AN3490

IS2083/BM83 Battery Charger Application Note

Introduction

This document describes the best practices to successfully set up the lithium battery charger of the IS2083 SOC/BM83 module. In addition, it describes the Constant Current (CC) and Constant Voltage (CV) modes, and recharging functions of the battery charger. It is strongly recommended to follow the given setup guidelines to achieve best performance using the IS208x_Config_GUI_Tool provided with the software release.

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1. Quick References

1.1 Reference Documentation

For further study, refer to the following:

- *"BM83 Bluetooth® Stereo Audio Module Data Sheet"* (DS70005402)
- *"BM83 Bluetooth® Audio Development Board User's Guide"* (DS50002902)
- *"IS2083 Bluetooth® Stereo Audio SoC Data Sheet"* (DS70005403)
- *"IS208x Config GUI Tool User's Guide"*

1.2 Software Prerequisites

- IS208x_Config_GUI_Tool, version 1.2.15

2. Charging the Battery

The battery charger includes a current sensor for charging control, user-programmable current regulator and high accuracy voltage regulator. The charging current parameters are configured using the IS208x_Config_GUI_Tool.

The IS2083 SOC/BM83 module is powered through the BAT_IN input pin. The external 5V power adapter should be connected to ADAP_IN in order to charge the battery.

Figure 2-1. BM83 and Battery Connection

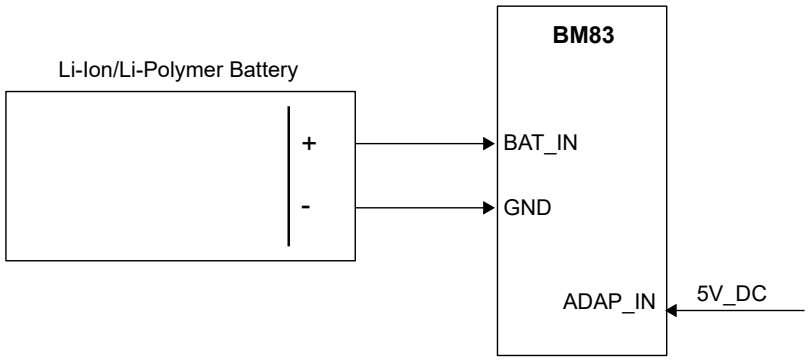
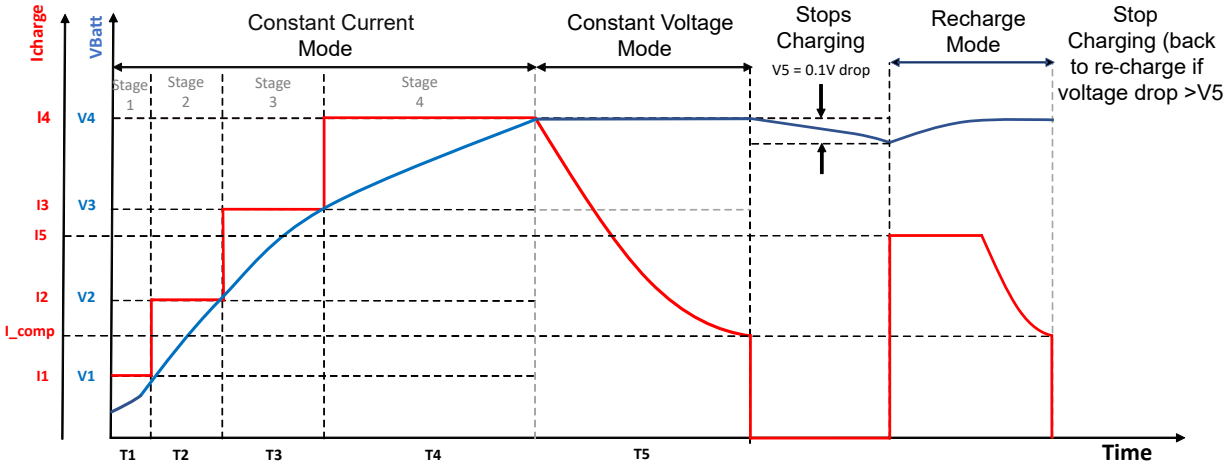


Figure 2-2. Battery Charging Curve



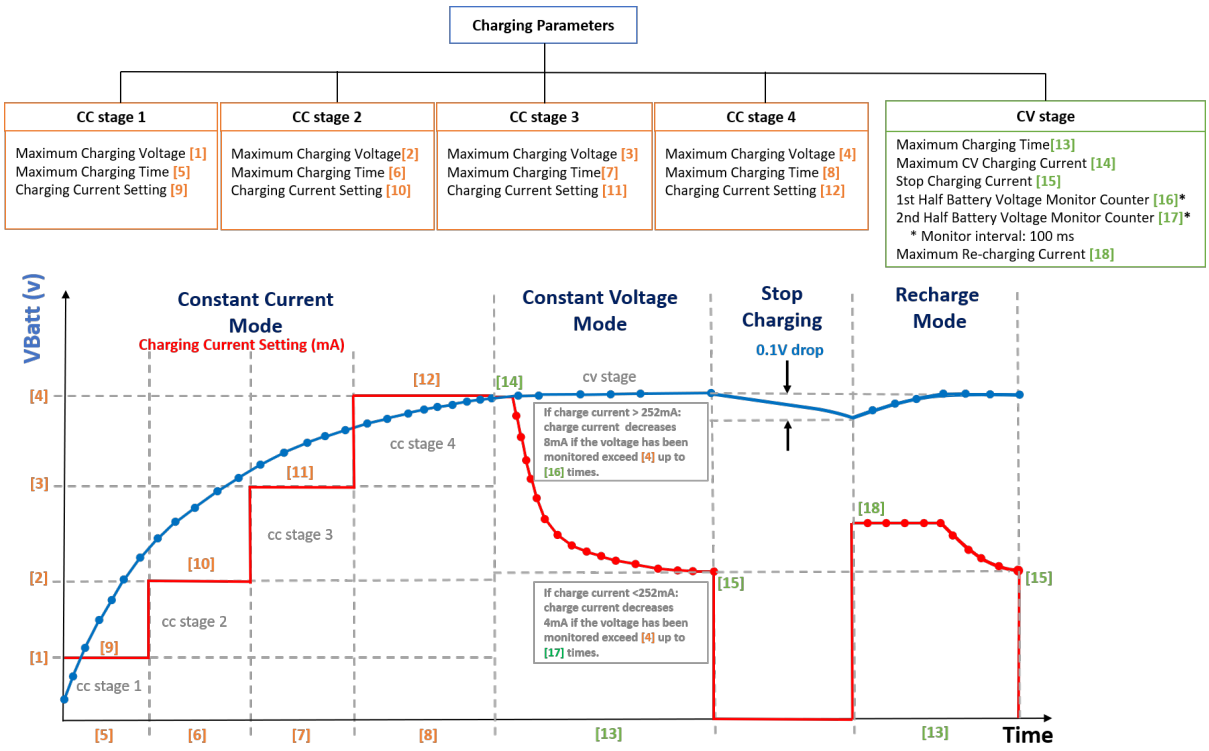
The preceding figure illustrates the current (red) and voltage (blue) charging curve of the battery:

- CC mode:
  - The charging current is kept at a constant value until Battery Voltage (V_{BATT}) reaches the final voltage (V4).
  - There are four stages of charging (stage 1 to stage 4).
  - In stage 1, trickle charge is employed to restore charge to deeply depleted cells and the charging current remains constant up to stage 4.
  - The charging state changes to CV mode when battery voltage reaches the limit V4 in stage 4 (normally 4.2V).
- CV mode:
  - The voltage is kept constant within V4 by slowly decreasing the current.
  - Charging is stopped when the current reaches the threshold value (I_comp).
    Note: In CV mode, Icomp denotes Charger Complete Current. It is configured as Stop Charging Current using the IS208x_Config_GUI_Tool. See [15] in Figure 3-3.
- Recharge mode:
  - This mode starts when V_{BATT} drops by 0.1V after charging is completed.
  - During this mode, the current and voltage are kept constant until the current reaches I_comp current.

3. Charger Configuration

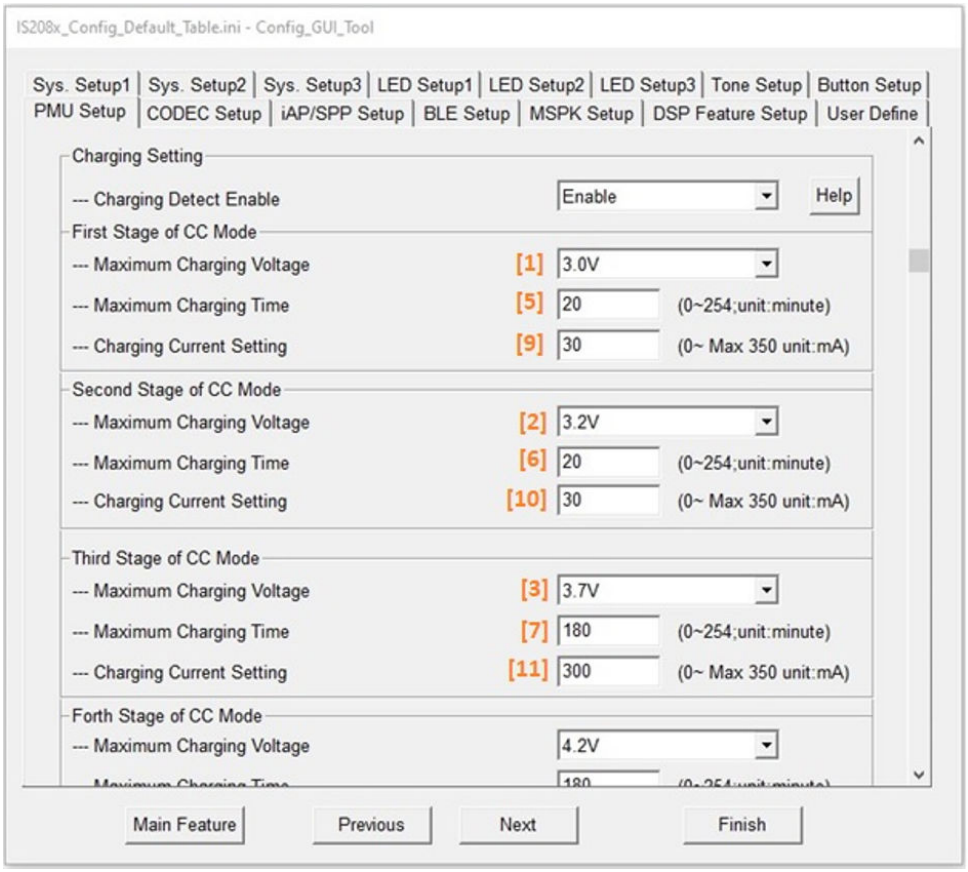
IS2083 SOC/BM83 charger function is configured using the IS208x_Config_GUI_Tool. The following figure illustrates the charging parameters ([#]) in each stage and charging curve, which are configurable in the IS208x_Config_GUI_Tool.

Figure 3-1. Charging Parameters and Charging Curve



The following figures illustrate the **PMU Setup** tab of the IS208x_Config_GUI_Tool. This tab provides the options to change the charging parameters.

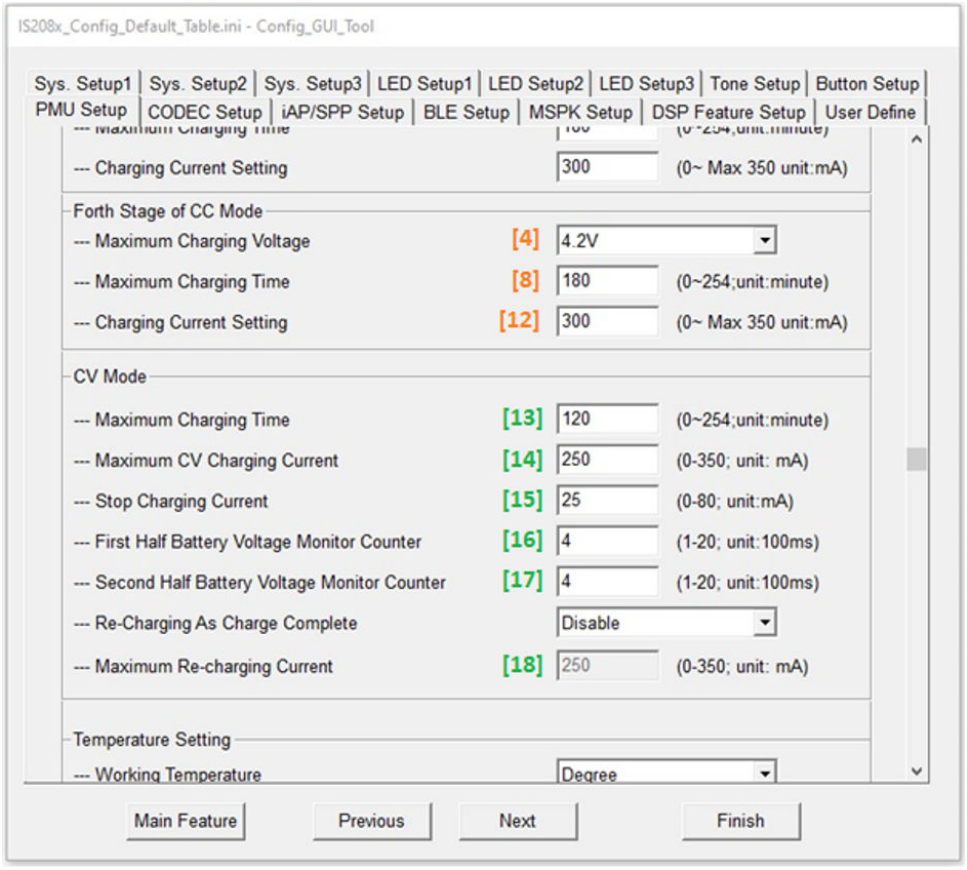
Figure 3-2. Charging Parameters on GUI Tool



The following parameters can be configured in the CC mode (stage 1 to stage 4):

- Maximum Charging Voltage [1] to [4]
- Maximum Charging Time(Protection time to stop the charger) [5] to [8]
- Charging Current Setting [9] to [12]

Figure 3-3. Charging Parameters on GUI Tool (Continued)



The following parameters can be configured in the CV mode:

- Second Half Battery Votage Monitor Counter [17]
- First Half Battery Voltage Monitor Counter [16]
- Stop Charging Current [15]
- Maximum CV Charging Current [14]
- Maximum Charging Time [13]
- Maximum Recharging Current[18]

Notes:

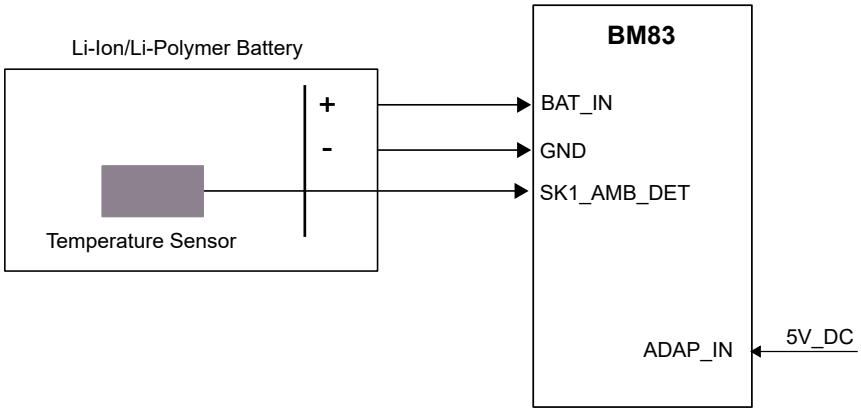
1. For more details on the GUI tool, refer to *"IS208x Config GUI Tool User's Guide".*
2. For maximum charging time of each stage, the IS208x_Config_GUI_Tool provides up to 254 minutes for users to configure the battery. The user must evaluate the maximum time required to stop charging the battery in each stage if the charger cannot switch to the next stage.
3. All charger parameters are described in detail in the **"Charging Setting"** section of the *"IS208x Config GUI Tool User's Guide"*.

3.1 Ambient Temperature Detection

Ambient temperature detection setting is configurable through the IS208x_Config_GUI_Tool. The firmware detects the temperature data through the ADC output to control the charger activity. Connect the ADC (SK1_AMB_DET pin of the IS2083 SOC/BM83 module) with the temperature sensor circuit to transfer the temperature data.

The following figure illustrates the application of charger function with a temperature sensor attached on the Li-Ion battery to detect the temperature by ADC (SK1_AMB_DET pin of the IS2083 SOC/BM83 module).

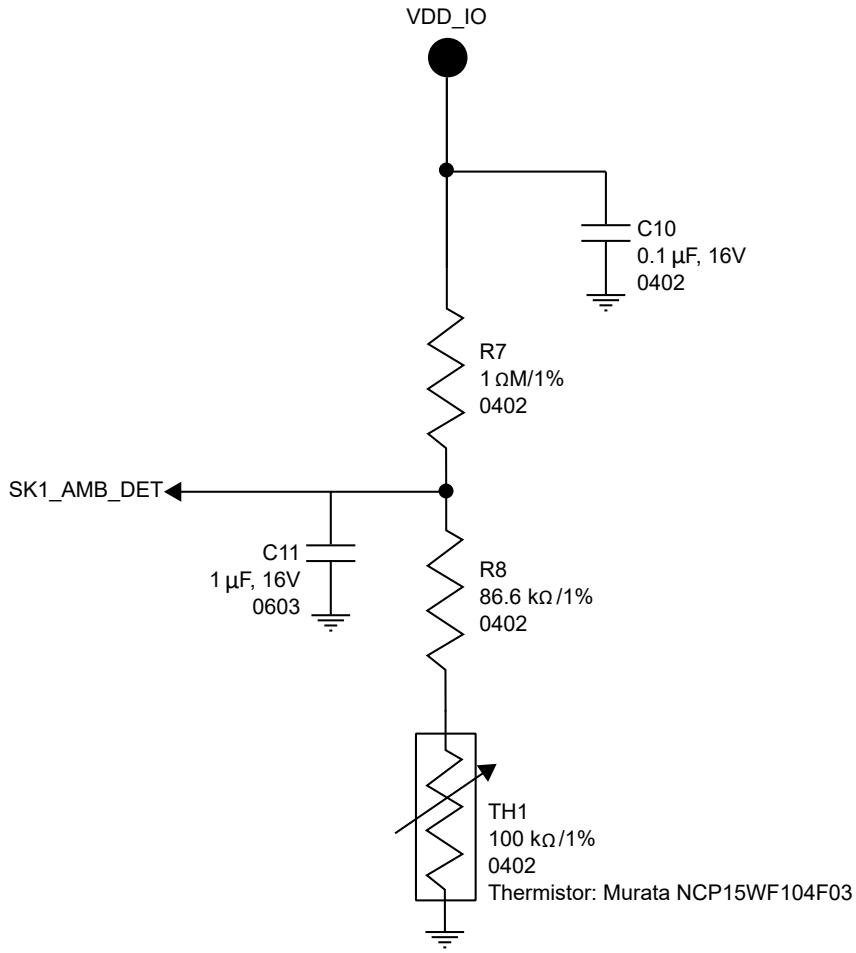
Figure 3-4. BM83 and Temperature Sensor Connection



Notes: The temperature sensor can be implemented as the following:

- Default circuit – thermistor is integrated in the battery
- Customized circuit – external thermistor is implemented to connect to the SK1_AMB_DET pin of the IS2083 SOC/BM83 module

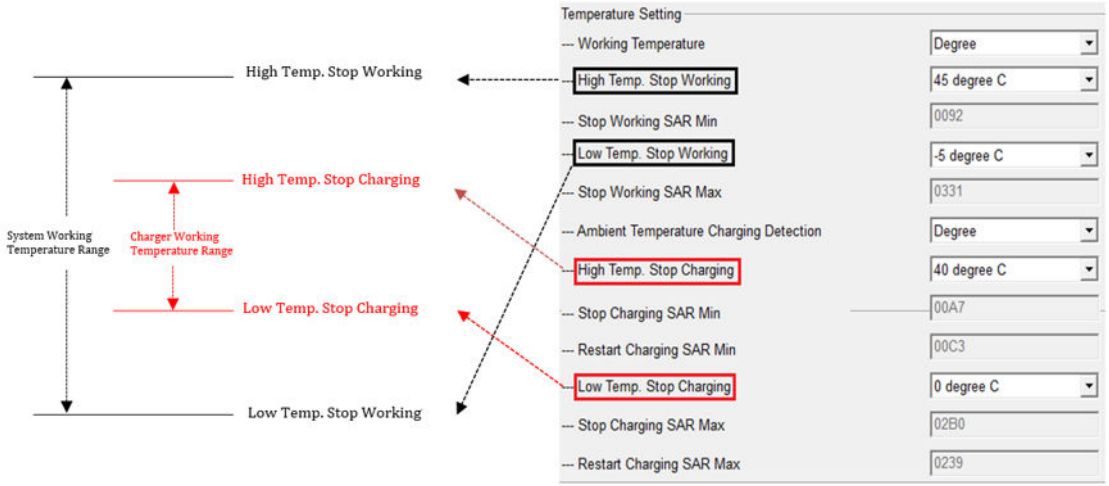
Figure 3-5. Ambient Detection Circuit



3.1.1 Default Temperature Sensor Configuration

For the default configuration, the working temperature range for the charger and the system is defined in the **Temperature Setting** tab of the IS208x_Config_GUI_Tool, as illustrated in the following figure.

Figure 3-6. Temperature Setting



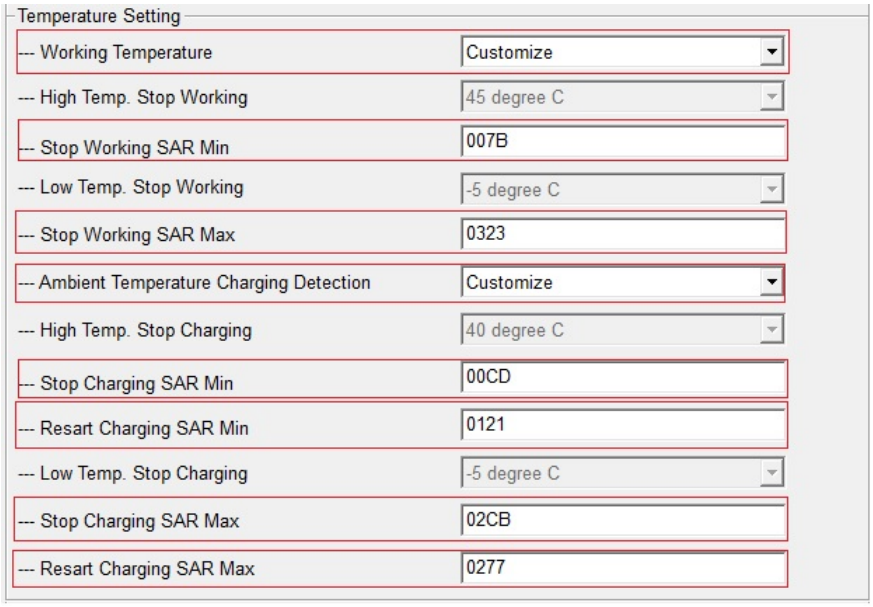
3.1.2 Customized Temperature Sensor Configuration

If a customized temperature sensor circuit is used, all the required ADC output values must be filled manually in the IS208x_Config_GUI_Tool, as illustrated in the following figure. The charger stops charging when the ADC value reaches the Stop Charging SAR Min/Max value and restarts charging when the ADC value recovers to the Restart Charging SAR Min/Max.

Set Working Temperature as *Customize* in order to customize the temperature sensor parameters using the IS208x_Config_GUI_Tool. When the temperature exceeds Stop Working SAR Min/Max, the system will stop both Bluetooth activity and charger function. If the temperature recovers to the range of restart charging SAR Min/Max, the charger will be restarted.

Since a different temperature sensor is used, the user must find out temperature vs. output voltage values for the new sensor. Then, refer to Table 3-1 to fill the values in the Temperature Setting of the IS208x_Config_GUI_Tool, as shown in the following figure.

Figure 3-7. Temperature Setting Example of Customized Temperature Sensor



The following table shows the example of SK1_AMB_DET (ADC input) voltage vs. output value mapping.

Table 3-1. Example of SAR ADC Input Voltage vs. Output Value

ADC Input Voltage	Output Value
0.3	0x004B
0.35	0x007B
0.4	0x00A8
0.45	0x00CD
0.5	0x00F7
0.55	0x0121
0.6	0x0151
0.65	0x017A
0.7	0x01A2
0.75	0x01CD
0.8	0x01F4
0.85	0x0228
0.9	0x0250
0.95	0x0277
1	0x02A0
1.05	0x02CB
1.1	0x02FA

.....continued

ADC Input Voltage	Output Value
1.15	0x0323
1.2	0x034B
1.25	0x0375
1.3	0x03A0

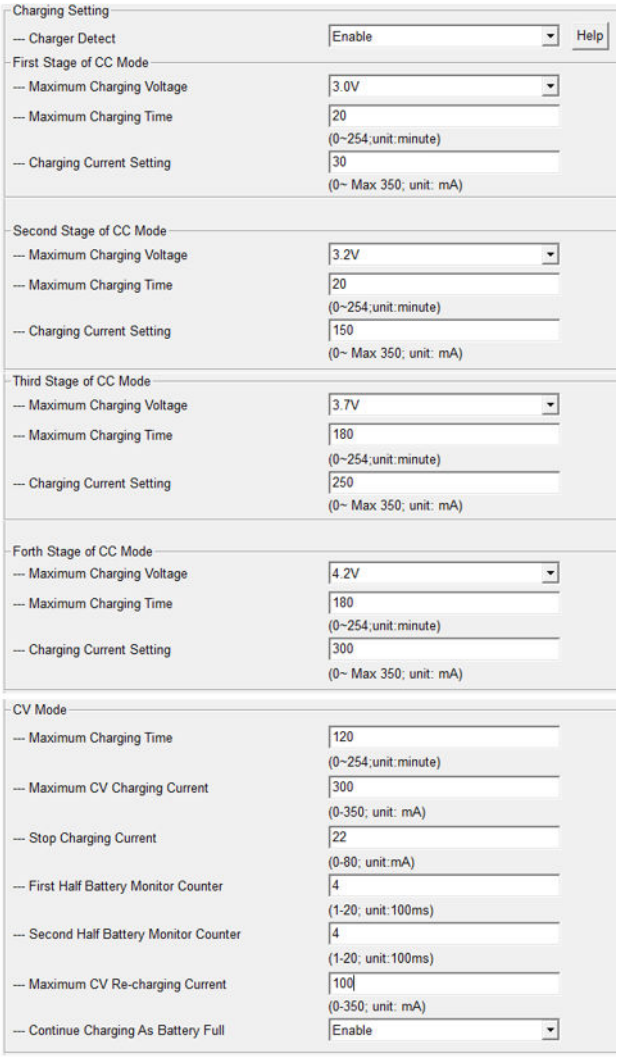
3.2 Sample Battery Charger Settings

This section describes the sample battery charger settings using the 550 mAh Li-Ion battery. At First Stage of CC mode, the trickle charging current is 30 mA and the maximum charging voltage is 3.0V. At Fourth Stage of CC mode, the maximum charging voltage of 4.2V and the maximum charging current of 300 mA (300/550 = 0.55°C) is configured. At CV mode, the maximum CV charging current is 300 mA and the stop charging current is set as 22 mA.

First Half Battery Voltage Monitor Counter = 4 is active, which means in CV mode, the charging current will decrease 8 mA/step if the setup charger charge current is more than 252 mA and the battery voltage exceeds 4.2V, up to four times (every 100 ms). The recharging current is 100 mA if battery voltage reduces to 4.1V. In each mode, the maximum charging time is set for charging protection.

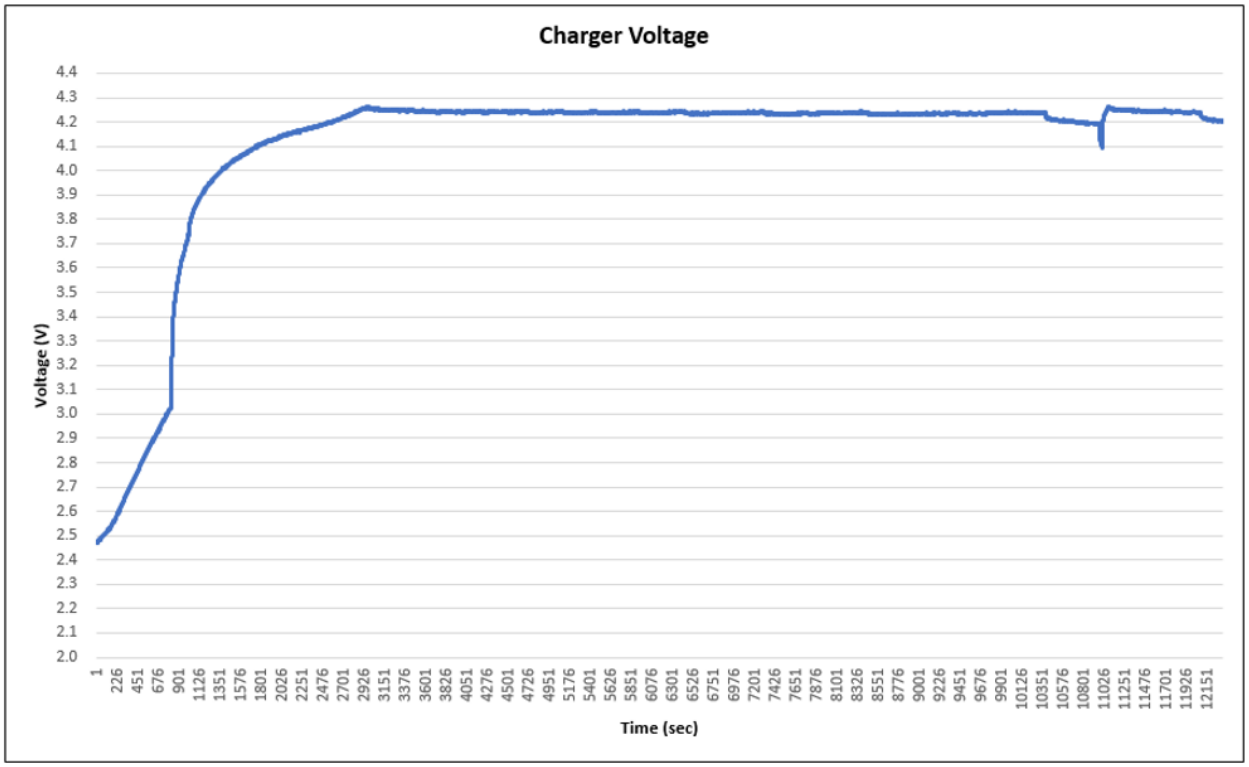
Note: In this example, IS208x_Config_GUI_Tool version 1.2.15 is used.

Figure 3-8. Charger Setup for 550 mAh Li-Ion Battery



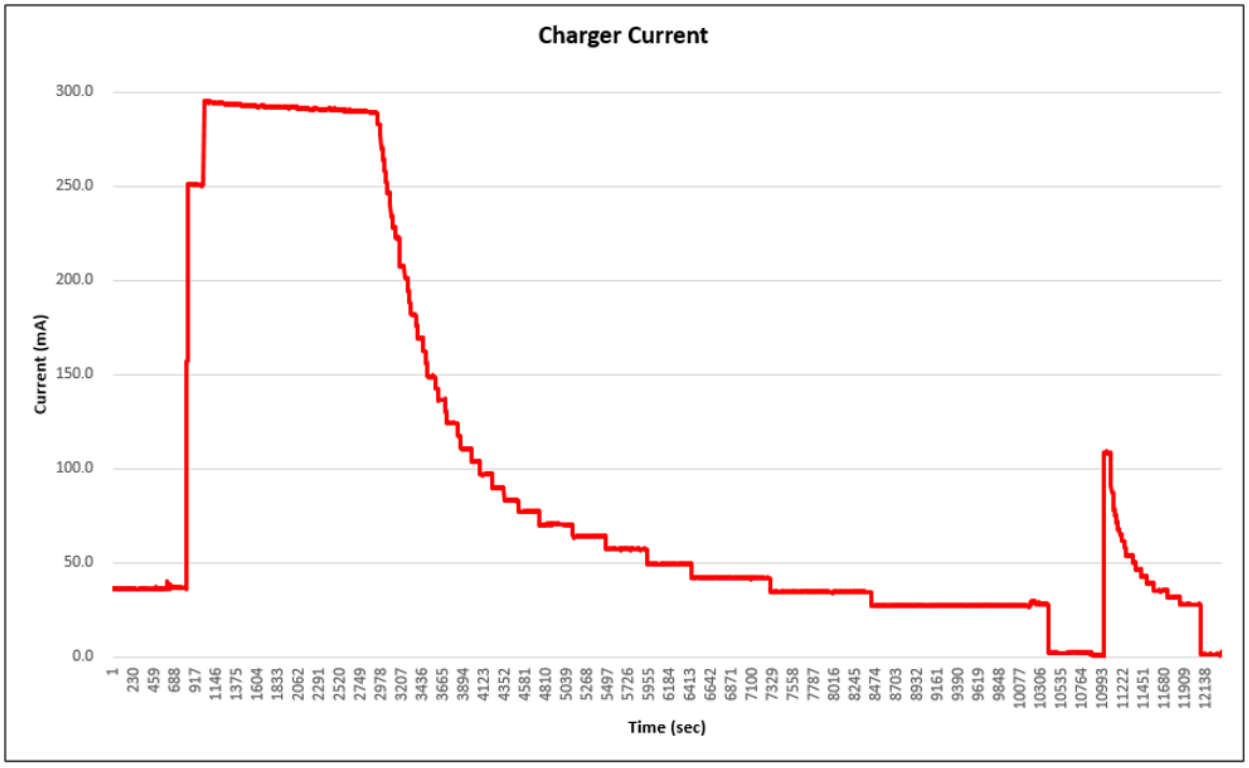
The following figure illustrates the measured charger voltage of the 550 mAh Li-Ion battery.

Figure 3-9. Measured Charger Voltage



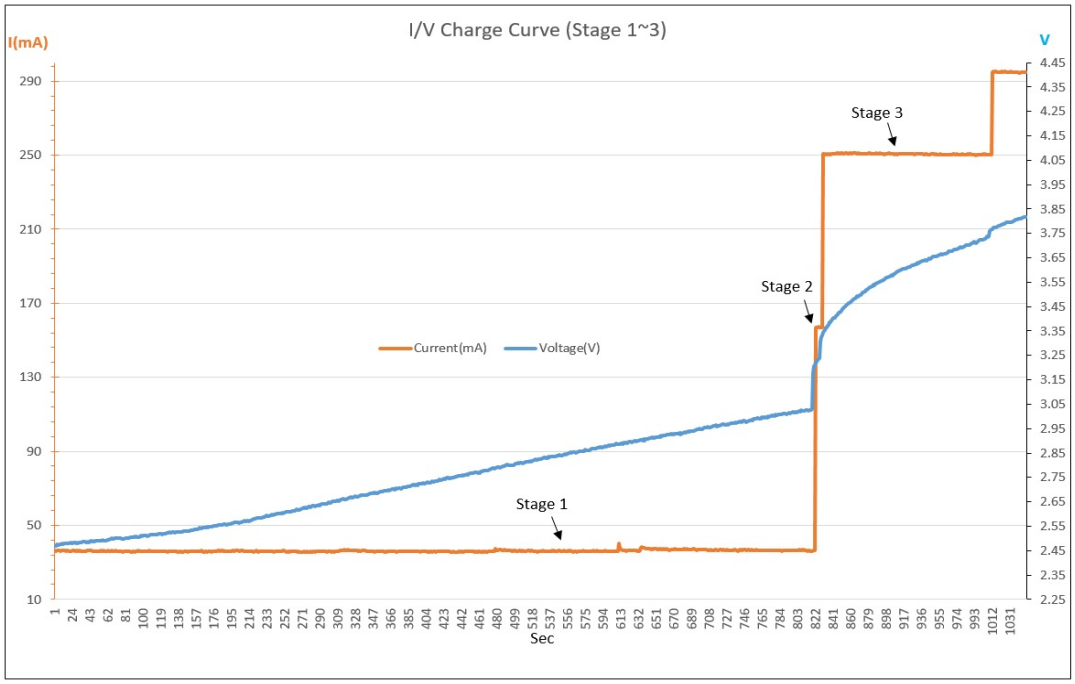
The following figure illustrates the measured charger current of the 550 mAh Li-Ion battery.

Figure 3-10. Measured Charger Current



The following figure shows the stage 1 to stage 3 of I/V charge curve in detail for the 550 mAh Li-Ion battery.

Figure 3-11. I/V Charge Curve



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Revision	Date	Section	Description
A	05/2020	Document	Initial Revision

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