ON Semiconductor®

Strata Enabled
Smart LiB Gauge Automatic Support Tool
User Guide

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Introduction

The Smart LiB Gauge Automatic Support Tool provides the cell voltage curve for a battery using the on-board programmable load and Smart LiB Gauge within the Strata Developer Studio. An example for discharged cell voltage curve with the load is shown in Figure 1. The unique curve to the battery is valuable to improve Relative State Of Charge (RSOC) accuracy of the Smart LiB Gauge. Figure 2 shows the process overview to evaluate the battery parameters of the Smart LiB Gauge using the curve. For more details about the Gauge Simulator tool that is shown in Figure 2, refer to the Gauge Simulator User Guide.

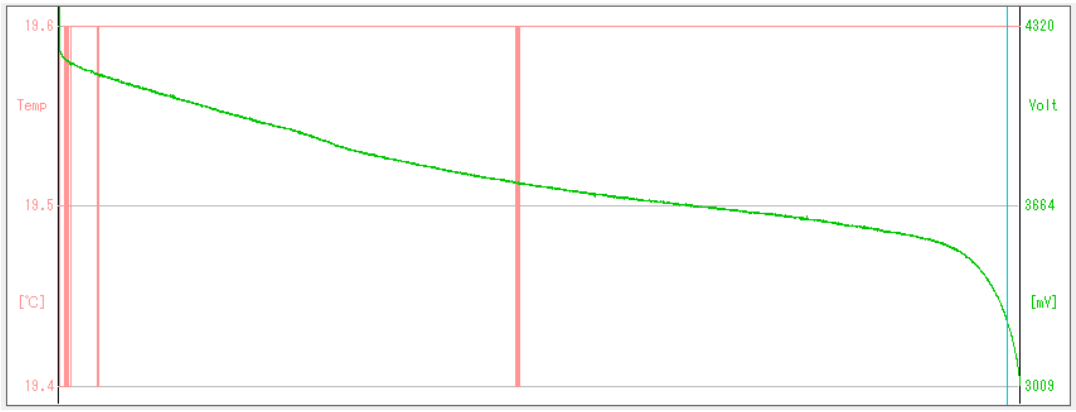

Figure 1. AN EXAMPLE OF CELL VOLTAGE CURVE WITH CONSTANT CURRENT DISCHARGING

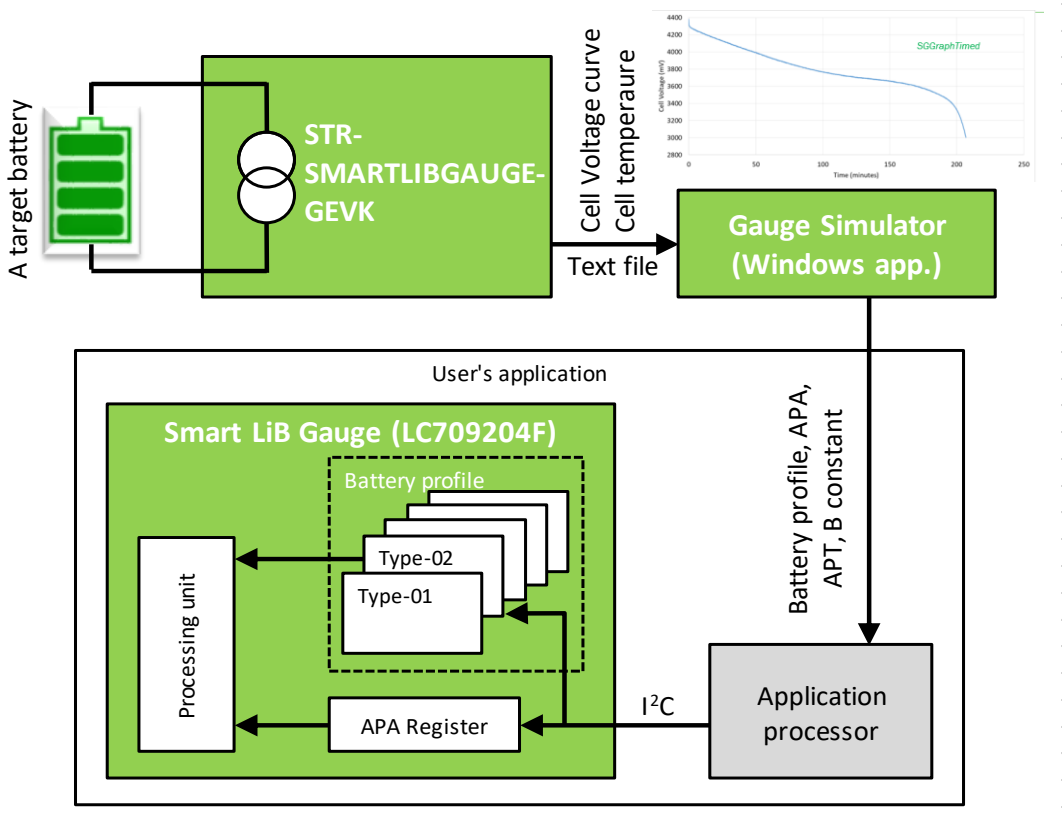

Figure 2. CONFIGURATION PROCESSES OF THE SMART LIB GAUGE

Table 1. SMART LIB GAUGE REGISTERS TO SET BATTERY PARAMETERS

Command Code	Register Name	Description
0x12	Change Of The Parameter	Selects an operating battery profile from pre-installed profiles.
0x0B	APA	Sets an adjustment parameter for an operating battery profile.

Note: If the user's actual application adopts the thermistor used for this board, following values obtained in this guide can be used for the gauge.
B constant: TSENSE1 Thermistor B (0x06)
APT: APT (0x0C)

Features

- LC709204F from the Smart LiB Gauge family measures cell voltage and cell temperature.
    - Voltage measurement accuracy is ±7.5 mV.
- An on-board programmable load of up to 1.5 A can be applied when measuring discharging characteristics.
- The Smart LiB Gauge Automatic Support Tool enables testing of charging and discharging with an external load and charger.
- Users can simulate RSOC within the GUI, using the cell voltage curve and optimum battery parameters.
- Built-in safety mechanism causes automatic measurement to cease when an unexpected condition is occurred.
    - No battery is detected
    - Excessively high voltage/current/temperature
    - Etc.
- All measured data and the configuration can be saved into a log file using the Strata Developer Studio for the Gauge Simulator.

Applications

- Wearables and IoT devices
- Smartphones and PDA devices
- Digital cameras
- Portable Game Players
- USB-related devices

User Guide

This guide will explain how to use the tool in a step-by-step manner. You can obtain a cell voltage curve and save their log data for the Gauge Simulator using the procedures given in this guide.

Hardware Setup

There are following three hardware setup methods for each purpose.

1. Discharging cell voltage curve measurement with on-board load
2. Discharging cell voltage curve measurement with an external load device
3. Charging cell voltage curve measurement with an external charger

The first setup is recommended to evaluate battery parameters for the Smart LiB Gauge using on-board load. The second setup is used when an external load device discharges battery. The third setup is used to evaluate charge dedicated battery parameters.

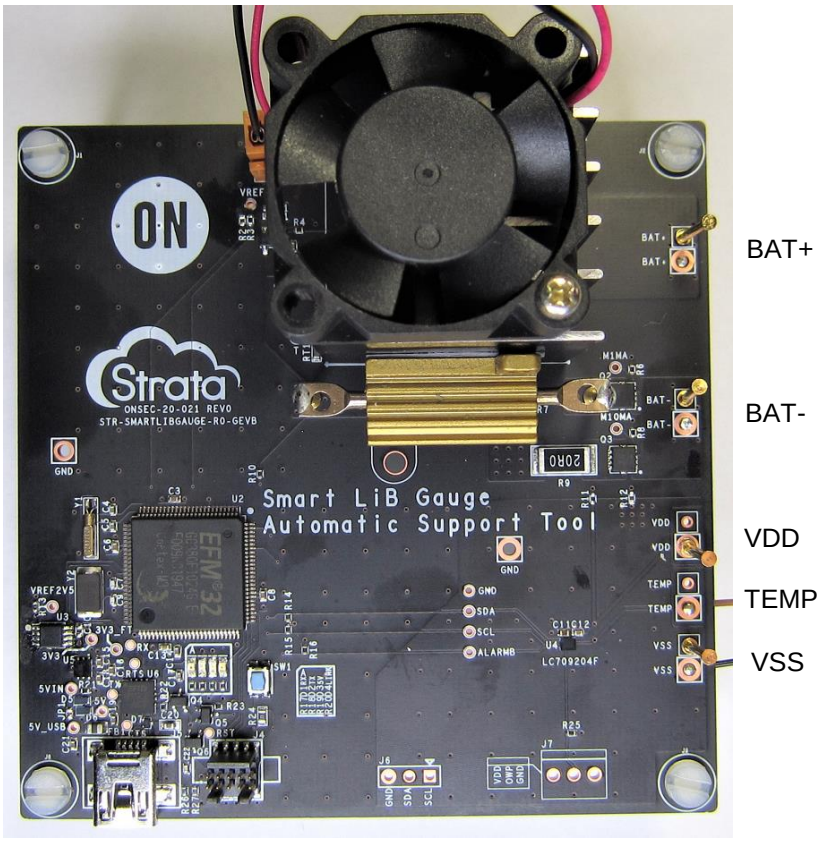

Figure 3: STR-SMARTLIBGAUGE-GEVK

Table 2. STR-SMARTLIBGAUGE-GEVK PIN DESCRIPTION

Symbol	Description
VDD	On-board gauge power supply. The gauge measures this input voltage as a cell voltage. Connect a battery positive terminal.
VSS	On-board gauge ground. Connect a battery negative terminal.
BAT+	On-board load positive terminal. When the load is enable, connect a battery positive terminal.
BAT-	On-board load negative terminal. When the load is enable, connect a battery negative terminal.
TEMP	Sense input and power supply for a thermistor. Connect 10 kΩ NTC thermistor to measure cell temperature.

1. Discharge cell voltage curve measurement with on-board load
    - Charge the target battery to full charge using an external charger.
    - Connect the battery positive terminal to BAT+ and the battery negative terminal to BAT-.
    - Pull the wires for VDD (or VSS) out from wiring between the battery and BAT+ (or BAT-).

Figure 4 shows the diagram. Note the branch point shown in the figure. These points should be kept nearer to the battery while measuring them using the STR-SMARTLIBGAUGE-GEVK. Detailed information regarding the branch connection is given in Figure 5. This will help to obtain the better parameters for Smart LiB Gauge, because it can reduce the voltage variation (so-called IR drop).

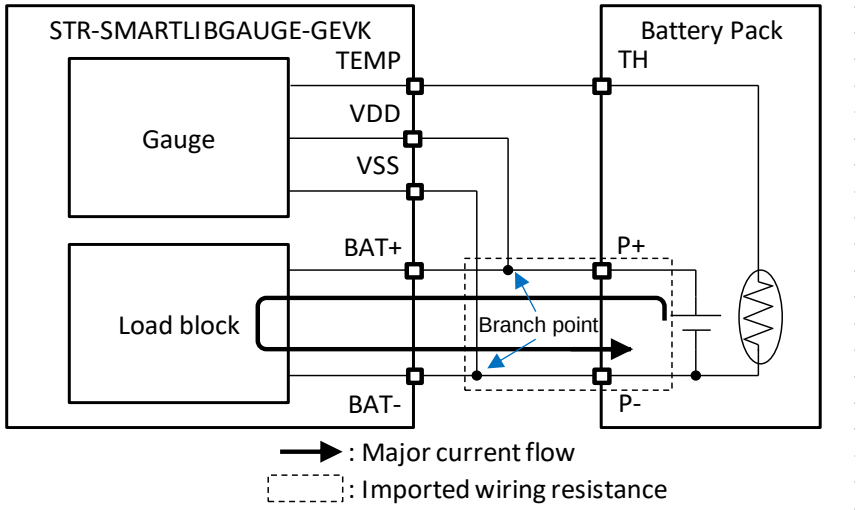

Figure 4. CONNECTION DIAGRAM UNDER DISCHARGE MEASUREMENT WITH ON-BOARD LOAD

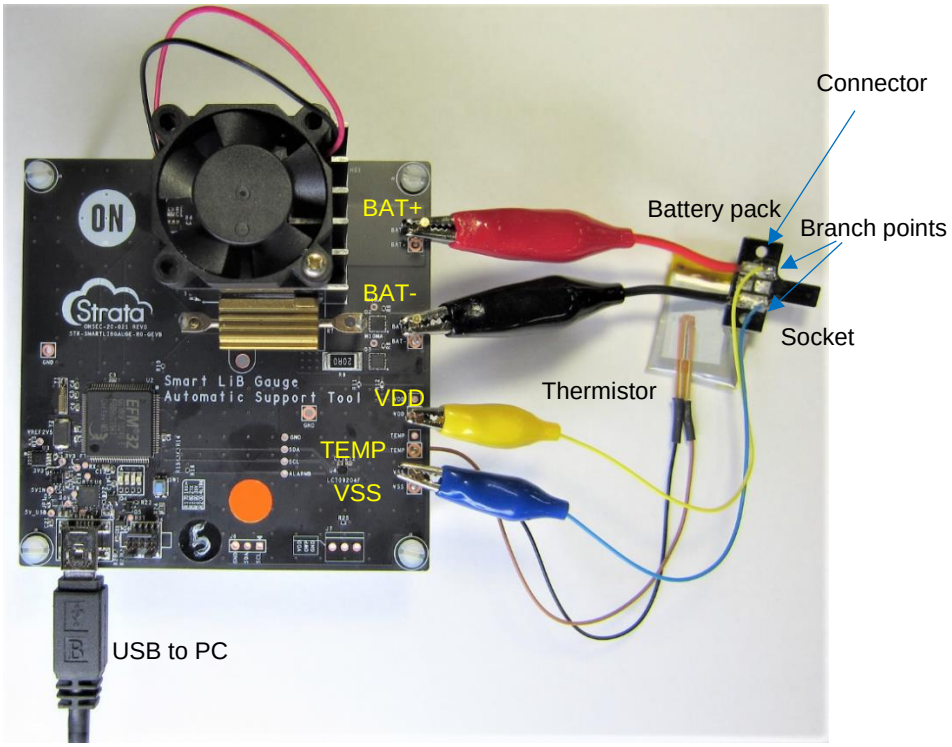

Figure 5. WIRING A CONNECTOR WITH THE BATTERY PACK

Note: If an actual application is connected to a battery pack using a socket, this evaluation board should be connected using the socket too. The wiring from the branch point to VDD (or VSS) doesn't require attention because of the low consumption current of the gauge.

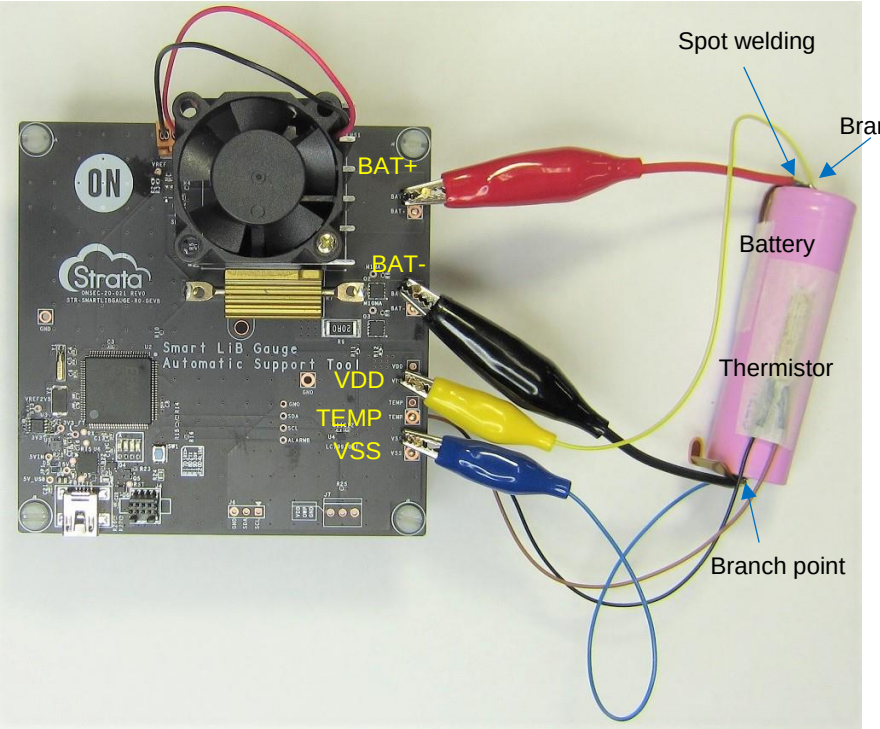

Figure 6. WIRING TO A CYLINDER TYPE BATTERY

Note: Do not solder the connecting wires and battery terminals directly. Use spot welding.

- Connect the 10 kΩ NTC thermistor to TEMP and VSS. To measure more reliable cell temperature, attach temperature sensing part to the battery using sticky tape as shown in Figure 7. If the battery pack has a built-in thermistor, this can be used instead.

Figure 7. A LEAD TYPE THERMISTOR MOUNTING

2. Discharge cell voltage curve measurement with an external load device
   - Charge the target battery to full charge using an external charger.
   - Connect the battery and an external load device. The load device may be a power supply instrument or user's application. The STR-SMARTLIBGAUGE-GEVK requires that the load device approximately discharge the battery with constant current or constant power.

     For example, if an application has an efficient power supply such a DC-DC converter, it may discharge the battery with constant power.

- Pull wires for VDD and VSS out from wiring between the battery and the load device. Keep BAT+ and BAT-terminals open and connect a thermistor in the same manner as shown in Figure 7. The procedure for the branch points is the same as explained in discharge measurement with the on-board load.

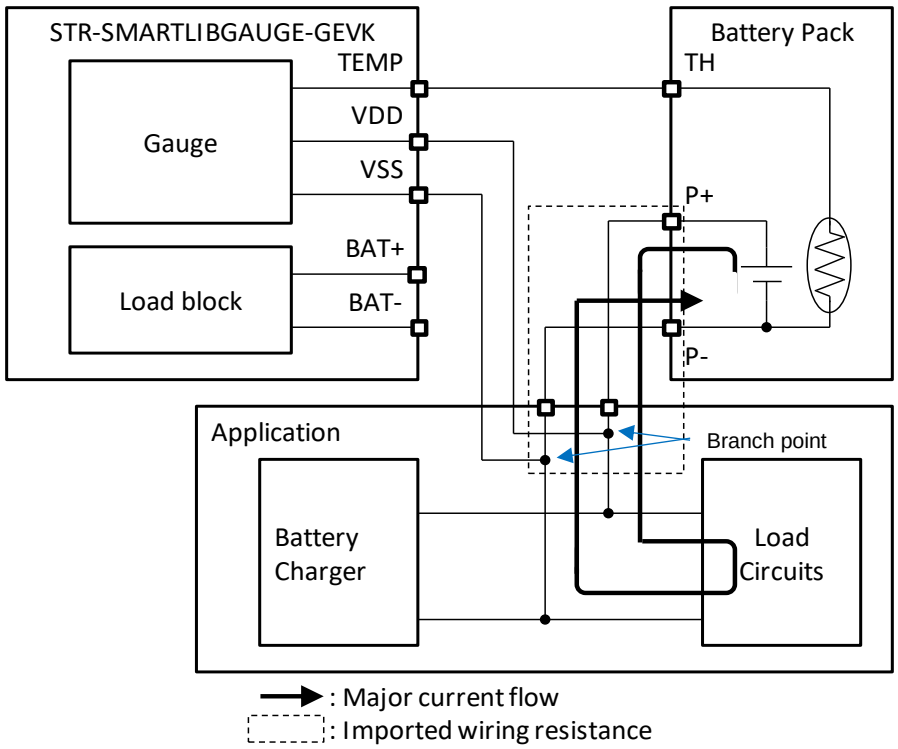

Figure 8. CONNECTION DIAGRAM UNDER DISCHARGE MEASUREMENT WITH AN EXTERNAL LOAD

Note: A load device should stop battery discharge and will not allow it to exceed the cut-off voltage.

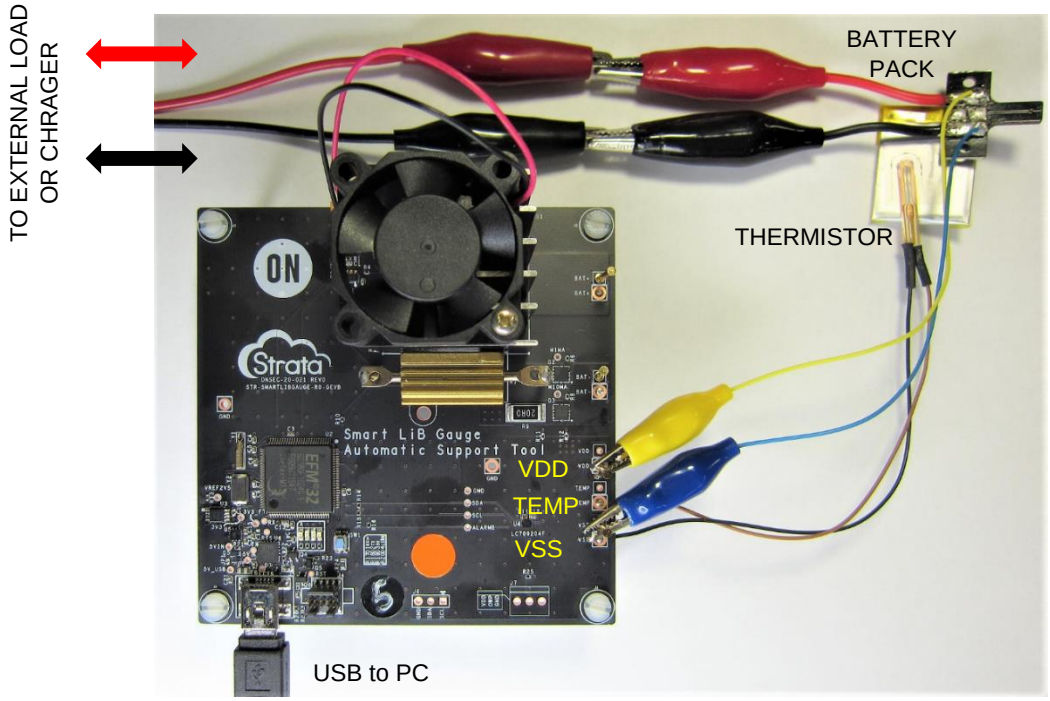

Figure 9. WIRING TO A BATTERY PACK WITH A CONNECTOR AND AN EXTERNAL LOAD DEVICE

3. Charge cell voltage curve measurement with an external charger
   - Discharge a target battery to empty state using the discharge measurement described above.
   - Connect the battery and a thermistor and an external charger in the same manner, as shown in Figure 9. The charger should follow general CC-CV charging methods and satisfy the battery charging specifications (e.g., charging voltage, charging current, etc.).

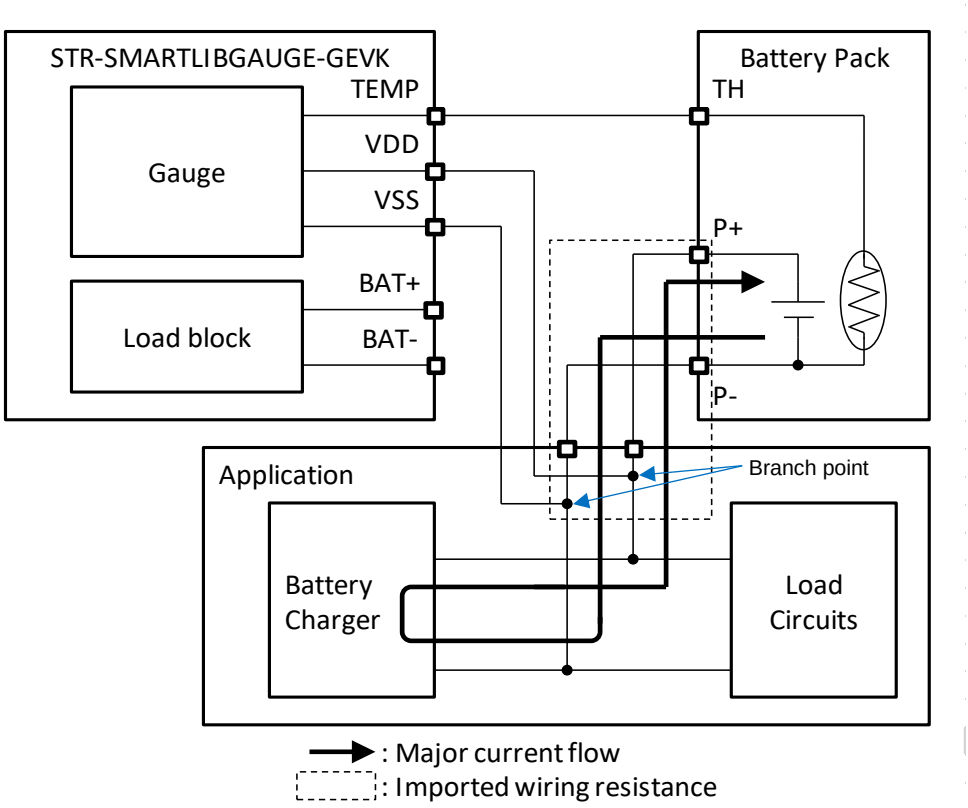

Figure 10. CONNECTION DIAGRAM UNDER CHARGE MEASUREMENT WITH AN EXTERNAL CHAGER

Platform Control

The platform control within the Strata Developer Studio allows you to set the measurement conditions and provide the result as graphs and a log file.

1. Open the Strata Developer Studio and Login to open the home screen.

2. Connect the Strata board to the PC using a USB Mini B cable. The Strata Developer Studio will automatically detect the device, and will bring up the platform control for the board as shown below.

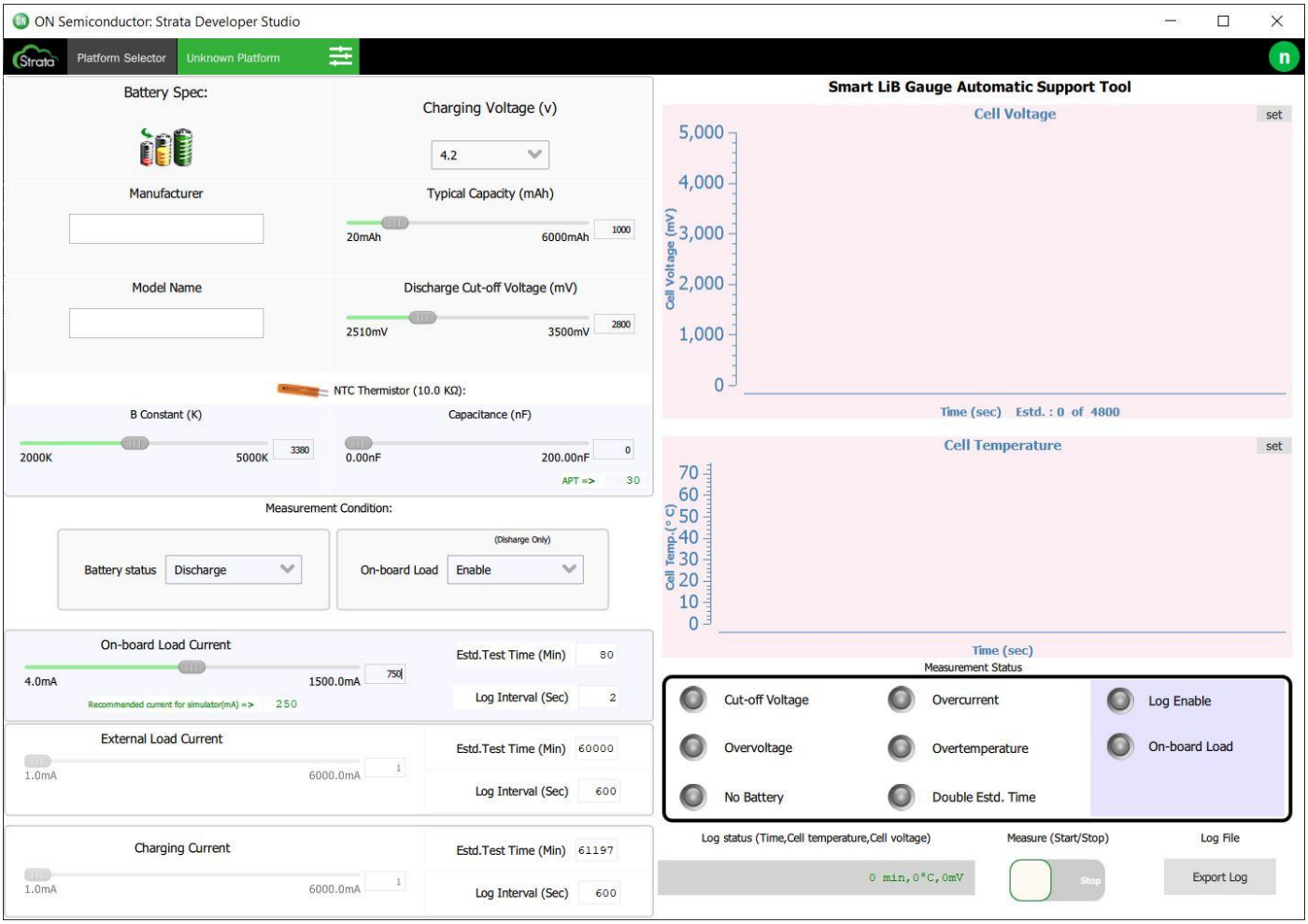

Figure 11. PLATFORM CONTROL

3. Battery Specifications Input Feature

In the Battery Specifications Input feature, you can set the target battery specifications.

1. Enter the user's battery manufacture and the model name.

This part is optional, entered values are saved into a log file so that it is easier to identify them later using the log data.

2. Select the charging voltage from the pull-down list.

The charging voltage is specified in the battery datasheet. It may also be called as terminal voltage of the battery. The pull-down list components refers to the battery profiles installed in the Smart LiB Gauge.

3. Move the slider to enter the battery typical capacity in mAh.

It may also be expressed as design capacity or nominal capacity in the battery datasheet.

4. Enter the Discharge Cut-off Voltage in mV.

This is the minimum cell voltage that the battery datasheet permits. If the STR-SMARTLIBGAUGE-GEVK detects the battery discharge cut-off voltage, the board will soon stop the measurement.

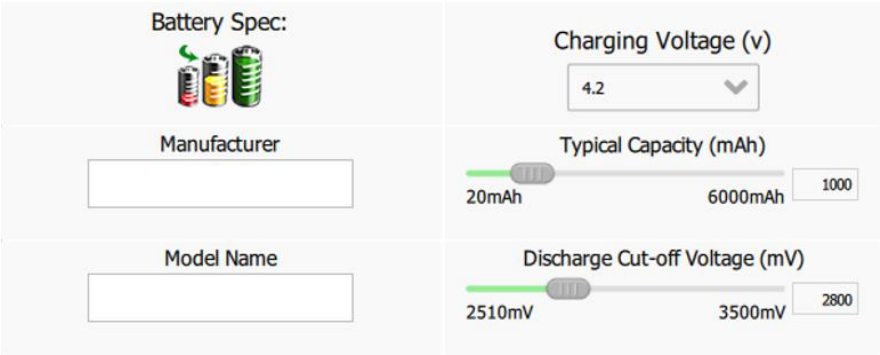

Figure 12. BATTERY SPECIFICATIONS INPUT FEATURE

4. NTC Thermistor Input Feature

In NTC thermistor input part, you can set parameters to measure cell temperature.

1. Enter B constant value of the thermistor in Kelvin.

If a capacitor as shown in Figure 13 and Figure 14 is placed in a target battery pack, enter the capacitance value in nanofarad (nF). Otherwise leave it as 0.00nF. APT at the bottom of Capacitance box is calculated from Capacitance value automatically. The STR-SMARTLIBGAUGE-GEVK uses the APT value to delay temperature measurement timing. For more details, refer to the LC709204F datasheet. B constant and APT are set to STR-SMARTLIBGAUGE-GEVK before starting the measurement.

Figure 13. NTC THERMISTOR INPUT FEATURE

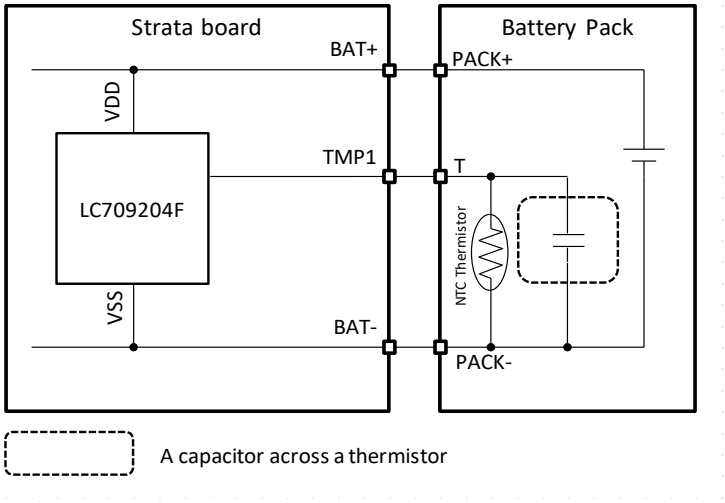

Figure 14. AN EXAMPLE OF A CAPACITOR ACROSS A THERMISTOR

5. Measurement Conditions Input Feature

In the Measurement Conditions Input Feature, you can select operational mode corresponding to the above hardware setup methods. Select the conditions according to the procedures given in Table 3.

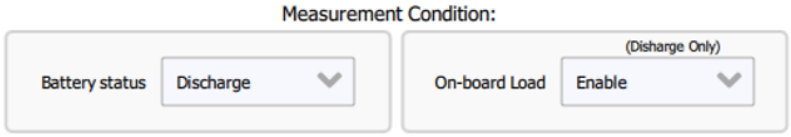

Figure 15. MEASUREMENT CONDITIONS INPUT FEATURE

Table 3. HARDWARE SETUP AND MEASUREMENT CONDITIONS

Hardware Setup	Battery Status	On-board Load	Current Slider
1. Discharge cell voltage curve measurement with on-board load	Discharge	Enable	On-Board Load Current
2. Discharge cell voltage curve measurement with an external load device	Discharge	Disable	External Load Current
3. Charge cell voltage curve measurement with an external charger	Charge	Disable	Charging Current

6. Current Value Input Feature

In the Current value Input Feature, you can set discharging or charging current. There are three sliders available, but only one (On-board Load Current) can be selected, as shown in Table 3. “Estd. Test Time” and “Log Interval” are displayed to the right of the slider. “Estd. Test Time” is used to stop measurements that are too long automatically. “Log Interval” controls the cell voltage measurement period. The platform control calculates these values automatically based on the users data. Input current value related details is given in Table 4.

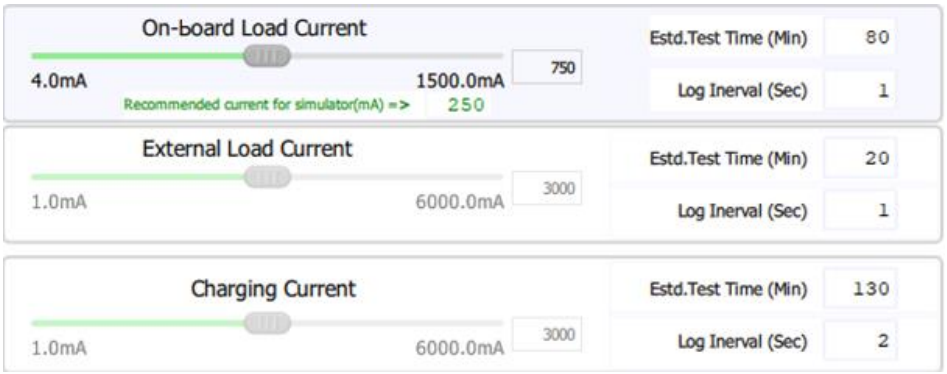

Figure 16. CURRENT INPUT FEATURE

Table 4. INPUT CURRENT FOR CURRENT SLIDER

Current Slider	Input Current
On-Board Load Current	On-board load current. The input range is from 4 mA to 1.5 A. This current controls on-board load circuits.
External Load Current	Discharging current for an external load device. The input range is from 1 mA to 6 A. If the current contains fluctuation, input the approximate average current. This current is used to calculate “Estd. Test Time” and “Log Interval” on right.
Charging Current	Constant charging current of external charger in CC charging mode. The input range is from 1 mA to 6 A. This current is used to calculate “Estd. Test Time” and “Log Interval”.

The following procedure explains how to use recommended discharge current value to evaluate the battery parameters for the Smart LiB Gauge. Generally, the recommended discharge current is 0.25C for typical capacity, which is calculated using following equation.

$$0.25C = 0.25 \times TypicalCapacity \quad \textbf{(equation. 1)}$$

The recommended current value is displayed below the current slider as “Recommended Current for Simulator (mA)”. You can copy that value to the current slider but, if the maximum discharging current value specified in the battery datasheet is lower than 0.25C, you can apply the lower value while performing their measurement. The charging current is not limited under 0.25C to evaluate the battery parameters. You can select charging current parameters applied for your intended application.

Figure 17. RECOMMENDED CURRENT FOR SIMULATOR

7. If you connect external load device or charger, start the charger or external load before clicking “Measure (Strat/Stop)”.

8. Click “Measure (Start/Stop)” to start the measurement. After the start “Log Enable” indicator will turn on. If the on-board load extracts discharge current, the “On-board Load” indicator will turn on. During the measurement, the on-board gauge continues to measure cell voltage and cell temperature on each “Log Interval” time specified on the UI. Simultaneously, this data will be plotted into graphs. If any one of the conditions shown in Table 5 is detected in measurement, the STR-SMARTLIBGAUGE-GEVK stops the measurement automatically. The indicator LED corresponding to that condition will turn on after the stop. You can also stop the measurement manually by clicking “Measure (Start/ Stop)” to stop.

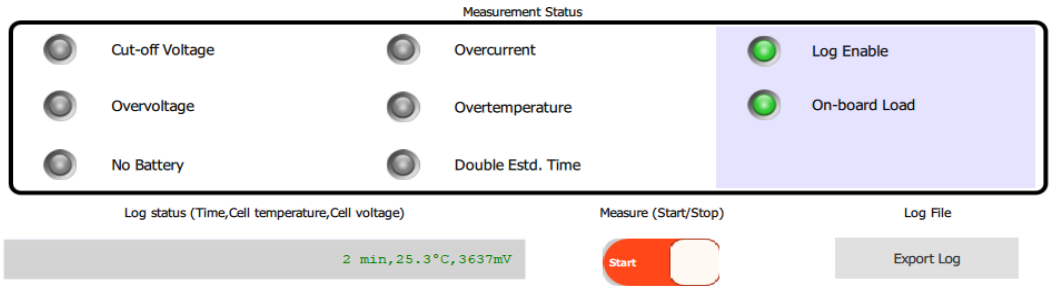

Figure 18. MEASUREMENT STATUS AND CONTROL SWITCHES

Table 5. STOP CONDITIONS

Measurement Status	Stop Condition	Threshold Register of The Smart LiB Gauge
Cut-off Voltage	Cell voltage lower than cut-off voltage is detected.	Alarm Low Cell Voltage (0x14) (Note 1)
Overvoltage	Cell voltage higher than charging voltage + 0.1 V is detected.	Alarm High Cell Voltage (0x1F) (Note 1)
Overcurrent	When on-board load is enable, the load current higher than followings is detected. Set current < 80 mA: 120 mA Set current >= 80 mA: 2 A	N/A
Overtemperature	Cell temperature higher than 75°C or lower than -25°C is detected.	Alarm High Temperature (0x21) (Note 1) Alarm Low Temperature (0x20)
No Battery	A battery has been removed.	N/A
Double Estd. Time	Double estimated test time elapses.	N/A

1. The STR-SMARTLIBGAUGE-GEVK detects these conditions and warns the on-board MCU of the exceeding conditions with the alarm functions. The platform control sets the threshold in the gauge registers automatically. For more details about the alarm functions, refer to LC709204F datasheet.

9. You can save all input data, measured cell voltage and cell temperature as a log file. Click “Export Log” to save the file. The Gauge Simulator can load the file to evaluate the battery parameters.

LOG FILE EXAMPLE

```
[SystemSpec]
AppVersion = 1.0.0
LsiName = LC709204
[BatterySpec]
Manufacturer = A Company
ModelName = B Model
TypicalCapacity = 200
ChargingVoltage = 4.35
DischargeCut-offVoltage = 3000
[ThermistorSpec]
BConstant = 3600
Capacitance = 0
APT = 30
[MeasurementCondition]
BatteryStatus = Discharge
On-boardLoad = Enable
LogInterval = 2
On-boardLoadCurrent = 50.0
ExternalLoadCurrent = 1.0
ChargingCurrent = 1.0
[StopCondition]
Cut-offVoltage = On
OverVoltage = Off
OverCurrent = Off
Over/UnderTemp = Off
DoubleEstimatedTime = Off
[Data]
Start_time= 2020/08/13 18:57:28
:25.6,4130
:25.6,4128
:25.6,4127
:25.6,4127
:25.6,4127
:25.6,4126
:25.6,4124
:25.6,4124
:25.3,4124
:25.3,4124
:25.3,4123
:25.3,4124
:25.3,4123
:28.8,2774
:28.8,2761
:28.8,2752
Stop_time= 2020/08/13 23:01:13
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