# Data memory plugin

- Allows device to be easily configured without needing to write complex commands to the gauge
- View/write individual bits within registers

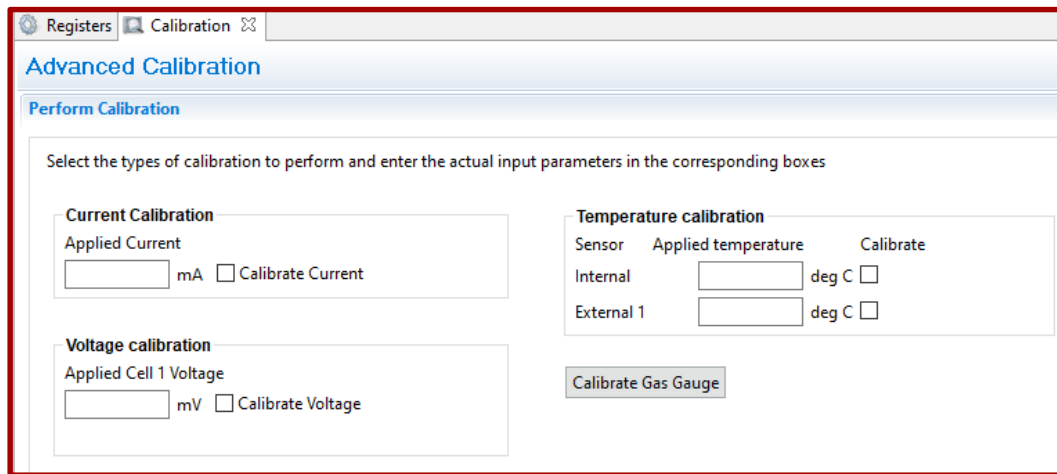


X DA Configuration								
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
MSB	CTEMP1	CTEMP0	RSVD	RSVD	RSVD	RSVD	RSVD	EMSHUT_PEXIT_DS
LSB	FTEMP	DISCONN_EN	EMSHUT_EN	SLEEP	IN_SYSTEM_SLEEP	NR	CC1	CC0

Write to Data Memory

# BQStudio calibration page (optional)

- Simplified calibration for gauge ADCs
- Calibrate the voltage, current and temperature
- Average multiple calibration results for golden file creation



The screenshot displays the 'Advanced Calibration' window in BQStudio. It features a 'Perform Calibration' section with the instruction: 'Select the types of calibration to perform and enter the actual input parameters in the corresponding boxes'. The interface is divided into three main calibration areas:

- Current Calibration:** Includes a text input for 'Applied Current' followed by 'mA' and a checkbox for 'Calibrate Current'.
- Voltage calibration:** Includes a text input for 'Applied Cell 1 Voltage' followed by 'mV' and a checkbox for 'Calibrate Voltage'.
- Temperature calibration:** Includes a table with columns for 'Sensor', 'Applied temperature', and 'Calibrate'.

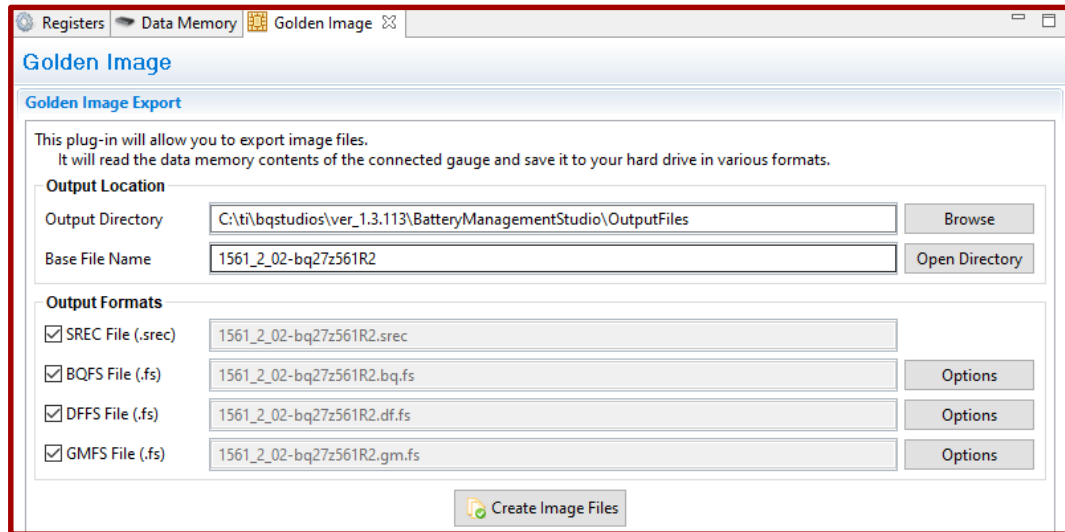
Sensor	Applied temperature	Calibrate
Internal	<input type="text"/> deg C	<input type="checkbox"/>
External 1	<input type="text"/> deg C	<input type="checkbox"/>

At the bottom right of the calibration area, there is a 'Calibrate Gas Gauge' button.

BQ27Z561 calibration page

# BQStudio programming and file export

- Golden image creation and programming
- Flash Stream or SREC format
- Application note SLUA801 for guide on programming Flash Stream



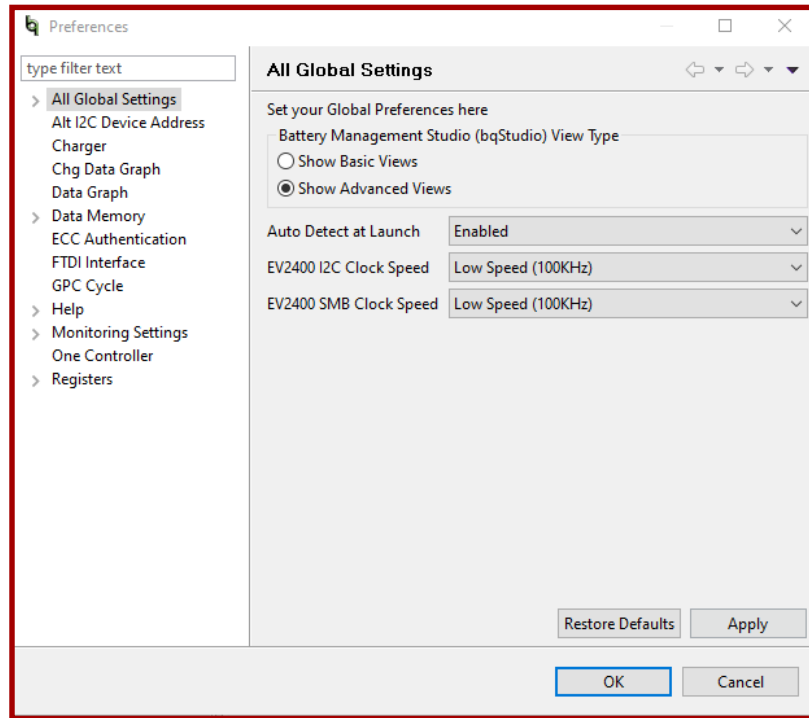
Example with BQ27Z561-R2

Note: some gauges only have programming tab

# How to setup and modify BQStudio

Preferences page allows many modifications to the GUI

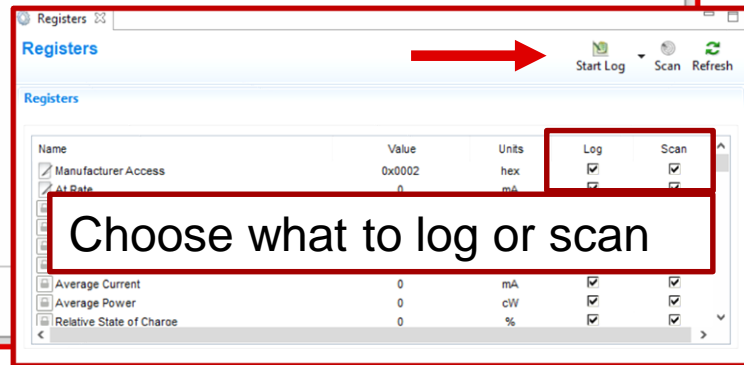
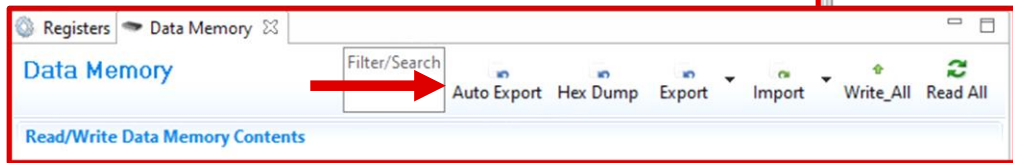
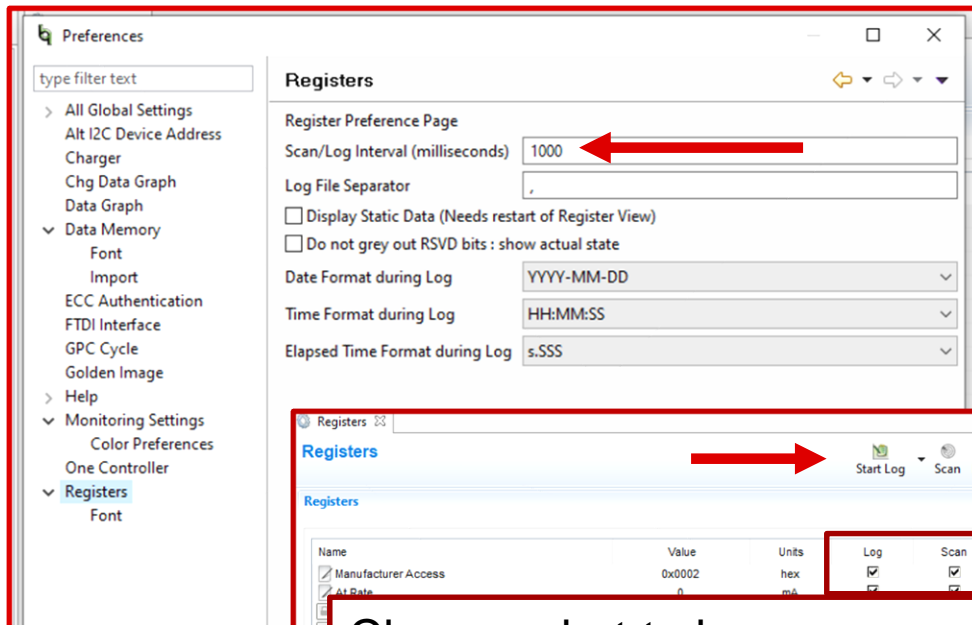
- Data logging speed
- Communication frequency



BQStudio preferences page

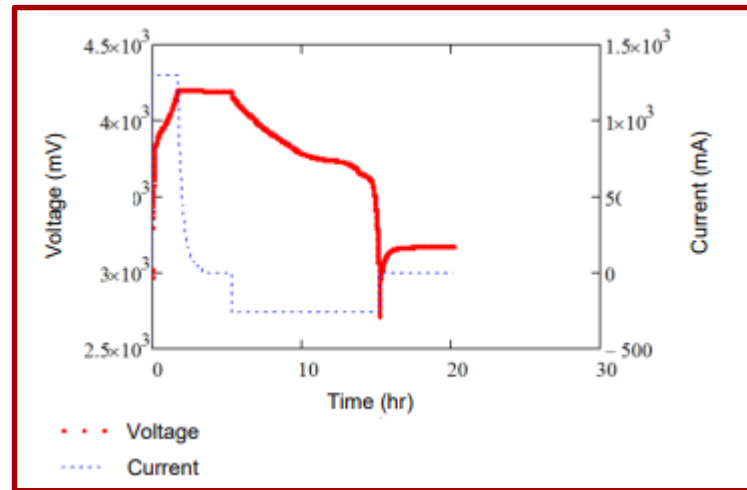
# How to setup and modify BQStudio

- Logging period and separator can be changed
- To start logging click the “start log” button in register tab
- To auto export GG files while logging click auto export in data memory



# Gauge parameter calculator (GPC) - GPCCHEM

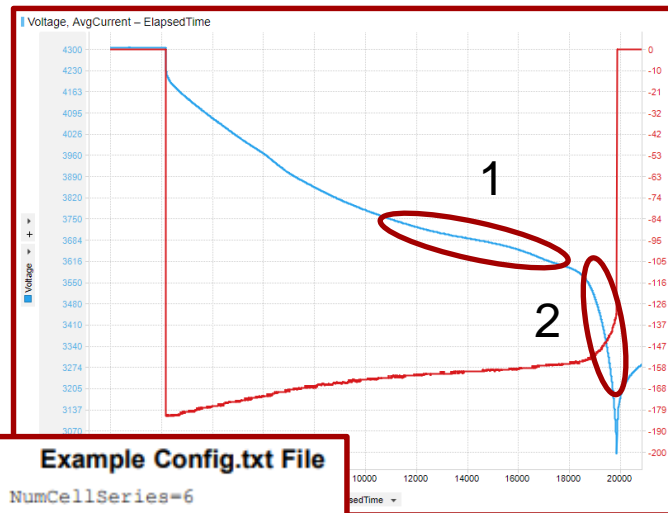
- Find the best fitting chemistry ID for your battery by submitting a relax-discharge-Relax (RDR) cycle
- Not needed if the exact model is available in the chemistry ID database
- Helps identify the best fitting ROM gauge version



Example GPCCHEM data

# Gauge parameter calculator (GPC) - GPCCEDV

- Used to find the CEDV algorithm temperature and load optimized coefficients for end discharge voltage (EDV) points
- Data submitted should be the **average** maximum and average typical current from the end application
- EDV1 and EDV2 should be within the FltMaxSOC% and FltMinSOC% ranges
  - LearnSOC% should be same as battery low %



## 2.2.2 Example Config.txt File

```
NumCellSeries=6
CellTermV=3000
ChemType=1
VoltageColumn=1
CurrentColumn=3
TemperatureColumn=2
ElapsedTimeColumn=0
FltMaxSOC%=12
FltMinSOC%=6
LearnSOC%=7
```

GPCCEDV config file



# Gauge parameter calculator (GPC) tools

## GPCRA0

- Optimize the gauge with the Qmax, Ra table, and temperature coefficients
- Same process the gauge does during the learning cycle in an online tool format
- Can be used in place of a learning cycle if needed

## GPCRB

- Cold temperature optimization for Impedance Track gauges
- Allows for more accurate gauging at temperatures below 0 °C
- High discharges in low temperature most common issue

# Summary

What is the TI gauge toolchain?

- EVM
- EV2400
- BQStudio
- Online tools

What is its purpose?

- Provides a streamlined process to help designs go from development to production as efficiently as possible

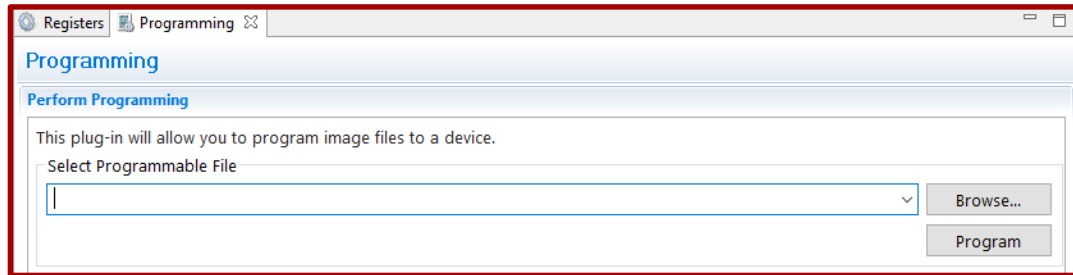
**Questions?**

# Resources

- [BQStudio download page](#)
- [BQ40Z50EVM example](#)
- [EV2400 home page](#)
- [GPCCHEM](#)
- [GPCCEDV](#)
- [GPCRA0](#)
- [GPCRB](#)

# BQStudio programming and file export

- Programming page allows SREC or Flash Stream to be uploaded to the gauge
- Ensure power is good and no interruptions during programming
- Use dropdown to select file format



BQ27Z561 programming page





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