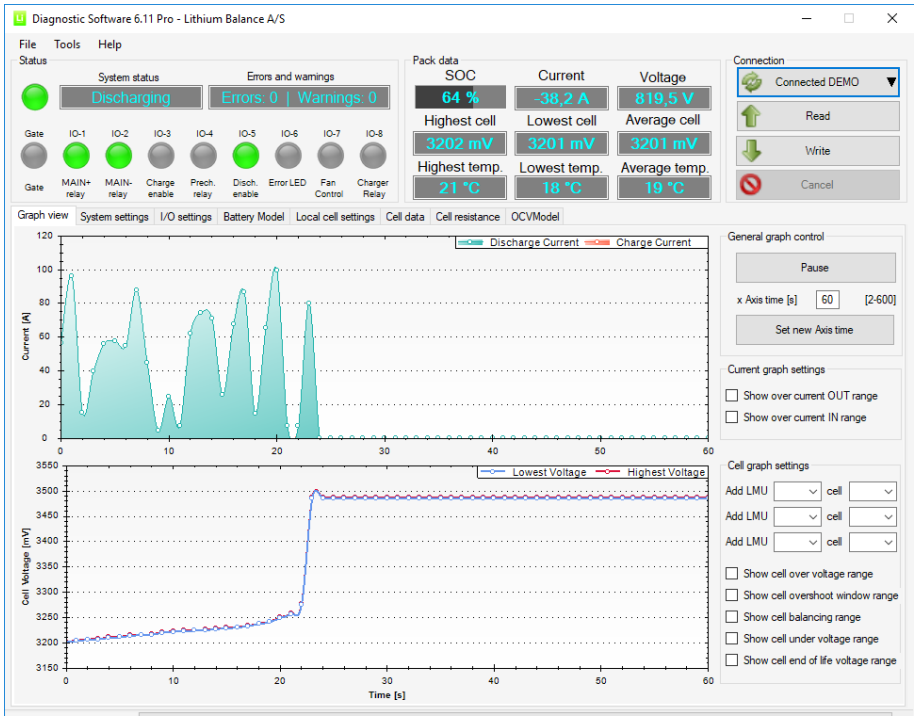


PC Configuration toolbox

LIBAL S-BMS PRO

LiBAL s-BMS PRO™ content

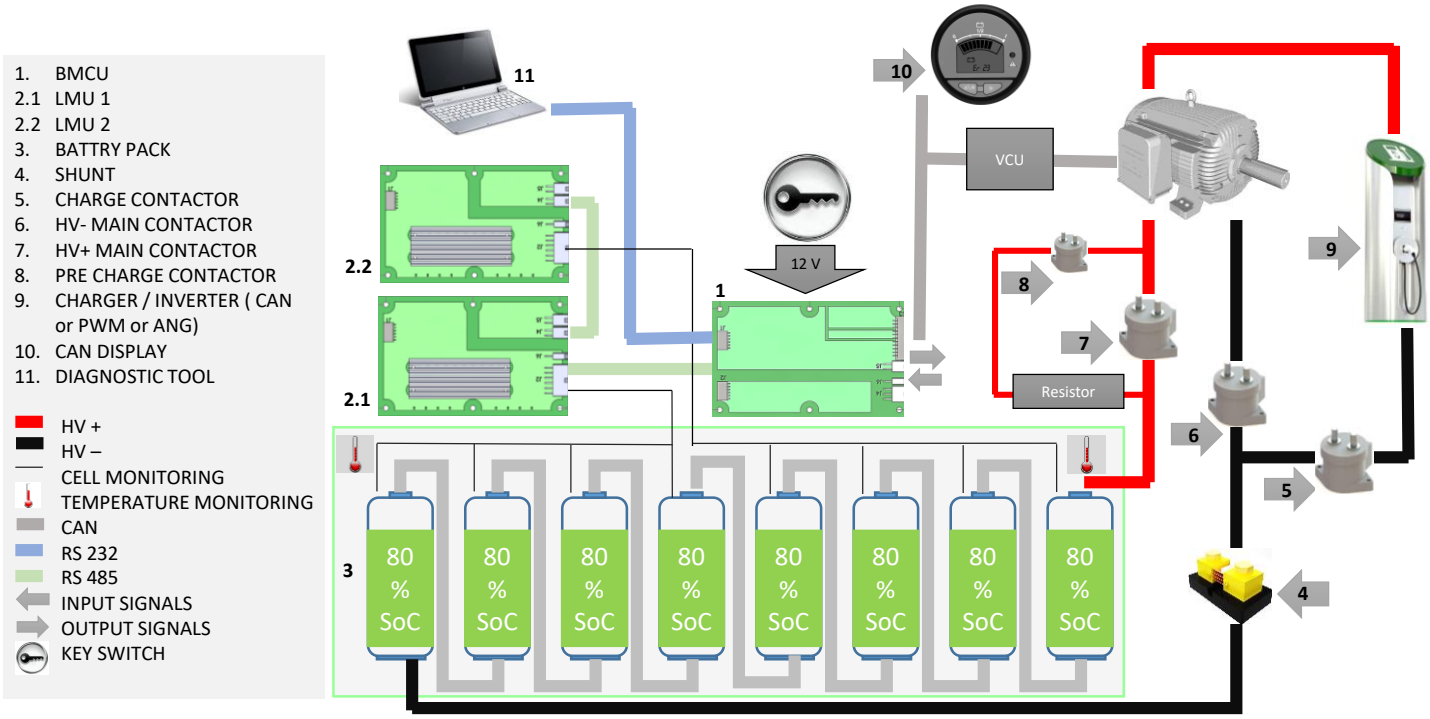
- Connection
- System architecture
- Basic functions in **LiBAL s-BMS PRO™** (Functions only available in read mode in **LiBAL s-BMS SERVICE™**)
  - Cell management
  - Current monitoring
  - Temperature monitoring
  - Cell balancing
  - Charger control
  - Charger interface
  - PWM and analog ports
  - SOC calculation
  - SOH estimation
  - Battery model
  - I/O ports
  - CAN bus
  - CAN configuration
  - Errors and warnings
  - AUTO-off Function
  - Product Support
- Basic functions in **LiBAL s-BMS PRO™ and LiBAL s-BMS SERVICE™**
  - Diagnostics
  - Configuration management
  - Bootload
  - Battery Lifetime diagnostics
  - Service entry
  - Logging

PC Connection

- The s-BMS PC toolbox license is supplied as a ”Softkey” that contains both licence key and the PC software
- The softkey is locked to a licensed PC.
- Along with the PC software tool 5 hours of application support is offered free of charge (remote)
- The connection to the PC is done via RS232 and the package contain a robust and proven USB/RS232 converter:

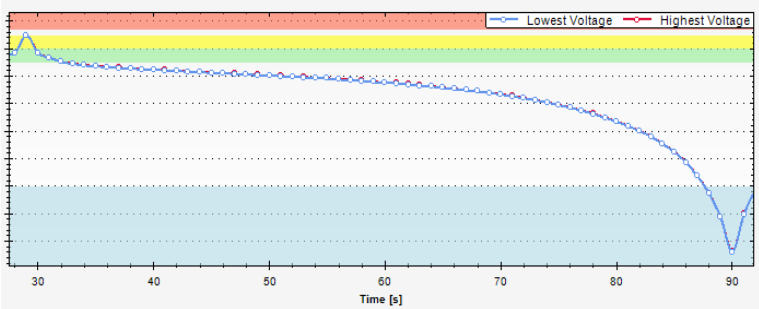
- The s-BMS PC toolbox comes in 2 versions:
  - PRO: All funtions are both ”READ” and ”WRITE”, which means that all parameters can be freely configured
  - SERVICE: All parameters are only READ accessible. Logging, and bootloading can be performed

s-BMS System architecture (example)



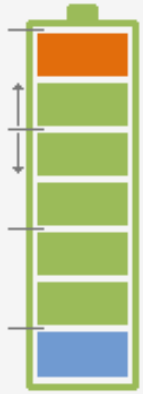
Cell management

- Cell-overshoot window defines normal charger overshoot.
- Charger-off window defines a window inside the charge complete window for balancing.
- These setting can we used to configure any type of Litihum-ion cell chemistry.
- Communication protected with 16 bit Checksum – ASIL D level which ensures no impact with misread Data enhancing the Data to Data interity.



Global cell settings

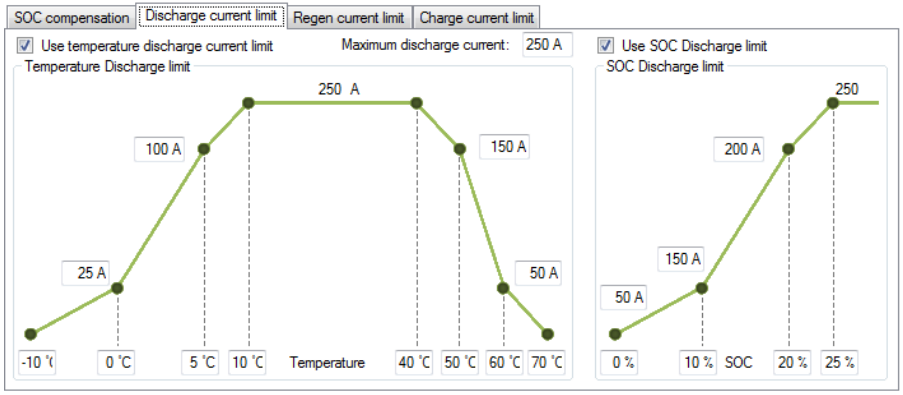
Cell over voltage	3800 mV
Cell overshoot window	50 mV
Cell target voltage	3700 mV
Charge complete window	50 mV
Charger off window	20 mV
Charge regulating voltage	3600 mV
Cell under voltage	2800 mV
Cell end of life voltage	2200 mV



Benefit: Compatibility with any Li-ion chemistries and/or cell type. Improved sourcing. Bargaining power.

Current monitoring

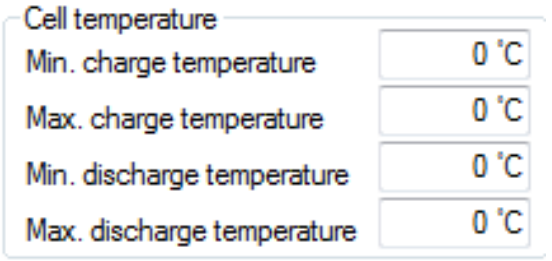
- High resolution current measurement (0.1A resolution)
- Calibrated measurement shunt (Class 1 or 0.5)
- Auto calibrated measurement input circuit
- Calibration for linearity faults and offset errors gives 0.1A accuracy at room temperature.



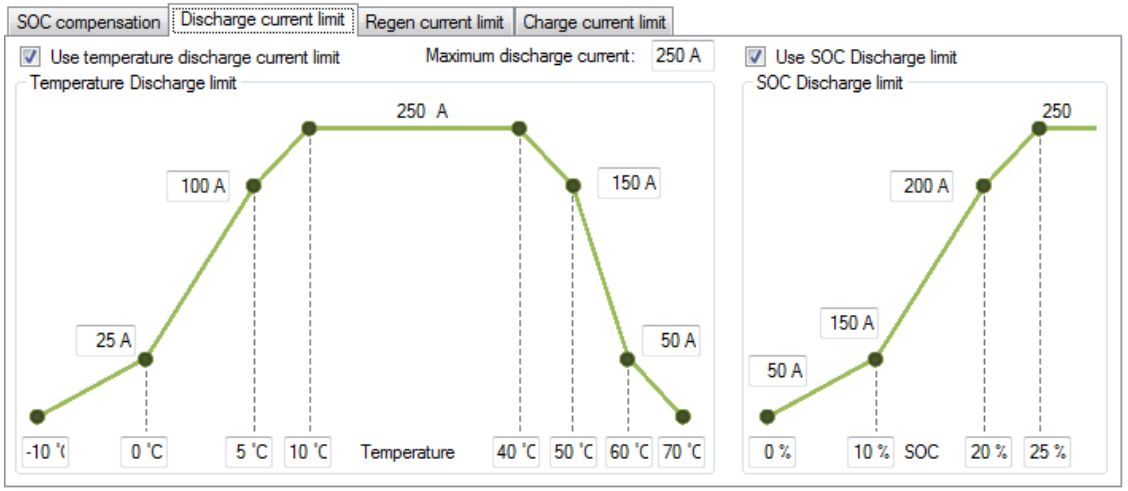
Max discharge current settings in s-BMS PC toolbox

Temperature monitoring

- 4 temperature sensors per LMU board
- Noise robust passive sensors
- Auto calibrated inputs



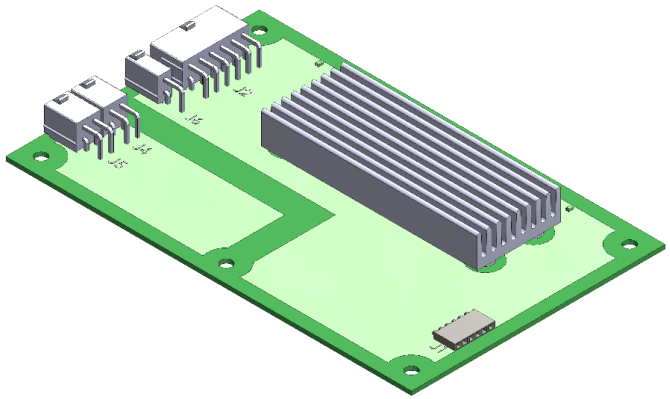
System level temperature settings in s-BMS PC toolbox



Advance temperature settings in s-BMS PC toolbox

Cell balancing

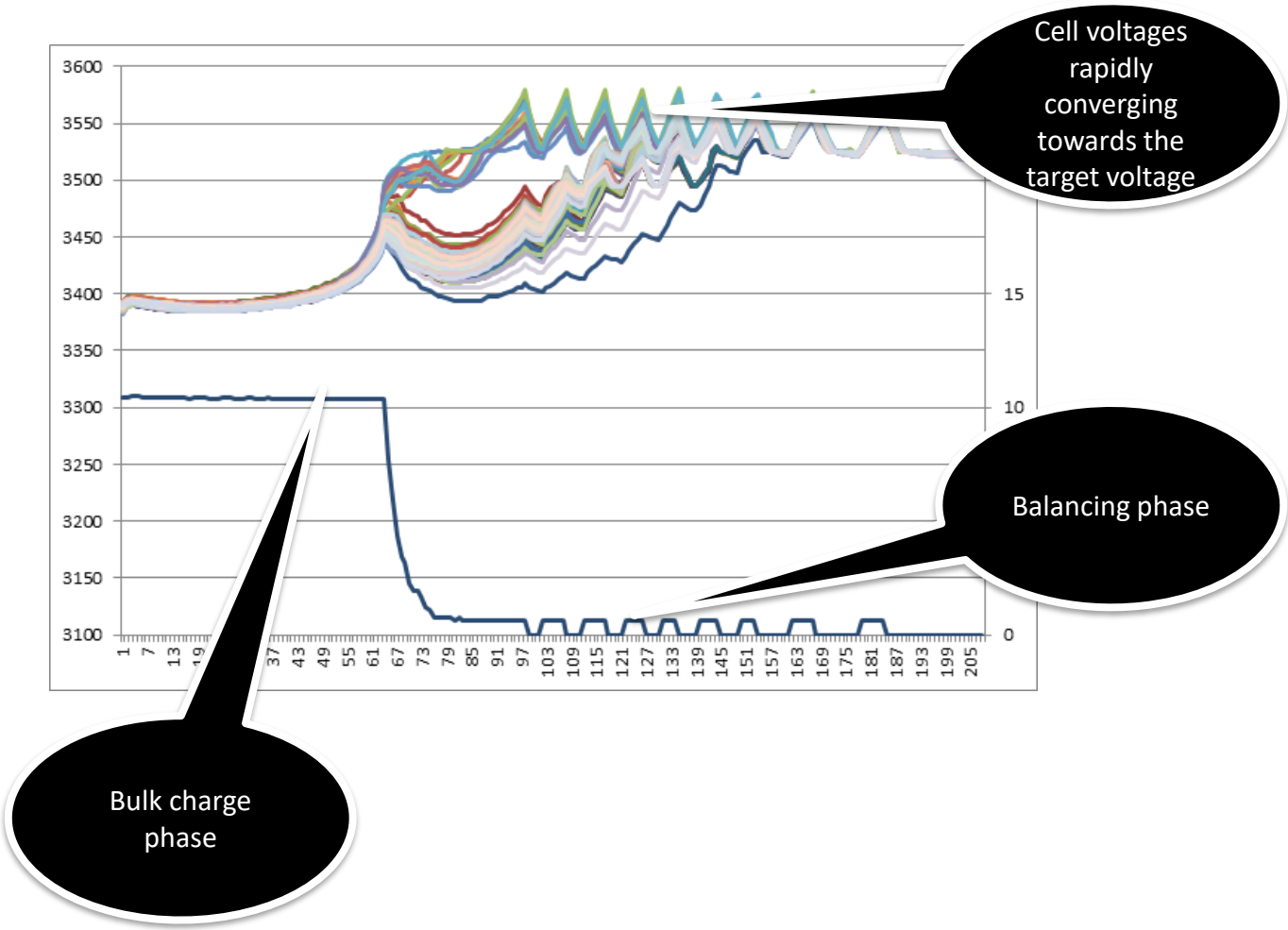
- Passive cell balancing with maximum 840mA @4.2 VDC.
- Multiple cell bleeding operations for faster completion of balancing process.
- Add-on heat-sink option further a balancing time.
- Mininized wear and tear on cells



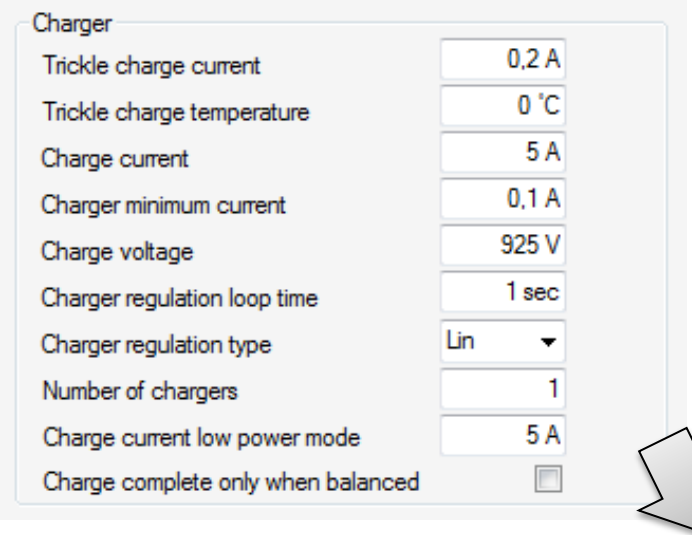
#	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Bat 1 °C	Bat 2 °C	Pcb 1 °C	Pcb 2 °C
1	3608	3609	3609	3608	3610	3612	3610	3613	17	-	42	39
2	3556	3346	3559	3556	3555	3556	3558	--	17	-	42	41

Benefit: Unmatched cell balancing performance. Faster charging.

Charger control

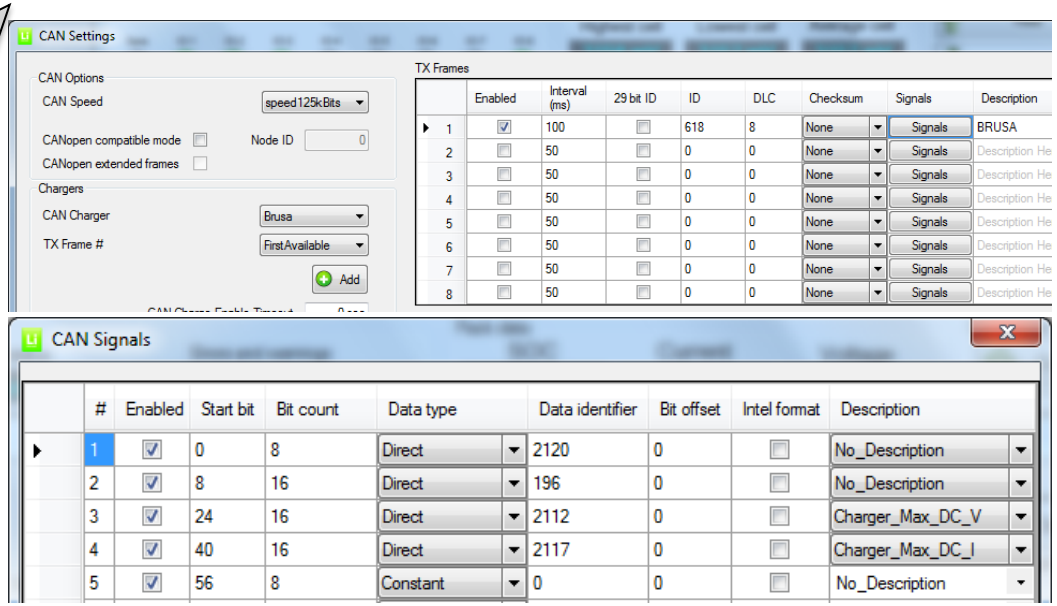


Charger interface



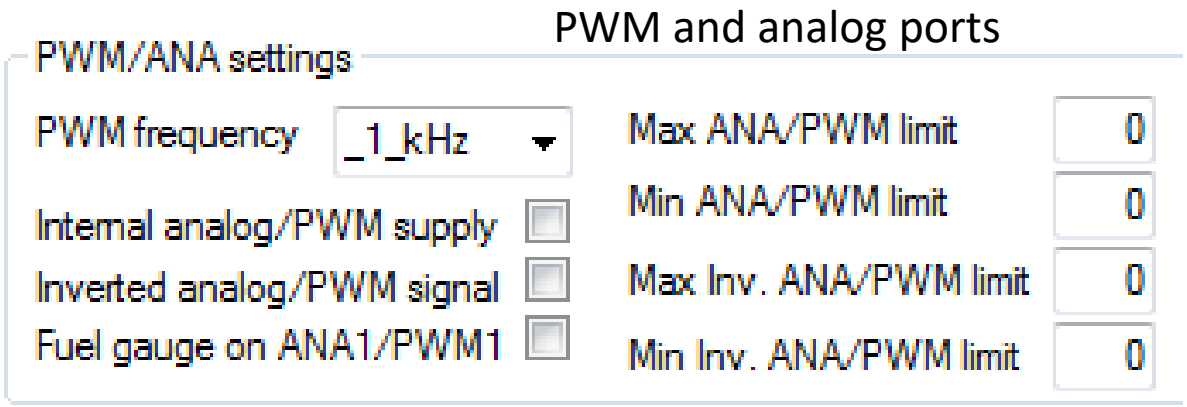
CAN control:

- CAN 2.0A or 2.0B
- 125 kbps to 1Mbps speed
- Bit level configuration
- Preconfigured for supported chargers



PWM and analog ports

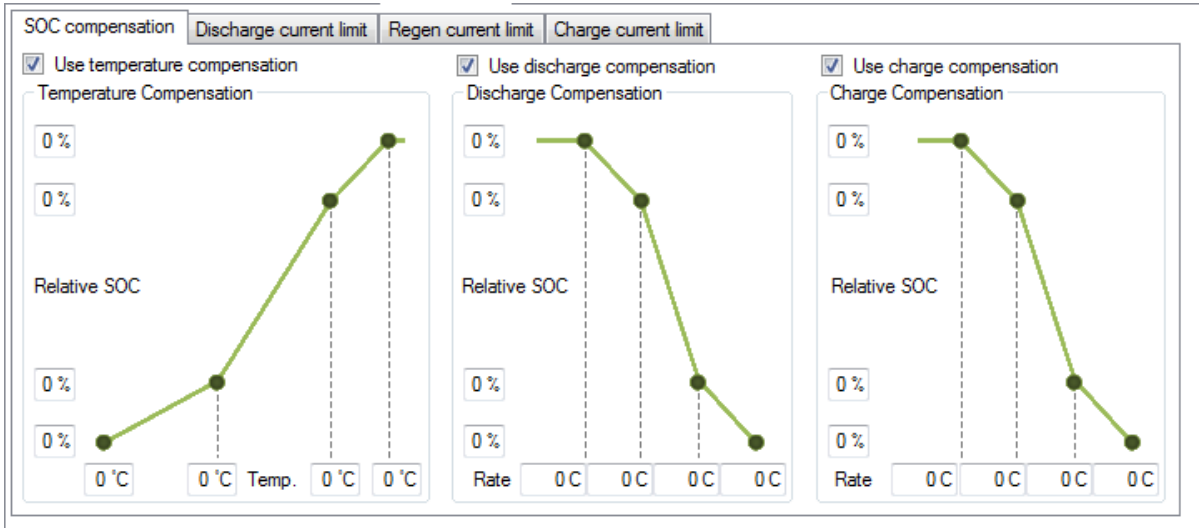
- One analog + PWM (hardwired) output for charger control
- One analog output for fuel gauge display
- One analog input programmable on a per-project basis



PWM/analog settings in s-BMS PC toolbox

Interface

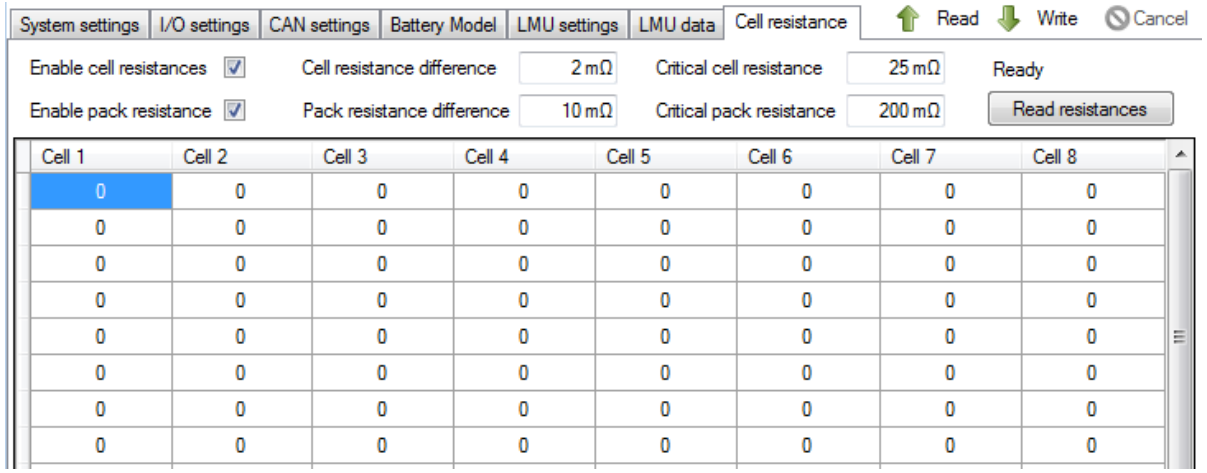
State-of-Charge (SOC) calculation



- Fudamental principle is Coloumb counting using the high precision current measurement
- The Coloumb counter is reset every time the battery is fully charged and balanced (SOC=100%)
- The Coloumb counter can be enhanced by the battery model to compensate for temperature and rate of discharge effects.

State-of-Health (SOH) estimation

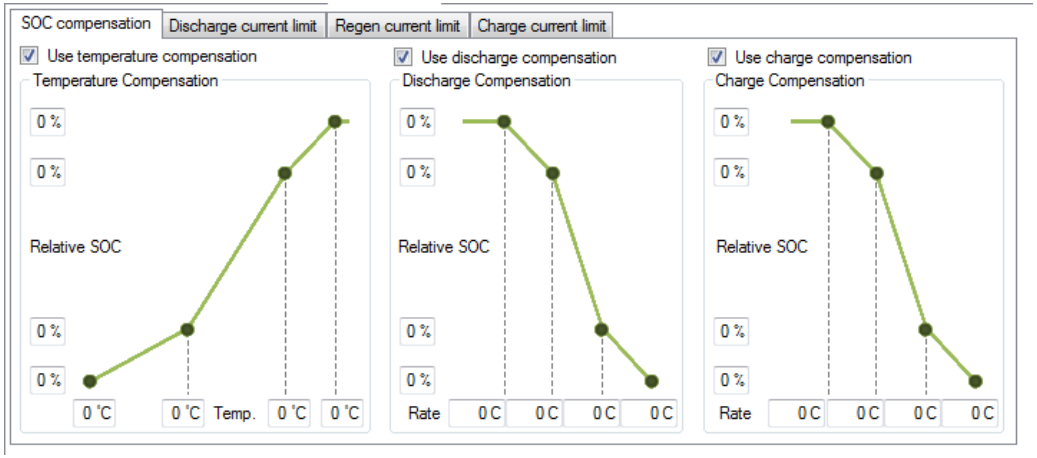
- Measures capacity based State of Health (SOH) each full discharge cycle
- Continuously measures pack resistance
- Measures cell resistance each charge cycle



Cell resistances in s-BMS PC toolbox

Battery Model

- Add advanced battery chemistry data to your battery management system by means of configuration.
- Enhance State of Charge calculation
- Optimize battery utilization in various temperature conditions
- Optimize battery utilization in various state of charge ranges
- Help application performance by dynamically adjusting system boundries like allowed regen and discharge current



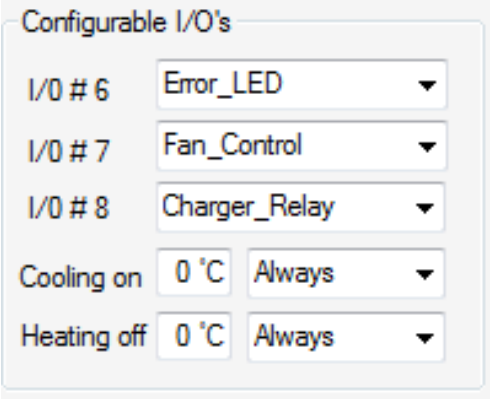
Battery model in s-BMS PC toolbox

Benefit: Performance improvement.

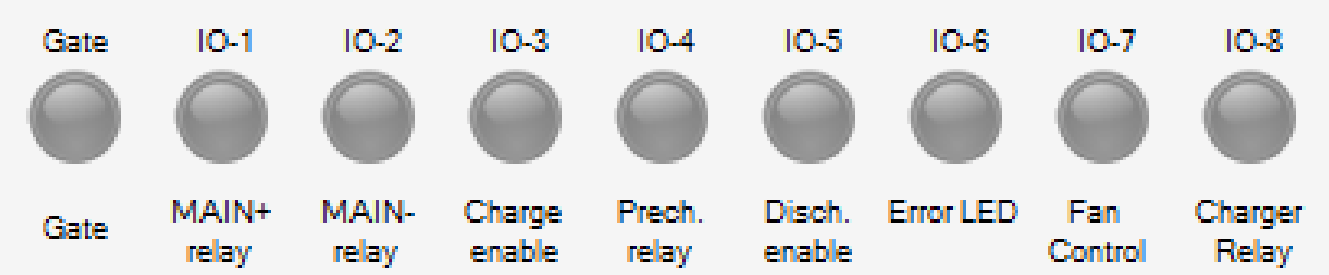
I/O ports

The BMCU supports 8 general purpose I/O ports

- 5 ports are pre-allocated to defined functions
- 3 ports can be configured on a per-project basis



I/O configuration in s-BMS PC toolbox



I/O monitor in s-BMS PC toolbox

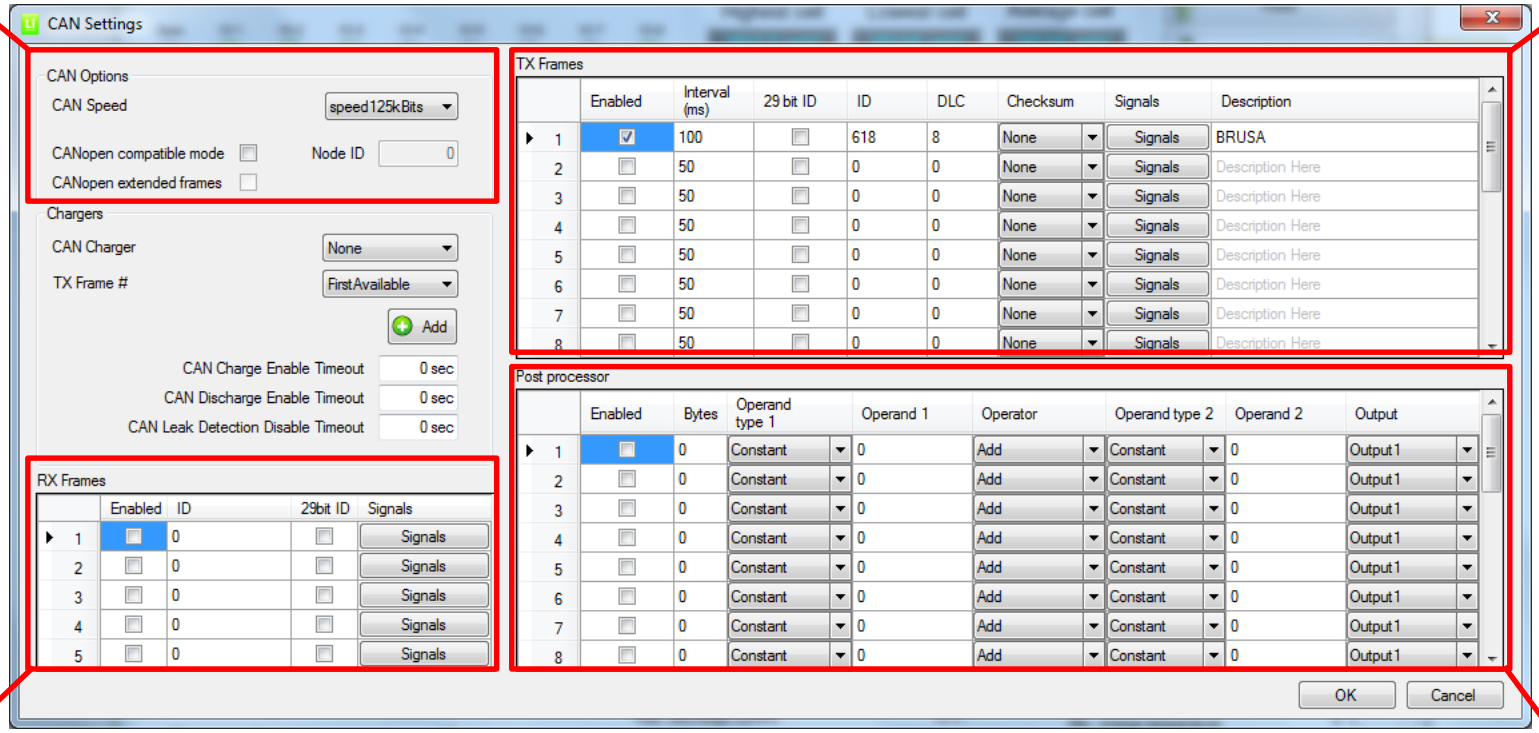
CAN bus

- Interface to vehicle control units, chargers, displays etc.
- Configurable speed from 125kbit/s up to 1Mbit/s
- Configurable to run 11 or 29 bit identifiers
- Fully flexible CAN frames that can broadcast any BMS parameters with bit level control of data alignment
- Post processing functions that allows dynamic re-scaling and arithmetic operations on BMS parameters

CAN-bus interface

Basic CAN settings

Define transmit frames



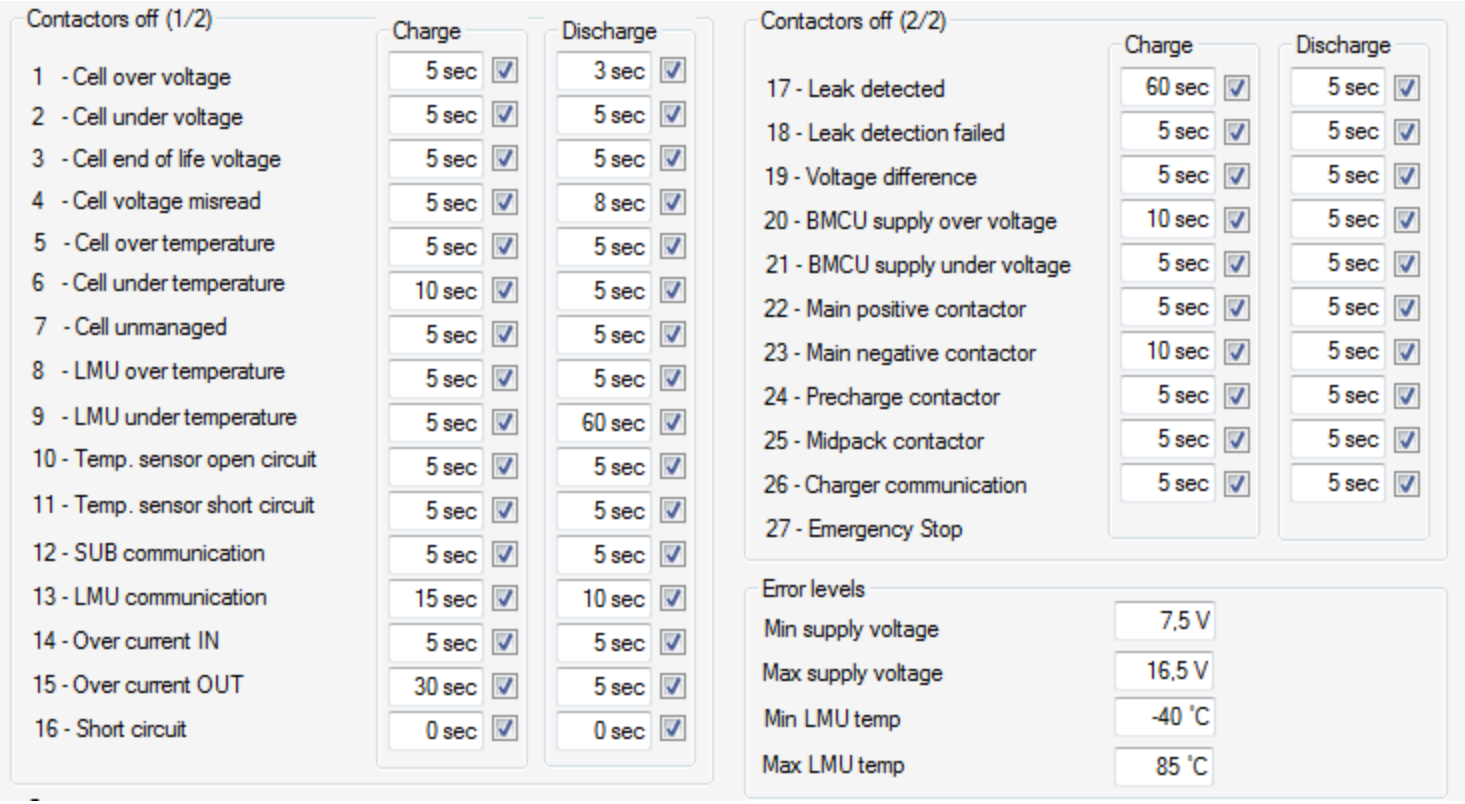
Define receive frames, and where to put the received data

Post processor allows data to be processed after being received or before being transmitted

Benefit: Best-in-class configuration. Reduced dev. costs.

Error behaviour

Appropriate contactor actions must be configured for all error conditions in the battery system for both charge and discharge state.



Contactors off (1/2)

	Charge	Discharge
1 - Cell over voltage	5 sec	3 sec
2 - Cell under voltage	5 sec	5 sec
3 - Cell end of life voltage	5 sec	5 sec
4 - Cell voltage misread	5 sec	8 sec
5 - Cell over temperature	5 sec	5 sec
6 - Cell under temperature	10 sec	5 sec
7 - Cell unmanaged	5 sec	5 sec
8 - LMU over temperature	5 sec	5 sec
9 - LMU under temperature	5 sec	60 sec
10 - Temp. sensor open circuit	5 sec	5 sec
11 - Temp. sensor short circuit	5 sec	5 sec
12 - SUB communication	5 sec	5 sec
13 - LMU communication	15 sec	10 sec
14 - Over current IN	5 sec	5 sec
15 - Over current OUT	30 sec	5 sec
16 - Short circuit	0 sec	0 sec

Contactors off (2/2)

	Charge	Discharge
17 - Leak detected	60 sec	5 sec
18 - Leak detection failed	5 sec	5 sec
19 - Voltage difference	5 sec	5 sec
20 - BMCU supply over voltage	10 sec	5 sec
21 - BMCU supply under voltage	5 sec	5 sec
22 - Main positive contactor	5 sec	5 sec
23 - Main negative contactor	10 sec	5 sec
24 - Precharge contactor	5 sec	5 sec
25 - Midpack contactor	5 sec	5 sec
26 - Charger communication	5 sec	5 sec
27 - Emergency Stop		

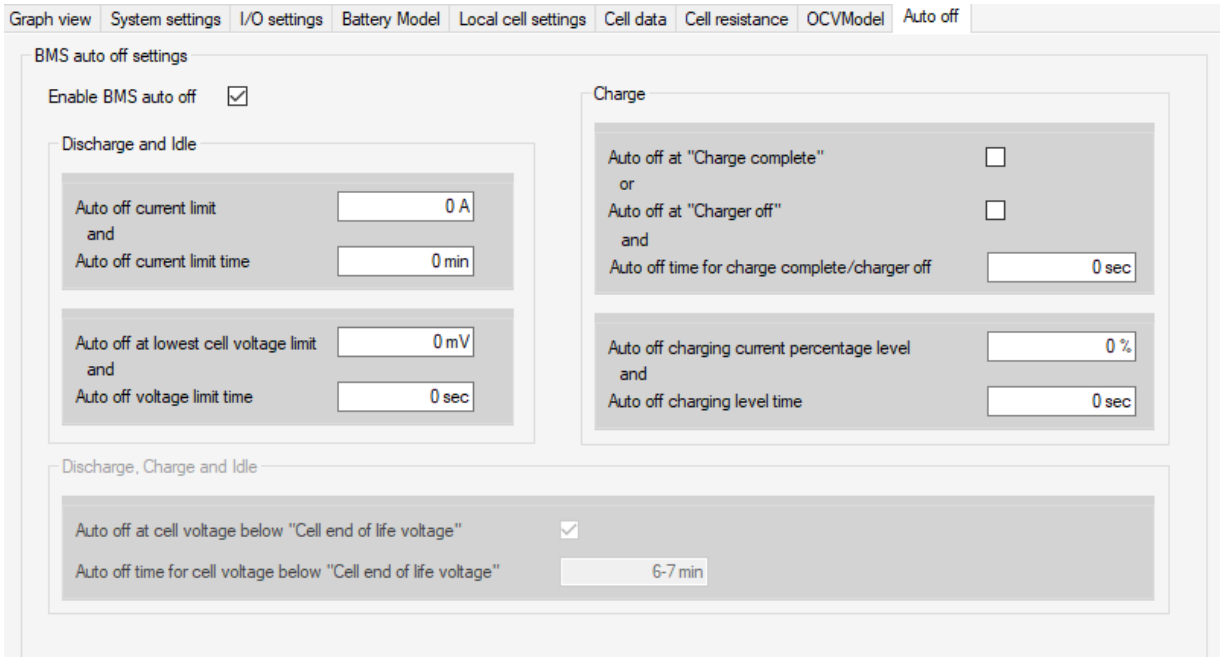
Error levels

Min supply voltage	7,5 V
Max supply voltage	16,5 V
Min LMU temp	-40 °C
Max LMU temp	85 °C

Benefit: User defined controls strategy. Improved safety.

AUTO-off function

- Purpose: To facilitate replacement of lead/acid batteries in Forklifts, where there is no ”key” function to disconnect the BMS
- The function can be enabled and the following parameters can determine AUTO-off
  - Current is low in longer times (meaning the truck driver left the vehicle without disconnecting)
  - The cell voltages are reaching a point where the battery will be destroyed (meaning driver ignore warnings and continue to engage system)
  - Charger has reached the point where balancing is complete and no other action for long time (Meaning the vehcile was left in the charger for longer time)
  - Charger is not responding. Could be disconnected or power loss to the charger (Meaning charge process should stop to prevent endless drain of battery)



Product Support

- The LiBAL s-BMS PRO is a very comprehensive tool. In order to facilite the introduction Lithium Balance offer 5 hour support:
  - Configuration of basic settings such as cell voltage cut off and balancing windows
  - Guidelines for setting up safety strategy and how to utlize the warnings and error states
  - Introduction to advanced functionality such as OCV curve and battery modelling (SOC compensation).
  - Introduction to CAN configuration (Charger set-up)

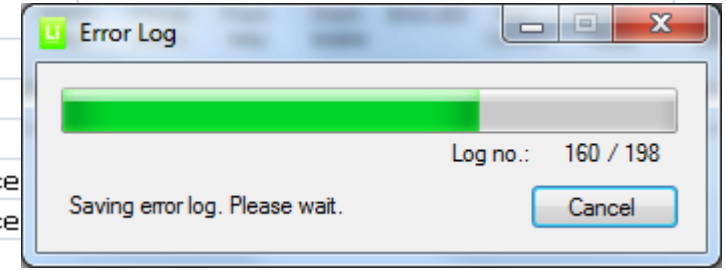
Service and Maintenance

Diagnostics

- Error log reads out the last 198 recorded problems
- The output is human readable *.csv file format
- Information on the time from startup to error, the error description, and data from the error.

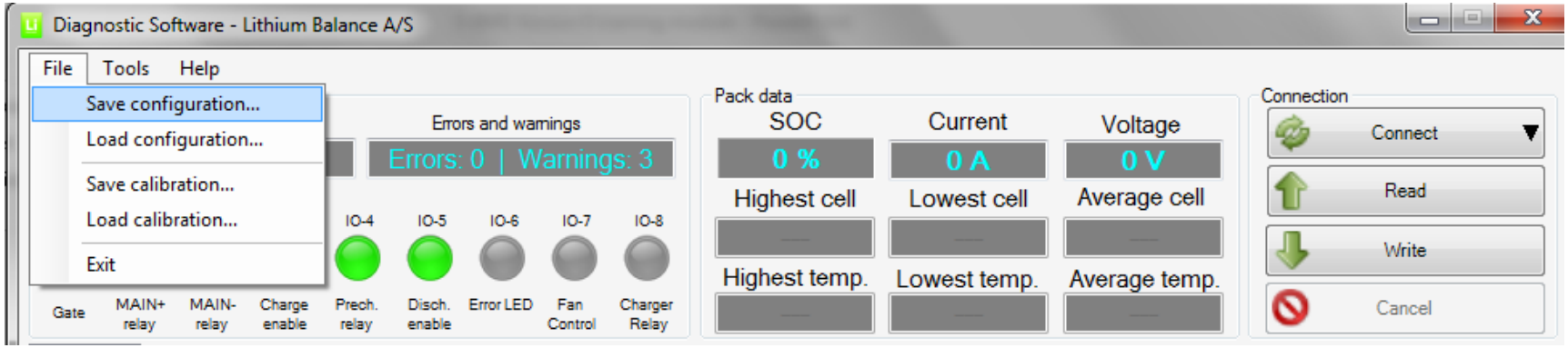
BMCU: 20000 02.05.c.005, SUB: 20000 02.05.c.000, LMUs: 02.05.c.005, 02.05.c.005, 02.05.c.005, 02.05.c.005, 02.05.c.005, 02.05

Error Code	Power Up Time (min)	Data	Error	Description
15	363	000C005A	Pack resistance difference	Previous: 120 mOhm, New: 900 mOhm
15	347	000300B6	Pack resistance difference	Previous: 30 mOhm, New: 1820 mOhm
9	347	4E204E20	Leak detected	Offboard leak detection triggered
15	284	003B0000	Pack resistance difference	Previous: 590 mOhm, New: 0 mOhm
15	282	005D0000	Pack resistance difference	Previous: 930 mOhm, New: 0 mOhm
15	278	00F0003C	Pack resistance difference	Previous: 2400 mOhm, New: 600 mOhm
17	277	01DF0000	Critical pack resistance	4790 mOhm
15	277	3590065	Pack resistance difference	Previous: 8570 mOhm, New: 1010 mOhm
19	275	2020000	Contactors off	
1	275	220AC000	Cell under voltage	
1	274	BF0AED00	Cell under voltage	
17	270	3590000	Critical pack resistance	
15	270	003E0674	Pack resistance difference	
15	168	005D0020	Pack resistance difference	



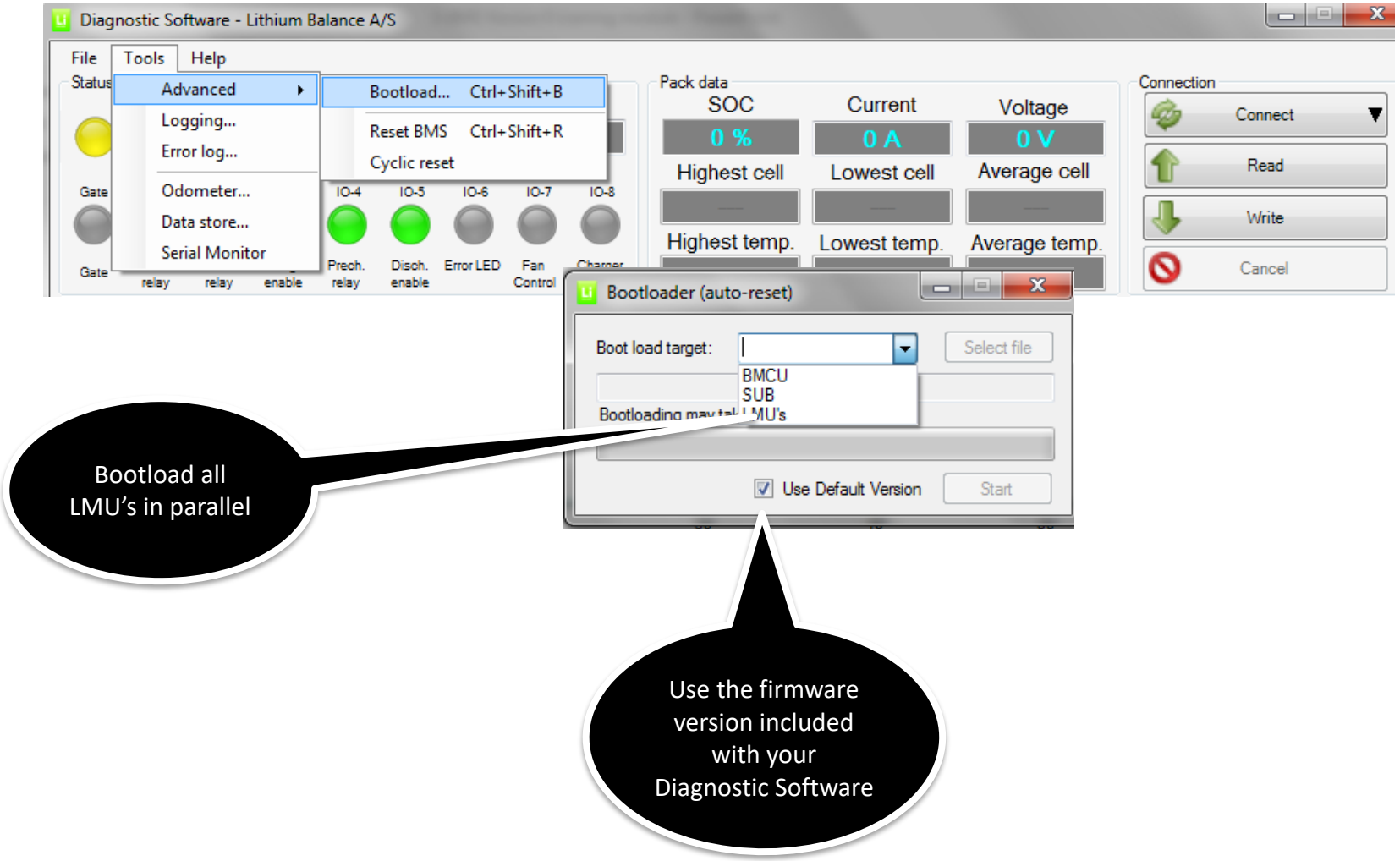
Configuration management

- Store and recall configurations.
- Use the “Read” and “Write” buttons to apply the settings to the connected BMS.



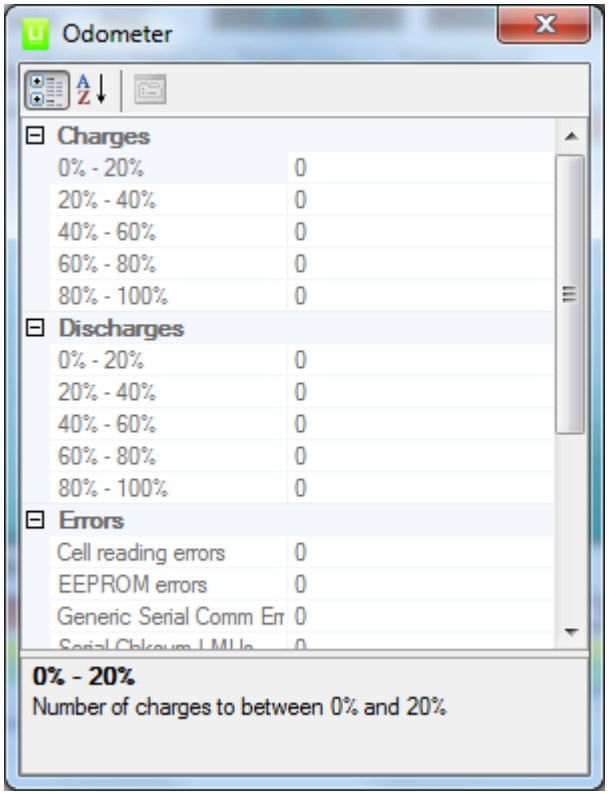
a) Accessing the error log
b) Using the service tag
c) Using the logging facility

Bootloader

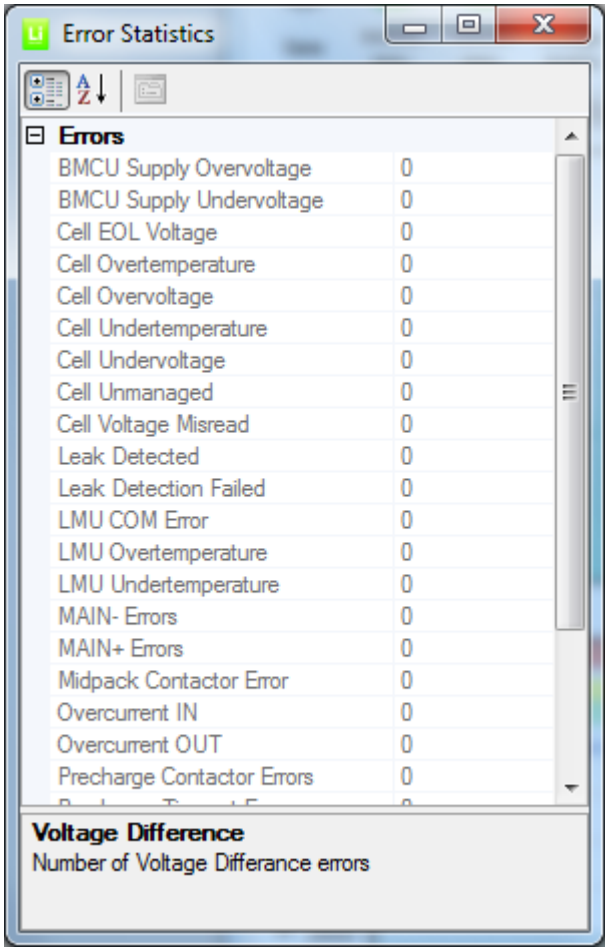

Diagnostic Software - Lithium Balance A/S
File
Tools
Help
Status
Advanced
Logging...
Error log...
Odometer...
Data store...
Serial Monitor
Bootload... Ctrl+Shift+B
Reset BMS Ctrl+Shift+R
Cyclic reset
Gate
Gate
IO-4
IO-5
IO-6
IO-7
IO-8
Prech. relay
Disch. enable
Error LED
Fan Control
Pack data
SOC
Current
Voltage
0 %
0 A
0 V
Highest cell
Lowest cell
Average cell
Highest temp.
Lowest temp.
Average temp.
Connection
Connect
Read
Write
Cancel
Bootloader (auto-reset)
Boot load target:
Select file
BMCU
SUB
LMU's
Use Default Version
Start
Bootload all LMU's in parallel
Use the firmware version included with your Diagnostic Software

Lifetime diagnostics

Information on usage

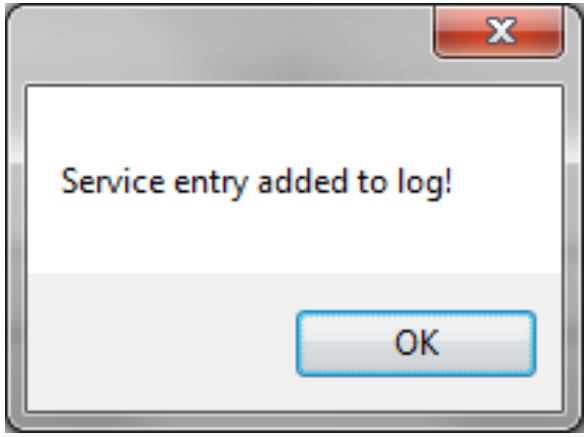


Information on problems



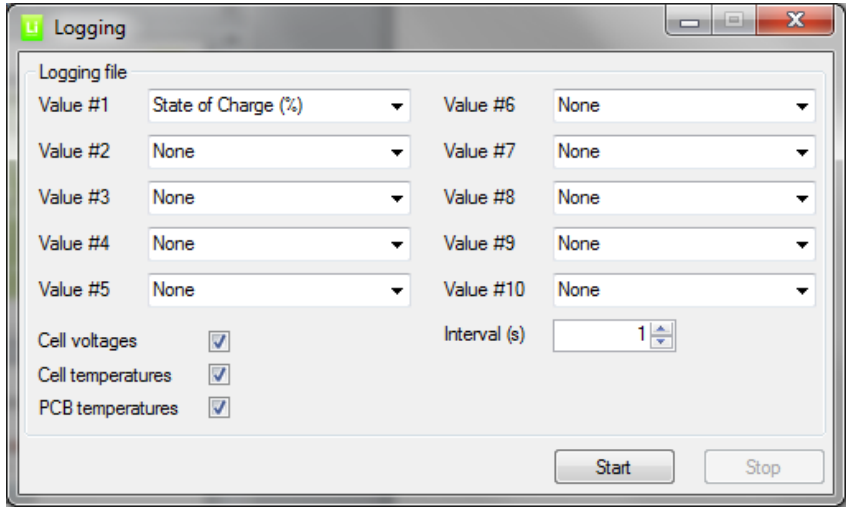
Service Entry

- The “Add Service Entry” function adds a service entry to the error log.
- This is useful to track how many errors that has occurred since the last service.



Logging

- The logging functions allow the Diagnostic Software to continuously log a number of parameters during operation
- The parameters are stored in a comma separated file (.csv)
- This file can be analysed for example in Microsoft Excel.



Summary

1. Unmatched cell balancing performance through configuration.
2. Possibility to integrate multiple chargers via PWM, analog or CAN-bus.
3. Internal communication protected with 16 bit Checksum – ASIL D level.
4. Battery model – improves accuracy, performance and pack life.
5. User defined controls/safety strategy and performance optimization.
6. OCV based SOC validation.
7. Facilitated warranty management.
8. Compatibility with any Li-ion chemistries.