

**2024 Formula Hybrid+Electric Electrical System Form 2 (ESF-2)**

## INTRODUCTION

The goal of the ESF is to ensure that vehicles are as safe as possible, and that they comply with the Formula Hybrid+Electric completion rules. The ESF is divided into fourteen main sections:

1. System Overview
2. Operating Voltage
3. Safety Circuit
4. TSMP
5. Cables & Fusing
6. Motors
7. Isolation & Insulation
8. IMD
9. AMS
10. Accumulator & Container
11. Pre-Charge & Discharge
12. Torque Control
13. GLV
14. Charger

A clear, concise ESF will help you to build a better car. It will also help you to pass tech testing as most common tech problems can be addressed before the car reaches the track.

**IMPORTANT INSTRUCTIONS AND REQUIREMENTS  
*Read carefully!***

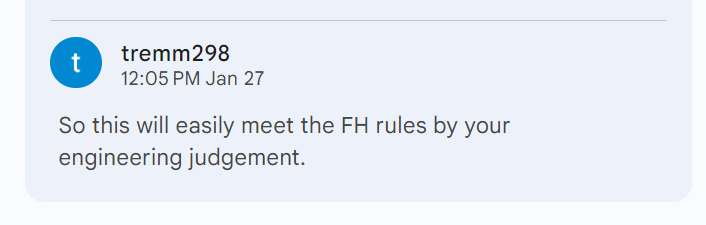
1. Every part of this ESF must be filled with content. If a section is not relevant to your vehicle, mark it as “N/A” and describe briefly why not.
2. Please leave the written instructions in place and add your responses below them.
3. All figures and tables must be included. An ESF with incomplete tables or figures will be rejected.
4. The maximum length of a complete ESF is 100 pages.
5. Note that many fields ask for information that was submitted in your ESF-1. This information must be reentered – in some cases will be different than what was entered in ESF-1, which is OK.
6. Submit this document in Word format *– do not convert it to PDF!*Submit to: <https://formulahybridupload.supportsystem.com/>

**ESF-2 REVIEW PROCESS**

Feedback on your ESF occurs through both your team’s Google Doc and the FH ticket system at: <https://formulahybridelectric.supportsystem.com/>

Your ESF will be reviewed by a team of “section reviewers” - experts in specific areas of the FH rules.

Reviewers will add comments in the Google doc:



Comments are coded as follows:

**(!!!) – Important – we need a team response, e.g.,**

*!!! We have a concern regarding your accumulator protection - how did you calculate required fuse sizes?*

(!!!) comments **require action** - either by responding to the comment in the Google doc, or opening a rules ticket (and adding a response, e.g., “See FH Ticket 1234 for resolution”.

**(!!! PLEASE OPEN A TICKET) – discussion needed via ticket system, e.g.,**

*!!! PLEASE OPEN A TICKET – your safety schematic is not rules compliant.*

The inspector wants a ticket opened for response.

**Comment Resolution**

When your team has reviewed a non (!!!) comment, you can resolve the comment to indicate that it has been seen and acknowledged.

For !!! comments, please wait for an inspector to review your response. Then they will resolve the comment.

Our goal is to have your ESF-2 form completed with all comments resolved before the competition.

*If you have not received a response to a critical Google doc question, please open a follow-up ticket at:* <https://formulahybridelectric.supportsystem.com/>

The ESF2 is a tool which was created to improve the probability that your vehicle will pass the electrical inspections on its first try.   
  
It is up to you and your team to follow up on all open items.

TITLE PAGE

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

|  |  |
| --- | --- |
| University Name: |  |
| Team Name: |  |
| Car Number: |  |

**Main Team Contact for ESF related questions:**

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

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*Must be hyperlinked*!

# List of Abbreviations

AIR Accumulator Isolation Relay

AMS Accumulator Management System

BRB Big Red Button

FH Rules Formula Hybrid Rule

GLV Grounded Low-Voltage

GLVMS Grounded Low Voltage Master Switch.

IMD Insulation Monitoring Device

IMI Insulation Monitoring Interrupter

RTDS Ready To Drive Sound

SMD Segment Maintenance Disconnect

ESOK Safety Systems OK

TS Tractive System

TSAL Tractive System Active Light

TSMP Tractive System Measurement Point

TSMS Tractive System Master Switch.

TSV Tractive System Voltage

***(Add additional abbreviations or acronyms specific to your diagrams or schematics)***

# Vehicle Overview

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

Check the appropriate boxes:

**Vehicle is**

☐ New (built on an entirely new frame)

☐ New, but built on a pre-existing frame

☐ Updated from a previous year vehicle

**Architecture**

☐ Hybrid

☐ Series

☐ Parallel

☐ Hybrid in Progress (HIP[[1]](#footnote-1))

☐ Electric-only

**Drive**

☐ Front wheel

☐ Rear wheel

☐ All-wheel

**Regenerative braking**

☐ Front wheels

☐ Rear wheels

☒ None

**NARRATIVE OVERVIEW**

*Provide a brief, concise description of the vehicles main electrical systems including tractive system, accumulator, hybrid type (series or parallel) and method of mechanical coupling to wheels. Describe any innovative or unusual aspects of the design.*

Include the following figures:

* **Figure 1** – an electrical system block diagram showing all major parts associated with the tractive-system. (Not detailed wiring).
* **Figure 2** – Drawings or photographs showing the vehicle from the front, top, and side
* **Figure 3** – A wiring diagram superimposed on a top view of the vehicle showing the locations of all major TS components and the routing of TS wiring.
* **Figure 4** -- A complete TSV wiring schematic per FH Rule **EV13.2.1** showing connections between all TS components.

This should include:

* + Accumulator Cells
  + AIRs
  + SMDs
  + Fuses
  + Wire Gauges
  + Motor controller
  + Motor
  + Pre-charge and discharge circuits
  + AMD
  + IMD
  + Charging port
  + Any other TS connections.

**IMPORTANT NOTICE**

When pasting drawings and schematics into the provided boxes, be certain that the graphics in the files are at a high enough resolution that the smallest details can be examined by enlarging the files.



*Figure 1 - Electrical System Block Diagram*



*Figure 2 - Drawings showing the vehicle from the front, top, and side*



*Figure 3 - Locations of all major TS components*



*Figure 4 - TSV Wiring Schematic*

# Operating Voltage

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

Fill in the following table:

|  |  |
| --- | --- |
| **Item** | **Data** |
| Nominal Tractive System Voltage (TSV*nom*) | VDC |
| Maximum Tractive System Voltage (TSV*max*) | VDC |
| Control System Voltage / Grounded Low Voltage system (GLV)  (Note: for 2024, Rule EV1.2, the GLV may be 48V max) | VDC |

*Table 1- General Electrical System Parameters*

# Safety Circuit

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Shutdown Circuit

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



*Figure 5 – Safety Shutdown Circuit Schematic*

*Describe the method of operation of your shutdown circuit, including the master switches, shut down buttons, brake over-travel switch, etc. Also complete the following table*

|  |  |
| --- | --- |
| **Part** | **Function  (Momentary, Normally Open or Normally Closed)** |
| Main Switch (for control and tractive-system; CSMS, TSMS) |  |
| Brake over-travel switch (BOTS) |  |
| Shutdown buttons (BRB) |  |
| Insulation Monitoring Device (IMD) |  |
| Battery Management System (AMS) |  |
| Interlocks (if used) |  |

*Table 2 - Switches& devices in the shutdown circuit*

*Describe wiring and additional circuitry controlling AIRs. Write a functional description of operation*

|  |  |
| --- | --- |
| Total Number of AIRs: |  |
| Coil holding current per AIR: | A |
| Current drawn by other components wired in parallel with the AIRs. | A |
| Total current in shutdown loop: | A |

*Table 3 - Shutdown circuit Current Draw*

Provide CAD-renderings showing the shutdown circuit parts. Mark the parts in the renderings



*Figure 6 – Location of Shutdown Circuit Components*

If your shutdown state diagram differs from the one in the Formula Hybrid rules, provide a copy of your state diagram (commented as necessary).

**

*Figure 7 - Shutdown State Diagram (if non-standard)*

## Shutdown System Interlocks

*(If used) describe the functioning and circuitry of the Shutdown System Interlocks. Describe wiring, provide schematics.*

# Indicator Operation

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Tractive System Active Lamp (TSAL)

*Describe the tractive system active lamp components and method of operation. Describe location and wiring, provide schematics. See* ***EV9.1.***

## Safety Systems OK Lamp (ESOK)

*Describe the Safety Systems OK Lamp components and method of operation. Describe location and wiring, provide schematics. See* ***EV9.3***

## Ready-To-Drive-Sound (RTDS)

*Describe your design for the RTDS system. See* ***EV9.2.***

# TSMP

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Tractive System Measurement Points (TSMP)

*The TSMP must comply with FH Rule* ***EV10.3****. Describe the TSMP housing and location. Describe TSMP electrical connection point.*

|  |  |
| --- | --- |
| TSMP Output Protection Resistor Value | kΩ |
| Resistor Voltage Rating | V |
| Resistor Power Rating | W |

*Table 4 – TSMP Resistor Data*

# Cables & Fusing

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Fusing & Overcurrent Protection

*List data for Primary TS and GLV fuses (or circuit breakers) and cross-reference to schematic.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mfg. | Fuse Part Number | Cont. Rating (A) | DC Voltage Rating | DC Interrupt Rating (A) | Schematic reference-designators (ref-des) |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

*Table 5 - Fuse Table*

## Component Fusing

*List data sheet max fuse rating for each major component (e.g., motor controller, dc-dc converter, etc.) Ensure that the rating of the fuse used is ≤ the maximum value for the component*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Component | Max Fuse Rating per data sheet (A) | Conductor  (Table 7  line number) | Installed Fuse Rating (A) | Fuse Part Number | Notes |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

*Table 6 - Component Fuse Ratings*

## System Wire Tables

*List wires and cables used in the Tractive System and the GLV system – (wires protected by a fuse of 1 A or less may be omitted.)*

*Cable capacity is the value from FH Rules* ***Appendix E*** *(Wire Current Capacity).*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Mfg. | Part Number | Size AWG / mm2 | Insulation Type | Voltage Rating | Temp. Rating (C) | Current capacity (A) |
| 1 |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |
| 9 |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |
| 11 |  |  |  |  |  |  |  |
| 12 |  |  |  |  |  |  |  |
| 13 |  |  |  |  |  |  |  |
| 14 |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |
| 16 |  |  |  |  |  |  |  |

*Table 7 - System Wire Table*

*(Add additional lines as required)*

# Motors

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Motor(s)

*Describe the motor(s) used. Copy and Paste additional tables if multiple motor types are used*

|  |  |
| --- | --- |
| Manufacturer and Model: |  |
| Motor type (PM, Induction, DC Brush) |  |
| Number of motors of this type used |  |
| Nominal motor voltage (Vrms l-l or Vdc) |  |
| Nominal / Peak motor current (A or A/phase) | Nom: / Peak: |
| Nominal / Peak motor power | Nom: / Peak: |
| Motor wiring – conductor | Table 7 Line Number: |
| Calculated max. road speed | MPH |

*Table 8 - Motor Data*

*Provide calculations for currents and voltages. State how this relates to the choice of cables and connectors used.*

*Provide a calculation of max. road speed based on motor voltage constant, nominal battery voltage, gear ratio and tire size.*

## Motor Controller

*Describe the motor controller(s) used. Copy and Paste additional tables if multiple motor controller types are used.*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Model Number** |  |
| Number of controllers of this type used: |  |
| Maximum Input voltage: |  |
| Nominal Input Current (A) |  |
| Output voltage (Vac l-l or Vdc) |  |
| Isolation voltage rating between GLV (power supply or control inputs) and TS connections |  |
| Is the accelerator galvanically isolated from the Tractive System per **EV3.5.7 & EV5.1**? | ☐Yes / ☐ No |

*Table 9 - Motor Controller Data*

*If the answer to the last question is NO, how do you intend to comply with* ***EV3.5*** *(an external isolator is acceptable).*

*Provide calculations for currents and voltages. State how this relates to the choice of cables and connectors used.*

# Isolation & Insulation

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Separation of Tractive System and Grounded Low Voltage System

*Describe how the TS and GLV systems are physically separated (****EV5.3****). Add CAD drawings or photographs illustrating TS and GLV segregation in key areas of the electrical system.*



*Figure 8 - TS and GLV separation*

## Grounding System

*Describe how you keep the resistances between accessible components below the required levels as defined in FH Rules* ***EV8.1****. If wire is used for ground bonding, state the AWG or mm2 of the wire*

## Conductive Panel Grounding

*If carbon fiber or coated conductive panels are used in your design, describe the fabrication methods used to ensure point to point resistances that comply with* ***EV8.1.2****. Describe results of*

*Figure 9 - Team Designed PCB Layout*

*List all purchased components that have connections to both TS and GLV*

|  |  |  |  |
| --- | --- | --- | --- |
| Component | TS/GLV Isolation (V) | Link to Document Describing Isolation | Notes |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

*Table 10 – Purchased Components*

## Isolation

*Provide a list of containers that have TS and GLV wiring in them. If a barrier is used rather than spacing, identify barrier material used (reference Table 12- Insulating Materials).*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Container Name | Segregation by Spacing (Y or N) | How is Spacing maintained | Actual Measured Spacing mm | Alt – Barrier Material P/N | Notes |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

*Table 11 – List of Containers with TS and GLV wiring*

*List all insulating barrier materials used to meet the requirements of* ***EV2.4.3*** *or* ***EV5.4***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Insulating Material / Part Number | UL Recognized(Y / N) | Rated Temperature ºC | Thickness mm | Notes |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

*Table 12- Insulating Materials*

## Conduit

*List different types of conduit used in the design. Specify location and if manufacturer’s standard fittings are used. Note Virtual Accumulator Housing FH Rules* ***EV2.12*** *requires METALLIC type LFMC.*

*Describe how the conduit is anchored if standard fittings are not used.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Conduit Type | MFR | Part Number | Diameter  Inch or mm | Standard Fittings  (Y or N) | Location / Use |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

*Table 13 - Conduit Data*

*Is all conduit contained within the vehicle Surface Envelope per* ***EV3.1.6****? (****Y or N****).*

*Does all conduit comply with* ***EV3.2****? (****Y or N****).*

## Shielded dual-insulated cable

*If Shielded, dual-insulated cable per* ***EV3.2.5(a)*** *used in the vehicle, provide specifications and where used:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| MFR | Part Number | Cross Section mm2 | Shield grounded at both ends (Y or N) | Location / Use |
|  |  |  |  |  |
|  |  |  |  |  |

*Table 14 - Shielded Dual Insulated Cable Data*

## Firewall(s)

## Description/materials

*Describe the concept, layer structure and the materials used for the firewalls. Describe how all firewall requirements in FH Rules* ***T4.5*** *are satisfied. Show how the low resistance connection to chassis ground is achieved.*

***Position in car*** *Provide CAD-rendering or photographs showing the location of the firewall(s).*

# Printed Circuit Boards

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

*List all electrical circuit boards designed by team that contain TS and GLV voltage in the following table.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Device / PCB | TS Voltage Present (V) | Minimum Spacing mm | Thru Air of Over Surface | Notes |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

*Table 15 - PCB Spacings*

*Add a figure (board layout drawing) for each team-designed PCB showing that spacings comply with* ***EV5.5.***



# IMD

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## IMD

*Describe the IMD used and use a table for the common operation parameters, like supply voltage, temperature, etc. Describe how the IMD indicator light is wired. Complete the following table.*

|  |  |
| --- | --- |
| MFR / Model |  |
| Set response value: | \_\_\_ kΩ (\_\_\_ Ω/Volt) |

*Table 16 - Parameters of the IMD*

*Describe IMD wiring with schematics.*

## Reset / Latching for IMD and AMS

*Describe the functioning and circuitry of the latching/reset system for a tripped IMD or AMS. Describe wiring, provide schematics.*

# AMS

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Accumulator Management System (AMS)

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Model Number** |  |
| Number of AMSs |  |
| Upper cell voltage trip | V |
| Lower cell voltage trip | V |
| Temperature trip | °C |

*Table 17 - AMS Data*

* *Describe how the AMS meets the requirements of* ***EV2.11.***
* *Describe other relevant AMS operation parameters.*
* *Describe how many cells are monitored by each AMS board, the configuration of the cells, the configuration of the boards and how AMS communications wiring is protected and isolated.*
* *Describe how the AMS opens the AIRs if an error is detected*
* *Indicate in the AMS system the location of the isolation between TS and GLV*

# Accumulator and Container

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Accumulator Pack

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

|  |  |
| --- | --- |
| Maximum Voltage (during charging): | VDC |
| Nominal Voltage: | VDC |
| Total number of cells: |  |
| Cell arrangement (x in series / y in parallel): | / |
| Are packs commercial or team constructed? | ☐Commercial / ☐ Team |
| Total Capacity (per FH Rules **Appendix A[[2]](#footnote-2)**): | kWh |
| Maximum Segment Capacity | MJ |
| Number of Accumulator Segments |  |

*Table 18 - Main accumulator parameters*

*Describe how pack capacity is calculated. Provide calculation at 2C (0.5 hour) rate. How is capacity derived from manufacturer’s data? If so, include discharge data or graph here. Include Peukert calculation if used (See FH Rules* ***Appendix A****)*

*Show your segment energy calculations. The segment energy is calculated as:*

(Note: The 80% factor is not applied for this calculation.)

## Cell description

*Describe the cell type used and the chemistry and complete the following table.*

|  |  |
| --- | --- |
| Cell Manufacturer |  |
| Model Number |  |
| Cell type (prismatic, cylindrical, pouch, etc.) | ☐Yes / ☐ No |
| Are these pouch cells | ☐Yes / ☐ No |
| Cell nominal capacity at 2C (0.5 hour) rate: | Ah |
| Data sheet nominal capacity | Ah at \_\_\_C rate |
| Maximum Voltage (during charging): | V |
| Nominal Voltage (data sheet value): | V |
| Minimum Voltage (AMS setting): | V |
| Maximum Cell Temperature (charging - AMS setting) | °C |
| Maximum Cell Temperature (discharging - AMS setting) | °C |
| Cell chemistry: |  |

*Table 19 - Main cell specification*

***IMPORTANT:*** *Show your calculations here for 2C nominal AH capacity if the data sheet uses a different discharge rate. Refer to FH rules* ***Appendix A***

## Cell configuration

*Describe cell configuration, show schematics, cover additional parts like internal cell fuses etc.*

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

*Does the accumulator combine individual cells in parallel without cell fuses?* ☐Yes / ☐ No

*If Yes, explain how* ***EV2.6.3*** *is satisfied.*

## Segment Maintenance Disconnect

*Describe segment maintenance disconnect (SMD) device, locations, ratings etc.*

|  |  |
| --- | --- |
| Is HVD used as an SMD? | ☐Yes / ☐ No |
| Number of SMD Devices / Number of Segments | / |
| SMD MFR and Model |  |
| SMD Rated Voltage (if applicable) | V |
| SMD Rated Current (if applicable) | A |
| Segment Energy (6 MJ max[[3]](#footnote-3)) | MJ |
| Segment Energy Discharge Rate (Ref FH Rules **Appendix A**) | C |

*Table 20 - SMD Data*

## Lithium-Ion Pouch Cells

*The vehicle accumulator uses individual pouch cells.* Yes ☐ No ☐

Note that 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, photographs and calculations demonstrating compliance with all sections of rule* ***EV11.*** *If your system has been issued a variance to* ***EV11*** *by the Formula Hybrid rules committee, include the required documentation from the cell manufacturer along with a copy of the variance.*

## Cell temperature monitoring

*Describe how the temperature of the cells is monitored, where the temperature sensors are placed, how many cells are monitored, etc. Show a map of the physical layout. Provide schematics for team-built electronics.*

|  |  |
| --- | --- |
| Number of Cells with Temperature Monitoring |  |
| Total Number of Cells |  |
| Percentage Monitored |  |
| Percentage Required by FH Rules: **Table 11** |  |
| If each sensor monitors multiple cells, state how many: |  |

*Table 21 - Cell Temperature Monitoring*

## Accumulator Isolation Relays (AIR)

*Describe the number of AIRs used and their locations. Also complete the following table.*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Model Number** |  |
| Contact arraignment: |  |
| Continuous DC current rating: | A |
| Overload DC current rating: | A for \_\_\_\_\_ sec |
| Maximum operation voltage: | VDC |
| Nominal coil voltage: | VDC |
| Normal Load switching: | Make and break up to \_\_\_\_\_ A |

*Table 22 - AIR data*

## Accumulator wiring, cables, current calculations

*Describe internal wiring with schematics if appropriate. Provide calculations for currents and voltages and show data regarding the cables and connectors used. Discuss maximum expected current, whether DC or AC, and duration Compare the maximum values to nominal currents*

## Accumulator indicator

*If accumulator container is removable, describe the voltage indicator, including indicating voltage range*

## Accumulator Container/Housing

*Describe the design of the accumulator container. Include the housing material specifications and construction methods. Include data sheets for insulating materials. Include information documenting compliance with UL94-V0, FAR25 or equivalent.*

*If the housing is made of conductive material, include information on how the poles of the accumulators are insulated and/or separated from the housing, and describe where and how the container is grounded to the chassis.*

*Include additional photographs if required, to illustrate compliance with rule* ***EV2.4.***

*Show how the cells are mounted, use CAD-Renderings, sketches or photographs showing compliance with FH Rule* ***EV2.4.7.***

## HV Disconnect (HVD)

*Describe your design for the HVD and how it is operated, wiring, and location. Describe how your design meets all requirements for* ***EV2.9.***

# Pre-charge / Discharge

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Pre-Charge circuitry

*Describe your design for the pre-charge circuitry. Describe wiring, connectors and cables used.*

* *Include a schematic of the pre-charge circuit*
* *Include a plot of calculated TS Voltage vs. time*
* *Include a plot of calculated Current vs. time*
* *Include a plot of resistor power vs time.*

*Provide the following information:*

|  |  |
| --- | --- |
| Resistor Type: |  |
| Resistance: | Ω |
| Continuous power rating: | W |
| Overload power rating: | W for sec |
| Voltage rating: | V |

*Table 23 - Data for the pre-charge resistor*

|  |  |
| --- | --- |
| Relay MFR & Type: |  |
| Contact arrangement: (e.g. SPDT) |  |
| Continuous DC contact current: | A |
| Contact voltage rating: | Vdc |

*Table 24 - Data of the pre-charge relay*

## Discharge circuitry

*Describe your concept for the discharge circuitry. Describe wiring, connectors and cables used.*

* *Include a schematic of the discharge circuit*
* *Include a plot of calculated TS Voltage vs. time*
* *Include a plot of calculated “Discharge current” vs. time*
* *Include a plot of resistor power vs time.*

*Provide the following information:*

|  |  |
| --- | --- |
| Resistor Type: |  |
| Resistance: | Ω |
| Continuous power rating: | W |
| Overload power rating: | W for \_\_\_\_\_ sec |
| Voltage rating: | V |
| Maximum expected current: | A |
| Average current: | A |

*Table 25 - Discharge circuit data*

# Torque Control

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Accelerator Actuator / Throttle Position Sensor

*Describe the accelerator actuator and throttle position sensor(s) used, describe additional circuitry used to check or condition the signal going to the motor controller. Describe wiring, cables and connectors used. Provide schematics and a description of the method of operation of any team-built signal conditioning electronics. Explain how your design meets all of the requirements of FH Rules* ***IC1.6*** *and* ***EV3.5.***

|  |  |
| --- | --- |
| Actuator / Encoder manufacturer |  |
| Model Number |  |
| Encoder type (e.g.Potentiometer): |  |
| Output: |  |
| Is motor controller accelerator signal isolated from TSV? | ☐Yes / ☐ No |
| If no, how will you satisfy rule **EV3.5**? |  |

*Table 26 - Throttle Position encoder data*

## Accelerator / throttle position encoder error check

*Describe how the system reacts if an error (e.g. short circuit or open circuit or equivalent) is detected. Describe circuitry used to check or condition the signal going to the motor controller. Describe how failures (e.g. Implausibility, short circuit, open circuit etc.) are detected and how the system reacts if an error is detected. State how you comply with* ***EV3.5.4.***

# GLV

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## GLV System Data

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

|  |  |
| --- | --- |
| GLV System Voltage (Same as Table 1)  (Note: for 2024, Rule EV1.2, the GLV may be 48V max) | V |
| GLV Main Fuse Rating | A |
| Is a Li-Ion GLV battery used? | ☐Yes / ☐ No |
| If Yes, is a firewall provided per **T4.5.1**? | ☐Yes / ☐ No |
| Is a dc-dc converter used from TSV? | ☐Yes / ☐ No |
| Is the GLV system grounded to chassis? | ☐Yes / ☐ No |
| Does the design comply with all requirements of **EV4**? | ☐Yes / ☐ No |

*Table 27- GLV System Data*

# Charger

Person primarily responsible for this section:

|  |  |
| --- | --- |
| Name: |  |
| e-mail: |  |

## Charging

*Describe how the accumulator will be charged. How will the charger be connected? How is the accumulator to be supervised during charging? Include a diagram showing how the charging circuit is fused.*



*Figure 10 – Charging Circuit with fusing*

*Complete the table*

|  |  |
| --- | --- |
| **Charger Manufacturer** |  |
| **Model Number** |  |
| Maximum charging power: | kW |
| Mains Isolation | ☐Yes / ☐ No |
| Galvanically Isolated | ☐Yes / ☐ No |
| Maximum charging voltage: | V |
| Maximum charging current: | A |
| Interface with accumulator (e.g. CAN, relay etc.) |  |
| Input voltage: | VAC (single phase) |
| Input current: | A |

*Table 28 - Charger data*

**Hybrid Battery Control Methods**

For hybrid vehicles, describe your on-board battery control methods including voltage and current limits. Describe method for dealing with a fully-charged pack (CV/CC algorithm etc.).

# Appendices

Include only highly-relevant data. A link to a web document in the ESF text is often more convenient for the reviewer.

The specification section of the accumulator data sheet, and sections used for determining accumulator capacity (FH Rules **Appendix A**) should be included here.

1. HIP does not need to be declared prior to the competition. If unsure, check “Hybrid” [↑](#footnote-ref-1)
2. This includes an 80% derating for available traction energy [↑](#footnote-ref-2)
3. Note *Segment energy = rated AH x nominal voltage*. The 80% derating is NOT applied for this calculation. [↑](#footnote-ref-3)