# 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 short 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

When completed, this document must be submitted in Microsoft Word format (“docx”) – NOT PDF - at: http://formula-hybrid.com/uploads/

# Table of Contents

## List of Figures



*Must be hyperlinked*!

## List of Tables



*Must be hyperlinked*!

LAFAYETTE
MOTORSPORTS

# TITLE PAGE

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

University Name: Lafayette College

Team Name: Lafayette Motorsports

Car Number: N/A

Main Team Contact for ESF related questions:

Name: Jordyn Brosemer

e-mail: brosemej@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

Frame members will be TIG welded. Frame construction is done by VR3 Engineering

## Body

### Materials

Aluminum sheet metal panels and carbon fiber nose cone cover.

### Construction

The body will be constructed with bent and rolled aluminum sheet metal attached to the frame with metal fasteners. A carbon fiber nose cone will be constructed around a mold and will be attached and grounded to the frame with metal fasteners.

# Section 3 **Engine**

*Skip this section if electric-only*

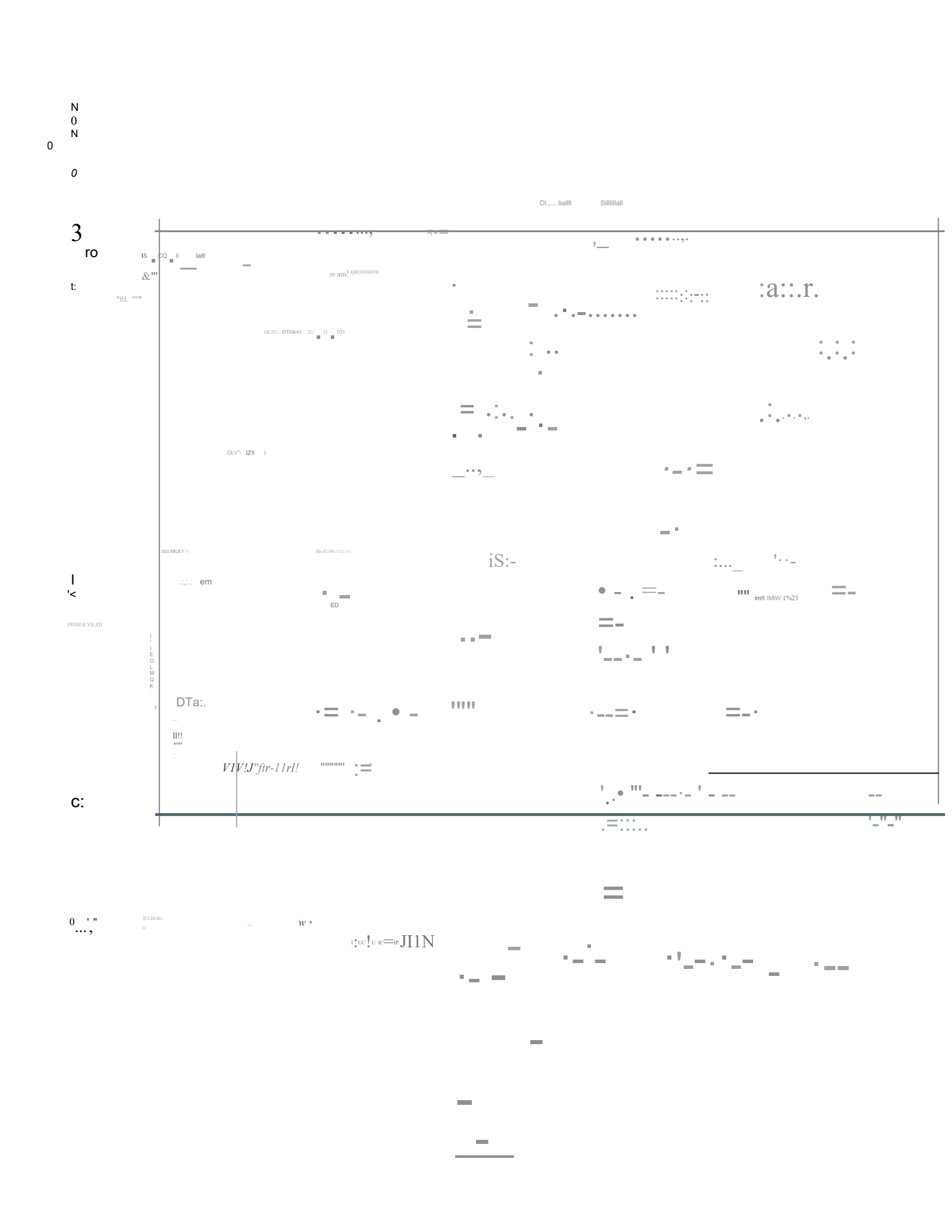
## 3.1 Engine Data

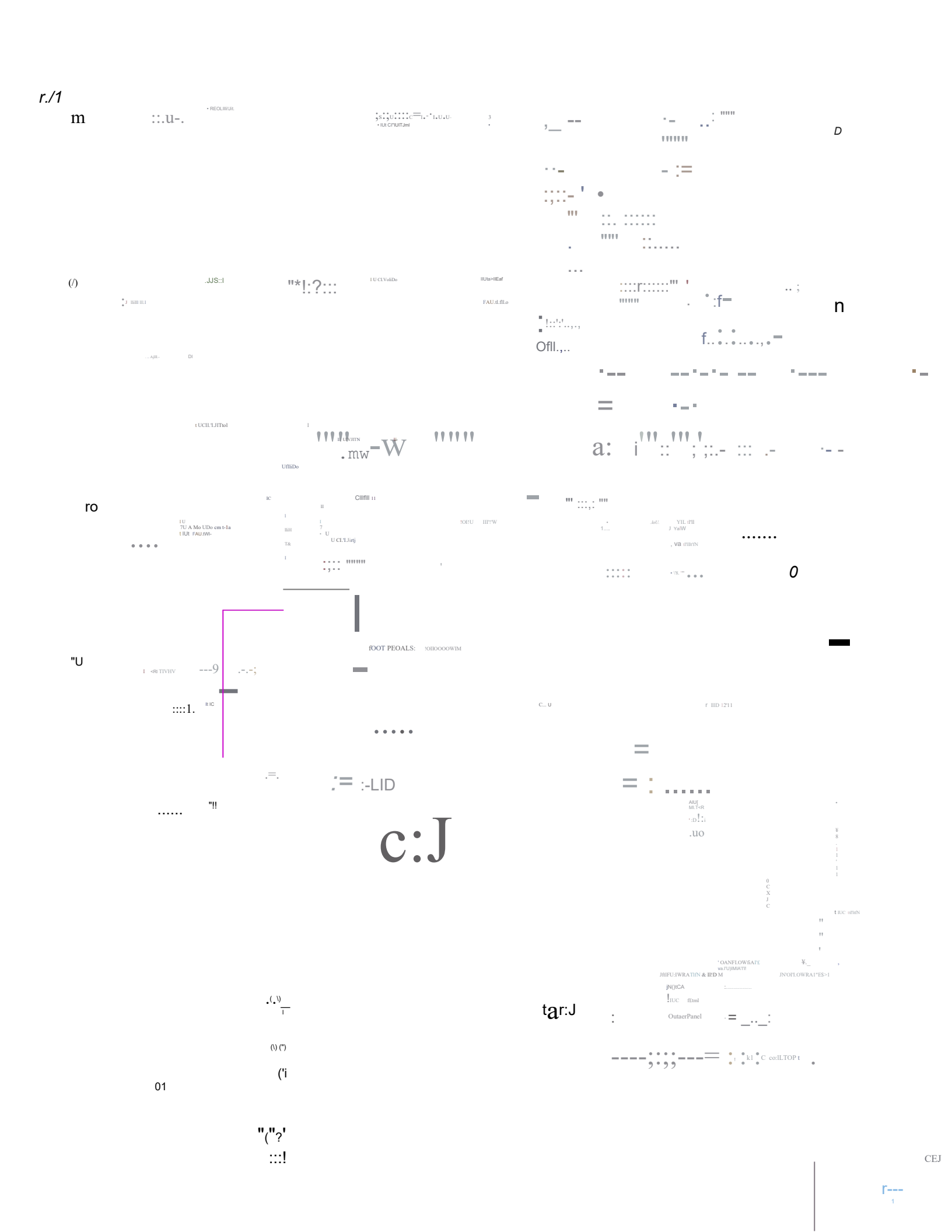
| | | |
|---|---|---|
| Manufacturer | | |
| Model Number | | |
| Modified? (Per **IC1.1(a)**) | ☐<br>☐ | |
| Number of Cylinders | | |
| Bore | | mm |
| Stroke | | mm |
| Displacement | | mm<br>liters |
| Fuel type | ☐ gasoline<br>☐ -85 | |
| Max. Power | | kW @ RPM |
| Max. Torque | | N.m @ RPM |
| 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.

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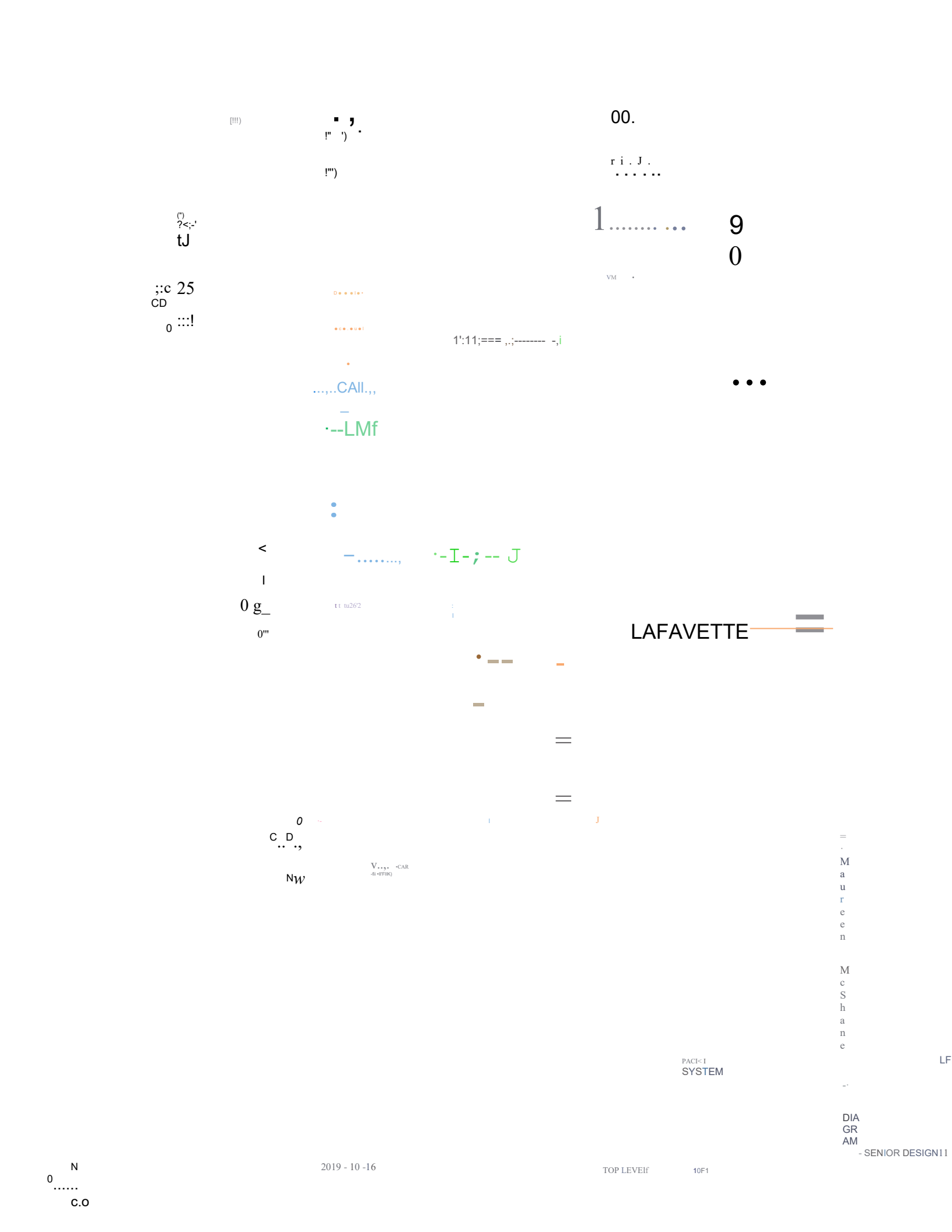
LAFAVETTE
Maureen McShane
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DIAGRAM
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## 4.1 Vehicle Layout

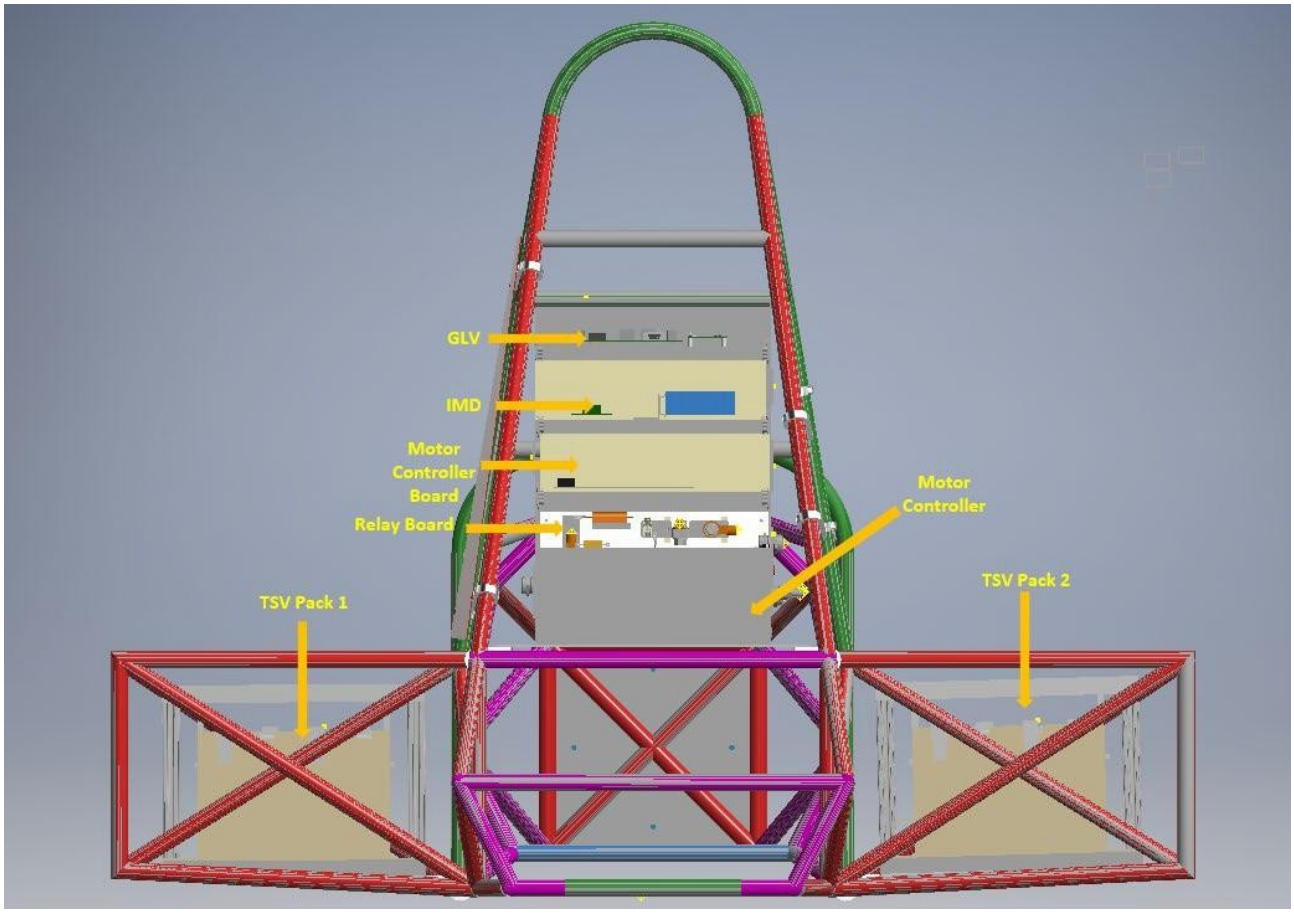


*Figure 2 Behind Car Layout*

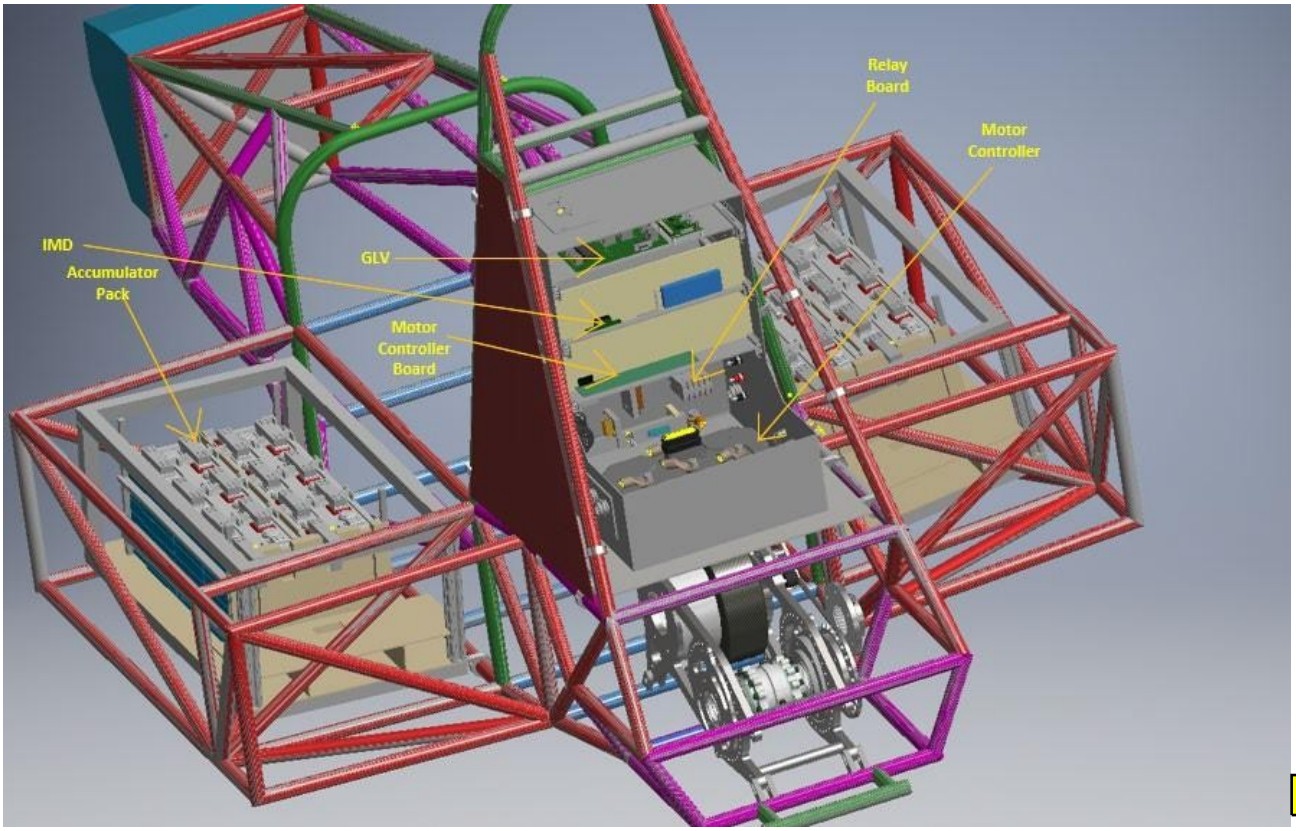


*Figure 3 Behind Car layout*

## 4.2 Electrical System Parameters

Fill out the following table:

| | |
|---|---|
| Nominal Tractive System Voltage (TSV) | 89.6 VDC |
| Max. TSV (typically this is during charging) | 100.8VDC |
| Control System voltage (GLV) | 24 VDC |
| Total Accumulator capacity | 5376 Wh |
| 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

## 4.3 Firewall(s)

**Description/materials**

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

The Firewalls are solid aluminum plates that are 1/16” thick.

**Position in car**

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

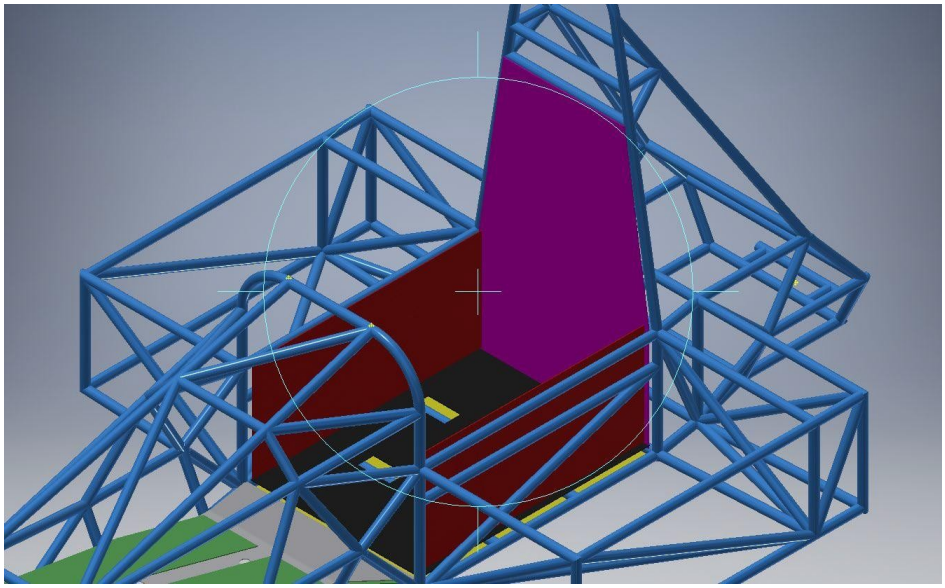

*Figure 4 Car Firewall layout*

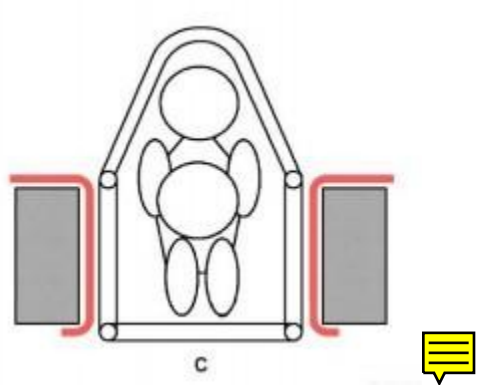


*Figure 5 Intended Pack Firewall Layout*

# Section 5 **Tractive System**

## 5.1 Motor(s)

Add additional tables if multiple motor types are used

| | | |
|---|---|---|
| Manufacturer | | EMRAX Innovative E-Motors |
| Model Number | | EMRAX 208 Low Voltage |
| Motor Type (PM, Induction, DC Brush…) | | DC Brushless |
| Number of motors of this type used | | |
| Nominal motor voltage ($V_{rms}$ l-l or $V_{dc}$) | | 125$V_{dc}$ (maximum) |
| Nominal / Peak motor current (A or A/phase) | Nom: 400 Arms | Peak: 800 Arms |
| Nominal / Peak motor power | Nom: 20-32 kW | Peak: 80 kW |

*Table 3 - Motor Specifications*

## 5.2 Motor Controller

| | |
|---|---|
| Manufacturer | Emsiso |
| Model Number | emDRIVE 500 |
| Number of controllers of this type used: | 1 |
| Maximum Input voltage: | 120 V |
| Nominal Input Current: | 300 A |
| Output voltage ($V_{ac}$ l-l or $V_{dc}$) | 84 $V_{ac}$ l-l |
| Isolation voltage rating between GLV and TS connections | 200 V |
| 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 two accumulator packs located on each side of the driver. Each pack contains 14 LiFeMnPO4 cells in series that individually have a 3.2V nominal voltage. The 14 cells are divided into two segments, and each segment is controlled by a SegMan board. Mounted on each cell is a CellMan board that communicates with the SegMan. There will be two Accumulator Isolation Relays in each pack, a 300A fuse, as well as an SMD. The Pack management board (PacMan) maintains an on pack display and interfaces with the SCADA system via CANBUS.

| | |
|---|---|
| Maximum Voltage (during charging): | 50.4 VDC |
| Nominal Voltage: | 44.8 VDC |
| Total number of cells: | 14 |
| Are packs commercially or team constructed? | ☐Commercial ☒Team |
| Total Capacity: | 2.688 kWh |
| Maximum Segment Capacity: | 4.84 MJ |

*Table 5 - Main Accumulator Parameters*

## 6.2 Cell Description - Batteries

| | |
|---|---|
| Cell Manufacturer | AA Portable Power Corp |
| Model Number | LFP-G60 |
| Cell type (prismatic, cylindrical, pouch, etc.) | Prismatic |
| Are these pouch cells | ☐Yes ☒No |
| Cell nominal capacity: | 60 Ah |
| Discharge rate for nominal capacity (e.g. 1C, 2C etc.) | 1 C |
| Maximum Voltage: | 4.0 V |
| Nominal Voltage: | 3.2 V |
| Minimum Voltage: | 2.5 V |
| Maximum Cell Temperature (charging) | 65 °C |
| Maximum Cell Temperature (discharging) | 65 °C |
| Cell chemistry: | LiFeMnPO4 |

*Table 6 - Main Cell Specification*

**Absolute maximum and minimum listed, should not exceed 3.8 V & not drop below 2.8 V.*

## 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*

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

## 6.4 Cell Configuration

There are a total of 28 cells in series across two accumulators. There are two accumulators, each accumulator contains two segments and each segment has seven cells.

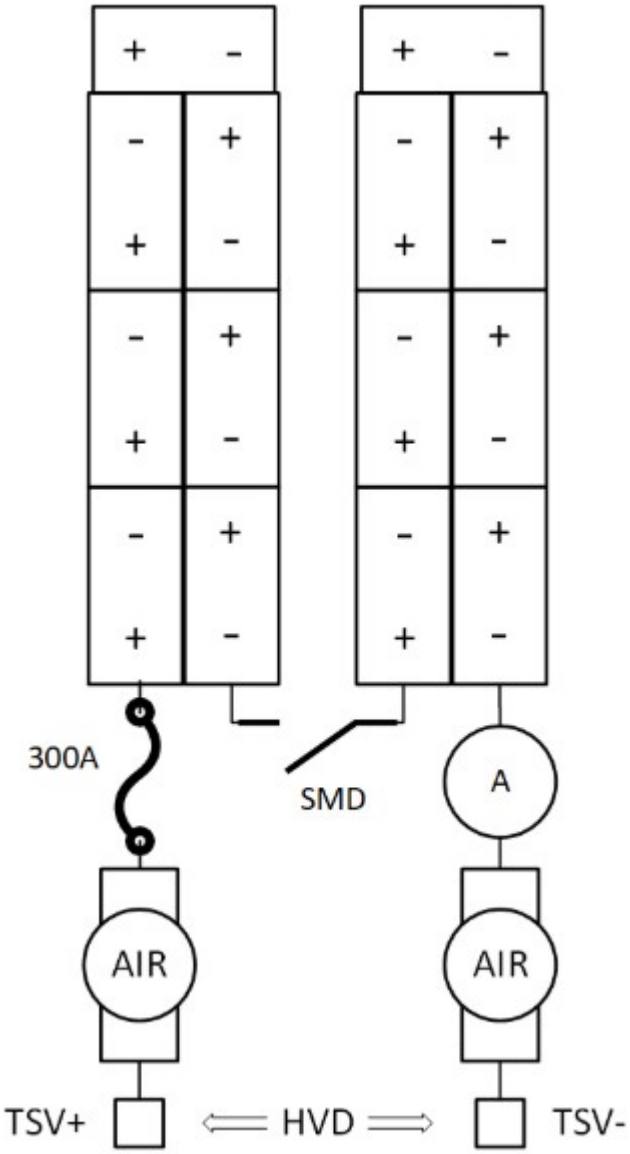


*Figure 6 Cell Configuration*

## 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 Motorsports |
| Model Number | N/A |
| Number of AMSs | 1 per pack |
| Upper Cell Voltage Trip | 3.65V |
| Lower Cell Voltage Trip | 2.6V |
| Temperature Trip | 60°C |

*Table 8 - AMS Data*

## 6.7 Charging

| | | |
|---|---|---|
| Charger Manufacturer | Mean Well Enterprises | |
| Model Number | HLG-480H-30A | |
| Maximum Charging Power: | | 0.48kW |
| GLV/TS isolation location:<br>(i.e. cell boards, main unit, etc.) | | Main Unit |
| UL Certification? | ☒Yes ☐No | |
| Maximum Charging Voltage: | | 30 V |

| | | |
|---|---|---|
| Maximum Charging Current: | | 16 A |
| Input Voltage: | 90-230 VAC continuous | |
| Input Current: | | 5.5 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 design of the accumulator container consists of 3 main parts: the bottom enclosure, the frame, and the battery segment mounting. The bottom enclosure is comprised of a thick aluminum base and is lined with a thin sheet of garolite insulation. The bottom enclosure serves as the foundation of the container and securely holds its contents. Garolite walls isolate high and low voltage components. The frame is composed of aluminum struts, secured to the bottom enclosure, and gives the container shape and structure. The frame is grounded and surrounded by removable aluminum plates. The battery segment mounting is composed of garolite walls and removable aluminum mounts.

Where will the accumulators be located?

The accumulators will be located on each side of the driver.

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

No virtual accumulators will be used.

## 6.9 Shutdown Circuit

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

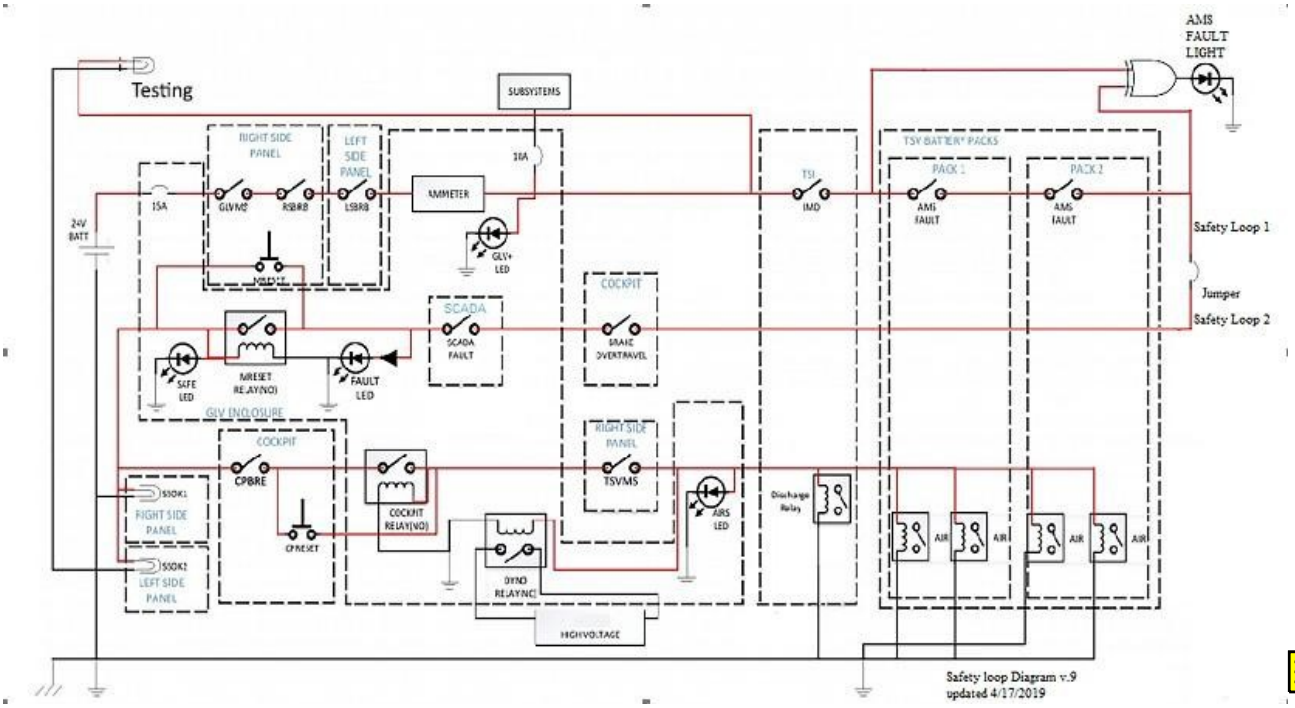


*Figure 7 Shutdown Circuit Schematic*

| | |
|---|---|
| GLVMS | Grounded Low Voltage Master Switch |
| LSBRB | Left Side Big Red Button |
| RSBRB | Right Side Big Red Button |
| MRESET | Master Reset |
| SCADA | Supervisory Control and Data Acquisition |
| TSI | Tractive System Interface |
| CPBRB | Cockpit Big Red Button |
| CPRESET | Cockpit Reset |
| TSVMS | Tractive System Voltage Master Switch |

*Table 10 – Safety Shutdown Circuit Acronyms*

## 6.10 IMD

Describe the IMD used and complete the following table:

The IMD The IMD under voltage will be set to 0V.

| | |
|---|---|
| Manufacturer | Bender |
| Model Number | IR155-3204 |
| Set response value: | 100 kΩ (1024 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.

GLV provides 24 V power to the low voltage subsystems in the car.

| | |
|---|---|
| GLV System Voltage | 24 V |
| GLV Main Fuse Rating | 10 A Circuit Breaker |
| GLV Accumulator type | 24V LiFePO4 battery |
| How is the GLV storage recharged? | Battery Charger |

*Table 12 – GLV Data*