ESVC ESF 2

INTRODUCTION

The goal of the ESF is to ensure that vehicles are as safe as possible, and that they comply with the Electric Solar Vehicle Championship rules. The ESF is divided seven main sections:

1 – Overview
2 – Cables, Fusing& Grounding
3 – Isolation& Insulation
4 – Electric Tractive System
5– Accumulator System
6 – Safety Controls and Indicators
7 – GLV System

The *Cables and Fusing* and *Insulation and Isolation* sections are at the beginning of the ESF as these are the areas where teams most often have trouble in complying with FI rules.

A clear, concise ESF will help you to build a better bike. 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

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. 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.
5. When completed, this document must be converted to a pdf and submitted to: esvc.isie@imperialsociety.in
6. Please submit any questions, corrections and suggestions for improvement to: esvc.isie@imperialsociety.in

REVIEW PROCESS

Once submitted, your ESF will be reviewed by at least two ESVC reviewers.

When you submit a revised ESF, please indicate the REVISION DATE AND LETTER (starting with Letter A) and which sections have been updated in the following table:

REVISION DATE:	
REVISION: (A, B, C, etc.)	
Section	Revised (Yes / No)
1 – Overview	
2 – Cables and Fusing	
3 – Insulation and Isolation	
4 – Electric Tractive System	
5 – Accumulator System	
6 – GLV System	
7 – Safety Controls and Indicators	
8 – Appendices / Datasheets	

TITLE PAGE

Please include team logo, Bike picture, etc..

University Name: _____

Team Name: _____

Car Number: _____

Main Team Contact for ESF related questions:

Name: _____

e-mail: _____

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I List of Figures

II List of Tables

Section 1 **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

Drive

☐Front wheel

☐Rear wheel

☐All-wheel

Regenerative braking

☐Front wheel

☐Rear wheel

☐All wheels

☐None

NARRATIVE OVERVIEW

Provide a brief, concise description of the vehicles main electrical systems including tractive system, accumulator, 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** -- Include a complete TSV wiring schematic showing connections between all TS components. This should include accumulator cells, motor controller, motor, pre-charge and discharge circuits, charging port and any other TS connections.

NOTE: Figure 4 is the most important diagram in the ESF

Replace this with your own figure

Figure 1- Electrical System Block Diagram

Replace this with your own figure

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

Replace this with your own figure

Figure 3 - Locations of all major TS components

Replace this with your own figure

Figure 4 - TSV Wiring Schematic

Fill in the following table:

Item	Data
Nominal Tractive System Voltage (TSV)	VDC
Max. TSV (typically this is during charging)	VDC
Control System voltage (GLV)	VDC
Total Accumulator capacity (Wh)	Wh
Accumulator type (Lead-acid, Li-Ion, NiMH)	
Number of electric motors, total	
Are wheel motors used?	☐Yes / ☐ No

Table 1- General Electrical System Parameters

Section 2 **Cables, Fusing & Grounding**

Person primarily responsible for this section:

Name: _____

e-mail: _____

2.1 Fusing & Over current Protection

List TS and GLV fuse (or circuit breaker) data, and where used

Mfg.	Fuse Part Number	Cont. Rating (A)	DC Voltage Rating	DC Interrupt Rating (A)	Where Used

Table 2 - Fuse Table

2.2 Component Fusing

List major components (e.g., motor controller, dc-dc converter)and data sheet max fuse rating. Ensure that the rating of the fuse used is less than the maximum value for the component

Component	Fuse Part Number	Max Fuse Rating A	Installed Fuse Rating A	Notes

Table 3 - Component Fuse Ratings

2.3 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.
Available fault current can be calculated from $Fault\ Current = Vsource / (Rsource + Rwiring)$

Mfg.	Part Number	Size AWG / mm2	Insulation Type	Voltage Rating	Temp. Rating C	Cable Capacity A	Fuse Part #	Fuse Cont. A	Fuse Interrupting Rating Adc	Avail. Fault Current A	Where Used & How fault current is calculated

Table 4- System Wire Table

2.4 Grounding System

Describe how you keep the resistances between accessible components below the required levels. If wire is used for ground bonding, state the AWG or mm^2 of the wire

Section 3 **Isolation& Insulation**

Person primarily responsible for this section:

Name: _____

e-mail: _____

3.1 Separation of Tractive System and Grounded Low Voltage System

Describe how the TS and GLV systems are physically separated. Add CAD drawings or photographs of how TS and GLV are segregated in key areas of the electrical system.

Replace this with your Replace

Figure 5 - TS and GLV separation

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 5 - PCB Spacings

Add a figure (board layout drawing) for each team-designed PCB showing that spacing.

Replace this with your Replace

Figure 6 - Team Designed PCB Layout

List all purchased components with both TS and GLV connections (at min motor controller and BMS)

Component	Isolation Method	Link to Document Describing Isolation	Notes

3.2 Isolation & Insulation

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.

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

Table 6 – List of Containers with TS and GLV wiring

List all insulating barrier materials used to meet the requirements.

Insulating Material / Part Number	Recognized	Rated Temperature ºC	Thickness mm	Notes

Table 7- Insulating Materials

3.3 Conduit

List different types of conduit used in the design. Specify location and if manufacturer's standard fittings are used.
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 8 - Conduit Data

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

Section 4 **Electric Tractive System**

Person primarily responsible for this section:

Name: _____

e-mail: _____

4.1 Motor(s)

Describe the motor(s) used and reason for this particular choice. Add additional tables if multiple motor types are used

Manufacturer and Model:	
Motor type (PM, Induction, DC Brush)	
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 size and type	

Table 10- Motor Data

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

4.2 Motor Controller

Describe the motor controller used and reason for this particular choice.

Manufacturer and Model:	
Maximum Input voltage:	
Nominal Input Current (A)	
Max Input Fuse (A) per Mfr.	
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?	☐Yes / ☐ No

Table 11 - Motor Controller Data

If the answer to the last question is NO, give information about insulation provided complying rulebook.

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

4.3 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*

Provide the following information:

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

Table 13- Data for the pre-charge resistor

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

Table 14- Data of the pre-charge relay

4.4 Discharge circuitry

Describe your concept for the discharge 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 "Discharge current" 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 15- Data of the discharge circuit.

Section 5 **Accumulator System**

Person primarily responsible for this section:

Name: _____

E-mail: _____

5.1 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 FI Rules):	kWh
Maximum Segment Capacity	MJ

Table 17- Main accumulator parameters

5.2 Cell description

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

Cell Manufacturer and Model	
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 18- Main cell specification

5.3 Cell Configuration

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

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

5.4 Accumulator Management System (AMS/BMS)

Describe the AMS and how it was chosen.

AMS MFR and Model	
Number of AMSs	
Upper cell voltage trip	V
Lower cell voltage trip	V
Temperature trip	°C

Table 22 - AMS Data

- *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.*
- *Indicate in the AMS system the location of the isolation between TS and GLV*

5.5 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, DC and AC, and duration Compare the maximum values to nominal currents

5.6 Accumulator indicator

Describe the indicator, including indicating voltage range

5.7 Charging

Describe how the accumulator will be charged. How will the charger be connected? How is the accumulator to be supervised during charging?

Complete the table

Charger Manufacturer and model:	
Maximum charging power:	kW
Isolation	☐Yes / ☐ No
Do you have a waiver from the FI rules committee?	☐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 23- Charger data

5.8 Accumulator Container/Housing

Describe the design of the accumulator container. Include the housing material specifications and construction methods. Include data sheets for insulating materials.

Section 6 **Safety Controls and Indicators**

6.1 Shutdown Circuit

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

Replace this with your own figure

Figure 7 – Safety Shutdown Circuit Schematic

Describe the method of operation of your shutdown circuit, including the master switches, shutdown 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)	
Shutdown buttons (BRB)	
Battery Management System (AMS)	
Interlocks (if used)	

Table 24- Switches& devices in the shutdown circuit

Replace this with your own figure

Figure 8 – Location of Shutdown Circuit Components

6.2 Shutdown System Interlocks

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

6.3 Tractive System Active Lamp (TSAL)

Describe the tractive system energized light components and method of operation .Describe location and wiring, provide schematics.

Section 7 **GLV System**

Person primarily responsible for this section:

Name: _____

e-mail: _____

7.1 GLV System Data

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

GLV System Voltage	V
GLV Main Fuse Rating	A
Is a Li-Ion GLV battery used?	☐Yes / ☐ No
If Yes, is a firewall provided?	☐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 **EV3.3**?	☐Yes / ☐ No

Table 27- GLV System Data

Section 8 **Appendices**

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

Data Sheets of the components and other related documents can be included here.