Table 2-1 Battery module technical specification

MODULE SPECIFICATION	
Dimensions (L x W x H)	1289.7 x 423.7 x 141.7 mm
Total Mass	99.1 kg
Dry Mass	98.3 kg
Coolant Mass	0.8 kg
Module volume	51.15 L
Weight percentage of cell in product	88 %
Volume percentage of cell in product	58 %
Configuration	20S10P
Total number of cells	200
Nominal capacity	325 Ah
Nominal energy	23.78 kWh
Specific energy	242 Wh/kg
Energy density	465 Wh/L
Nominal voltage	72.8 V
Storage voltage	70 – 72 V
Maximum voltage (-40 °C < T < 65 °C)	84 V
Minimum voltage (0 °C < T < 65 °C)	50 V
Minimum voltage cold (-40 °C < T < 0 °C)	42 V
Maximum discharge current (10 sec)	3000 A
Maximum discharge power (10 sec @ 90% SOC)	155 kW
Continuous discharge power (@ 50% SOC)	45 kW
Maximum charge current	830 A
Maximum charge power	56 kW
Coolant	50/50 water/glycol
Cell Operating temperature	-40 °C to +65 °C
Cell Safety temperature	-40 °C to +80 °C

2.3 Battery Module Safety Features

Table 2-3 Battery module safety features

Pressure safety feature	Built in vent disc on each cell
Contact safety features	IPXXB in mated and unmated state
Fire safety features	Non-flammable materials
Fuse safety feature	Built in fuses on CCS for over current/short circuit protection
Ingress protection	IP54

2.4 Battery Module Cooling Specification

Table 2-4 Battery module cooling specification

Maximum Flow rate	4.2 L/min
Maximum pressure drop	0.1 bar @ 4.2 l/min & 18 °C
Maximum coolant pressure	2.5 bar (relative)
Operating temperature	-40 °C to 65 °C
Safety feature	Temperature acquisition via NTCs, no active monitoring at module level
Coolant	Water – Glycol (50:50 vol%), e.g. Frostox HT-12

2.5 Battery Module Storage Requirements

Table 2-5 Battery module storage requirements

Temperature	10°C – 40 °C
Humidity	25% - 75%
State of charge (SoC)	30 ± 2 %
Recommended storage voltage	3.56 - 3.60 V per cell @RT

2.6 Standard charging - SCH

Table 2-6 Standard charging parameters

Charging temperature range	23 ± 2 °C
Charge current	C/3
Cut off current	C/50
Maximum voltage	4.20 V

2.7 Standard discharging – SDCH

Table 2-7 Standard discharging parameters

Charging temperature range	23 ± 2 °C

Discharge current	C/3
Minimum Voltage	2.5 V

2.8 Standard cycle - SC

A standard cycle is defined as the sequence of SCH-SDCH-SCH.
SoC for the test is adjusted with standard discharge (SDCH) or with standard charge (SCH). Rest period is 30 min after adjusting SoC for the test.

Start SoC for each test is specified in the test specification.

Table 2-8 Standard cycle parameters

Charge C-rate	C/3
Cut off current	C/50
Maximum voltage	4.20 V
Discharge C-rate	C/3
Minimum Voltage	2.5 V
Rest period after charge/discharge	60 min
Test temperature	RT
Delta temperature	2 K

Table 2-9 Standard cycle test steps

TEST STEPS	
Step	*Description*
1	Installation of the DUT in the support frame or device.
2	Connect the HV cables and communication harness to module according to the test setup.
3	Condition the module to RT till the average of cells temperature differs maximum of 2 K from it. *Temperatures shall be read-out trough LV connector A and B.*
4	*Standard charge (SCH):* Charge the DUT with **C/3** constant current till one parallel of cells reaches the cell max voltage of **4.20 V**. Continue the charge with constant voltage phase until reaching cut-off current of **C/50**. *Cell voltages shall be read-out trough LV connector A and B.*
5	Rest the module for 60 min and verify delta temperature is within defined limit.
6	*Standard discharge (SDCH):* Discharge the DUT with **C/3** constant current till one parallel of cells reaches the cell min voltage of **2.5 V**. *Cell voltages shall be read-out trough LV connector A and B.*
7	Rest the module for 60 min and verify delta temperature is within defined limit.
8	*Standard charge (SCH):* Charge the DUT with **C/3** constant current till one parallel of cells reaches the cell max voltage of **4.20 V**. Continue the charge with constant voltage phase until reaching cut-off current of **C/50**. *Cell voltages shall be read-out trough LV connector A and B.*
9	Rest the module for 60 min.

2.10 Cell operating and safety limits, OCV

Battery module does not have cell safety limits implemented. The test bench needs to be programmed to stop/abort the test if one of the following cell voltage safety limits are reached:

Table 2-10 Cell voltage safety limits

SAFETY LIMITS		Voltage (V)	Single duration (s)	Reuse duration (s)
Safety limits (maximum)	Voltage Max1	4.25	10	175200
	Voltage Max2	4.26	10	116800
	Voltage Max3	4.27	5	43800
	Voltage Max4	4.3	2	195
Safety limits (minimum)	Voltage Min1	2.00	10	175200
	Voltage Min2	1.90	10	87600
	Voltage Min3	1.80	2	2920

Test bench needs to be programmed to stop/abort the test if the cell safety limits specified in Table 2-11 are reached in dependence of temperature of the cell.

Table 2-11 Cell current safety limits

TEMPERATURE LIMITS		
Temperature [°]	Current - Discharge [A]	Current - Charge [A]
-40	0	0
-39.9	3000	1
-37	3000	40
-25	3000	190
-20	3000	360
-10	3000	710
0	3000	1030
10	3000	1380
25	3000	1380
35	3000	1380
40	3000	1380
45	3000	1380
50	3000	1380
55	3000	1380
60	3000	1380
65	0	0

Cell operating limits are as follows:

1. Cell voltage upper limit: **4.2 V.**
2. Cell voltage lower limit: **2.5 V at temperature >5 °C**
3. Cell voltage lower limit: **2.1 V at temperature <5°C.**

Table 2-12 shows D2 cell OCV at different SOC and temperature levels during charge and discharge with C/3. Average value of CHG and DCH value can be used to obtain the OCV curve.

Table 2-12 Cell OCV Vs SOC (Temperature 0°C, 10°C, 25°C, 45°C)

SoC / %	0 °C		10 °C		25 °C		45 °C	
	CHG	DCH	CHG	DCH	CHG	DCH	CHG	DCH
100					4.147	4.178		
95					4.094	4.095		
90					4.083	4.08		
85					4.074	4.072		
80					4.044	4.047		
75					3.983	3.987		
70					3.936	3.935		
65					3.905	3.902		
60					3.851	3.837		
55					3.794	3.786		
50					3.744	3.736		
45					3.697	3.689		
40					3.661	3.652		
35					3.63	3.604		
30					3.596	3.554		
29					3.587	3.541		
28					3.577	3.528		
27					3.567	3.516		
26					3.556	3.503		
25					3.544	3.49		
20					3.487	3.451		
15					3.435	3.374		
10					3.374	3.278		
8					3.328	3.212		
6					3.28	3.152		
4					3.221	3.088		
2					3.112	3.006		
0					2.891	2.889		

Figure 2-3 Module single cells

Table 4-2 LV Connector Code A Pinout

LV CONNECTOR CODE A PINOUT			
#	Pin Name	Description	Externally to device
1	/	/	/
2	Cell10_POS	Voltage cell 10 positive	Data logging acquisition
3	Cell8_POS	Voltage cell 8 positive	Data logging acquisition
4	Cell6_POS	Voltage cell 6 positive	Data logging acquisition
5	/	/	/
6	Cell4_POS	Voltage cell 4 positive	Data logging acquisition
7	Cell1_POS	Voltage cell 1 positive	Data logging acquisition
8	/	/	/
9	/	/	/
10	NTC1_PWR	NTC 1 Power	Data logging acquisition
11	NTC2_PWR	NTC 2 Power	Data logging acquisition
12	NTC3_PWR	NTC 3 Power	Data logging acquisition
13	/	/	/
14	Cell9_POS	Voltage cell 9 positive	Data logging acquisition
15	Cell7_POS	Voltage cell 7 positive	Data logging acquisition
16	/	/	/
17	Cell5_POS	Voltage cell 5 positive	Data logging acquisition
18	Cell3_POS	Voltage cell 3 positive	Data logging acquisition
19	Cell2_POS	Voltage cell 2 positive	Data logging acquisition
20	Cell1_NEG	Voltage cell 1 negative	Data logging acquisition
21	/	/	/
22	NTC1_GND	NTC 1 Ground	Data logging acquisition
23	NTC2_GND	NTC 2 Ground	Data logging acquisition
24	NTC3_GND	NTC 3 Ground	Data logging acquisition

Table 4-3 LV Connector Code B Pinout

LV CONNECTOR CODE B PINOUT			
#	Pin Name	Description	Externally to device
1	NTC4_GND	NTC 4 Ground	Data logging acquisition
2	NTC6_GND	NTC 6 Ground	Data logging acquisition
3	NTC5_GND	NTC 5 Ground	Data logging acquisition
4	/	/	/
5	/	/	/
6	Cell19_POS	Voltage cell 19 positive	Data logging acquisition
7	Cell16_POS	Voltage cell 16 positive	Data logging acquisition
8	/	/	/
9	Cell14_POS	Voltage cell 14 positive	Data logging acquisition
10	Cell12_POS	Voltage cell 12 positive	Data logging acquisition
11	/	/	/
12	/	/	/
13	NTC4_PWR	NTC 4 Power	Data logging acquisition
14	NTC6_PWR	NTC 6 Power	Data logging acquisition
15	NTC5_PWR	NTC 5 Power	Data logging acquisition
16	/	/	/
17	Cell20_POS	Voltage cell 20 positive	Data logging acquisition
18	Cell18_POS	Voltage cell 18 positive	Data logging acquisition
19	Cell17_POS	Voltage cell 17 positive	Data logging acquisition
20	/	/	/
21	Cell15_POS	Voltage cell 15 positive	Data logging acquisition
22	Cell13_POS	Voltage cell 13 positive	Data logging acquisition
23	Cell11_POS	Voltage cell 11 positive	Data logging acquisition
24	/	/	/

The NTC thermistors (Code: ### ###) reading can be linearized through the lookup table provided in "### RT.txt". At 25 °C the respective resistance value is 10 kOhm.