

LITHIUM BALANCE A/S

LIBAL n-BMS HIGH VOLTAGE™

BATTERY MANAGEMENT SYSTEM

System overview



- Designed for ISO26262 at ASIL C level
- 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



CMU – Cell Monitoring Unit (new)



CMU – Cell Monitoring Unit



MCU – Master Control Unit

Safety



- Robust key components and design prepared for ISO 26262 requirements
- Realtime operating system (RTOS) TÜV certified to meet ISO 26262 at ASIL D level
- Sampling rate at 150 mS allow to react to rapid fluctuations in current without loosing precission
- All 4 safety critical functions has built in self-diagnostics meeting ASIL C level

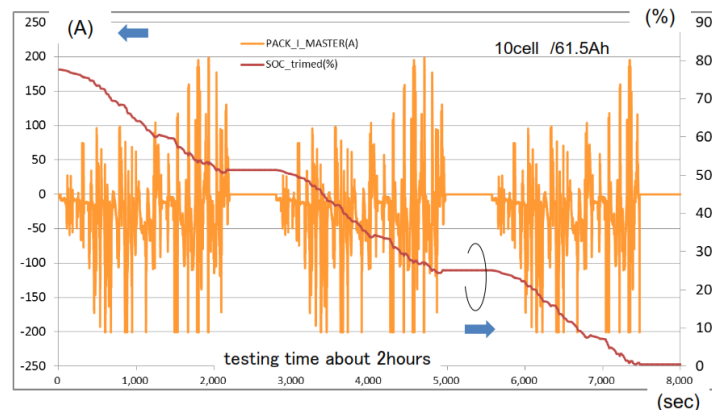


Performance



- High speed ISO26262 pre-qualified 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.

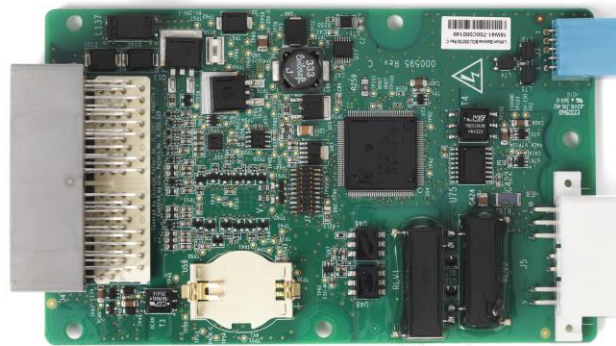
Evaluation of measured and calculated SOC w/Hall sensor



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



Usability



- BMS Creator™ , PC configuration tool for easy, fast and intuitive set-up. Enables the battery designer to create a UNIQUE BMS based on standard HW and SW platform
- Supports UDS CAN protocol
- Full CAN open compliant
 - SDO access to all BMS data
 - 40 TPDO's and 10 RPDO's, all dynamical programmable
 - TIME support for setting of BMS time and date.
 - EMCY support for error reporting
 - CANopen node ID is configurable and also possible to set via GPIO inputs
- On board Real time clock allow timestamp for errors and events for efficient warranty handling and service management



The screenshot shows the 'live view' dashboard of BMS Creator v2.1, displaying MCU Measured Data and MCU Internal Data tables. The MCU Measured Data table lists 8 sensors (ALIX temperature sensor 1-8) with values ranging from 20 to 22 C. The MCU Internal Data table lists 4 parameters (Dynamic Current #1 limit, Dynamic Current #2 limit, Requested Charge Current, and Remaining Battery Pack Capacity) with values ranging from 74.4 A to 1612829 As. Below these tables is an 'Alarm' table with columns for Entry, Alarm, Origin, Severity, Timer Init (s), and Timer (s).

ID	MCU Measured Data	Value	Unit	ID	MCU Internal Data	Value	Unit
138	MCU ALIX temperature sensor 1	22	C	32	Dynamic Current #1 limit	370.4	A
139	MCU ALIX temperature sensor 2	23	C	33	Dynamic Current #2 limit	88.3	A
140	MCU ALIX temperature sensor 3	21	C	26	Requested Charge Current	74.4	A
141	MCU ALIX temperature sensor 4	23	C	48	Charge complete? (latched)	True	
142	MCU ALIX temperature sensor 5	24	C	17	Remaining Battery Pack Capacity	1612829	As
143	MCU ALIX temperature sensor 6	23	C				
144	MCU ALIX temperature sensor 7	23	C				
145	MCU ALIX temperature sensor 8	20	C				

Entry	Alarm	Origin	Severity	Timer Init (s)	Timer (s)
1	2031 - SYS_CONTRACTOR_RETRIES	25 - GPIO	2	6370.2	5774.6
2	2032 - SYS_PROCESS_CHAL_DATA	19 - IO_MAP	3	3477.0	4646.5
3	2023 - SYS_FL_PREGMARG_MISSING	6 - ADC_EXT	4	4866.7	2128.1
4	2033 - SYS_PACK_Q_CALC	13 - ERROR_HANDLING	2	373.8	5432.0
5	2031 - SYS_CONTRACTOR_RETRIES	30 - TASK_MONITOR	6	4733.1	3601.6
6	2029 - SYS_PACK_CELL_LOW	9 - PACK_LAND_CELL	6	4403.1	2968.5
7	2007 - SYS_LIM_CELL_DT_POS	27 - TASK_HANDLER	6	2089.7	3158.3
8	2007 - SYS_LIM_CELL_DT_POS	30 - TASK_MONITOR	4	1318.8	1176.9

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