To: LFEV-ESCM Team

From: Drew Jeffrey

Date: 14 May 2014

Subject: Battery Pack Errata / Future Improvements Memo

Abstract:

The 2014 LFEV team delivered a functional battery pack which conforms with many of the Formula Hybrid rules relating to accumulator containers. However, a few necessary Formula EV requirements were missed in the current pack design. This memo documents the improvements and errors found in the current battery pack design in the hope they will be corrected next year.

HV/GLV Wire Separation:

Most of the battery pack components run off of TSV. However, there are a few components such as the AIR control signals and the safety loop which are completely GLV. In the current pack, these GLV wires are run through the same wire duct as the other wires in the pack. This defeats the spacing restrictions between GLV and TSV circuits outlined in the Formula EV rules.

Precharge Relay:

The formula EV rules call for something called a "pre-charge" circuit to be attached between the AIRs. The purpose of the precharge circuit is to allow one AIR to close, power up the circuits between the two AIRs, then open the second AIR once the circuits in between are powered up to at least 90% of their typical voltage. The FEV rules relating to the pre-charge circuitry should be analyzed and this circuit should be added to the current pack design.

Fuse/Resistor Protected Sense Wires:

EV 3.6.4 states all voltage sensing wires connected to the AMS should be protected by either fuses or resistors to limit any dangerous short circuit current from damaging the AMS. Currently all sensor wires connected to the AMS boards or Pack Manager are not protected at all.

Additional Temperature Sensors:

In the current pack, only two external temperature sensors are being used. One is on the current shunt as it is needed for current measurement correction. The other is monitoring the main discharge fuse temperature. The PacMan BoB has additional slots for 2 more sensors and if the BoB PCB is modified, the remaining 2 ADCs can be used to increase the number of external sensors to 6. Additional temperature measures should be taken of ambient temperature of the pack as well as charging fuse temperatures.

Rear Battery Access:

The current design of the battery pack uses a wire duct attached to the back panel in order to cleanly route wires. However, this makes it very difficult to access the back side of the pack for maintenance. It is suggested that the location of the wire duct be changed to allow removal of the back panel or access hatches be made.

Charge Relay Bypass:

In the current design of the pack, the charge relays are powered by voltage supplied by the charger and triggered by a DIO pin on the Pack Manager. However, if the battery pack discharges too far and there is not enough voltage to turn on the Pack Manager, the charge relays will be stuck close and cannot charge the packs without opening up the accumulator container. It is suggested that a charge relay bypass button be installed that will allow the charger voltage to "jump" the relay contacts when pressed and allow the user to charge a completely dead pack without opening it up. It should preferably be a momentary button that won't latch so the user will have to actively supervise the pack will bypassing the charge relays.

30V Indicator:

EV Rules 3.3.6 specifies that there must be an indicator on the accumulator container which will illuminate whenever a voltage of 30V or more is present on the vehicle side of the AIRs. Our design does not have this feature in it at all. We suggest using a simple analog voltmeter and wiring it to the outside of the AIRs to meet this requirement.

Stuck Charging Relay:

In the current PacMan BoB PCB layout, no circuitry was included to open the charging relays should the TS-8160-4200 computer sudden crash while the unit is charging. Ideally, if the watchdog timer times out for any reason, both the safety loop should be opened and the charging relays should be forced open as well to stop charging. This will prevent the system from accidently overcharging cells should the computer stall and keep the DIO pin activating the charge relays high. Even though the software does not appear to be prone to failures during its observed operation period, THIS IS A MAJOR SAFETY CONCERN AND SHOULD BE ADDRESSED AS SOON AS POSSIBLE!

AMS Retainer Bar:

The AMS boards on each cell are currently not held tightly in place in order to allow easy replacement should a board fail. However, this might create problems during the competition as the boards may vibrate out of place on the course. A physical fixture is desired to hold each AMS board in place in order to prevent them from accidentally falling out of place under the strenuous race conditions.

Temperature Correction for Current Calculation:

Current measurement of the TSV path is still a bit flaky in nature due to heating of the current shunt during charge or discharge cycles. As the shunt heats up, its resistance changes. The current current measurement scheme in the Pack Manager software assumes that the resistance of the shunt does not change, so it can be a bit off from the actual current flowing in the pack. A temperature-based calculation of the shunt resistance should be implemented in the software of the Pack Manager.