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D.3400.4

2nd Assembly of Supercapacitors (SC) modules

Summary

This deliverable deals with the assembly, performed by DimacRed, of the second generation of supercapacitor (SC) modules, based on storage specifications, described in deliverable report D.3100.1 [1] and on the preliminary test results arising from Task 3440 and preparatory assembly work of the SC system, carried out in SP5000. The activity described in this report has been performed in WP 3400 "Module Assembly and Testing", Task 3410 "Assembly of modules", and was aimed to provide supercapacitors (SC) modules for testing purposes within SP3000 "Energy storage systems". The 2nd generation module design and assembly are substantially moved from a prototype assembly in the 1st generation [2] without case, engineered geometry and control electronics to an industrialized configuration, subsequently used for the module testing in SP3000 and for the final SC systems in SP5000. This 2nd generation modules have not yet been distributed for testing.

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Acronyms

SC Supercapacitor (electrochemical capacitor)

Introduction

This deliverable is prepared as planned in the WP 3400 “Module Assembly and Testing”, in Task 3410 “Assembly of modules”. The activity done is a prosecution of the work described in D3400.3 [2] on the 1st generation of SC modules and has been completed for the part related to the final design and assembly of the 2nd generation SC modules, and described in this report.

The assembly takes into account the following characteristics:

- modularity;

- integration of the voltage and temperature measurements needed to monitor the module state of charge (SOC) and temperature;

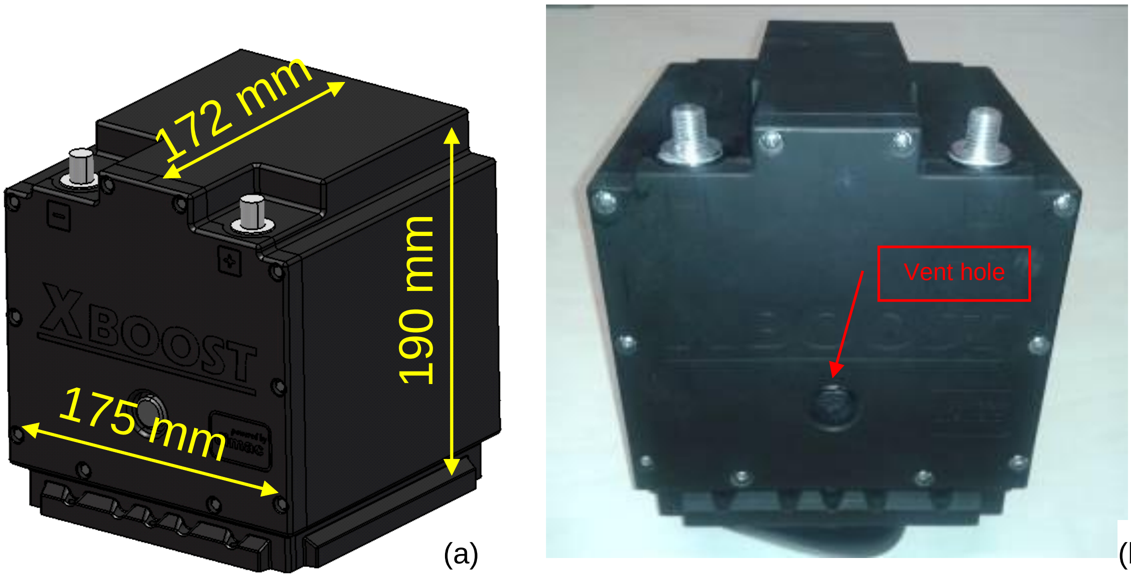
- integration with commercially available components in order to guarantee the module standardization, reliability and availability.

However, a final set has not been yet decided, completed and distributed to the testing laboratories for the safety and electrical testing. Three modules have been used at DimacRed for preliminary testing, reported in D.3400.7 [3], and a fourth one is completely new and ready for testing. Finally, a set of 42 SC cells is available for cell testing and assembling additional modules (six cells per module).

Technical progress

Mechanical Assembly

For the second assembly generation we have decided to integrate the standard Maxwell cells BCAP3000P270 into a plastic case, which will become a standard Dimac product under the commercial name of X-BOOST 500 (Figure 1). The external case, realized in PC-ABS is characterized by a 2 aluminium pole power terminal M12 screw. Each single module, in addition, is equipped with a 4 poles Deutsch connector, DTM04-4P, in order to ensure the CAN signal communication.



(a) (b)

Figure 1. Mechanical drawing module layout (a) Drawing, (b) Real sample.

The main dimensional characteristics are reported in Table 1.

Table 1. Main dimensional data of the single SC module.

Length	175 mm
Height	190 mm
Width	172 mm
Weight	4.4 kg

Each single module is designed in order to ensure the mechanical installation in each possible direction. A vent hole applied on a side surface avoids the humidity from being trapped inside the module.

Internally the module consists of 6 series-connected SC cells (Maxwell BCAP 3000 P270 screw terminal cell) and, in Figure 2, the exploded view of the XBoost 500 module is reported.

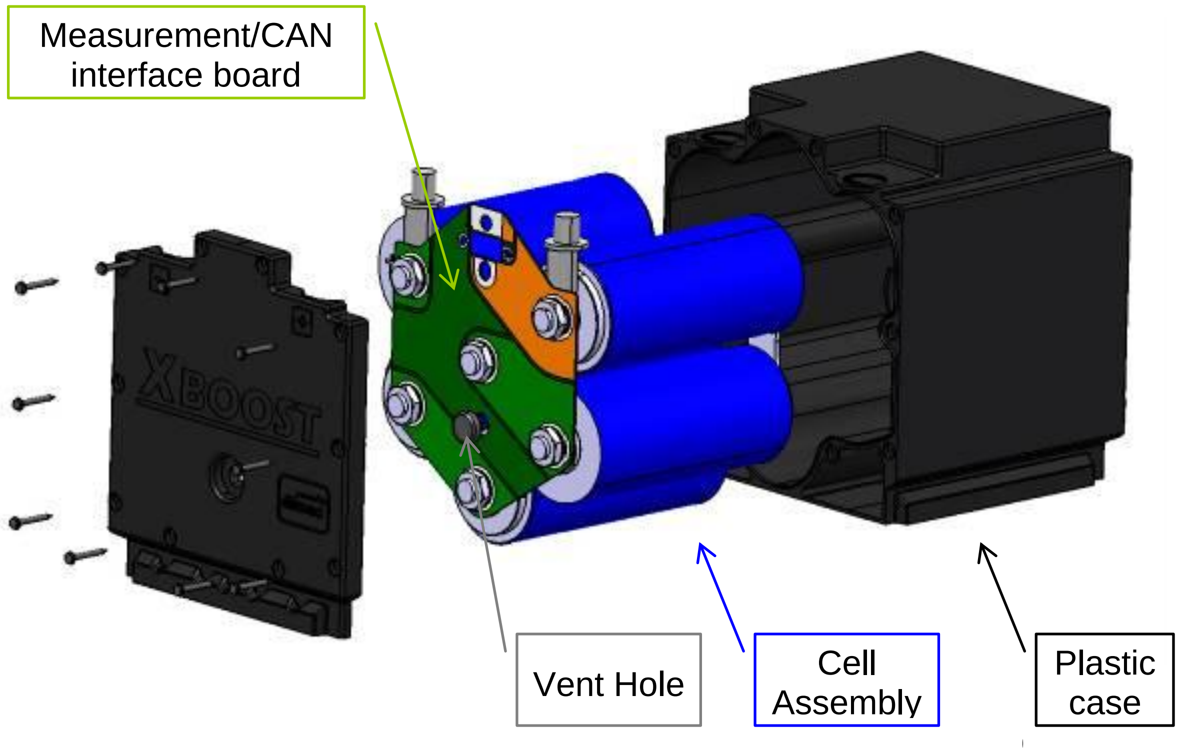


Figure 2. Exploded view of the single SC module Xboost500.

Mechanically, the 6 cells are connected by means of aluminum bus bars. An additional measurement and CAN communication board is applied to one side of the cells in order to ensure the module voltage measurement and temperature monitoring. An additional analog/CAN interface is mounted on it.

Electrical Specifications

The electrical specifications of the module are summarized in Table 2 and are the same as those of the 1st Assembly.

Table 2. Electrical Specifications of the module.

Vn	**16.2**	**V**
Cn	**500**	**F**
Rdc	**1.74**	**mΩ**
Rac	**1.44**	**mΩ**
Continuous Current I_c	**50**	**A**
Maximum Continuous Current I_{max}	**147**	**A**
Max Peak Current I_{peak} for 1s	**2100**	**A**
V surge	**17**	**V**
Operative Temperature Range	**-40 +65**	**°C**
Maximum Specific Power Density	**5900**	**W/kg**
Maximum Specific Energy Density	**5.96**	**Wh/kg**

The maximum current value for this assembly is 2100A. The continuous current value, instead, is the current delivered by the cells continuously without a dedicated cooling system. In this operative condition (charged and discharged with the continuous current), the over-temperature, is 20°C.

It is important to underline that the maximum continuous current is the value with which the module can be charged and discharged with an adequate cooling system and, in this condition, the module temperature increases by 20°C.

For the scope of the project this current value exceeds the system specifications and the aim of the laboratory activities in Task 3440 is also to identify the maximum power cycle that can be allowed in order to avoid the cooling system.

CAN interface specifications

Each single module is provided with an interface CAN board able to collect the analogue module voltage and temperature signals and convert them into CAN messages.

The developed board is reported in Figure 3.

Figure 3. Measurement and CAN-communication control board.

In Figure 4 the layout of the CAN communication architecture is reported. On the CAN BUS "SC" the messages reporting the information of temperature and voltage of each single module are exchanged, while on the VEHICLE CAN BUS are the messages exchanged between the MIDAC and the Vehicle control unit according to the "CAN Bus Message J1939 BMS 5.P".

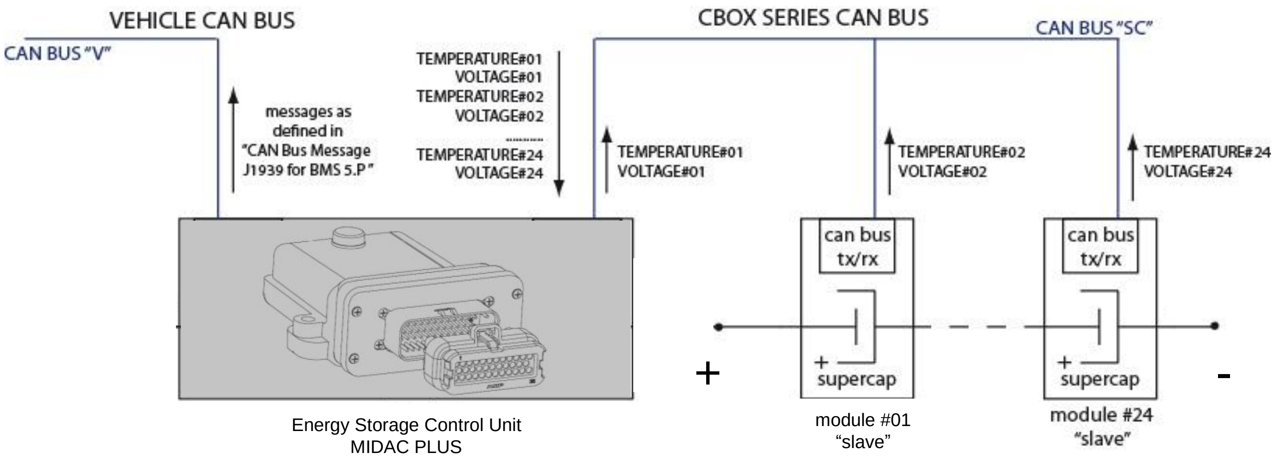


Figure 4. Schematic layout of the CAN communication architecture between modules.

Protocol details

Each slave module on the CAN BUS SC exchanges the messages described in Table 3.

Table 3. Messages sent from each "Salve" supercapacitor module toward the CAN BUS "SC".

Message	Name	Description	Code
Request DATA	status_XXX (**)	Voltage, temperature, Alarm	0x10
Command	id_change	ID module change	0x30
Request DATA	fw_version	Request of firmware version	Not implemented
Command	type_change	Change the module status (Master/Slave/S.A.)	0x50
Command	alarm_setup	Alarm level reference	Not implemented
Command	calibration	Offset calibration	Not implemented
Alarm	over_volt_moduleXXX	Module Over voltage >16.2 V	In status_XXX
Alarm	over_temp_moduleXXX	Module Over temperature >65°C	In status_XXX
Alarm	under_temp_moduleXXX	Module Low – temperature <-40°C	In status_XXX

XXX is the identification module number with 3 digits (001, 002, …,024).

Conclusions

The SC storage module has been improved with respect to the 1st generation and designed in a final 2nd generation mostly addressing mechanical and control architecture and assembly with a dedicated case. The technical characteristics are exactly the same as those of the 1st generation, confirming the technical specifications initially agreed with Altra.

Four modules (3) have been initially assembled with electronic control equipment and ready for electrical testing. DimacRed has already performed preliminary characterization tests on three modules for verifying assembly and functionality has now been preliminarily tested from an electrical point of view according to WP3440. The storage performances in terms of thermal stability, voltage balancing, power and energy performances have been measured at

DimacRed and will be further analysed in other testing laboratories. Safety testing will be also carried out on module samples.

In parallel, the module, named XBoost500, has been used to realize the whole system (SP5000 activity) that will be installed on board the hybrid commercial van of Altra.

References

1. Hybrid Commercial Vehicle (HCV) FP7-Project, " Technical specifications for HEV, D3100.1," Altra, 2011.
2. Hybrid Commercial Vehicle (HCV) FP7-Project, " 1st Assembly of SC modules, D3400.3," DimacRed, 2013.
3. Hybrid Commercial Vehicle (HCV) FP7-Project, " 1st technical report on electrical tests on SC modules, D3400.7," ENEA, 2013