Höcherl & Hackl
The electronic load

Customer Application #14

PLI6412 in the Development of Drive Batteries for Electrical Racing Cars

Kaiserslautern Racing Team (KaRaT) has been developing electrically powered racing cars since 2012 according to the international Formula Student regulations. Self-designed components are also used in the drive chain; especially for the high-voltage battery no finished components are available.

Problem Definition

The battery can be assembled with lithium-ion rechargeable cells of mainly Chinese manufacturers, which can meet the requirements with regard to high energy density, performance and last but not least moderate purchase price.

Previous developments have shown that there have been significant deviations in the cells of some manufacturers, both from the specifications in the technical data sheets and between individual samples within the same batch. Relevant factors here are the usable capacity, the internal resistance and the thermal behaviour, especially under cyclic load, as they are in operation.
Thermal characteristic values are not specified by the manufacturers and have been neglected in the selection of cells. This led to problems in the cooling of the battery pack and the use of cell types unsuitable for this application.

Consideration

In order to be able to make a fact-based decision, sample cells were purchased for an experimental comparison.
Since the internal resistance and voltage of the cells are not constant during discharge, a comparable situation can only be achieved by using an electronic load. With such a load, discharge curves should be recorded at constant current to verify the data sheets.
Subsequently, a load profile similar to the actual application is to be used to determine the internal resistance and the actual usable capacity until the discharge voltage is reached.

After installing the battery stacks, the electronic load should also be used to monitor the internal resistance and temperature development under load.

Execution

Together with Höcherl & Hackl, a PLI6412 was selected that meets all requirements for the planned application range:

	Requirement	PLI6412
Min. voltage	2 V (single cell)	1.2 V
Max. voltage	100 V (battery stack)	120 V
Max. current	300 A	300 A
Accuracy	1 %	0.2 %
Continuous power	4 kW (battery stack)	6.4 kW
Short-time power	10 kW (battery stack)	12.8 kW

A test bench was set up around the device, which enables the charging and discharging of individual cells with continuous recording of measured values and temperature monitoring by means of a thermal imaging camera.

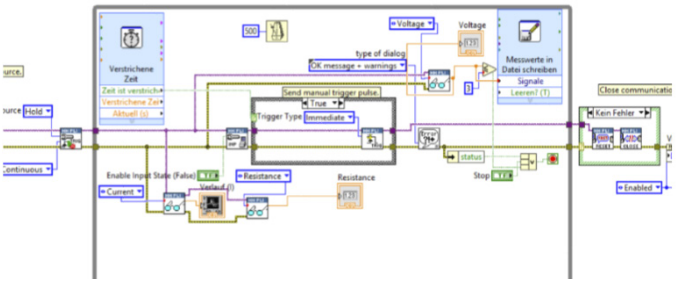
The following measurements were taken:
Discharge curve with single and triple nominal capacity per hour (1C/3C): These are used to compare the measurement results with the values indicated in the data sheet (1C discharge) or the average load in use of the vehicle (3C). The device's constant current discharge function with recording of the measured values directly on a USB flash drive was used for this purpose. The discharge current, discharge cut-off voltage and limits for the capacity and duration of discharge can be preselected on the control panel. During discharge, the consumed charge is continuously integrated and shown at the display.

Hardware-in-loop simulation of a realistic driving situation:
In addition to the above-mentioned static tests, the sample cells were discharged with a load spectrum that determines the power instead of the currents. As a result, currents become higher and higher as the voltage decreases during discharge. This leads to a reduced usable capacity in case of a high internal resistance of the cell, because during short current peaks the discharge cut-off voltage is undershot.

Since the internal memory of the device is not sufficient for a twenty-minute cycle and recording on a USB flash drive is not possible in list mode, the control via LabVIEW is used for this test. For this purpose, a separate LabVIEW VI was created which, based on the manufacturer's example VIs, also enables list operation with power setting value and continuous data recording.
During the discharge process, thermal images were taken in order to investigate the distribution of heat loss at the cell lugs, especially on the cell lugs of pouch cells, during peak loads.
The maximum temperature of 60°C must not be exceeded.

Internal Resistance Measurement

The corresponding function of the PLI series was used to check the assembled battery stacks. Two current values with corresponding durations are given and the internal resistance is determined from the resulting voltage drop. This is displayed directly so that the measurement including evaluation takes only a few seconds.



Result

The test results made it possible to select the battery cells according to their intended use. The causes of the problems of previous years were identified and the design was optimized in addition to the selection of more suitable cells for connection and cooling. For the first time, the drive battery developed in this way met all the demands of driving, which contributed significantly to the team's good performance in the driving disciplines of the competitions in Hockenheim and Barcelona.
The PLI 6412 proved to be a valuable instrument in the development process and convinced with its intuitive operability of the functions available on the device. Only the control via LabVIEW caused some difficulties at the beginning, a corresponding manual with explanation of the example VIs would simplify the introduction.

Ausblick

For future developments, an extension of the test bench with a regulated current source is planned in order to also map recuperation currents. This would also make it possible to control and record all measurements, including intermediate charging processes, fully automatically with LabVIEW.

This application report was produced in association with Kaiserslautern Racing Team.