Formula Hybrid ESF -- Part 1

INTRODUCTION

Part 1 of the Formula Hybrid ESF is intended to help teams solidify those design decisions that need to be made early in the program. This will also help the technical reviewers identify possible areas of concern early.

Many of the fields in this form will also be found in the ESF Part 2 and the information in those fields will need to be reentered when the ESF Part 2 is submitted.

It is expected that some of the information will change during the development of the vehicle. Teams should not feel "locked in" by the data provided here, however data entered in the ESF Part 2 will be considered final.

The information in this form will also be provided to the design judges, so teams may expect questions during the design event relating to why a particular aspect of the vehicle was changed during development.

INSTRUCTIONS AND REQUIREMENTS

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1. Enter the information requested as accurately as possible. If a particular portion of the design has not been finalized, give a <u>short</u> description of the options being considered.

2. Please submit any questions, corrections and suggestions for improvement to:

   http://www.formula-hybrid.org/level2/support/index.php

3. When completed, this document <u>must be converted to a pdf</u> and submitted to:

   http://formula-hybrid.com/uploads/

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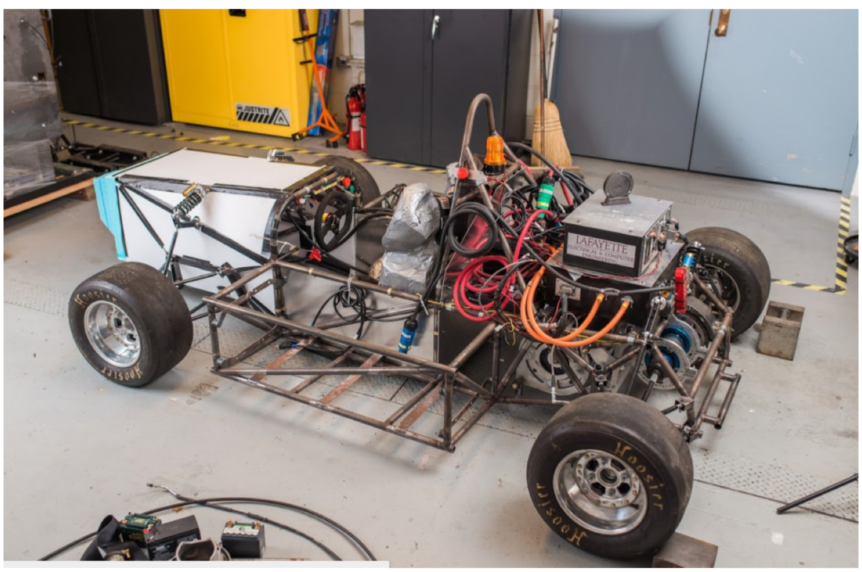
TITLE PAGE

Please include team logo, car picture, team picture, etc..

LAFAYETTE MOTORSPORTS



University Name: Lafayette College

Team Name: Lafayette Motorsports

Car Number: 212

<u>Main Team Contact for ESF related questions:</u>

Name: John Alger

e-mail: algerj@lafayette.edu

Section 1 **Vehicle Overview**

Check the appropriate boxes:

Vehicle is

☒New (built on an entirely new frame)

☐New, but built on a pre-existing frame (FSAE, FS, FH electric-only, etc.)

☐Updated from a previous year vehicle

Architecture

☐Hybrid

  ☐Series

  ☐Parallel

☐Hybrid in Progress (HIP)

☒Electric-only

Drive

☐Front wheel

☒Rear wheel

☐All-wheel

Regenerative braking

☐Front wheels

☐Rear wheels

☐All wheels

☒None

Section 2 **Frame and Body**

List the materials used and the construction methodology for the frame and body. Include CAD drawings, photos or sketches as appropriate.

Frame

Materials

Minimum FSAE required steel- no laminates or composites.

- Young's Modulus=200 GPa
- Yield Strength=305 MPa
- Ultimate Tensile Strength=365 MPa

Joining Methods and Construction

Welding frame members.
Frame fabricated by VR3 Engineering in Canada.

Body

Materials

Aluminum sheet metal panels and carbon fiber nose cone cover.

Construction
Bent and rolled aluminum sheet metal attached with fasteners.
Carbon fiber nose cone constructed around a mold.

Section 3 **Engine**

Skip this section if electric-only

3.1 Engine Data

Manufacturer	
Model Number	
Modified? (Per **IC1.1(a)**)	☐Yes ☐No
Number of Cylinders	
Bore	mm
Stroke	mm
Displacement	liters
Fuel type	☐Gasoline ☐E-85
Max. Power	kW @ RPM
Max. Torque	N·m @ RPM
Weight (Approximate)	kg

Table 1 - Engine Data

3.2 Architecture

Describe how the outputs from the I.C. engine and electric drive systems are merged:

No I.C engine.

4.1 Block Diagram

Figure 1 – include an electrical system block diagram showing all major parts associated with the tractive-system. (Not detailed wiring).

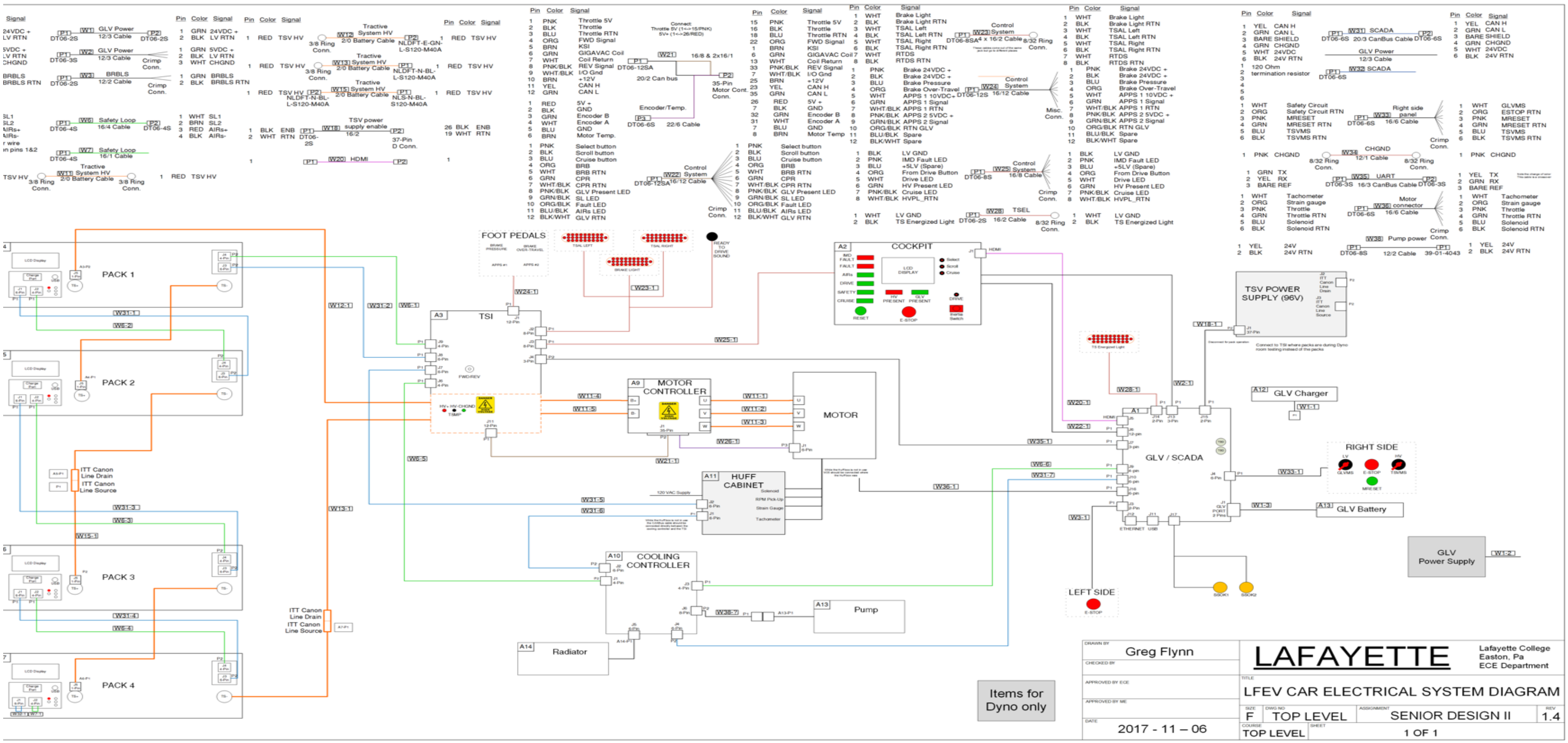


Figure 1- Electrical System Block Diagram

4.2 Vehicle Layout

Figure 2 – include a diagram showing the location of all major parts associated with the tractive-system superimposed on a top view of the vehicle.

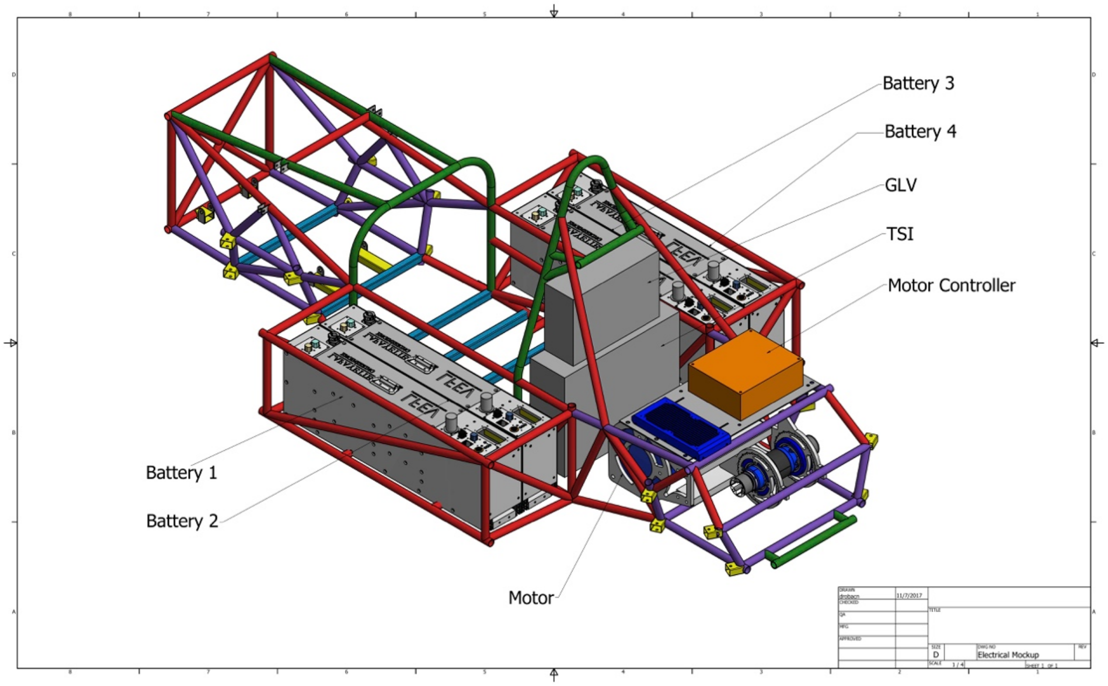


Figure 2 - Locations of major TS components

4.3 Electrical System Parameters

Fill out the following table:

Nominal Tractive System Voltage (TSV)	89.6 VDC
Max. TSV (typically this is during charging)	106.4 VDC
Control System voltage (GLV)	24 VDC
Total Accumulator capacity	4.5kWh
Accumulator type (Lead-acid, Li-Ion, NiMH, Ultracap…)	LiFePO4
Number of electric motors. (Total)	1
Are wheel motors used?	☐Yes ☒No

Table 2 - General Electrical System Parameters

4.4 Firewall(s)

Description/materials

Describe the concept, layer structure and the materials used for the firewalls.

1/16" Aluminum sheet. There are 3 firewalls- 2 are on the side to shield the cockpit from the side mounted accumulators and 1 rear firewall to shield the cockpit from the rear electronics including the motor, motor controller, TSV and GLV boxes.

Position in car

Provide CAD-rendering or sketches showing the planned location of the firewall(s).

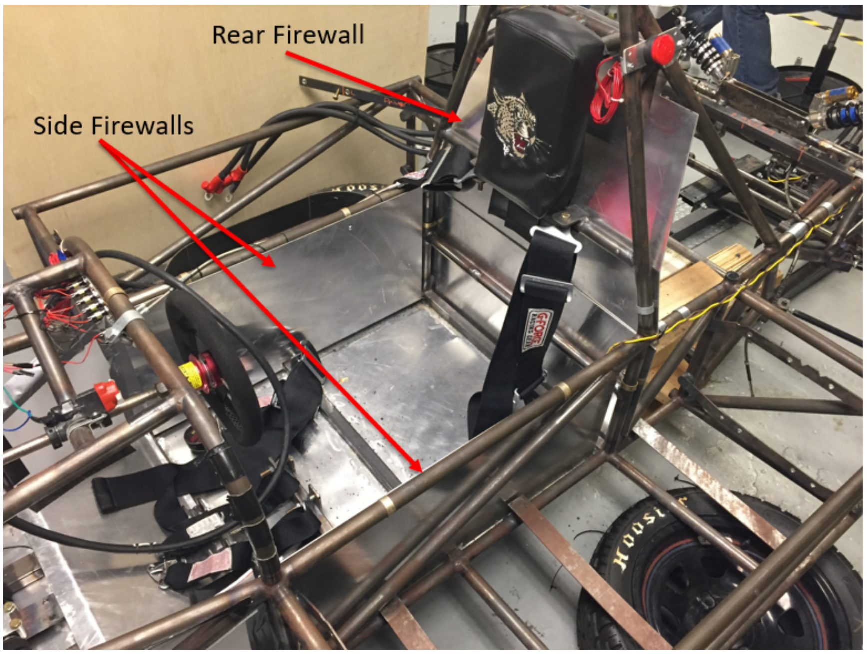


Figure 3 – Locations of the Firewall

Section 5 **Tractive System**

5.1 Motor(s)

Add additional tables if multiple motor types are used

Manufacturer	HPEVS. Inc
Model Number	AC50-27.28.11
Motor Type (PM, Induction, DC Brush…)	AC-50 Induction Motor Brushless
Number of motors of this type used	1
Nominal motor voltage (V_{rms} l-l or V_{dc})	96
Nominal / Peak motor current (A or A/phase)	Nom: 200 Peak: 600A
Nominal / Peak motor power	Nom: 18HP Peak: 71 HP

Table 3 - Motor Specifications

5.2 Motor Controller

Manufacturer	Curtis
Model Number	1238R
Number of controllers of this type used:	1
Maximum Input voltage:	96V
Nominal Input Current:	200A
Output voltage (V_{ac} l-l or V_{dc})	96 V_{ac}
Isolation voltage rating between GLV and TS connections	24-96V
Is motor controller accelerator input isolated from TSV?	☒Yes ☐No

Table 4 - Motor Controller Specifications

Section 6 **Accumulator System**

6.1 Accumulator Pack

Provide a narrative design of the accumulator system and complete the following tables.

The Tractive System Voltage is provided by four accumulator containers placed in series to provide the power necessary to operate the motor. An accumulator segment, housed within each container, is comprised of a battery of 7 LiFeP04 cells (3.2 V nominal) connected in series. Each cell is monitored for temperature and voltage by an AMS (accumulator management system), which communicates this information to the Pack Management Computer (PacMAN). The PacMAN utilizes an AT90CAN128 Atmel microcontroller. There are also two Accumulator Isolation Relays present in each pack. They ensure no TS voltage presence outside the accumulator section when the TS is shut down.

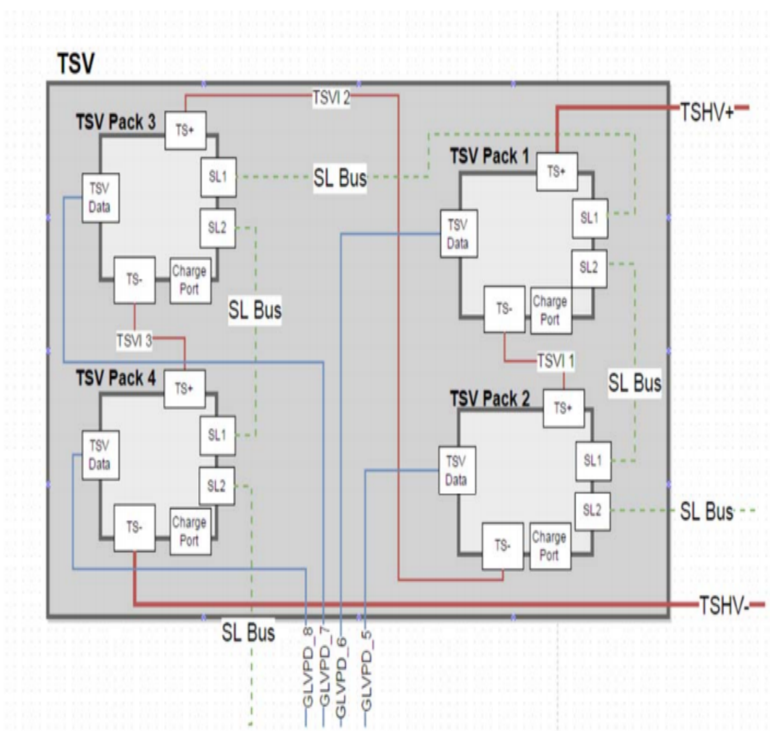


Figure 4 - 4 Pack Configuration for Accumulator

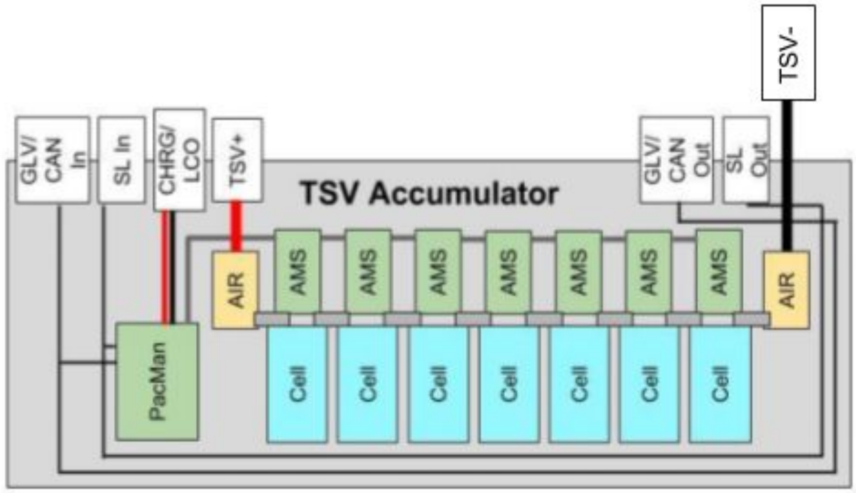


Figure 5 - Single Pack Configuration

Maximum Voltage (during charging):	26.6 VDC per pack
Nominal Voltage:	22.4 VDC per pack
Total number of cells:	28 in total (all 4 packs)
Are packs commercially or team constructed?	☐Commercial ☒Team
Total Capacity (all segements):	4.5kWh
Maximum Segment Capacity:	4.05MJ

Table 5 - Main Accumulator Parameters

Total Capacity = Nominal cell Voltage * 7 * 4 * Cell Nominal Capacity

Maximum Segment Capacity = Vnom for 1 cell*cell Ah *num of cells * 3.6(kJ)/4

6.2 Cell Description - Batteries

Cell Manufacturer	AA Portable Power Corp, LFP-G60
Model Number	20121024
Cell type (prismatic, cylindrical, pouch, etc.)	Prismatic
Are these pouch cells	☐Yes ☒No
Cell nominal capacity:	50.3 Ah

Discharge rate for nominal capacity (e.g. 1C, 2C etc.)	1 C
Maximum Voltage:	3.9 V
Nominal Voltage:	3.2 V
Minimum Voltage:	2.0 V
Maximum Cell Temperature (charging)	60 °C
Maximum Cell Temperature (discharging)	60 °C
Cell chemistry:	LiFeP04

Table 6 - Main Cell Specification

6.3 Cell Description - Capacitors

Capacitor Manufacturer:	N/A
Model Number:	N/A
Rated Capacitance:	N/A
Rated Voltage:	N/A
Stored Energy[1]	N/A
Maximum Temperature	N/A

Table 7 - Capacitor Specifications

6.4 Cell Configuration

Describe configuration: e.g., *N* cells in parallel then *M* packs in series, or *N* cells in series then *M* strings in series.

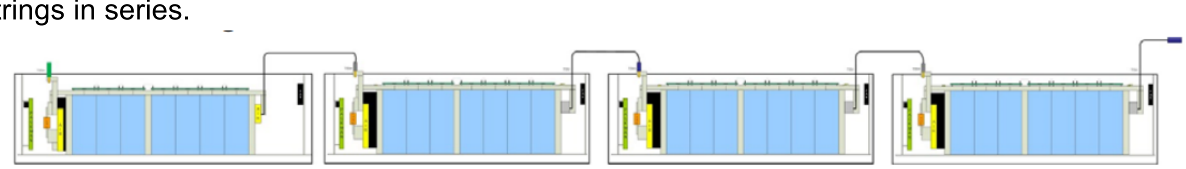


Figure 6 – Cell Configuration

In each accumulator segment, seven cells are placed in series. Each segment is within an accumulator container. There are four containers, each of which is placed in series. In total, seven cells in four containers are all in series.

[1] Use the formula given in Appendix A of the Formula Hybrid rules. This will differ slightly from the manufacturer's rating.

6.5 Lithium-Ion Pouch Cells

The vehicle accumulator ☐DOES / ☒DOES NOT use individual pouch cells. (Check one)

Note: Designing an accumulator system utilizing pouch cells is a substantial engineering undertaking which may be avoided by using prismatic or cylindrical cells.

If your team has designed your accumulator system using individual Lithium-Ion pouch cells, include drawings and calculations demonstrating compliance with all sections of **Article EV11** If your system has been issued a variance to **Article EV11** by the Formula Hybrid rules committee, include the required documentation from the cell manufacturer.

6.6 Accumulator Management System (AMS)

AMS Manufacturer	Lafayette College
Model Number	N/A
Number of AMSs	1 per cell
Upper Cell Voltage Trip	3.9 V
Lower Cell Voltage Trip	2 V
Temperature Trip	60 °C

Table 8 - AMS Data

6.7 Charging

Charger Manufacturer	TDK-Lambda
Model Number	GENH30-25-U
Maximum Charging Power:	0.75 kW
GLV/TS isolation location: (i.e. cell boards, main unit, etc.)	Main Unit
UL Certification?	☒Yes ☐No
Maximum Charging Voltage:	30 V
Maximum Charging Current:	25 A
Input Voltage:	85-265 VAC continuous
Input Current:	9.5 A

Table 9 - Accumulator Charging Data

6.8 Accumulator Container/Housing

Describe the design of the accumulator container. Include the housing material specifications and construction methods.

The accumulator container will be made of 1/16" steel sheet/plate and each (2) will contain 2 battery packs. The container will have a latching cover that can be removed so that the accumulators can be removed from the vehicle. The cover will also have cutouts so that the high voltage 2/0 wires can go from pack to pack. The wires are connected to the poles of the accumulators and are encased in an insulated casing. That entire accumulator container will go in the side pods on the car, the area designated for the storage of the packs. There will also be cutouts for small amounts of air to help cool the accumulators, although the cells don't end up reaching that high of a temperature during discharge. There will also be through-holes for the mounting method for the battery packs and accumulator containers.

Where will the accumulators be located?

- 2 accumulator packs on each side of the driver.

Will you be using a virtual accumulator housing? (**EV2.12**)

- No

6.9 Shutdown Circuit

Include a schematic of the shutdown circuit for your vehicle including all major components in the loop.

Note: *The design of the shutdown circuit and team members understanding of how it works is extremely important. Take the time to be sure it is right.*

GLVMS	Ground Low Voltage Master Switch
BRBLS	Big Red Button Left Side
BRBRS	Big Red Button Right Side
SCADA	Supervisory Control and Data Acquisition
TSI	Tractive System Interface
MRESET	Master Reset
TSVMS	Tractive System Voltage Master Switch

Table 10: Acronyms for Safety Shutdown Circuit

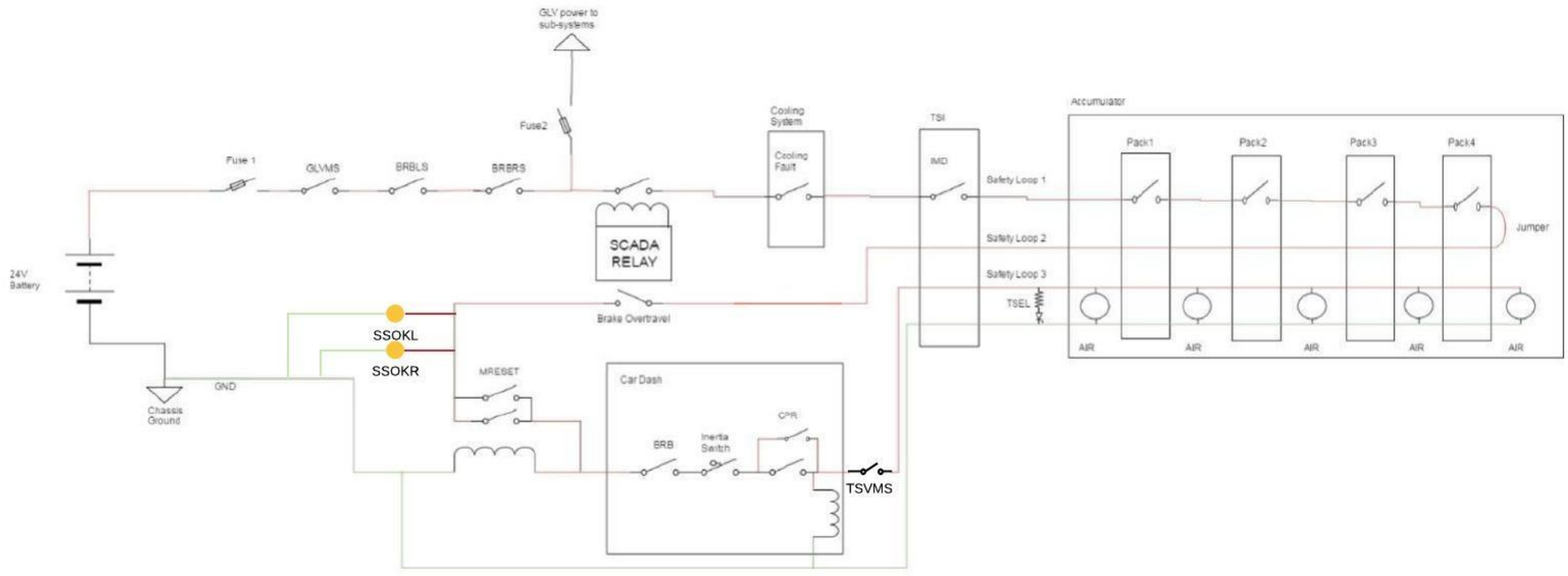


Figure 7 – Safety Shutdown Circuit Schematic

6.10 IMD

Describe the IMD used and complete the following table:

Manufacturer	Bender
Model Number	IR155-3204
Set response value:	_100_ kΩ (_1042_ Ω/Volt)

Table 11 - IMD parameters

Section 7 **GLV System**

7.1 GLV System Data

Provide a brief description of the GLV system and complete the following table.

The GLV system is comprised of the 24V battery, vehicle computer interface(VCI), the vehicle user interface(VUI) and the safety loop. The battery provides 24V to all low voltage electrical systems and AIRs in TSV. The VCI provides hardware for VSCADA interfacing. The VUI is the driver interface including buttons and dashboard display screen. The safety loop assures all systems are functioning properly before opening airs and allowing HV from the accumulators. The system also controls two Safety System OK Lamps.

GLV System Voltage	24V
GLV Main Fuse Rating	15A Circuit Breaker
GLV Accumulator type	24V LiFePo4 battery
How is the GLV storage recharged?	Battery charger

Table 12 - GLV Data