MOTORSPORT BATTERY TESTING WITH A CINERGIA B2C+ BIDIRECTIONAL CONVERTER

INTRODUCTION

Regenerative braking is an important technology in electric motorsport, as it allows for batteries to be smaller, and therefore lighter. In the racing category Formula Student Electric, where ETSEIB (Barcelona School of Industrial Engineering) Motorsport participates, the amount of recuperated energy can be specially high because motors can be mounted on all four wheels of the vehicle. For the battery, regenerating by braking means short high current bursts that accelerate the cells' wear. This document presents the accelerated life testing protocol ETSEIB Motorsport has used to determine whether the cells can endure a whole season with this work load.

Figure 1. The CAT12e, ETSEIB Motorsport's car for the 2018-2019 season.

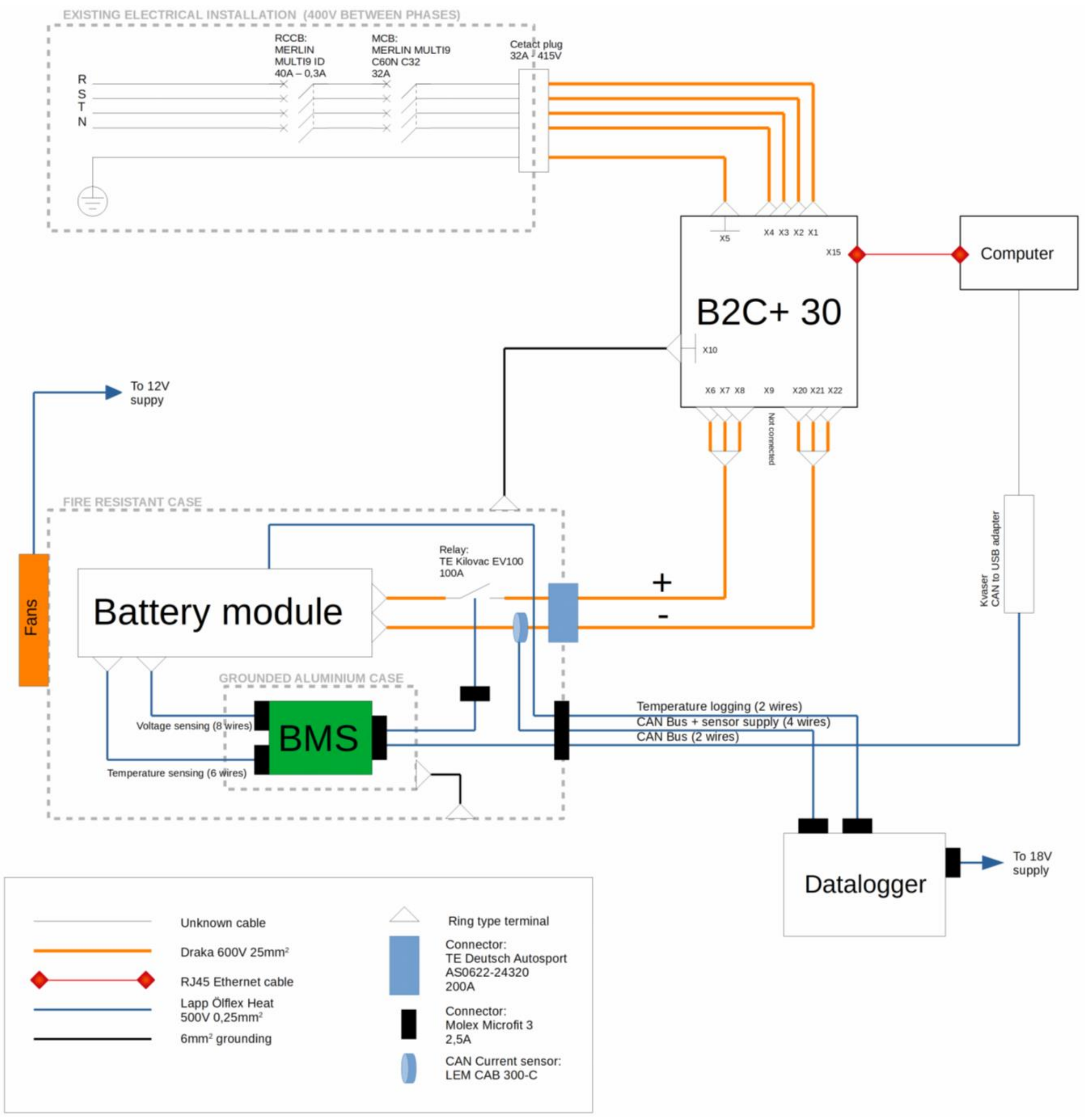
FEATURES OF THE B2C+ 30 BIDIRECTIONAL CONVERTER

- 3 channels
- ± 30A per channel (90A when working in parallel mode)
- 20 to 750V in unipolar connection, -350 to 350V in bipolar connection
- 30kVA
- Operating modes: constant current, constant voltage, constant power, constant impedance and CC-CV-CC-CV battery charging.
- Controllable via its touchscreen or connecting a computer (comes with user-friendly interface)
- Returns discharged current to the grid

In this application, unipolar parallel mode has been used as currents of 75A were needed. The user interface has been essential as it allows to send a current profile by opening a csv file.

Figure 2. The converter's front view. For scale, it can be noted that is is 1.1m high.

TESTING RIG



Platform details:

- AC/DC Converter: Cinergia B2C+ 30
- Battery module: Melasta li-ion pouch cells. 7s1p configuration. For each cell: 3V to 4.2V and 6.8Ah.
- BMS: self-developed. Opens the power circuit if the cells voltage or temperatures values go beyond safe levels.
- Datalogger: self-developed. Saves current and temperature readings every 20ms.
    - Current sensing: LEM CAB 300-C (hall effect)
    - Temperature sensing: 3 Vishay lug type thermistors.
- Fire resistant battery container on a hand cart, for safety reasons.

METHODOLOGY

The experiment means to discharge the module 50 times by repeatedly applying a current profile that simulates a lap of a race. The profile has been obtained from modifying real data that was recorded during the previous season.

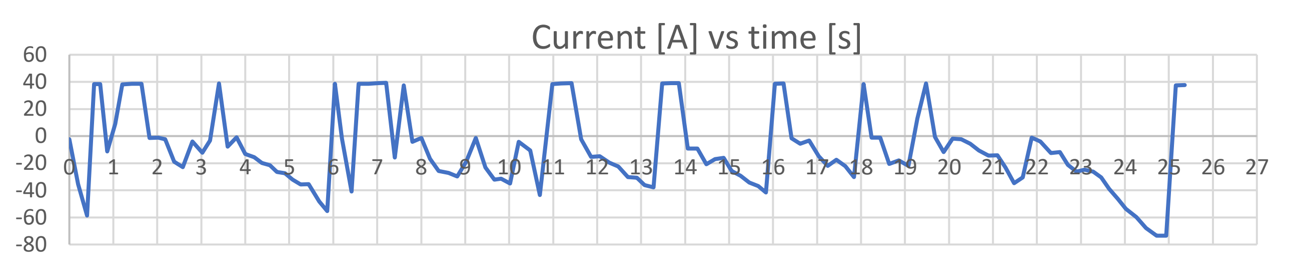


Figure 3. The used current profile

It should be noted that at high SoC values, another profile that doesn't have positive (charging) currents has been used in order to avoid reaching voltages that are too high for the cells.

Every one of the 50 cycles has the following structure (we choose a fully charged module as the cycle starting/ending point):

1. Turn on the datalogger.
2. Apply the current profile repeatedly until a cell reaches 3.2V.
3. Turn off the datalogger and turn on the fans.
4. Let the cells rest for 10 minutes or until they reach 45ºC (datasheet value for continuous charging).
5. Charge the module at 5A.
6. During charging, keep the fans on until the module reaches room temperature.
7. The charging cut-off voltage is 4.19V.
8. Let the cells rest for 10 minutes.
9. Calculate capacity by coulomb counting and make sure its value is not too low before beginning the next cycle.

Each one of these cycles takes aproximatively 2 hours.

In order to be in a worst case scenario, the module has been thermally insulated so it approaches its maximum operating temperature (60ºC) at the end of the discharge.

SAFETY CONSIDERATIONS

Repeatedly applying high currents to lithium cells always has a risk. The testing rig has been designed so as, in case of battery fire, the fire could not spread nor hurt anybody. This has been achieved by using a fire resistant battery container, which is itself mounted on a hand cart. The hand cart combined with easy to disconnect wiring makes it possible to push the module to a concrete courtyard in 30 seconds from the detection of the problem.

RESULTS

A part from visually inspecting the cells, the indicators that have been used to assess the cell's state of health are capacity fade and internal resistance rise.

Capacity fade:

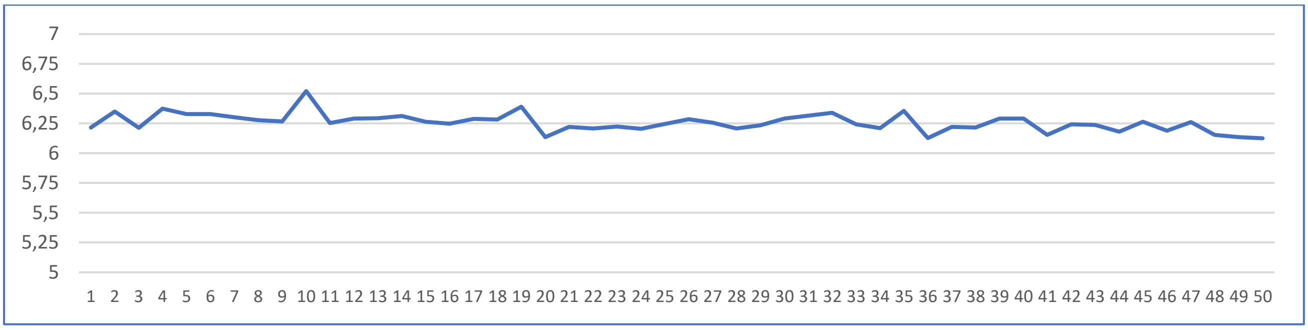


Figure 4. Capacity [Ah] evolution through the 50 discharges.

The average of the first 5 values is 6.30 Ah and the average of the last 5 is 6.17 Ah. This represents a relative decrease of 2 %.

Internal resistance rise:

What has been measured is the difference between the maximum temperature reached by the module and the ambient temperature. This indicator has been considered sufficient to detect significant changes in the internal resistance.

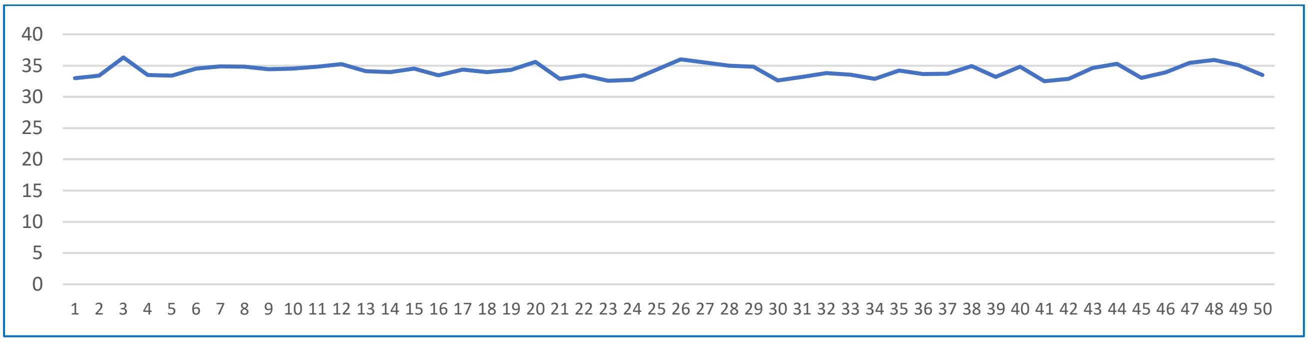


Figure 5. Temperature rise above ambient [ºC]. Evolution through the 50 discharges.

The average of the first 5 values is 33.92 ºC and the average of the last 5 is 34.76 ºC. This change has not been considered significant.

CONCLUSIONS

None of the measurements show any worrying sign of ageing whatsoever. The fact that seven cells have been tested at the same time gives proper significance to the results, providing confidence that this work load can be applied to the whole battery pack.

Author: Pol Molénat Gené