

Chapter 4: *Tiny BMS* configuration

4. Introduction

Tiny BMS device can be configured using *Battery Insider Windows* application. Alternatively all the *Tiny BMS* configuration can be done using *UART*, *MODBUS* or *CAN* communication commands (refer to *Tiny BMS Communication Protocols* documentation) from the user side integrated device or existing industrial system.

4.1. *Battery Insider* application overview

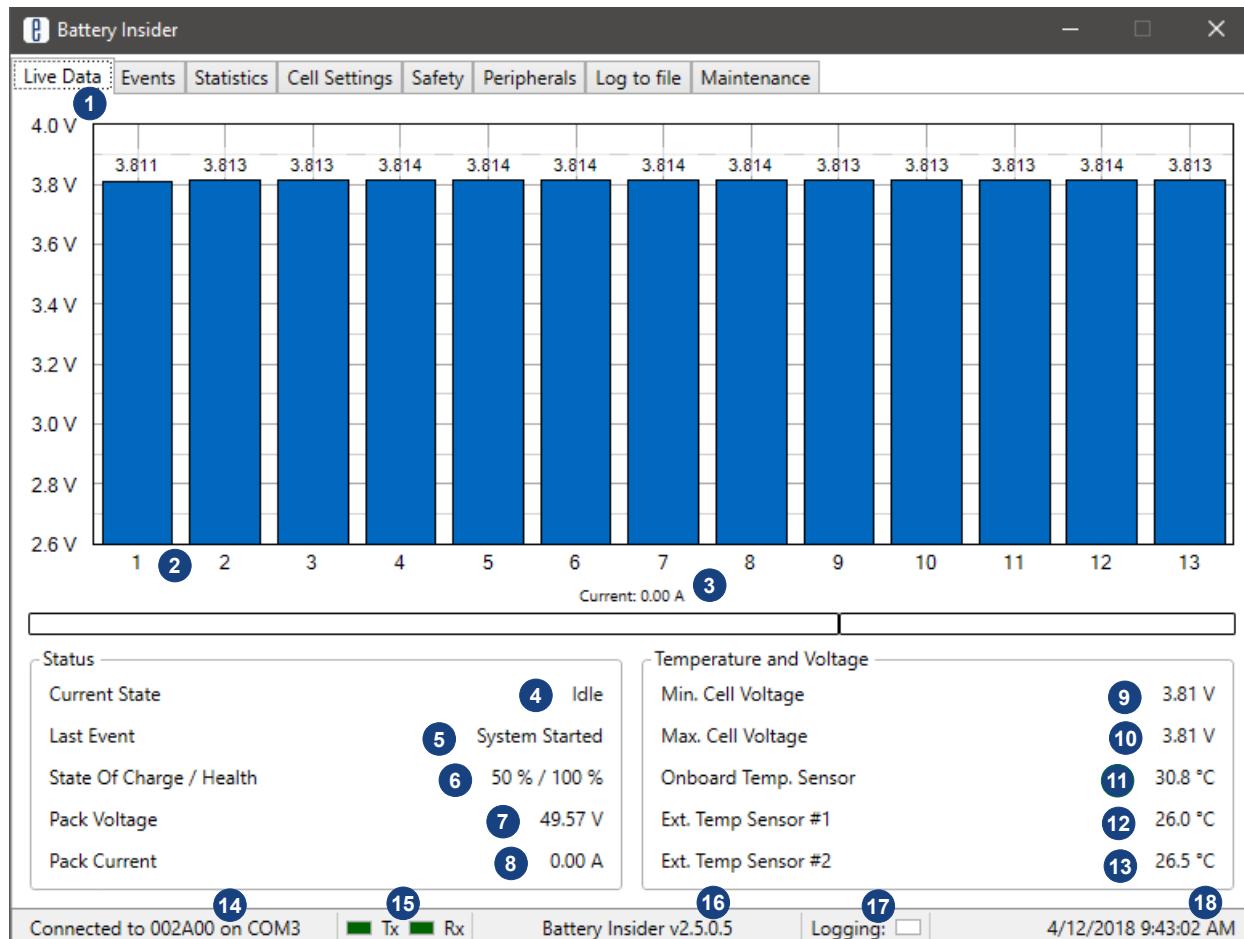


Figure 4.1: *Battery Insider* BMS Live Data tab screenshot

Table 4.1: *Battery Insider* Live Data tab information

1	<i>BMS</i> Live Data tab
2	<i>BMS</i> cells voltages graph. The number of showing cells is equal to <i>Number of Series Cells</i> 35 parameter in the <i>Cell Settings</i> 29 tab. When cell is in balancing state, the orange color bar is shown on top of the blue cell voltage column.
3	Charging / discharging current status bar. Blue color bar to the left means discharging current (negative), orange color bar to the right (positive) means charging or regeneration current.
4	<i>BMS</i> current operation state.
5	<i>BMS</i> last event record from the all <i>BMS Events</i> list 19.

- 6** BMS estimated State-of-Charge (SOC) and State-of-Health value.
- 7** Battery pack voltage is calculated as voltages sum of all battery pack cells connected in series. For correct battery pack voltage calculation the correct *Number of Series Cells* **35** parameter should be set in the *Cell Settings* **29** tab.
- 8** Battery pack current.
- 9** Minimal battery pack cell voltage.
- 10** Maximal battery pack cell voltage.
- 11** BMS onboard NTC temperature sensor temperature value.
- 12** External NTC or Active Multipoint temperature sensor #1 temperature value.
- 13** External NTC or Active Multipoint temperature sensor #2 temperature value.
- 14** *Battery Insider* connection to BMS status. Links to *Device Manager* when mouse clicked.
- 15** *Battery Insider* communication status on *USB-UART TX* and *RX* lines.
- 16** *Battery Insider* version. Links to *Maintenance* **82** tab when mouse clicked.
- 17** *Battery Insider* BMS data logging status. Links to *Log to file* **76** tab when mouse clicked.
- 18** *Battery Insider* current date time.

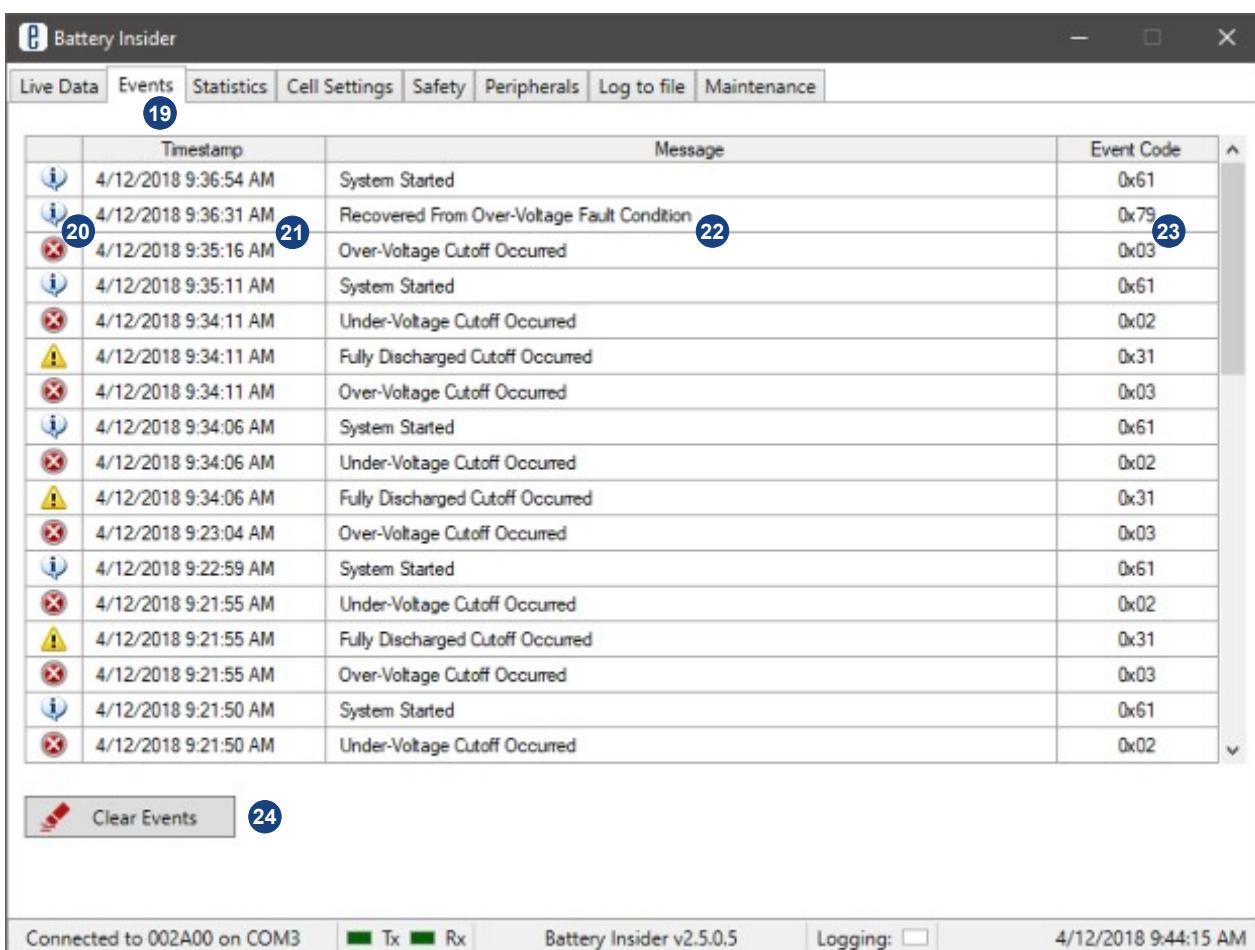


Figure 4.2: Battery Insider BMS Events tab screenshot

Table 4.2: Battery Insider Events tab information

19 BMS Events list tab**20** BMS events types:

- 27** BMS lifetime statistics records values. Statistics records are stored in the BMS non-volatile internal memory and the data is not lost even if the battery has been disconnected from the BMS device.
- 28** BMS Clear Statistics button. *Clear Statistics* button erases all statistics records values from BMS internal memory.

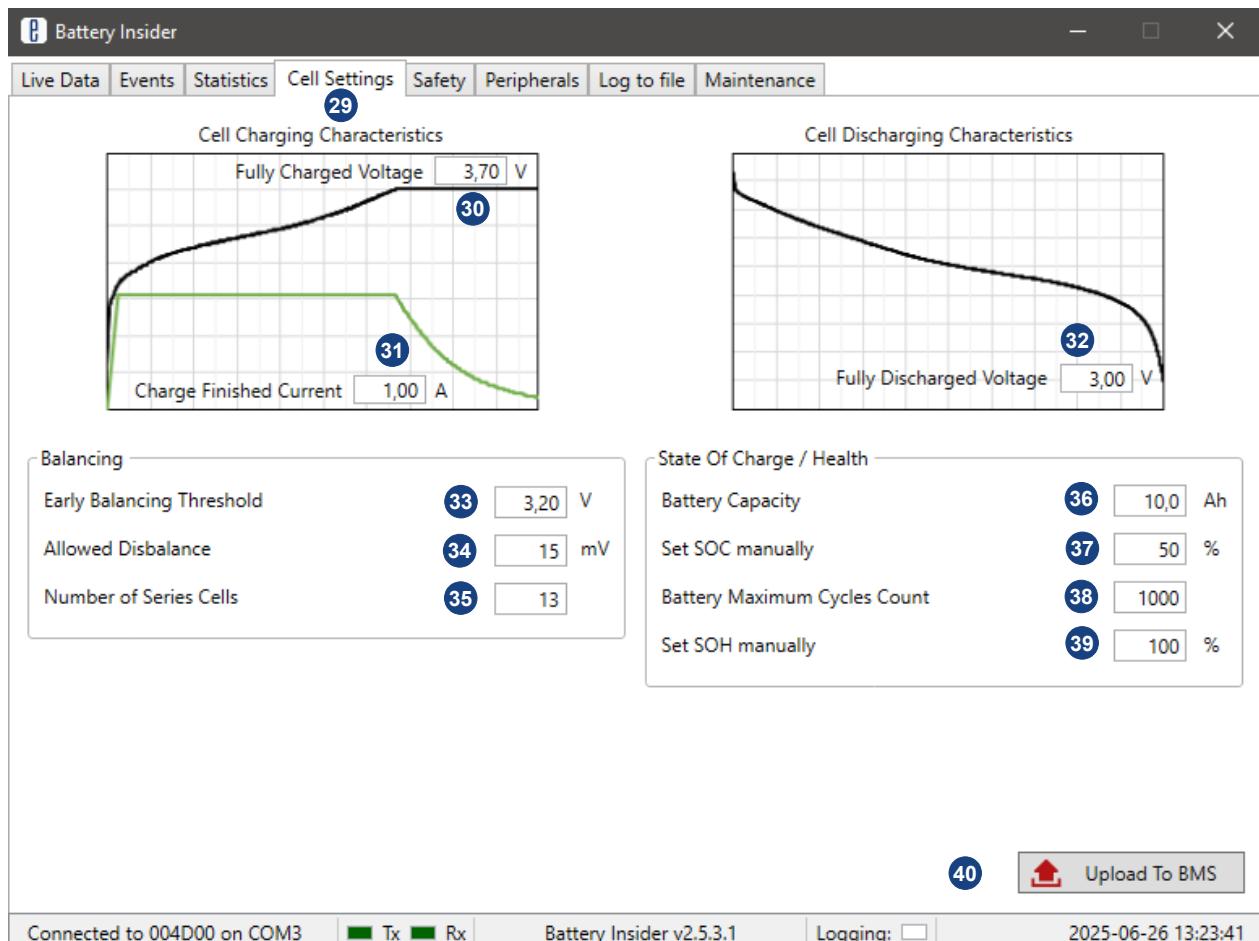


Figure 4.4: Battery Insider BMS Cell Settings tab screenshot

Table 4.4: Battery Insider Cell Settings tab information

29 BMS Cell Settings tab	
30 Fully Charged Voltage:	Min. value – (<i>Fully Discharged Voltage</i> 32 + 10 mV); Max. value – (<i>Over-Voltage Cutoff</i> 42 – 10 mV); Note: <i>Fully Charged Voltage</i> must be always lower than <i>Over-Voltage Cutoff</i> and greater than <i>Fully Discharged Voltage</i> . If the <i>Fully Charged Voltage</i> needs to be set out of range, it is recommended at first set correct <i>Fully Discharged Voltage</i> 32 and <i>Over-Voltage Cutoff</i> 42 thresholds and then set <i>Fully Charged Voltage</i> value in this range.
31 Charge Finished Current	min. and max. values are BMS PCB power type, used current sensor, BMS mode and charger switch type settings dependent.
32 Fully Discharged Voltage:	Min. value – (<i>Under-Voltage Cutoff</i> 43 + 10 mV); Max. value – (<i>Fully Charged Voltage</i> 30 – 10 mV); Note: <i>Fully Discharged Voltage</i> must be always lower than <i>Fully Charged Voltage</i> and greater than <i>Under-Voltage Cutoff</i> . If the <i>Fully Discharged Voltage</i> needs to be set out of range it is recommended at first set correct <i>Fully Charged Voltage</i> 30 and <i>Under-Voltage Cutoff</i> 43 thresholds and then set <i>Fully Discharged Voltage</i> value in this range.

33	<i>Early Balancing Threshold</i> (voltage threshold at which cells starts balancing): Min. value – 1 V; Max. value – 4.5 V.
34	<i>Allowed Disbalance</i> : Min. value – 15 mV; Max. value – 100 mV.
35	<i>Number of Series Cells</i> : Min. value – 4 cells; Max. value – 16 cells.
36	<i>Battery Capacity</i> : Min. value – 0.1 Ah; Max. value – 655 Ah.
37	<i>Set SOC manually</i> : Min. value – 0 %; Max. value – 100 %.
38	Charge/discharge cycles it can handle before its capacity starts to drop significantly
39	<i>Set SOH manually</i> : Min. value – 0 %; Max. value – 100 %.
40	<i>Upload To BMS</i> button writes all changed settings to <i>BMS</i> internal memory. After new settings was successfully uploaded to <i>BMS</i> , <i>Battery Insider</i> reads back from <i>BMS</i> all newest settings information, min. and max. settings values.

Table 4.5: *Battery Insider Safety settings tab* information

41	<i>BMS Safety settings tab</i>
42	<i>Over-Voltage Cutoff</i> : Min. value – (<i>Fully Charged Voltage</i> 30 + 10 mV); Max. value – 4.5 V. Note: <i>Over-Voltage Cutoff</i> must be always greater than <i>Fully Charged Voltage</i> . If the <i>Over-Voltage Cutoff</i> needs to be set out of range it is recommended at first set correct <i>Fully Charged Voltage</i> 30 and then set <i>Over-Voltage Cutoff</i> value in this range.
43	<i>Under-Voltage Cutoff</i> : Min. value – 0.8 V; Max. value – (<i>Fully Discharged Voltage</i> 32 - 10 mV). Note: <i>Under-Voltage Cutoff</i> must be always lower than <i>Fully Discharged Voltage</i> . If the <i>Under-Voltage Cutoff</i> needs to be set out of range it is recommended at first set correct <i>Fully Discharged Voltage</i> 32 and then set <i>Under-Voltage Cutoff</i> value in this range.
44	<i>Discharge Over-Current Cutoff</i> min. and max. values are <i>BMS PCB</i> power type, used current sensor, <i>BMS</i> mode and load switch type settings dependent.
45	The <i>Discharge Over-Current Cutoff</i> timeout defines the maximum time duration that the discharge current is allowed to remain above the configured threshold (<i>Discharge Over-Current Cutoff</i>) before the <i>BMS</i> disconnects the load.
46	The <i>Discharge Peak-Current Cutoff</i> defines the maximum instantaneous current that the battery is allowed to deliver during discharge, regardless of duration. If the discharge current exceeds this peak threshold even momentarily, the <i>BMS</i> will immediately disconnect the discharge circuit to prevent potential damage. <i>Discharge Peak-Current Cutoff</i> value must be higher than <i>Discharge Over-Current Cutoff</i> . While <i>Discharge Over-Current Cutoff</i> handles sustained moderate overcurrent (with an optional timeout). <i>Discharge Peak-Current Cutoff</i> reacts to sharp spikes without any delay.
47	<i>Charge Over-Current Cutoff</i> min. and max. values are <i>BMS PCB</i> power type, used current sensor, <i>BMS</i> mode and charger switch type settings dependent.

48	Over-Heat Cutoff: Min. value – 20 °C; Max. Value – 90 °C.
49	Low Temperature Charger Cutoff: Min. value – -40 °C; Max. Value – 10 °C.
50	Automatic Recovery: Min. value – 0 s (BMS warning / fault state automatic recovery feature disabled); Max. value – 30 s. Note: when BMS automatic recovery function is disabled (zero value in the <i>Automatic Recovery</i> setting), BMS recovers from warning or fault condition only when charger was connected to BMS, BMS was manually restarted, or ignition signal was toggled, if BMS ignition feature was enabled (<i>Ignition</i> 58 setting in the <i>Peripherals</i> 54 tab).
51	Inverted current readings value.
52	Disable or enable load/charger switch diagnostics.
53	<i>Upload To BMS</i> button writes all changed settings to BMS internal memory. After new settings was successfully uploaded to BMS, <i>Battery Insider</i> reads back from BMS all newest settings information, min. and max. settings values.

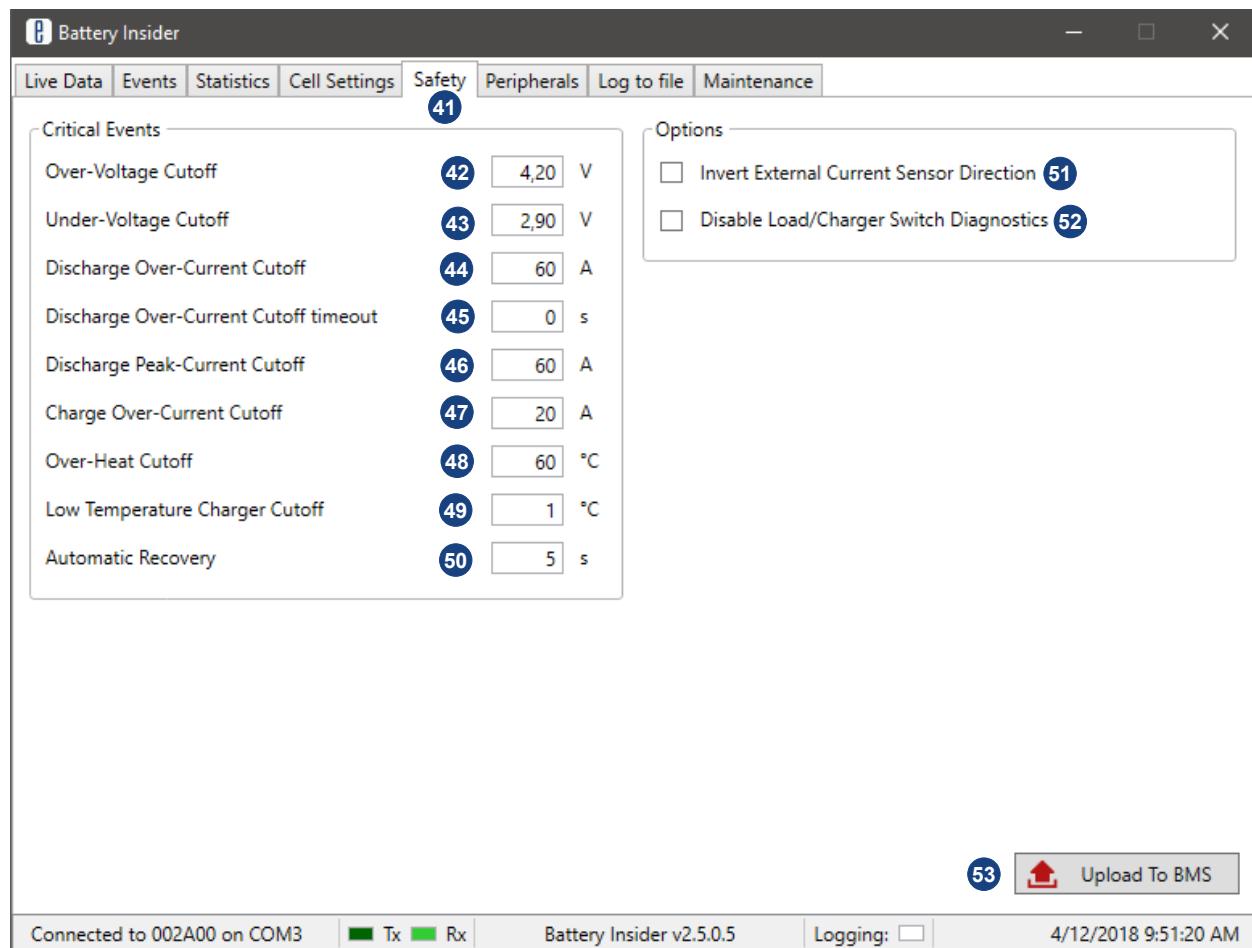


Figure 4.5: Battery Insider BMS Safety settings tab screenshot

Table 4.6: Battery Insider Peripherals settings tab information

54	BMS Peripherals settings tab
55	BMS Operation Mode: <i>Dual Port</i> – Separate switches for load and charger (L- and C- BMS ports);

	<p>Single Port – Same switch for load and charger (only C- BMS port must be used).</p> <p>Note: when BMS mode has been changed and settings successfully uploaded to BMS, it automatically restarts itself and reconnects again with <i>Battery Insider</i>.</p>
56	<p>Single Port Switch Type setting are active and allowed to change only when <i>BMS Mode</i> 55 has been changed to <i>Single Port</i>):</p> <p><i>Internal FET</i> – Only C- BMS port is used (L- BMS port must be left unconnected). <i>Internal FET</i> cannot be selected when <i>Precharge</i> 59 feature has been enabled;</p> <p><i>AIDOx / DIDOx / AIHOx</i> – External output for relay / contactor control (only available on high power 150 A BMS). External relay / contactor must be connected as low side switch. Negative load / charger contact must be connected to relay / contactor together with BMS C- port for internal load / charger detection.</p> <p>Note: External I/O pins <i>AIDOx / DIDOx / AIHOx</i> are active and allowed to change only when pins has not been selected in other settings.</p>
57	<p>Load Switch Type setting are active and allowed to change only when <i>BMS Mode</i> 55 has been changed to <i>Dual Port</i>):</p> <p><i>Discharge FET</i> – L- BMS port. <i>Discharge FET</i> cannot be selected when <i>Precharge</i> 59 feature has been enabled;</p> <p><i>AIDOx / DIDOx / AIHOx</i> – External output for load relay / contactor control (only available on high power 150 A BMS);</p> <p>Note: External I/O pins <i>AIDOx / DIDOx / AIHOx</i> are active and allowed to change only when pins has not been selected in other settings.</p>
58	<p>Ignition feature:</p> <p><i>Disabled</i> – BMS <i>Ignition</i> feature is disabled;</p> <p><i>AIDOx</i> – Ignition feature enabled (low power 30 A BMS).</p> <p><i>AIDOx / DIDOx / AIHOx</i> – <i>Ignition</i> feature enabled (high power 150 A BMS).</p> <p><i>Ignition on</i> – High logic level on selected <i>AIDOx / DIDOx / AIHOx</i> input pin!</p> <p><i>Ignition off</i> – Low logic level on selected <i>AIDOx / DIDOx / AIHOx</i> input pin!</p> <p>Note: External I/O pins <i>AIDOx / DIDOx / AIHOx</i> are active and allowed to change only when pins has not been selected in other settings.</p>
59	<p>Precharge feature only available for high power 150 A BMS:</p> <p><i>Disabled</i> – BMS load <i>Precharge</i> feature is disabled;</p> <p><i>Discharge FET</i> – Option is inactive and is not allowed when <i>Discharge FET</i> has been selected as <i>Load Switch Type</i> 57 or <i>Charge FET</i> has been selected as <i>Charger Switch Type</i> 70 or <i>Single Port</i> has been selected as <i>BMS Mode</i> 55;</p> <p><i>AIDOx / DIDOx / AIHOx</i> – External output pin for load precharge control.</p> <p>Note: External I/O pins <i>AIDOx / DIDOx / AIHOx</i> are active and allowed to change only when pins has not been selected in other settings.</p>
60	<p>Precharge Duration:</p> <p>Possible values are 0.1 s, 0.2 s, 0.5 s, 1.0 s, 2.0 s, 3.0 s, 4.0 s.</p>
61	<p>Speed Sensor Input:</p> <p><i>Disabled</i> – BMS speed calculation feature is disabled;</p> <p><i>DIDOx</i> – BMS speed calculation feature is enabled.</p> <p>Note: External I/O pins <i>DIDOx</i> are active and allowed to change only when pins has not been selected in other settings.</p>
62	<p>Distance Unit:</p> <p>Possible values are <i>Meters</i>, <i>Kilometers</i>, <i>Feet</i>, <i>Miles</i>, <i>Yards</i>.</p>
63	<p>Pulses Per Unit:</p> <p><i>Battery Insider</i> automatically recalculates entered value, min. and max. thresholds according to selected <i>Distance Unit</i> 62 parameter.</p>
64	<p>Broadcast Protocol:</p> <p><i>CA V3</i> – Used to communicate with <i>Ebike Analyzer Android App</i>;</p> <p><i>ASCII</i> – Used to broadcast main BMS data in text format;</p> <p><i>SOC BAR</i> – Used to communicate with <i>LED SOC-BAR</i> indicator.</p>
65	<p>Broadcast:</p>

	<p><i>Disabled</i> – BMS data broadcast disabled; 0.1 s - 10.0 s – BMS data broadcast enabled. Note: Broadcast values 0.1 s - 0.5 s are not allowed when SOC BAR has been selected as broadcast Protocol 64.</p>
66	<p>Charger Type: Currently only <i>Generic CC/CV</i> charger type is supported and can be selected.</p>
67	<p>Charger Detection feature: <i>Internal</i> – BMS internal charger detection; <i>AIDOx / DIDOx / AIHOx</i> – External input pin for charger detection. <i>Charger connected state</i> – High logic level on selected <i>AIDOx / DIDOx / AIHOx</i> input pin! <i>Charger disconnected state</i> – Low logic level on selected <i>AIDOx / DIDOx / AIHOx</i> input pin! Note: External I/O pins <i>AIDOx / DIDOx / AIHOx</i> are active and allowed to change only when pins has not been selected in other settings.</p>
68	<p>The Charger Startup Delay defines the maximum amount of time the BMS will wait for charging current to begin after detecting a charger connection. If no charging current is detected within this period, the BMS will turn off the charge FET, effectively disconnecting the charger from the battery.</p> <p>Example Operation-(Charger Startup Delay = 20 sec)</p> <ul style="list-style-type: none">- Charger is connected (BMS detects voltage at input).- BMS enables charge FET and waits up to 20 seconds.- If charging current is detected → normal charging continues.- If no current flows for 20 seconds → charge FET is turned OFF. <p>Note: You can tune this delay based on how long your charger typically takes to initialize and deliver current after connection.</p>
69	<p>The Charger Disable Delay defines the amount of time the BMS waits before disabling the charger circuit after the charger has been unplugged (i.e., charger presence signal is lost). When the charger is detected, the BMS enables the charge circuit.</p> <ul style="list-style-type: none">- If the charger is then unplugged, the BMS does not immediately turn off the charge FET. Instead, it waits for the Charger Disable Delay duration (e.g., 5 seconds).- If the charger is reconnected within this time, charging resumes uninterrupted.- If the charger remains disconnected after the delay expires, the BMS disables the charging path.
70	<p>Charger Switch Type setting are active and allowed to change only when <i>BMS Mode</i> 55 has been changed to <i>Dual Port</i>): <i>Charge FET</i> – C- BMS port. <i>Charge FET</i> cannot be selected when <i>Precharge</i> 59 feature has been enabled; <i>AIDOx / DIDOx / AIHOx</i> – External output for load relay / contactor control (only available on high power 150 A BMS); Note: External I/O pins <i>AIDOx / DIDOx / AIHOx</i> are active and allowed to change only when pins has not been selected in other settings.</p>
71	<p>The Charge Restart Level defines the minimum State of Charge (SoC) at which the BMS will automatically re-enable charging after it has been disabled due to full charge conditions. This setting applies only when the charger remains continuously connected to the system.</p> <p>When "Enable Charger Restart Level" is Checked:</p> <ul style="list-style-type: none">- Restart is based on SoC- Charging is paused once the SoC reaches 100%.- Charging resumes automatically only after SoC drops below the configured restart threshold, e.g., 90%. <p>When "Enable Charger Restart Level" is Not Checked-</p> <ul style="list-style-type: none">- The BMS does not monitor SoC for restart.- Once charging is disabled due to full charge, it waits until the battery self-discharges significantly to the Fully Discharge Voltage parameter — before charging resumes.- This allows the battery to fully discharge before recharging begins again.
72	<p>Charge Restart Level:</p>

Min. value – 60%; Max. Value – 95%.
<p>73 Temperature Sensor Type: <i>Dual 10K NTC Sensor</i> – One NTC temperature sensor on each BMS temperature channels can be connected. Supported NTC sensor 10 K @ 25 °C, Beta value 3977 K; <i>Multipoint Active Sensor</i> – Special Enepaq Multipoint Active NTC temperature sensor for max. temperature detection.</p>
<p>74 External Current Sensor Type.</p>
<p>75 <i>Upload To BMS</i> button writes all changed settings to BMS internal memory. After new settings was successfully uploaded to BMS, <i>Battery Insider</i> reads back from BMS all newest settings information, min. and max. settings values.</p>

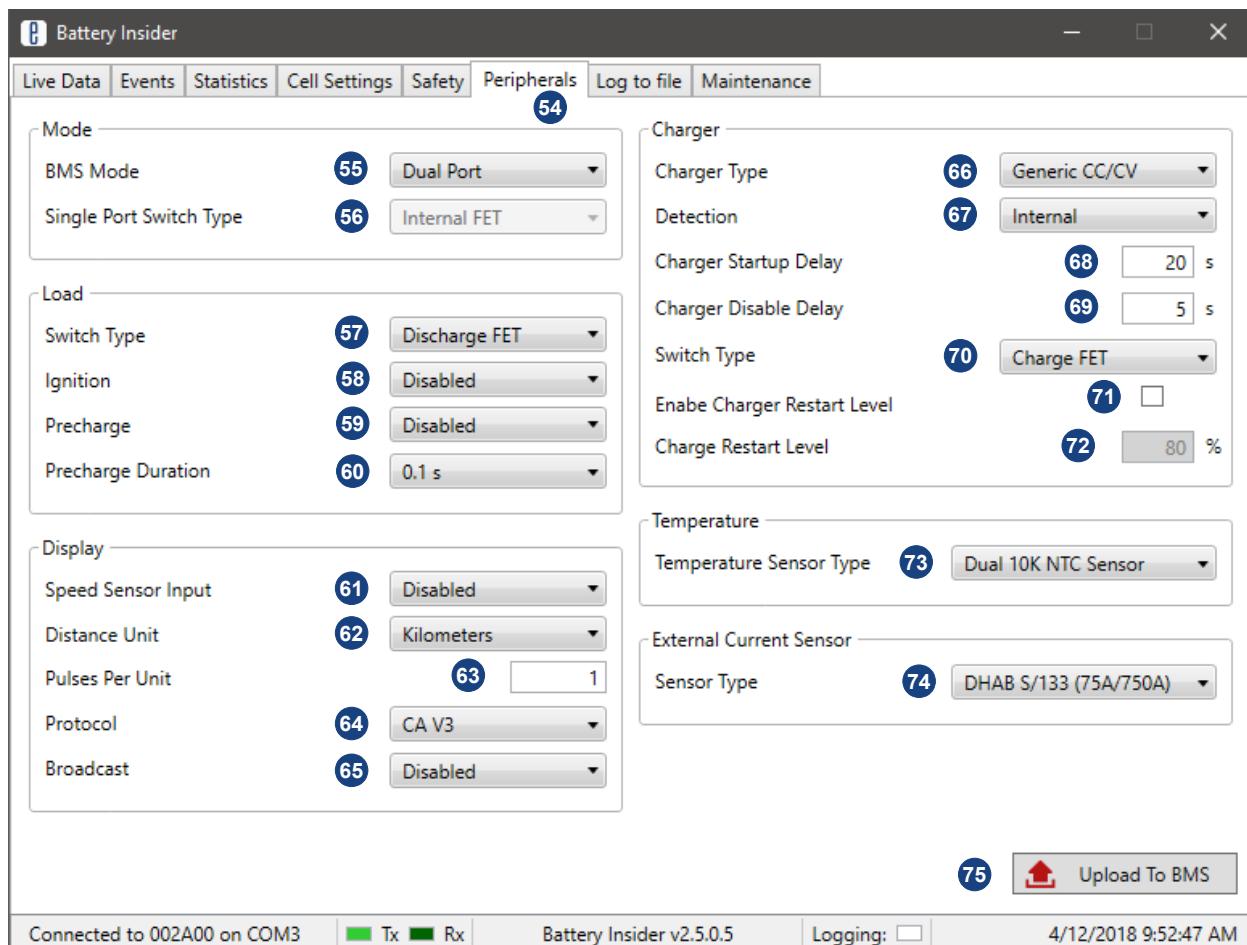


Figure 4.6: Battery Insider BMS Peripherals settings tab screenshot

Table 4.7: Battery Insider Log to file settings tab information

76	BMS Log to file settings tab
77	BMS data which will be included in the log file.
78	Logging time interval. Min. value – 1 s; Max. value – 3600 s.
79	Log file size: Min. value – 2 MB; Max. value – 1024 MB.
80	Start logging from file beginning when file size exceeds max. file size.

- 81 Start / Stop logging.

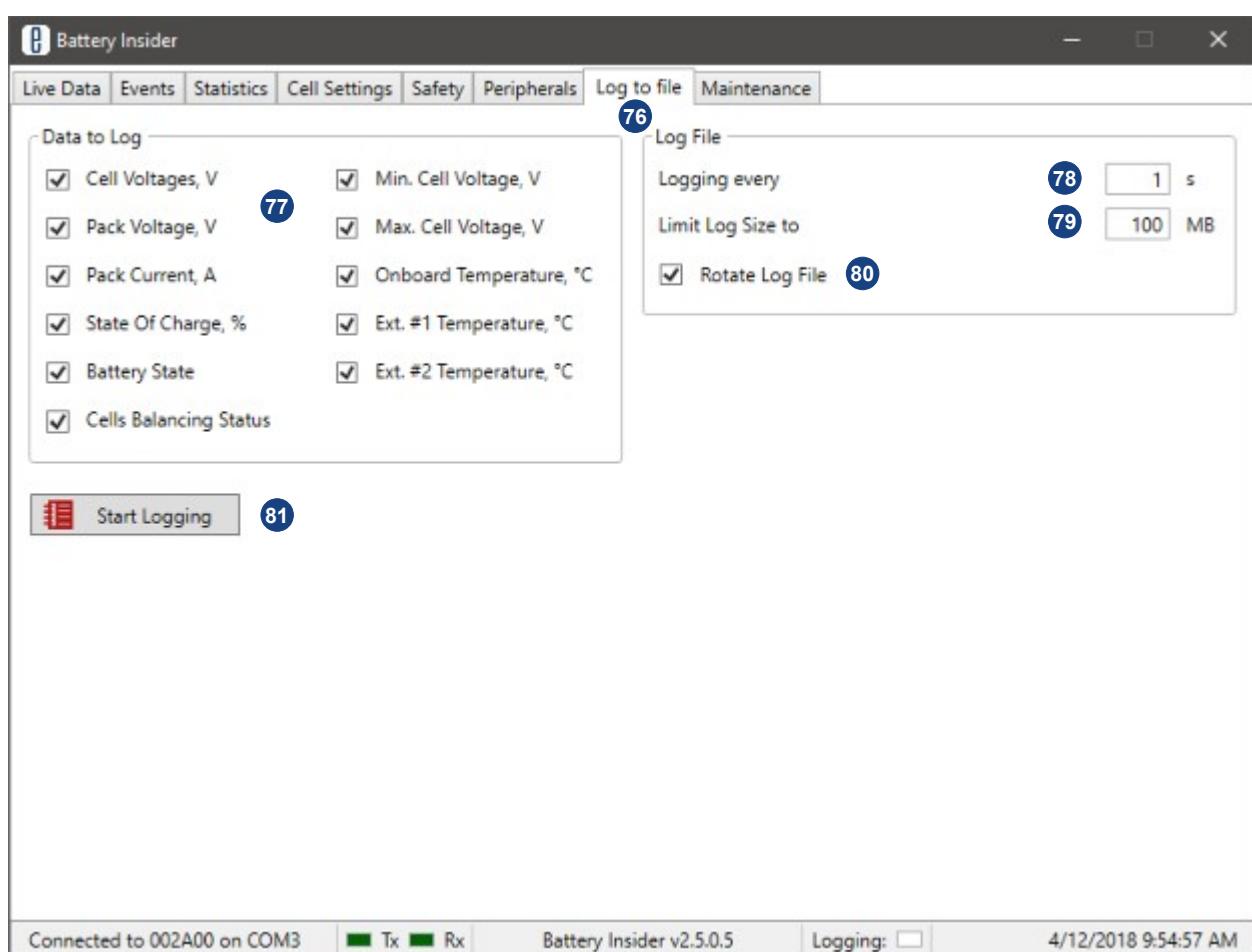


Figure 4.7: Battery Insider Log to file settings tab screenshot

Table 4.8: Battery Insider Maintenance tab information

82	BMS Maintenance tab
83	Load BMS settings from configuration file.
84	Save BMS settings to configuration file.
85	Upload Configuration To BMS button writes all settings to BMS internal memory. After new settings was successfully uploaded to BMS, Battery Insider reads back from BMS all newest settings information, min. and max. settings values.
86	Load / Save / Upload BMS configuration settings status.
87	BMS safe system restart button. BMS restart is required after an external current sensor was connected or disconnected, to recover BMS from incorrect state (e.g. Under-Voltage Fault after the initial connection of the cells), after BMS firmware malfunction occurred.
88	BMS firmware update button.
89	Firmware update status.
90	Current Battery Insider version.
91	BMS firmware version.
92	BMS hardware version.
93	BMS product version
94	BMS hardware serial number.

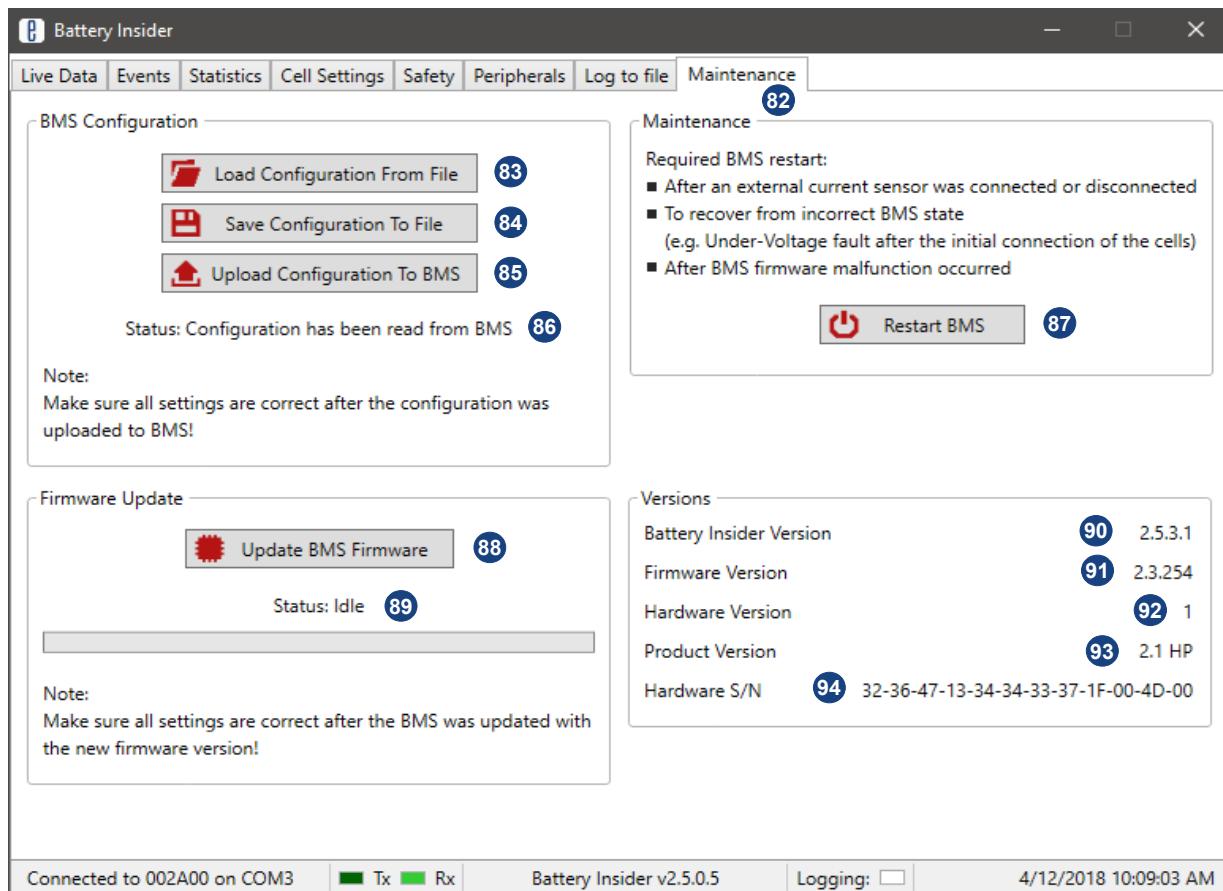


Figure 4.8: Battery Insider Maintenance tab screenshot

4.2. Battery Insider communication settings

The key feature of the *Battery Insider* and the *Tiny BMS* is that there is no need to configure any communication parameters on the *Battery Insider* side. The *Enepaq USB-UART* cable is based on genuine *Silicon Labs CP2102* chipset and all recent *Windows* operating system already include the drivers, therefore the cable will work straight away. However, if there is a problem, download a driver version that is confirmed as compatible from *Enepaq* website, or alternatively, driver can be downloaded directly from *Silicon Labs* support website, just make sure to get v6.73 or later and running on at least *Windows 7* OS. When the cable is connected, it will appear as a virtual COM port and the *Battery Insider* will connect to it automatically. Communication between *BMS* device and *Battery Insider* using *USB-UART* cable is always ongoing, even, if the *BMS* is in deep sleep mode, the *Battery Insider* will wake up the device. More attention should be taken, if the bluetooth connection is used between *Tiny BMS* and *Battery Insider*. First of all bluetooth module must be connected to the *Tiny BMS* and the *BMS* must be in active state (in sleep mode bluetooth module is not working due to its internal 5 V shutdown). This means, that charger or load should be connected to wakeup the device from sleep mode, or alternatively, *Ignition* feature must be enabled before, using *USB-UART* cable. Once the *BMS* device is in active state and its bluetooth module is up and running, the *Tiny BMS* bluetooth module should be paired on the *PC* side (*Enepaq* bluetooth module pin code is always 0516). After the *PC* and *Tiny BMS* is successfully paired, only then the *Battery Insider* application can be launched and it will automatically finds the bluetooth virtual COM port and connects to it.

Note: Keep in mind, that using bluetooth connection *Battery Insider* may require much more time to find the correct virtual COM port and connect to *Tiny BMS* device. Besides, to update BMS firmware using

Bluetooth communication is not possible at the moment.

When the *Battery Insider* successfully connects to the *Tiny BMS* device, the connection status is displayed in the lower left corner of the *Battery Insider* application window (Figure 4.9).

Connected to 002A00 on COM3 Tx Rx

Figure 4.9: *Battery Insider* connection status

4.3. *Battery Insider* cell settings

The correct order of setting the battery and cells parameters would be at first adjust the settings under *Balancing* and *State of Charge* group boxes in the *Cell Settings* tab of the *Battery Insider* (Figure 4.10). Upload the settings to the *Tiny BMS*. Then on *Safety* tab adjust the cells critical parameters *Over-Voltage Cutoff* and *Under-Voltage Cutoff*. Upload the settings again to the device. Only then go back to *Cell Settings* tab and adjust *Fully Charged Voltage* and *Fully Discharged Voltage* parameters accordingly. These settings has a relationship *Under-Voltage Cutoff* < *Fully Discharged Voltage* < *Fully Charged Voltage* < *Over-Voltage Cutoff* and the *Battery Insider* will not allow the user to set these values in any other way which would contradict that parameters relationship.

Step 1

Balancing

- Early Balancing Threshold: 3.20 V
- Allowed Disbalance: 15 mV
- Number of Series Cells: 13

Step 2

State of Charge

- Battery Capacity: 10.0 Ah
- Set SOC manually: 50 %

Step 3

Critical Events

- Over-Voltage Cutoff: 4.20 V
- Under-Voltage Cutoff: 2.90 V

Step 4

Upload To BMS

Step 5

Cell Charging Characteristics

Fully Charged Voltage: 4.00 V

Charge Finished Current: 1.00 A

Step 6

Cell Discharging Characteristics

Fully Discharged Voltage: 3.00 V

Step 7

Upload To BMS

Figure 4.10: *Battery Insider* cell settings configuration sequence

4.4. *Battery Insider* peripherals and safety settings

Some *Tiny BMS* safety parameters such as all over-current settings depends on configured peripherals and current sensor used: *BMS* operation mode, *Load Switch Type*, *Charger Switch* or *Single Port Switch Type* parameters. These main parameters are located under *Mode*, *Load* and *Charger* group boxes in the *Peripherals* tab of the *Battery Insider*. When *Tiny BMS* is used in the high current applications where

relays / contactors should be used and it is needed to set over-current thresholds at a much higher level, it can be done only by setting *Load Switch / Charger Switch* as external I/O pins and properly connecting the external current sensor at first. Only then *Battery Insider* allows the user to set higher overcurrent limits. The recommended way to adjust *Tiny BMS* peripherals and safety settings is shown in Figure 4.11. How to properly connect and configure *Tiny BMS* external current sensor refer to the next chapter.

Note: When *BMS* mode has been changed and settings successfully uploaded to *BMS*, it automatically restarts itself and automatically reconnects again with the *Battery Insider*.

The screenshot shows a step-by-step configuration process for the *Battery Insider*:

- Step 1:** Mode settings. BMS Mode is selected, and Step 1 is set to "Dual Port" with "Internal FET".
- Step 2:** "Upload To BMS" button.
- Step 3:** Load settings. Includes "Switch Type" (Discharge FET), "Ignition" (DIDO1), "Precharge" (Disabled), and "Precharge Duration" (0.1 s).
- Step 4:** Charger settings. Includes "Charger Type" (Generic CC/CV), "Detection" (Internal), and "Switch Type" (Charge FET).
- Step 5:** "Upload To BMS" button.
- Step 6:** Safety settings. Includes "Discharge Over-Current Cutoff" (2 A), "Charge Over-Current Cutoff" (2 A), "Over-Heat Cutoff" (60 °C), "Low Temperature Charger Cutoff" (1 °C), and "Automatic Recovery" (5 s).
- Step 7:** Cell Charging Characteristics graph. Shows a curve with "Fully Charged Voltage" at 4.00 V and "Charge Finished Current" at 1.00 A.
- Step 8:** "Upload To BMS" button.

Figure 4.11: *Battery Insider* peripheral and safety settings configuration sequence

4.5. *Tiny BMS LEM* external current sensor configuration

External current sensor can be connected only to the 150 A high power *Tiny BMS* hardware version. Current sensor is the essential component of the battery application, therefore due to the safety reasons there is an important sequence how to connect and use *LEM* external current sensor.

4.5.1. External current sensor connection sequence:

After *Tiny BMS* power up or restart, if the external current sensor is not connected yet, an internal *BMS* HALL current sensor is used. Allowed battery charging and discharging as usual. After the external current sensor was connected, the *BMS* generates event on connected sensor *External Current Sensor Connected (BMS restart required)* (0x0F). After this event, the *BMS* needs to be restarted (Figure 4.12). After restarting, an external current sensor will be used to measure current. If, after connecting an external current sensor, it is disconnected again and *BMS* is not restarted, *BMS* generates event *External Current*

Sensor Disconnected (0x7D). In this case, the internal *HALL* current sensor is used as before and no *BMS* restart action is required.

	Timestamp	Message	Event Code
	7/19/2018 4:14:23 PM	External Current Sensor Connected (BMS restart required)	0x0F
	7/19/2018 4:14:11 PM	System Started Step 1	0x61

Maintenance

Required BMS restart:

- After an external current sensor was connected or disconnected
- To recover from incorrect BMS state
(e.g. Under-Voltage fault after the initial connection of the cells)
- After BMS firmware malfunction occurred

Step 2 Restart BMS

Figure 4.12: External current sensor connection sequence

4.5.2. External current sensor disconnection sequence:

After external current sensor was disconnected from the *BMS* device, it generates the event *External current sensor Disconnected (BMS restart required) (0x0E)*. The *BMS* switches to the fault state, the battery charging and discharging is restricted (*Load Switch*, *Charger Switch*, or *Single Port Switch* is turned off). *BMS* generates an audible signal to alert the user about the lost current sensor connection. To confirm that external current sensor is unused and needs to be disconnected the user must restart the *BMS* (Figure 4.13). After the *BMS* is restarted, the internal *HALL* current sensor is used again to measure the current. When the external current sensor is disconnected, but the *BMS* is not restarted and the external current sensor is reconnected again, the *BMS* automatically goes out of the fault state, the event *External Current Sensor Connected (0x7C)* is generated and the current measurement is continued using an external current sensor.

	Timestamp	Message	Event Code
	7/19/2018 4:28:14 PM	External Current Sensor Disconnected (BMS restart required)	0x0E
	7/19/2018 4:27:59 PM	System Started Step 1	0x61

Maintenance

Required BMS restart:

- After an external current sensor was connected or disconnected
- To recover from incorrect BMS state
(e.g. Under-Voltage fault after the initial connection of the cells)
- After BMS firmware malfunction occurred

Step 2 Restart BMS

Figure 4.13: External current sensor disconnection sequence

4.6. Tiny BMS configuration to use with Ebike Analyzer android application

To use *Tiny BMS* with *Ebike Analyzer* android application *Enepaq* bluetooth adapter is needed. *BMS* device must stay in the active mode to establish connection to *Ebike Analyzer* application. For that purpose it is highly recommend to use the *Tiny BMS Ignition* feature, otherwise the charger or load should be connected to the *BMS* to keep the device in active state. Therefore, at first time *Tiny BMS* must be configured using *USB-UART* cable and the *Battery Insider* windows application and then *USB-UART* cable replaced by the bluetooth module. In the *Battery Insider* the *Ignition* feature, CA V3 broadcast protocol and duration, and *Speed Sensor Input* feature (*Ebike Analyzer* can show the vehicle speed value) should be enabled and

configured properly (Figure 4.14). On the android device side, before launching *Ebike Analyzer* application for the first time, the android device must be properly paired with the *Tiny BMS* (*Enepaq* bluetooth module pin code is always 0516). Once, pairing completed successfully and bluetooth connection is established, after launching the *Ebike Analyzer* application the connection status on the top left of the screen should be *Connected* and all battery parameters should be displayed on the dashboard. Next time the *Ebike Analyzer* app can be launched directly skipping the pairing process.

The configuration interface is divided into two main sections: **Load** and **Display**.

- Load:**
 - Switch Type: Discharge FET
 - Ignition: DIDO1 (Step 1)
 - Precharge: Disabled
 - Precharge Duration: 0.1 s
- Display:**
 - Speed Sensor Input: DIDO2 (Step 2)
 - Distance Unit: Kilometers
 - Pulses Per Unit: 1000
 - Protocol: CA V3 (Step 3)
 - Broadcast: 0.2 s (Step 4)

At the bottom, there is a large blue button labeled **Step 5** with an upward arrow icon and the text **Upload To BMS**.

Figure 4.14: Tiny BMS configuration to use with Ebike Analyzer application

4.7. Tiny BMS configuration to use with SOC-BAR indicator

To use the *Tiny BMS* device with the *Enepaq* SOC-BAR LED indicator it is required to configure SOC BAR broadcast protocol and the broadcast duration to 1 second or a higher value (Figure 4.15). SOC-BAR LED indicator is working only when *BMS* is in active state, otherwise indicator is kept shutdown. SOC-BAR LED indicator represents the *Tiny BMS* estimated battery pack State-Of-Charge level. SOC-BAR indicator scale: one line corresponds to 10 % of SOC vale, but some rows are hardware level grouped by two, therefore when SOC level falls below 90 % - the top row goes out, when it falls below 70 % - 3 rows goes out, when it falls below 50 % - 5 rows goes out, when it falls below 40 % - 6 rows goes out, 30 % - 7 rows goes out, below 20 % - 8 rows goes out, below 10 % - the bottom two rows starts to blink. When SOC level drops to 0 % level, the SOC-BAR indicator shuts down.

The configuration interface is divided into two main sections: **Display**.

- Display:**
 - Speed Sensor Input: DIDO2
 - Distance Unit: Kilometers
 - Pulses Per Unit: 1000
 - Protocol: SOC BAR (Step 1)
 - Broadcast: 1.0 s (Step 2)

At the bottom, there is a large blue button labeled **Step 3** with an upward arrow icon and the text **Upload To BMS**.

Figure 4.15: Tiny BMS SOC-BAR indicator configuration

4.8. Tiny BMS temperature sensor configuration

When 10 K @ $25\text{ }^{\circ}\text{C}$ (*Beta* value 3977 K) NTC thermistors are used, the *Temperature Sensor Type* parameter should be configured to *Dual 10K NTC Sensor*. Otherwise, *Multipoint Active Sensor* value should be configured when *Enepaq* multipoint sensors available in the *Enepaq Cell Modules* are used.

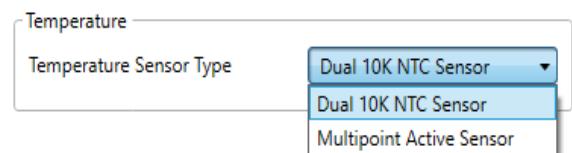


Figure 4.16: Tiny BMS temperature sensor configuration

Chapter 5: Tiny BMS maintenance

5. Introduction

This section contains information and step-by-step guides on how to perform certain *Tiny BMS* maintenance operations. These operations cover battery pack data logging, firmware update, *BMS* restart, etc.

5.1. Battery Insider live BMS data logging

Battery Insider can log basic *Tiny BMS* and battery live data values to a file, which is useful to monitor and analyze the battery processes like charging and discharging and determine battery behavior in different conditions. Also it is very useful to determine some problems of the *BMS* or the battery application itself, when the system malfunction or the unforeseen behavior has been occur. Unfortunately, due to the lack of the *Tiny BMS* internal memory, the data logging is only available until *Tiny BMS* is directly connected to the *Battery Insider* application through *USB-UART* or bluetooth interface. The user can choose which *BMS* and battery data to log. The log file is created in the same directory from which the *Battery Insider* application was launched. How to control *Battery Insider* logging feature is shown in Figure 5.1.

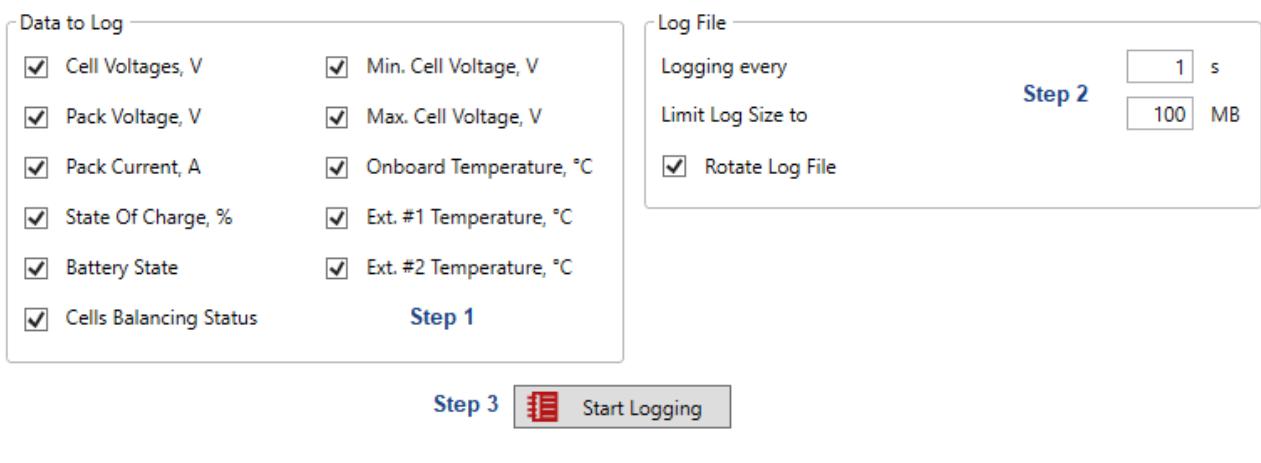


Figure 5.1: Battery Insider data logging control

5.2. Tiny BMS device restarting

Tiny BMS device can be restarted in a safe way during operation when the system malfunction has been occurred using the *Battery Insider* application or *Enepaq* proprietary communication commands via *UART*,

bluetooth or CAN bus interfaces. Take a note that the CAN bus and bluetooth connection does not work when the BMS is in sleep mode, so BMS device restarting with CAN bus or bluetooth connection is possible only with the device in active mode. Before restarting process *Tiny BMS* device turns off *Load* and *Charger Switches (Dual Port mode)*, or *Single Switch (Single Port mode)*, saves all settings, records and events and after the restart operation is completed all modules and peripherals are reinitialized again. *Tiny BMS* also recalibrates the current sensor after restarting. Besides, there are several cases where the restart of the *Tiny BMS* device is highly recommended or even desirable. For example, to recover from incorrect *BMS* state, which occurs after the initial connection of the cells or after an external current sensor was connected or disconnected. The restart button is located in the *Maintenance* tab of the *Battery Insider* (Figure 5.2). How to restart the *Tiny BMS* device using *Enepaq* communication commands refer to *Tiny BMS communication protocols* documentation.

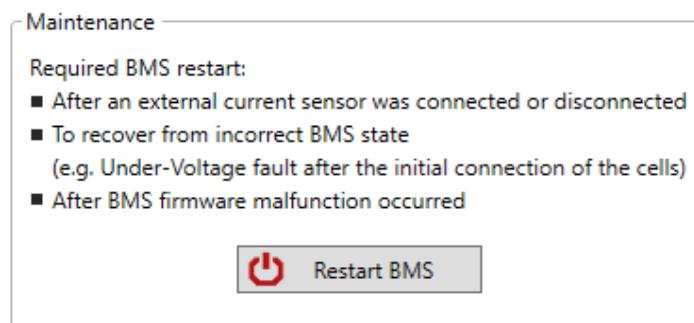


Figure 5.2: *Tiny BMS* restarting feature

5.3. *Tiny BMS* importing and exporting settings

Both export and import *Tiny BMS* settings options can be reached from *Battery Insider* *Maintenance* tab (Figure 5.3). Special care must be taken, when loading settings from file, especially when different *Tiny BMS* power versions or different 150 A high power *Tiny BMS* configurations are used, because some of the parameters are dependent on different control configurations (internal FETs or external relays / contactors) and current sensor used. It is highly recommended to double check the settings, loaded from file, before directly uploading these settings to *Tiny BMS* device.

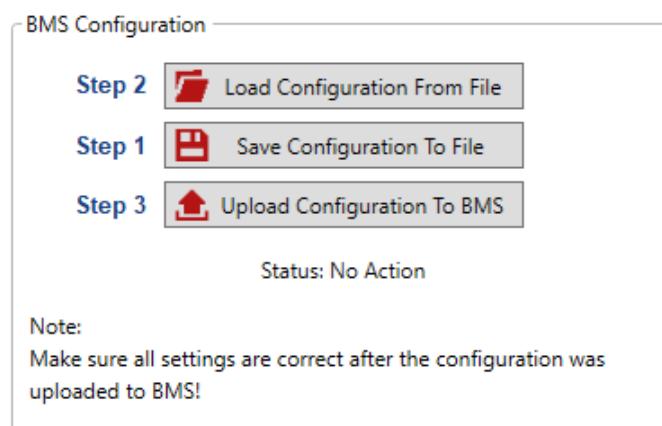


Figure 5.3: *Battery Insider* importing and exporting *Tiny BMS* settings

5.4. Tiny BMS firmware update

In order to ensure that *Tiny BMS* would have all the latest features and bug-fixes, it is recommended to periodically check the *Tiny BMS* firmware release notes online at <https://enepaq.com> and perform firmware update procedure. The firmware image can be downloaded upon request. However, firmware update procedure also can be revert back to an older firmware version if necessary. Officially, for use with the *v2.5.3.0 Battery Insider* version, described in this document, and later versions, the *v2.3.254* or higher *Tiny BMS* firmware versions are recommended. *Tiny BMS* firmware image is an *Enepaq* proprietary encrypted binary file with the extension *.bms*. Normally, in most cases during firmware update process all the *Tiny BMS* settings are saved in the internal non-volatile memory and after the update process is completed successfully, all settings are restored. When the firmware update process fails or the *Tiny BMS* is updated to the out of date or unsupported firmware version, the settings are set to factory defaults values. Therefore, it is highly recommended to save all the settings to the file, that tey can be restored in case of an error. If the firmware update process fails to complete successfully, *Tiny BMS* device enters the bootloader mode and the update process can be restarted again. In this case it is recommended to close the *Battery Insider* application and launch it again to be able to detect *Tiny BMS* device trapped in the bootloader mode (Figure 5.5).

Note: Before selecting desired *Tiny BMS* firmware file in the opened *Update BMS Firmware* dialog of the *Battery Insider* make sure, that firmware file is unzipped and the extension is *.bms* (Figure 5.4).

Note: It is unsafe to leave the *Tiny BMS* device trapped in the bootloader mode for a longer period of time connected to the battery, because it can drain the battery.

Note: The same *Battery Insider* application can be used to update the *Enepaq UART-CAN* converter firmware. Just connect *UART-CAN* module to a *PC* using *Enepaq USB-UART* cable, wait for connection with *Battery Insider*. After *Battery Insider* detects connected module, the update process can be started. Special care must be taken in order to avoid the situation when *UART-CAN* module and *Tiny BMS* device firmware versions are swapped. In this case, the *Tiny BMS* device or *UART-CAN* converter can be damaged permanently.

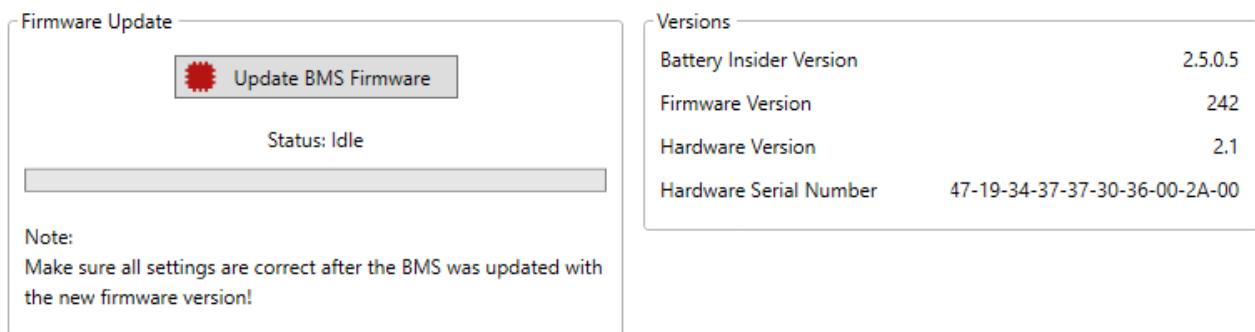


Figure 5.4: *Battery Insider* firmware update dialog

Status	
Current State	In Bootloader
Last Event	-
State Of Charge	-
Pack Voltage	-
Pack Current	-

Figure 5.5: *Tiny BMS* trapped in the bootloader after the failed update process