SAFETY

Patented system for measuring the temperature and voltage of each cell.

MONITORING

Cloud-based battery fleet management system State of Health estimation and asset management.

MODULARITY

Maximum flexibility, modules can be connected in series or in parallel to achieve the desired configuration

SELF-SUPPORTING

The self-supporting structure of LiBER modules allows the installation of batteries without additional frames

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FEATURES

ACTIVE SAFETY	The LiBER solution has the unique feature of carefully measuring the temperature of each cell of the pack with an advanced Battery Management System BMS architecture. The BMS processes all cells temperatures for an accurate estimate of the State of Safety (SOS) of the battery pack. The BMS can detect the activation of thermal anomalies of the cell at their initial stage, thus preventing the triggering of destructive phenomena at module or pack level.
PASSIVE SAFETY	The LiBER cell to module integration encapsulates and separates the cells from the adjacent ones reducing the risk of thermal runaway propagation. The insulating material of the LiBER container adds protection from the direct contact with live parts at post-crash, even in case of extremely severe events. Electrical abuse is managed at both module and cell level, reducing the risk of activation of uncontrolled thermal events
SERVICE SAFETY	Low voltage modules with dedicated disconnection and protection. When tuned off, there are no parts at high voltage inside the battery pack leading to safer assembly and maintenance operations.
SYSTEM INTEGRITY	The redundant architecture of the BMS system guarantees the continuity of service in case of first fault of BMS peripherals.

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Description

A LiBER HV battery pack is composed of groups of modules, named semi-packs, which are connected in parallel and connected to the application in the LiBER switch box.

A LiBER HV battery pack can be composed by *P* semi-packs in parallel. *P* from 1 to 4.

Each LiBER semi-pack is composed by *M* LiBER modules connected in series. *M* from 1 to 14.

Each LiBER module contains a string made of *S* series connection of cell units. *S* from 7 to 15.

Each LiBER cell unit, contains *p* cells connected in parallel. *p* from 1 to 64.

p is further limited by cell chemistry and cell format. See table I to table IV for the full list of combinations.

The number *S* of cells in series determines the length of the module. See Fig. 1

The maximum LiBER module voltage is limited to 63V.

The maximum LiBER HV battery pack voltage is limited to 882 V.

Modules having different number of cells in series can be used to form a semi-pack.

All semi-packs must have the same configuration.

All modules of the pack (with the same length) have the same control architecture. Module addressing is obtained through encoding in the wiring harness. See Section XXX.

All LiBER HV modules have the same internal power circuit: internal fuse, main switch and circuit scheme.

The LiBER modules are sealed and equipped with power and control connectors which can be made available in different arrangements to facilitate the electrical connection among the modules and the integration of the pack with the final application.

The cell type defines the power and energy performance of the module. Two main configuration available: Standard Energy – High Power SEHP and High Energy – Standard Power HESP. See Table I and II.

The LiBER module is equipped with an internal liquid cooling circuit. The module can be used without liquid cooling at reduced power performance See Tab I and II. Installation position and ambient temperature affect the performance of the system.

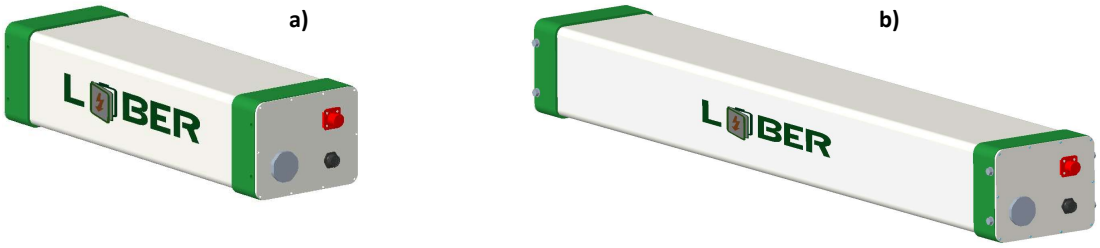

Fig. 1 a) module containing 7 cells in series (S7); b) module containing 15 cells in series (S15)

Fig. 2 shows an example of mechanical arrangement for a pack composed by 12 modules.

Fig. 2 Possible assembly of a semi-pack made of 12 modules.

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LiBER module Technical Data

	Data	Unit
Technology	Li-ion 21700	
BMS	Single cell monitoring	
Thermal system	Liquid cooling No cooling	
Ambient Temperature range	-40 to +60	°C
Altitude range	0 – to 4000	m
Energy density	140	Wh/kg
Protection Index	IP69	
Fire test	UL94V0	

Liquid Cooling System

	Data	Unit
Fluid	Water + glicole	
Fluid pressure	1	bar
Fluid pressure drop of	220	mbar
Fluid flow	1	l/min
Rated fluid temperature	20	°C

Certification

	Regulation	
Homologation	ECE R100.2	
Standards	ISO 62660	
Tansportation	UN38.3	

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Table I. LiBER HV NMC modules - Standard Energy - High Power SEHP

SEHP	type	S7	S8	S9	S10	S11	S12	S13	S14	S15
Type		NMC	NMC	NMC	NMC	NMC	NMC	NMC	NMC	NMC
Nominal voltage	[V]	25,2	28,8	32,4	36,0	39,6	43,2	46,8	50,4	54,0
Nominal capacity	[Ah]									
Nominal energy	[Wh]	5080	5806	6532	7258	7983	8709	9435	10161	10886
Max voltage	[V]	29,4	33,6	37,8	42	46,2	50,4	54,6	58,8	63
Min voltage (absolute)	[V]	17,5	20	22,5	25	27,5	30	32,5	35	37,5
Weight	[kg]	45,8	51,2	56,6	62	67,4	72,8	78,2	83,6	89
Rated discharge power	[kW]	5080	5806	6532	7258	7983	8709	9435	10161	10886
Rated charge power	[kW]	5080	5806	6532	7258	7983	8709	9435	10161	10886
Max discharge current 60s (1)	[A]									
Max. charge current 60s (1)	[A]									
Thermal current no cooling	[A]									
Thermal current with cooling	[A]									
Module cross section WxH	[mm]									
Module length L	[mm]	755	840	925	1010	1095	1180	1265	1350	1435

Table II. LiBER NMC - High Energy - Standard Power HESP

HESP	type	S7(2)	S8(2)	S9	S10	S11	S12	S13	S14(2)	S15(2)
Type		NMC	NMC	NMC	NMC	NMC	NMC	NMC	NMC	NMC
Nominal voltage	[V]	25,2	28,8	32,4	36,0	39,6	43,2	46,8	50,4	54,0
Nominal capacity	[Ah]									
Energy	[Wh]	5806	6636	7465	8294	9124	9953	10783	11612	12442
Max voltage	[V]	29,4	33,6	37,8	42	46,2	50,4	54,6	58,8	63
Min voltage (absolute)	[V]	17,5	20	22,5	25	27,5	30	32,5	35	37,5
Weight	[kg]	45,8	51,2	56,6	62	67,4	72,8	78,2	83,6	89
Rated discharge power	[kW]	1161	1327	1493	1659	1825	1991	2157	2322	2488
Rated charge power	[kW]	1742	1991	2239	2488	2737	2986	3235	3484	3732
Max discharge current 60s 1	[A]									
Max. charge current 60s 1	[A]									
Thermal current no cooling	[A]									
Thermal current with cooling	[A]									
Module cross section WxH	[mm]									
Module length L	[mm]	755	840	925	1010	1095	1180	1265	1350	1435

Note 1: not for lifecycle
Note2: standard product

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PACK DESCRIPTION

The LiBER pack HV can be implemented by following two the main configurations depending on the number of semi pack P connected in parallel as shown in fig. 3.

Pack composed by one string only (*P=1*). No semi-packs in parallel. Fig. 3a.

Pack composed by semi packs in parallel (*P=2, 3, 4*).Fig. 3b

Battery Management system is based on a master-slave configuration composed by:

- One *module BMS* installed inside each module.
- One *master BMS* per semi-pack placed near the semi-pack
- One *pack BMS* which interfaces with the application.

In single string configuration (*P=1, Fig. 3a*) the *master BMS* behaves as *pack BMS* and interfaces directly with the application through external CAN and control lines.

In multi-string string configuration (*P>1, Fig. 3b*) each *master BMS* controls the modules of its semi-pack and interfaces with the *pack BMS* which interfaces the pack with the application through external CAN and control lines.

The *pack BMS* also manages the switch box SB for the connection in parallel of the semi-packs and for the control of the connection of the pack with the application.

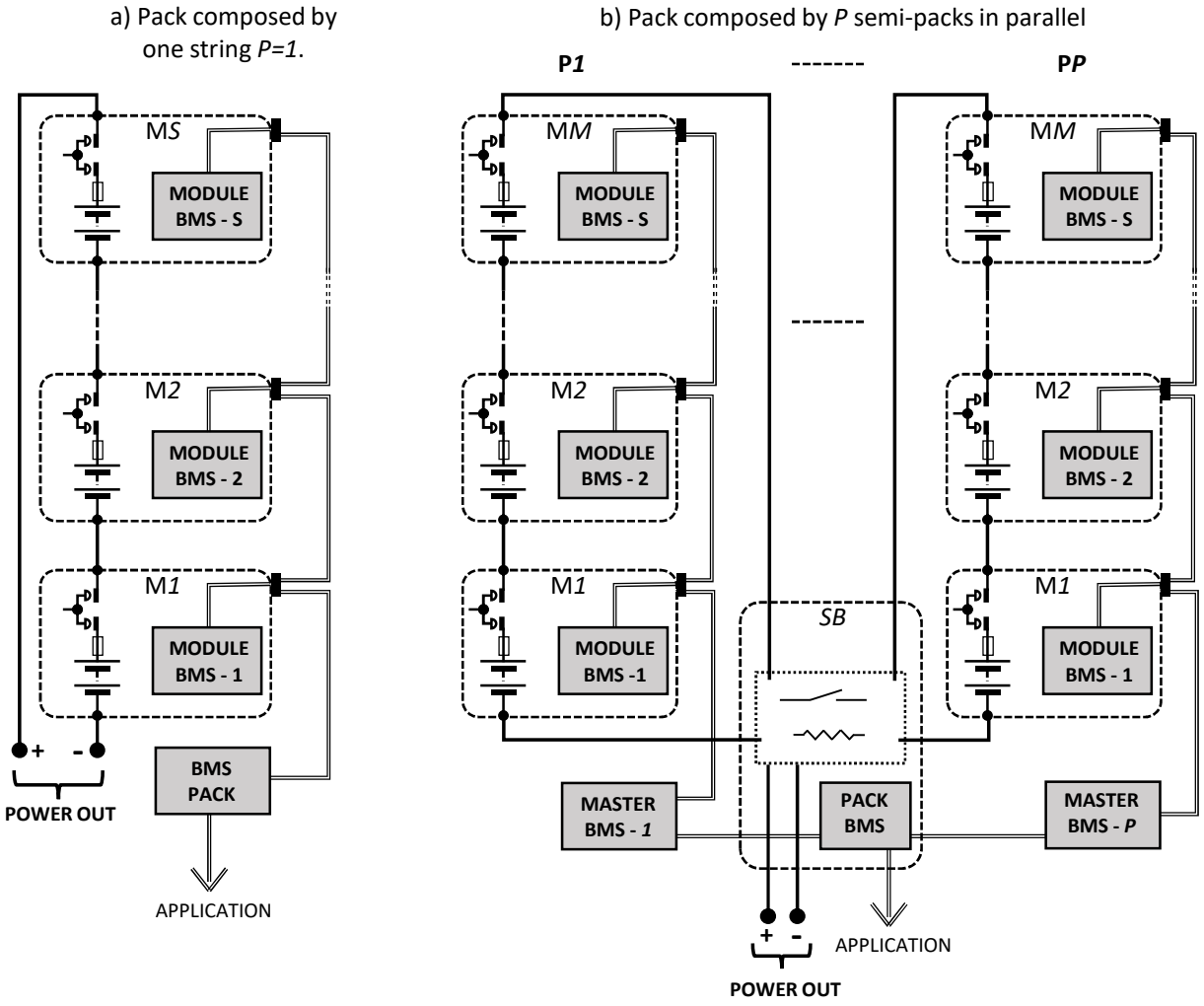

Fig. 2 BMS architecture and control lines for pack configurations:
a) single string P=1.
b) P semi-packs in parallel.

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LiBER Module HV

The LiBER *module HV* is based on the reference scheme of Fig. 3.

The module includes a string of *S* connection in series of cell units, containing *p* cells in parallel.

The internal architecture of the module BMS depends on the cell type and on the *p-S* configuration of the module.

The *module BMS* sense the physical quantities:

- current of the cell unit
- voltage of the cell unit
- temperature of all the cells.

qualifies the readings and calculates summary variables for representing the state of the cells in the module.

The *module BMS* implements the additional monitoring and control functions:

- monitors the state of the power fuse,
- drives and monitors the state of the main switch,
- actuates and monitors the equalization circuit,
- manages HVIL - High Voltage Inter Lock circuit or MSD Manual Service Disconnect.

The *module BMS* communicates with the master BMS through the CAN B. The master BMS collects all data from the module BMS and implements the control, protection and limitation function described in SectionYY.

The *module BMS* has an additional CAN line, named CAN A used for diagnosis and service only.

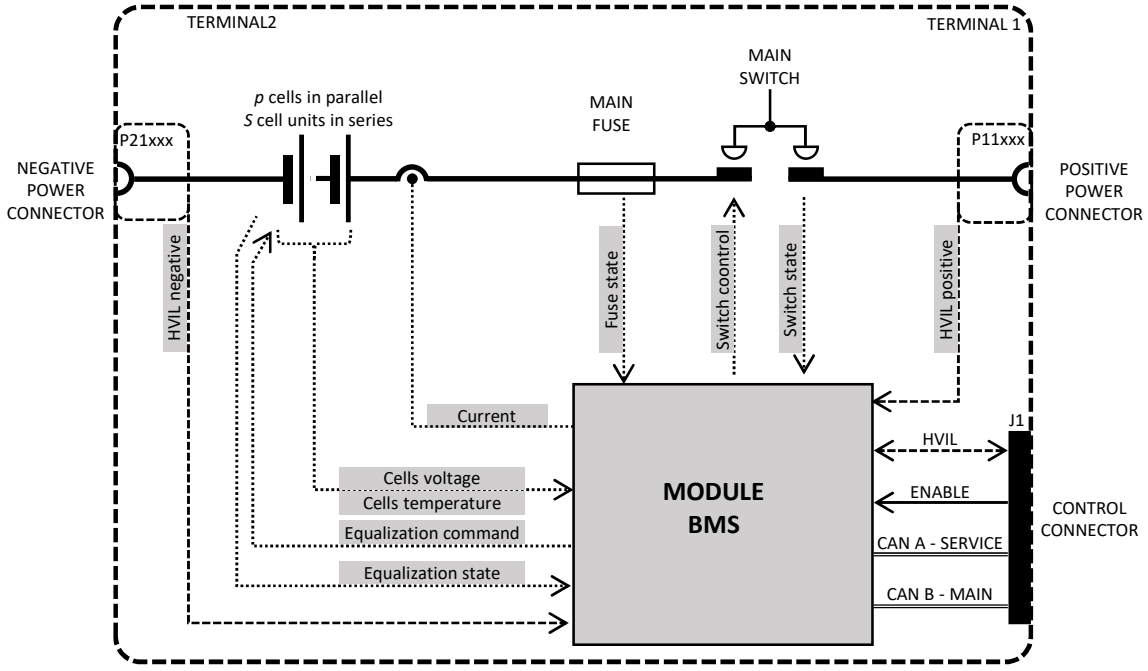

Fig. 2 Scheme of the electric power circuit of a LiBER module HV