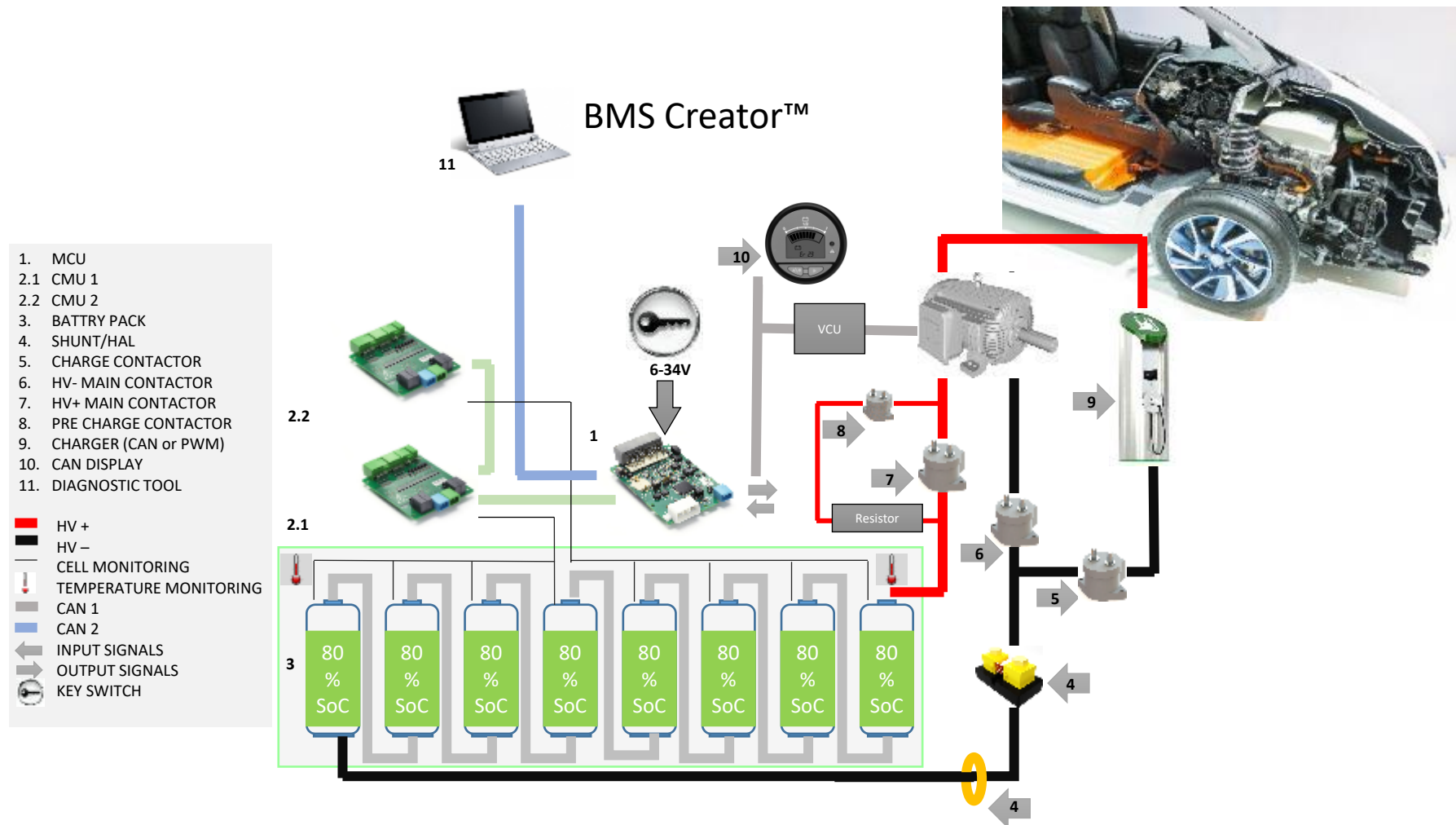


LiTHIUM BALANCE A/S

LIBAL n-BMS HIGH VOLTAGE™

BATTERY MANAGEMENT SYSTEM

System overview



System overview



- 12 cells per Cell Monitoring Unit (CMU)
- 32 CMU's per system (384 cells in series)
- Up to 12 or 4 temp sensors per CMU
- All cell voltages measured in 150 [ms]
- Current measured in 150 [ms]
- Pack temperature measured in 150 [ms]
- 1,5 [mV] maximum cell voltage error
- CMU error diagnostics on all inputs
- MCU dual core master controller
- MCU safe real time operating system
- MCU safe power supply
- MCU real time clock
- 16 General Purpose I/O on MCU
- 11 Temperature sensors on MCU



MCU – Master Control Unit



CMU – Cell Monitoring Unit(s)



*CMU
100801*



*CMU
000705*



*CMU
100808*

Safety



- Robust key components
- Realtime operating system (RTOS) at ASIL D level
- All 4 safety critical functions has built in self-diagnostics meeting ASIL C level
- Open wire detection
- Build in leak detection

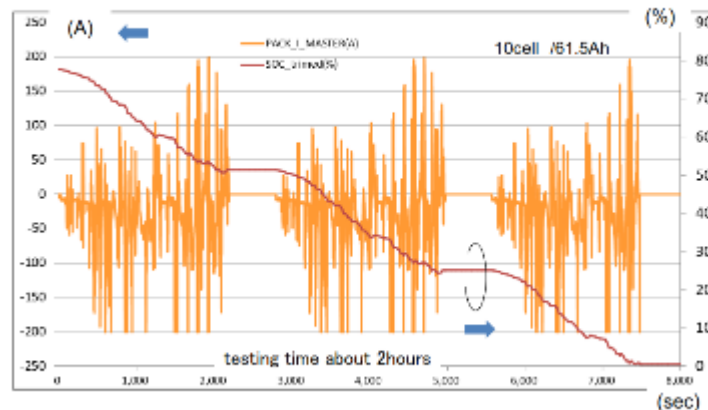


Performance



- High speed main processor enables system to do advanced algorithms for high precision SOC.
- BMS tested by leading Japanese automotive Tier 1, where SOC accuracy in a vehicle drive cycle show an impressive $\pm 0,37\%$ deviation (see below)
- isoSPI internal communication protocol reduce the CMU cost and provide enable efficient service when software need to be updated in the field.

Evaluation of measured and calculated SOC w/Hall sensor



difference between measured SOC and calculated SOC(trimmed) is 0.37%

Lifetime optimization

- Intelligent balancing and SOC algorithms enabled by high speed (150 ms) and accurate measurements ($\pm 1,5\text{mV}$).
- Synchronized measurement of current, temperature and voltage ensure a precise status of each individual cell.



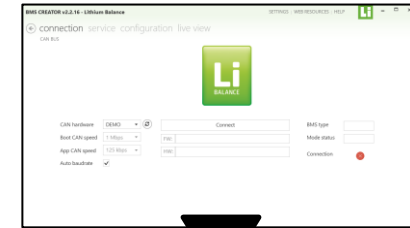
MCU – Master Control Unit



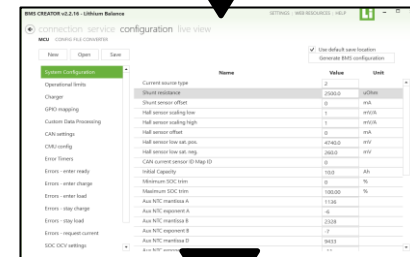
n-BMS CREATOR™



- PC configuration tool with comprehensive possibilities for customization
- Enables the battery designer to create a UNIQUE BMS based on "off the shelf" HW and SW platform
- Key Parameter configuration:
 - Error settings
 - Battery model
 - SOC model based on OCV
 - Current regulation
 - I/O controls
 - CAN communication incl. full CAN open support
 - CAN Custom processing machine
- Live view monitoring and Control
- Service



CONNECT



CONFIGURE



CONTROL

#	Status	Timestamp	Origin	Code	Description
001	Detected	2020-11-02 13:00:02	06	0568	ADC_AFE REPORTED UNKNOWAN ERROR CODE
002	Detected	2020-05-19 11:00:00	12	1010	CSR REPORTED UNKNOWAN ERROR CODE
003	Checked	2020-11-14 00:00:00	23	1946	FLASG_SPS REPORTED UNKNOWAN ERROR CODE
004	Detected	2020-08-20 00:00:00	23	0951	BOOT REPORTED UNKNOWAN ERROR CODE
005	Checked	2020-10-23 04:45:51	14	1071	BAL (JAG) REPORTED UNKNOWAN ERROR CODE
006	Checked	2020-04-10 01:00:00	06	0602	SPC_CTR REPORTED UNKNOWAN ERROR CODE
007	Detected	2020-08-15 14:00:04	12	1180	PGA_ANALOGSR REPORTED UNKNOWAN ERROR CODE
008	Detected	2020-08-23 20:26:26	20	0730	TRM_ANALOGSR REPORTED UNKNOWAN ERROR CODE
009	Detected	2020-05-28 08:24:42	20	1272	SRAM_INTERFACE REPORTED UNKNOWAN ERROR CODE
010	Detected	2020-08-01 16:28:20	22	0607	BCMP REPORTED UNKNOWAN ERROR CODE
011	Checked	2020-04-09 19:52:50	12	1434	CSM_CTR REPORTED UNKNOWAN ERROR CODE
012	Checked	2020-04-27 07:51:11	06	0625	UCR000 REPORTED UNKNOWAN ERROR CODE
013	Checked	2020-10-16 22:02:57	21	1047	MSRAM REPORTED UNKNOWAN ERROR CODE
014	Checked	2020-05-05 19:02:02	01	0038	CPM REPORTED UNKNOWAN ERROR CODE
015	Checked	2020-04-22 04:47:12	24	0419	APSD0000 REPORTED UNKNOWAN ERROR CODE
016	Checked	2020-03-03 11:30:05	00	0717	ADC_AFE REPORTED UNKNOWAN ERROR CODE
017	Checked	2020-11-08 01:40:01	12	0988	CSR REPORTED UNKNOWAN ERROR CODE
018	Checked	2020-09-17 12:29:00	29	1426	PC0272 REPORTED UNKNOWAN ERROR CODE
019	Checked	2020-02-06 14:47:04	14	0909	BAL (JAG) REPORTED UNKNOWAN ERROR CODE
020	Detected	2020-10-11 23:51:58	16	0534	USER REPORTED UNKNOWAN ERROR CODE

SERVICE

Specifications



Module specifications

Cells per CMU: 5 – 12 (min. 11 V)

Cell voltage: 0,5 V – 4,5 V (0V – 5V with reduced accuracy)

Cell voltage measurement accuracy: $\pm 1,5\text{mV}$ (full temp. range)

Cell voltage sampling frequency: 150 ms

Temperature sensors: up to 12 or 4 per CMU

Temperature measurement accuracy: $\pm 1^{\circ}\text{C}$

Communication: isoSPI

PCB Dimensions: MCU: 92mm x 166mm / CMU 92x118mm
(new CMU 75x80mm)

Balancing current: 200mA (at 4,2 V)

Specifications



System specifications

Supply Voltage: 6-34 (VDC)

Pack voltage: Up to 1000 (VDC)

Pack current: Up to 2000 (ADC)

Communication: 1 isolated CAN bus (CAN 2.0A, CAN 2.0B up to 1Mb/s) and 1 non-isolated CAN bus

Pack current measurement accuracy: $\pm 0.2\%$ maximum, with SHUNT sensor error: $\pm 0.5\%$ maximum (HOBUT CLASS 0.5) or HALL effect sensor error: $\pm 1\%$ maximum (LEM DHAB S/18) and @25°C

Pack temperature and current sampling rate: 150 ms

SOC, SOH calculations: Coulomb counting and OCV models

Temperature range: Operational -40°C to 85°C, Storage -40°C to 105°C

Test and validation



System tests

CISPR 25: EMC susceptibility 150 kHz – 2 GHz

ISO 11452: EMC susceptibility

ISO 10605: ESD for road vehicles

ISO 16750-2: Electrical Loads (Code A, Reversed, over voltage ect.)

ISO 16750-3: Mechanical Loads (Sinusoidal and random vibration)

ISO 16750-4: Climatic Loads (Code G: -40 to 85°C)

ISO 7637: Electrical disturbances from conduction and coupling