Höcherl & Hackl
The electronic load

Customer Application #23

Testing of a Low-Voltage Accumulator for an Electric Racecar

HWRacing is Heriot-Watt University's Formula Student team, founded in 2009 in Edinburgh.

In 2022, the team entered its first electric vehicle named HWR-11 into the Formula Student UK competition. HWR-11 marked two of the team's most significant developments to date – a fully-developed electric powertrain, and the team's first aerodynamics package.
The team finished 20th out of 61 teams and 9th out of the 27 electric vehicles.


HWRacing team at the Formula Student UK 2022 competition

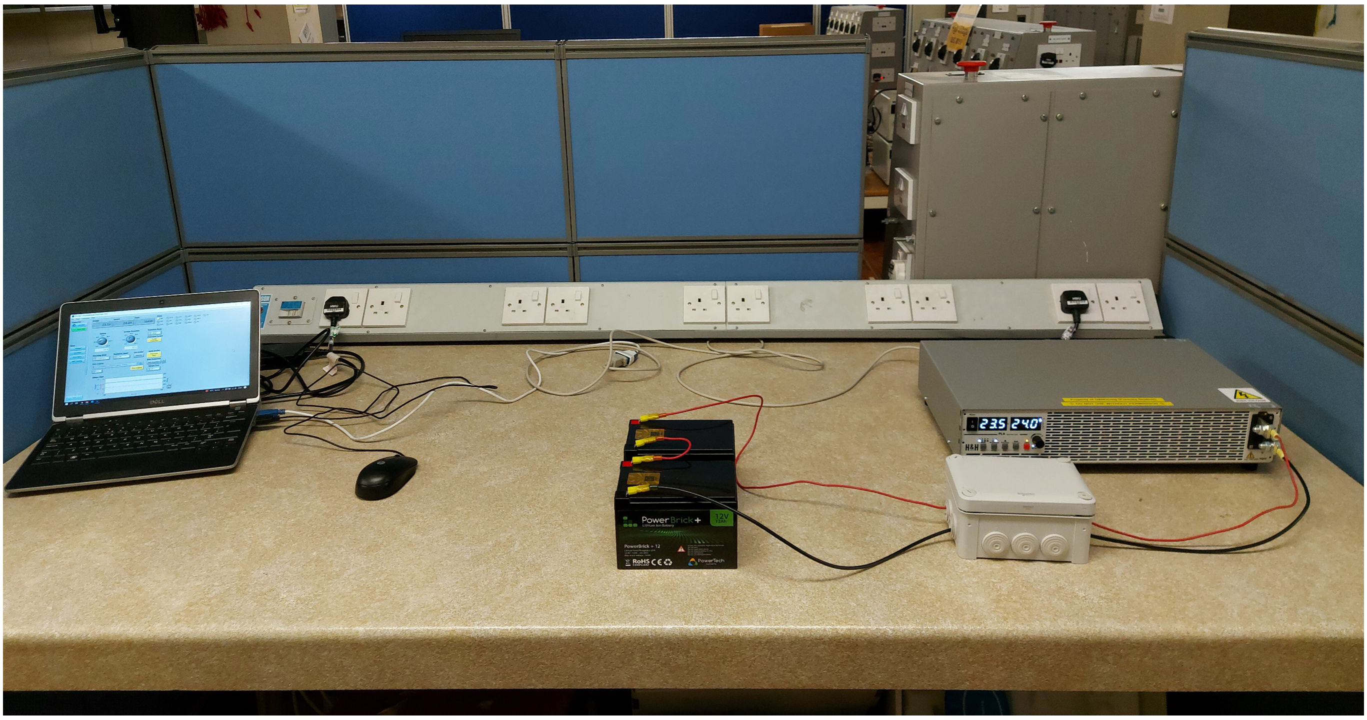
Höcherl & Hackl has supported HWRacing in the development of future electric vehicles by providing a PLA1206 electronic load. This electronic load supports a maximum input power of 1200 W, which can be reached through any combination of input voltage and current, up to a maximum of 60 V and 120 A respectively. This flexibility allows a wide range of systems to be tested, from individual high-power cells to bespoke power distribution electronics.

The Vehicle's Accumulators

The team's latest vehicle, HWR-12, has two batteries (referred to as accumulators). The HV accumulator (350 V nominal) is used to power the vehicle's electric powertrain. It consists of a 96s9p configuration of 18650 lithium-ion cells. The LV accumulator supplies the vehicle's control electronics and other low-voltage systems (such as cooling fans and pumps). HWR-12 uses a 24 V low-voltage system, which allows for a lighter wiring harness and less wiring losses compared to a 12 V system.
In this application note, we detail the testing process of HWR-12's new LV accumulator. To reduce development time, two off-the-shelf 12 V lithium iron phosphate batteries were used instead of designing a custom LV accumulator. These batteries are wired in series to reach the full system voltage.

LV Accumulator Testing

The initial LV power and capacity budget for HWR-12 stated that the LV accumulator will require a minimum constant power output of 400 W and a minimum capacity of 200 Wh (assuming a nominal voltage of 24 V). This budget was intentionally pessimistic to ensure the LV accumulator capacity was sufficient to allow the vehicle to run for extended periods if required.
To ensure the LV accumulator met these requirements, a test was performed using the electronic load. The LV accumulator was fully charged using an off-the-shelf charger. Then, it was discharged at a constant current of 24 A (its maximum rated continuous current) until the BMS of one or both batteries disabled its output due to an undervoltage condition.

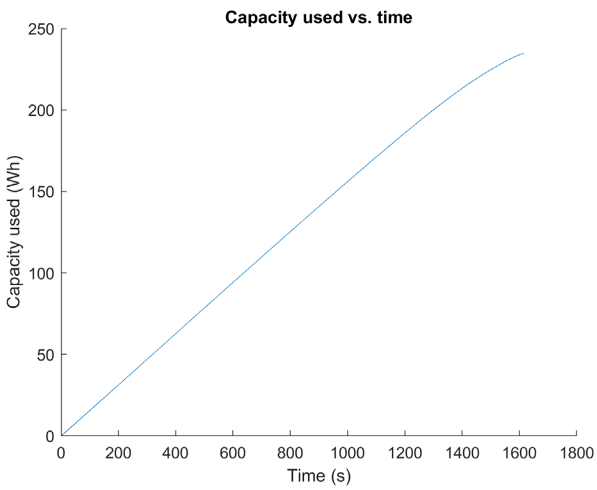


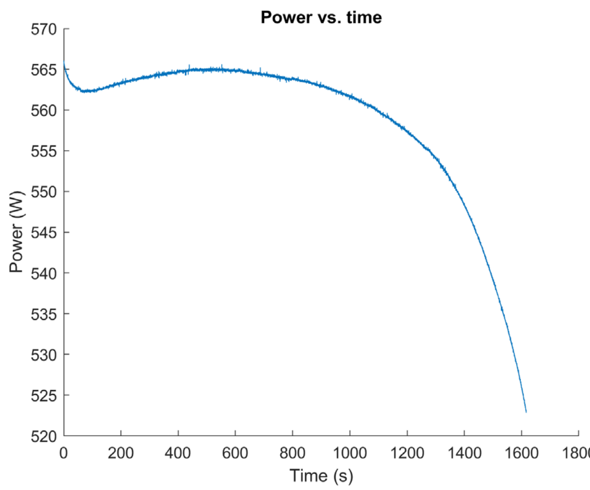
Low-voltage accumulator test setup

The electronic load's undervoltage protection feature was used as an additional safety measure to prevent over-discharge. It was set to disable the input when the system voltage dropped to 21 V.
Using the PLA Tool software, the voltage and current measurements performed by the electronic load were logged for the duration of the test. The measurement log was then processed by a Matlab script.

Results

The results from this test showed that the LV accumulator could deliver a constant current of 24 A (equating to a maximum power significantly greater than 400 W) throughout the duration of the test. The LV accumulator delivered a total energy of 234.7 Wh to the electronic load before one of the batteries disabled its output.
This means that the LV accumulator exceeds the minimum capacity requirement by 17%. Although this test was only performed at one temperature, the excess capacity means that the LV accumulator should perform reliably even under worst-case conditions where the ambient temperature is low and the capacity is degraded.





Future Work

In the near future, the students will perform initial tests on their new HV accumulator packs using the electronic load. They will cycle the packs to ensure the BMS and temperature monitoring system are functioning correctly before assembling the packs into the HV accumulator.

After the 2023 Formula Student UK competition, they are looking to significantly change the architecture of the HV accumulator. In particular, they want to characterise larger 21700 cells and evaluate them against the current cells, as they may allow tighter packaging and offer better performance. The electronic load will allow us to push the new cells to the limit and determine figures such as their capacity and internal resistance. This work will also assist the team in the development of a new, more tightly packaged LV accumulator.

The students would like to investigate developing software for automated testing. This would be useful for any cell characterisation project, and would be very useful for testing other electronic systems. For example, the high-current power distribution systems could be subjected to simulated overload conditions to ensure protection functions activate as intended. The team's newly-created software development staff could use the programming capability of the electronic load with custom software written in Python to develop flexible automated test systems.

This application report was produced in association with Heriot-Watt University's HWRacing Team