



# 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

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

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

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*Must be hyperlinked!*

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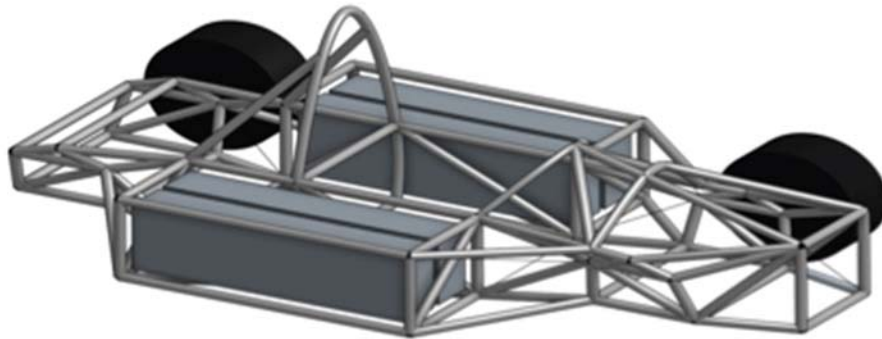
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*Must be hyperlinked!*

# TITLE PAGE

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



University Name: Lafayette College

Team Name: Lafayette Motor Sports

Car Number: 217

Main Team Contact for ESF related questions:

Name: Graham Thomas

e-mail: thomasg@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
- Bending & Buckling strength calculations
  - Youngs Modulus = 200 GPa
  - Yield Strength = 305 MPa
  - Ultimate Strength = 365 MPa

#### Joining Methods and Construction

- Welds
- We are outsourcing manufacturing of our frame to VR3

### Body

#### Materials

- Fiberglass

#### Construction

- Student fabricated in-house
- No CAD drawings for body yet

## Section 3

## Engine

*Skip this section if electric-only*

### 3.1 Engine Data

|                               |   |
|-------------------------------|---|
| Manufacturer                  |   |
| Model Number                  |   |
| Modified? (Per <b>IC1.1</b> ) | <input type="checkbox"/> Yes <input type="checkbox"/> No  |
| Number of Cylinders           |   |
| Bore                          | mm  |
| Stroke                        | mm  |
| Displacement                  | liters  |
| Fuel type                     | <input type="checkbox"/> Gasoline <input type="checkbox"/> E-85 <input type="checkbox"/> Diesel |
| 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:

# Section 4

# Electrical System Overview

## 4.1 Block Diagram

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

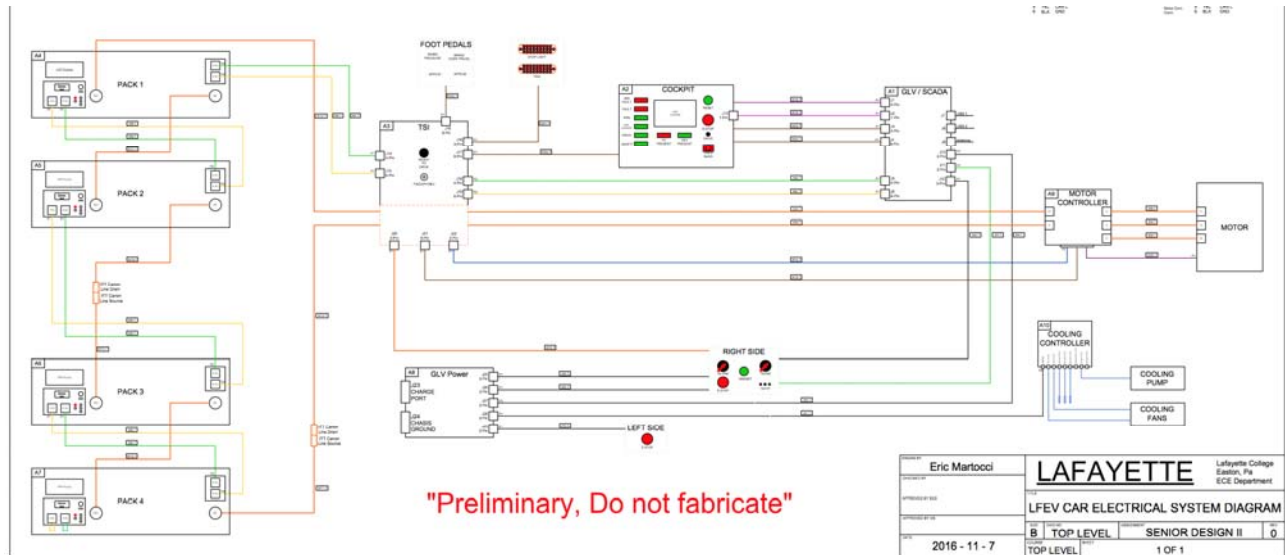


Figure 1- Electrical System Block Diagram

## 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.

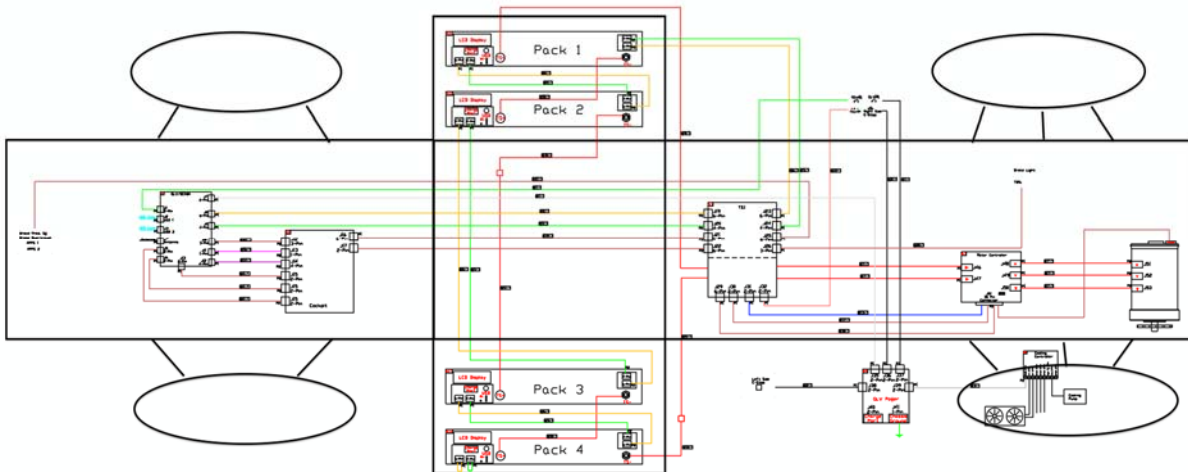


Figure 2 - Locations of major TS components



### 4.3 Electrical System Parameters

Fill out the following table:

|   |   |
|---|---|
| Nominal Tractive System Voltage (TSV)                   | 96 VDC  |
| Max. TSV (typically this is during charging)            | 120 VDC   |
| Control System voltage (GLV)                            | 24 VDC  |
| Total Accumulator capacity                              | 16 Wh   |
| Accumulator type (Lead-acid, Li-Ion, NiMH, Ultracap...) | Li-Ion Polymer  |
| Number of electric motors. (Total)                      | 1   |
| Are wheel motors used?                                  | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |

*Table 2 - General Electrical System Parameters*

### 4.4 Firewall(s)

#### Description/materials

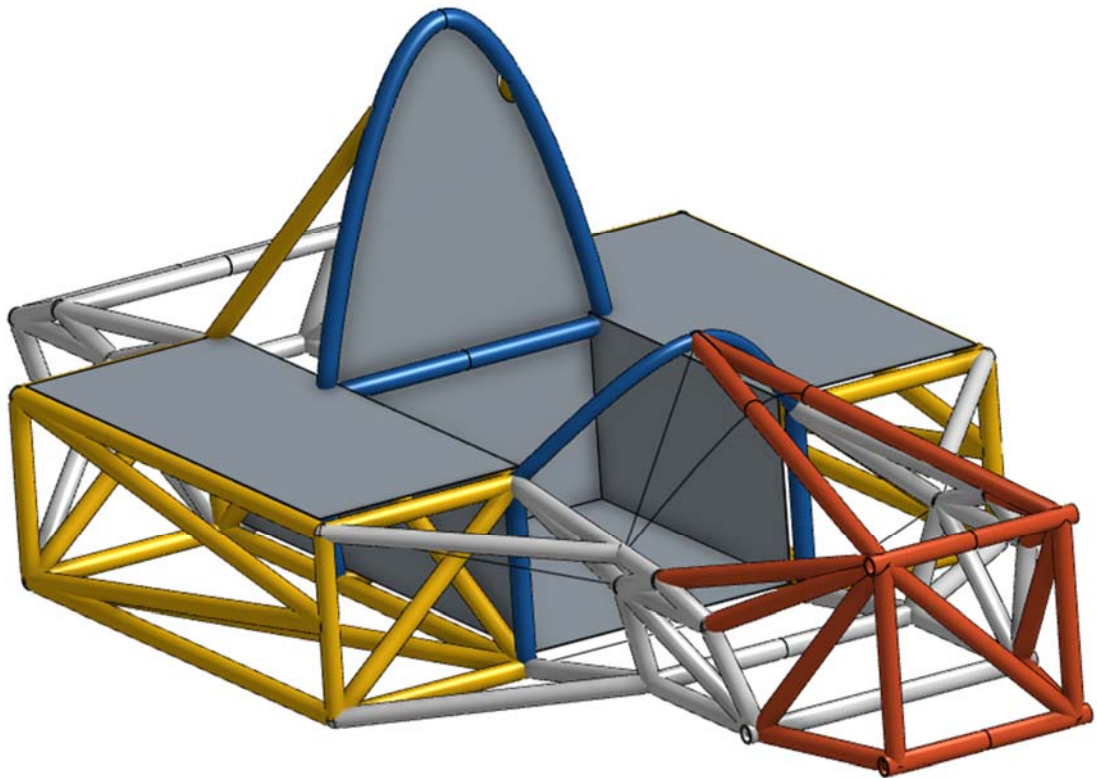
Describe the concept, layer structure and the materials used for the firewalls.

- Sheet steel welded to frame and covered with fire resistant tape
- Layers
  - Sheet aluminum
  - Fire resistant tape

#### Position in car

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

- The grey sheets underneath and seperating the driver from the accumulators as well as on top of the accumulators and behind the main roll hoop in the drawing is our firewall (1.5 mm aluminum)
- There will be conduits for all the TSV wiring, not on the CAD-rendering yet (haven't made a decision where it will be yet)



## 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 ( $V_{rms}$ I-I or $V_{dc}$ ) | 96                              |              |
| Nominal / Peak motor current (A or A/phase)         | Nom: 200                        | Peak: 600    |
| Nominal / Peak motor power                          | Nom: 52 HP                      | Peak: 100 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:                                   | 96 V  |
| Nominal Input Current:                                   | 200 A   |
| Output voltage ( $V_{ac}$ I-I or $V_{dc}$ )              | 24 V  |
| Isolation voltage rating between GLV and TS connections  | .25 V   |
| Is motor controller accelerator input isolated from TSV? | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |

*Table 4 - Motor Controller Specifications*

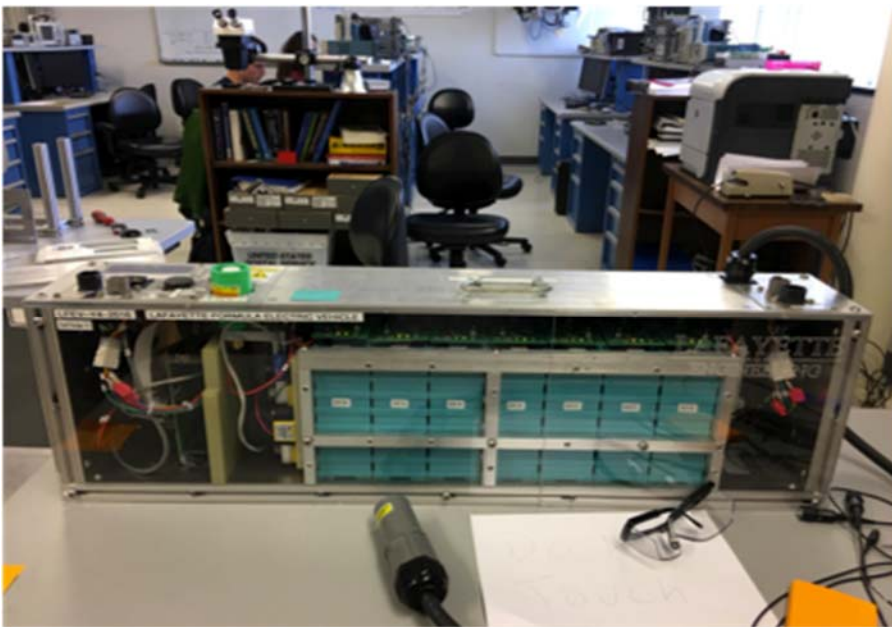
## Section 6

# Accumulator System

### 6.1 Accumulator Pack

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

- The accumulator system is divided into four separate battery packs in series each at 24 V. This makes the total accumulator system voltage 96 V which supplies power to the motor controller. Within the accumulator system there are five Accumulator Isolation Relays, which remain open until the safety loop is closed.



|   |  |
|---|--|
| Maximum Voltage (during charging):          | 26 VDC   |
| Nominal Voltage:                            | 26 VDC   |
| Total number of cells:                      | 7  |
| Are packs commercially or team constructed? | <input type="checkbox"/> Commercial <input checked="" type="checkbox"/> Team |
| Total Capacity:                             | 4 Wh   |
| Maximum Segment Capacity:                   | 4.8384 MJ  |

*Table 5 - Main Accumulator Parameters*

### 6.2 Cell Description - Batteries

|  |   |
|--|---|
| Cell Manufacturer                                      | Powerizer   |
| Model Number   | 20121024  |
| Cell type (prismatic, cylindrical, pouch, etc.)        | Prismatic   |
| Are these pouch cells                                  | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Cell nominal capacity:                                 | 60 Ah   |
| Discharge rate for nominal capacity (e.g. 1C, 2C etc.) | 1C  |
| Maximum Voltage:                                       | 4.1 V   |
| Nominal Voltage:                                       | 3.2 V   |
| Minimum Voltage:                                       | 2.3 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 <sup>1</sup> | 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.

- 7 Cells in Series then 0 strings in series

---

<sup>1</sup> 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 rule **EV3.9**. If your system has been issued a variance to **EV3.9** 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 | 4.05 V            |
| Lower Cell Voltage Trip | 2.35 V            |
| Temperature Trip        | 50 °C             |

*Table 8 - AMS Data*

## 6.7 Charging

|   |   |
|---|---|
| Charger Manufacturer  | TDK-Lambda  |
| Model Number  | GENH30-25-U   |
| Maximum Charging Power:   | .48 kW  |
| GLV/TS isolation location:<br>(i.e. cell boards, main unit, etc.) | Main unit   |
| UL Certification?   | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Maximum Charging Voltage:   | 29 V  |
| Maximum Charging Current:   | 20 A  |
| Input Voltage:  | 120 VAC single phase  |
| 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 is designed with 8020 aluminum. All of the walls and barriers were designed to the rulebook set by FSAE electric to ensure that we it will pass tech. but more importantly be safe to use. There are small air intakes and fans to ensure that the packs do not overheat during charging or usage. We also took the time to make sure that every structural component is well within our factor of safety.

Where will the accumulators be located?

- 2 accumulator packs on each side of the driver

Will you be taking advantage of the virtual accumulator housing rule? (EV3.3)

- 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.*

- The Red Circles on the Diagram are our emergency stops. There is an emergency stop in the cockpit for the driver and one on each side of the car around the roll hoop (left and right). There is also an emergency stop on the brake pedal over travel switch, which is in the foot pedals box. The emergency shut off switches are either a push button that must stay pulled to keep the car running or turn on. There are also key switches that will be on the roll hoop.

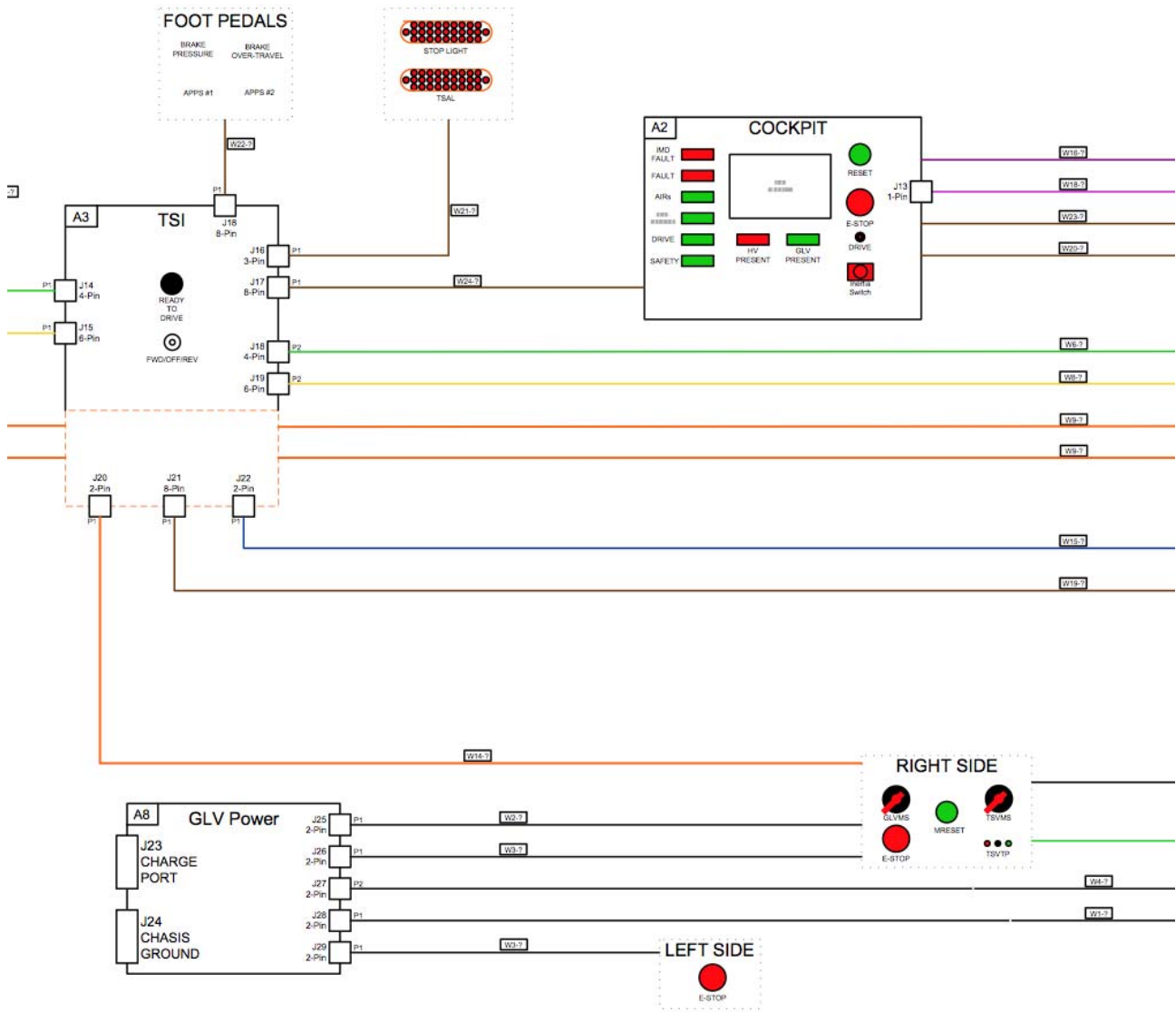


Figure 3 – Safety Shutdown Circuit Schematic

### 6.10 IMD

Describe the IMD used and complete the following table:

Standard Bender board that will be wired correctly

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

Table 10 - IMD parameters



## Section 7

## GLV System

### 7.1 GLV System Data

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

We are using two 24V batteries to power the following components: VSCADA, cockpit controls/display, brake press/over-travel switch, accelerator pedal potentiometers, and tentative cooling controller

|                                   |                    |
|-----------------------------------|--------------------|
| GLV System Voltage                | 24 V               |
| GLV Main Fuse Rating              | 20 A               |
| GLV Accumulator type              | IMH                |
| How is the GLV storage recharged? | Commercial charger |

*Table 11 - GLV Data*