E Bike Challenge 2024 ESF 2

INTRODUCTION

The goal of the ESF is to ensure that vehicles are as safe as possible, and that they comply with the E Bike Challenge rules. The ESF is divided seven main sections:

1 – Overview
2 – Cables, Fusing & Grounding
3 – Isolation & Insulation
4 – Electric Tractive System
5 – Battery Pack 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 SIEP E Bike Challenge rules.

A clear, concise ESF will help you to build a better E 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 online
6. Please submit any questions, corrections and suggestions for improvement to online

REVIEW PROCESS

Once submitted, your ESF will be reviewed by at least two 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 – Battery Pack System	
6 – GLV System	
7 – Safety Controls and Indicators	
8 – Appendices / Datasheets	

TITLE PAGE

University/Institute Name:	New Horizon College of Engineering
Team Name:	Lion Racing
Team ID:	SIEP-4.0-2086

Main Team Contact for ESF related questions:

Name: Dayas A Dixen
E-Mail: dayasadixen2002@gmail.com

Table of Contents

I List of Figures

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III List of Abbreviations

AIR	Accumulator Isolation Relay
AMS	Accumulator Management System
FI Rules	Formula Hybrid Rule
GLV	Grounded Low-Voltage
IMD	Insulation Monitoring Device
SMD	Segment Maintenance Disconnect
TS	Tractive System
TSEL	Tractive System Energized Light
TSMP	Tractive System Measurement Point
TSV	Tractive System Voltage
TSVP	Tractive System Voltage Present

1. SECTION I – VEHICLE OVERVIEW

Person primarily responsible for this section:

Name: Dayas A Dixen

e-mail: dayasadixen2002@gmail.com

NARRATIVE OVERVIEW

The core of the vehicle's powertrain system is centered around a robust 2000 W Brushless Direct Current (BLDC) motor, seamlessly integrated with a sophisticated motor driver. This driver, crucial for optimal performance, draws its power from a high-capacity 60 V 41.6 Ah lithium-ion battery pack.

In terms of mechanical configuration, the motor is intricately linked to a gearbox, forming a seamless union of power and precision. This gearbox, in turn, establishes a mechanical connection to the wheel through a meticulously designed chain mechanism. This intricate arrangement ensures the efficient transmission of power from the motor to the wheels, contributing to the overall dynamic performance of the vehicle.

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, insulators, fuses, charging port and any other TS connections.

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

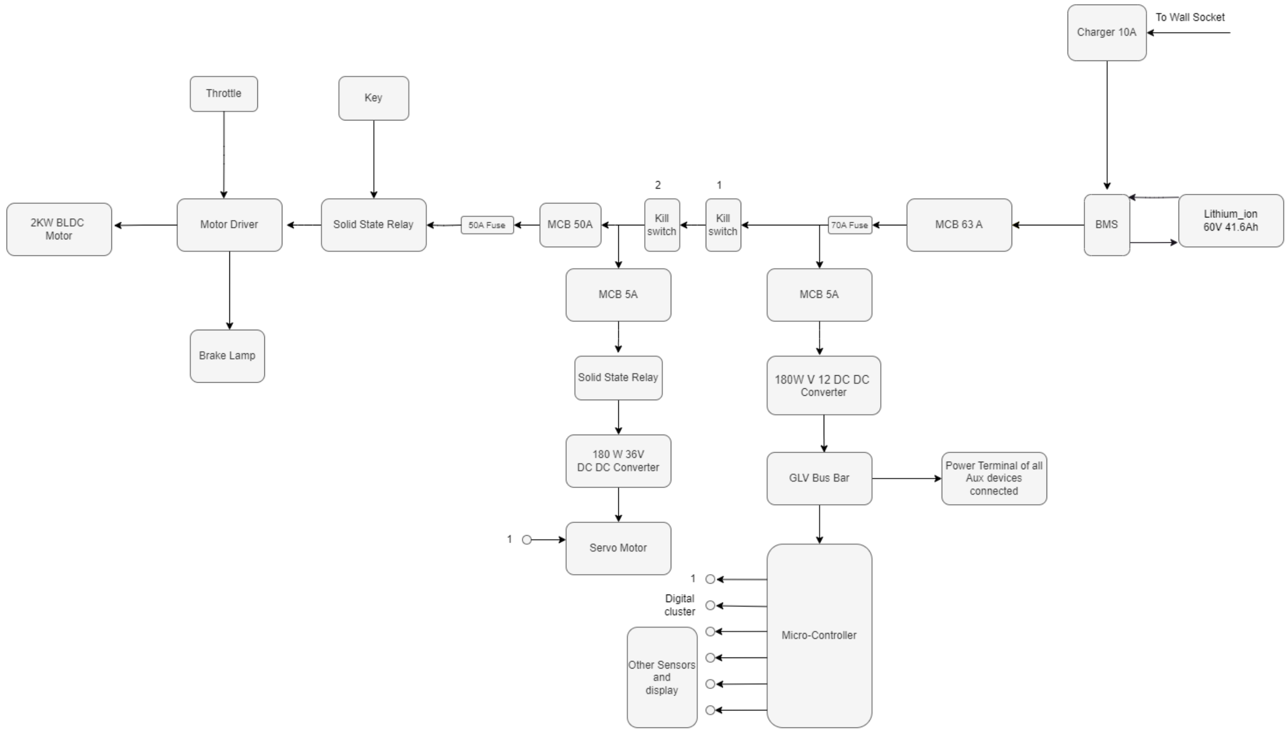


Figure 1- Electrical System Block Diagram

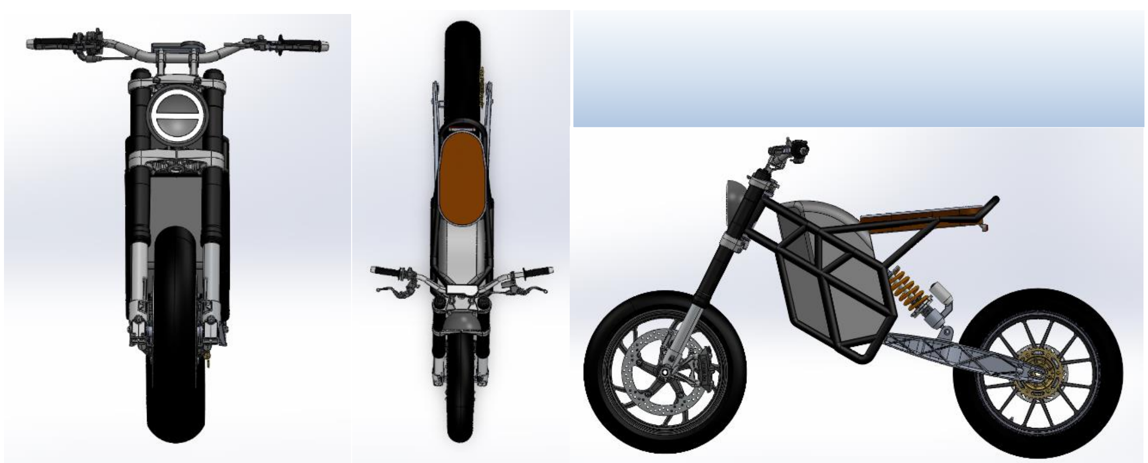


Figure 2 - Drawings showing the vehicle from the front, top, and side

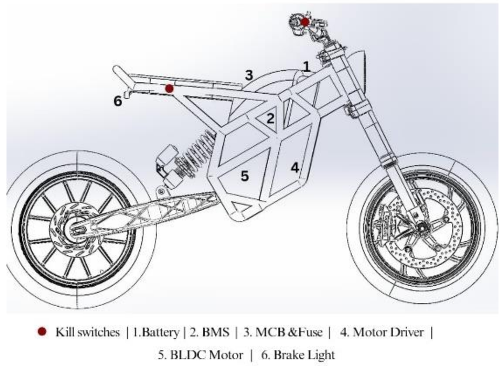


Figure 3 - Locations of all major TS components

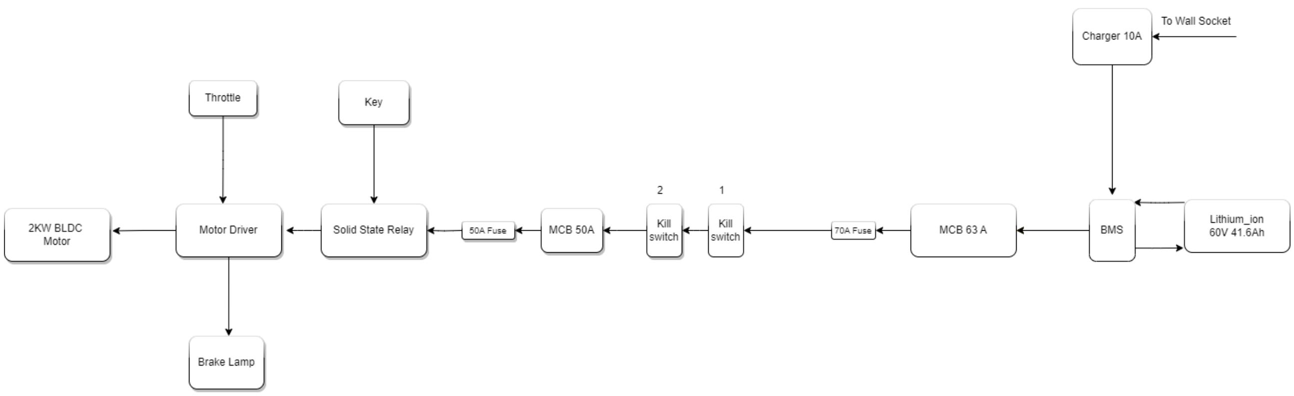


Figure 4 - TSV Wiring Schematic

Fill in the following table:

Item	Data
Nominal Tractive System Voltage (TSV)	60 VDC
Max. TSV (typically this is during charging)	67.2 VDC
Control System Voltage (GLV)	12 VDC
Total Accumulator Capacity (Wh)	2490 Wh

Table 1- General Electrical System Parameters

SECTION II – CABLES, FUSING AND GROUNDING

Person primarily responsible for this section:

Name: Dayas A Dixen
e-mail: dayasadixen2002@gmail.com

1. 2-A) Fusing & Over current Protection

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

Mfg.	Fuse Part Number	Cont. Rating (A)	DC Voltage Rating	DC Interrupt Rating (A)	Where Used
N/A	NBI-63DC 1PC50DC2 50V	40A	60V	50	Towards the drive MCB
N/A	NBI-63HIPC63 DC250V	50A	60V	65	From the battery terminal MCB
	166.7000.5 15	15	80V		Blade fuse for GLV
N/A	142.5631.5 702	70A	58V	70	Bolt fuse too far TS
N/A	142.5651.5 50C	50A	58V	50	Fuse between controller and MCB

Table 2 - Fuse Table

2. 2-B) Component Fusing

List major components (e.g., motor controller) 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
Drive/motor	142.563 1.5502	50A	50A	N/A

Table 3 - Component Fuse Ratings

3. 2-C) System Wire Tables

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
N/A	N/A	8AWG	silicone	600V	60~200	200	142.56 31.572	70	70		
N/A	N/A	12AWG	silicone	600V	60~200	50	166.70 00.515	15	15		

Table 4- System Wire Table

SECTION III – ISOLATION AND INSULATION

Person primarily responsible for this section:
Name: Dayas A Dixen
e-mail: dayasadixen2002@gmail.com

1. 3-A) Separation of Tractive System and Grounded Low Voltage System

Using DC/DC buck converter TS and GLV system are physically separate.

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
Driver	60V	N/A	N/A	Pre-manufacture
Raspbery Pico	3.3V	N/A	N/A	Control System (Pre-manufacture)
Raspbery Pic 3	3.3V	N/A	N/A	Control System (Pre-manufacture)

Table 5 - PCB Spacings

Component	Isolation Method	Link to Document Describing Isolation	Notes
Motor Driver	Solid State Relay	SSR	
GLV Systems	DC DC converters	Converter	

2. 3-B) 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	Recog nized	Rated Temperature °C	Thickness mm	Notes
Silicone Wires		20° - 200°	3.26	Power distribution from battery.
GLV Bus Bar		N/A	N/A	Power distribution for GLV systems

Table 7- Insulating Materials

3. 3-C) Conduit

Conduit Type	MFR	Part Number	Diameter Inch or mm	Standard Fittings (Y or N)	Location / Use
Plastic	N/A	N/A	25 mm	Y	N/A

Table 8 - Conduit Data

SECTION IV – ELECTRIC TRACTIVE SYSTEM

Person primarily responsible for this section:

Name: Dayas A Dixen
e-mail: dayasadixen2002@gmail.com

1. 4-A) Motor(s)

The Motor we are using is Mechatronic M2048. This motor works with 60V DC and can pull 70A maximum current. The reason for this motor was the availability of this motor in the market.

Manufacturer and Model:	Mechatronic M2048
Motor type (PM, Induction, DC Brush)	PM
Nominal motor voltage (Vrms l-l or Vdc)	Vdc
Nominal / Peak motor current (A or A/phase)	Nom: 50 / Peak:70
Nominal / Peak motor power	Nom: 2000 / Peak:3000
Motor wiring – conductor size and type	Star connected

Table 10- Motor Data

The motor, with a peak current handling capacity of 60 A, is paired with an 8 AWG silicone wire capable of withstanding up to 200 A. This wire selection offers a significant safety margin, ensuring reliable performance and minimizing the risk of overheating. The 8 AWG silicone wire's flexibility and high current capacity make it a suitable choice, providing a robust and secure electrical connection for the motor's operational needs.

4-B) Motor Controller

The Motor we are using is Mechatronic SK05021. This motor controller works with 60V DC and can pull 50A current (Rated). The reason for this motor controller was the availability of this motor in the market.

Manufacturer and Model:	Mechatronic SK05021
Maximum Input voltage:	60 V
Nominal Input Current (A)	50 A
Max Input Fuse (A) per Mfr.	50 A
Output voltage (Vac l-l or Vdc)	60 V
Isolation voltage rating between GLV (power supply or control inputs) and TS connections	N/A
Is the accelerator galvanically isolated from	N/A

the Tractive System?	

Table 11 - Motor Controller Data

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

2. 4-C) Pre-Charge circuitry (If any)

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:	N/A
Resistance:	N/A
Continuous power rating:	N/A
Overload power rating:	N/A
Voltage rating:	N/A

Table 13- Data for the pre-charge resistor

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

Table 14- Data of the pre-charge relay

3. 4-D) Discharge circuitry (If any)

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:	N/A
Resistance:	N/A
Continuous power rating:	N/A
Overload power rating:	N/A
Voltage rating:	N/A
Maximum expected current:	N/A
Average current:	N/A

Table 15- Data of the discharge circuit.

SECTION V – ACCUMULATOR (BATTERY PACK) SYSTEM

Person primarily responsible for this section:

Name: Dayas A Dixen

Email: dayasadixen2002@gmail.com

1. 5-A) Accumulator Pack (Battery Pack)

The specified battery is a commercially assembled pack designed for Formula One use. It consists of 128 cells arranged in a 16S 8P configuration, resulting in a nominal voltage of 60 VDC. The maximum charging voltage is 68.2 VDC. The total capacity meets Formula One rules at 2.5 kWh, and the maximum segment capacity is specified at 8985.6 MJ. This battery is constructed and produced commercially.

Maximum Voltage (during charging):	67.2$\pm$1 VDC
Nominal Voltage:	60 VDC
Total number of cells:	128 cells
Cell arrangement (x in series / y in parallel):	16S 8P
Are packs commercial or team constructed?	Commercial
Total Capacity (per FI Rules):	2.5 kWh
Maximum Segment Capacity	8985.6 MJ

Table 17- Main accumulator parameters

2. 5-B) Cell Description

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

Cell Manufacturer and Model	Micronix/Mx6040-1658P-26650-M01
Cell type (prismatic, cylindrical, pouch, etc.)	Yes
Are these pouch cells	No
Cell nominal capacity at 2C (0.5 hour) rate:	20.8Ah
Data sheet nominal capacity	N/A
Maximum Voltage (during charging):	67.2$\pm$1 V
Nominal Voltage (data sheet value):	60 V
Minimum Voltage (AMS setting):	60 V
Maximum Cell Temperature (charging - AMS setting)	50 °C
Maximum Cell Temperature (discharging - AMS setting)	60°C
Cell chemistry:	Lithium-ion

Table 18- Main cell specification

3. 5-C) Cell Configuration

The calculations for a 16S 8P battery configuration provide key parameters. The nominal voltage per cell (V_n) is determined as 3.75 V, derived from the nominal pack voltage divided by the number of cells in series. The maximum charging voltage (V_{max}) is given as 68.2 VDC. The configuration consists of 16 cells in series and 8 cells in parallel (P). The total capacity per cell (C) is computed as 19.53 Wh, assuming an even distribution of capacity among cells. These calculations offer insights into the battery's electrical characteristics, including its nominal voltage, maximum charging voltage, and capacity per cell, essential for understanding its performance in the 16S 8P arrangement.

4. 5-D) Accumulator Management System (AMS)/Battery Management System (BMS)

AMS MFR and Model	N/A
Number of AMSs	1
Upper cell voltage trip	67.7 V
Lower cell voltage trip	51 V
Temperature trip	60 °C

Table 22 - AMS Data

5. 5-E) Accumulator wiring, cables, current calculations

The Battery can discharge maximum 60A from the battery terminals. So, the wires connected to the battery terminals are rated for 200A. These wires can handle both charging and discharge currents. Usually charging current will be low. The battery which we are using has a charging current of 10 A.

6. 5-F) Charging

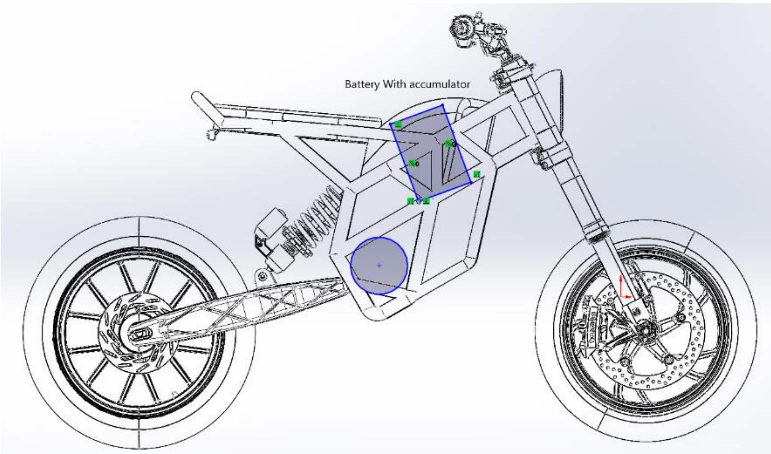
The charging system for the specified battery involves connecting the charger to the battery through a Battery Management System (BMS). The BMS assumes a crucial role in overseeing and regulating the charging process. It monitors various parameters, including cell voltages and temperature, to ensure the charging conditions are optimal. Additionally, the BMS is responsible for controlling the charging rate and implementing safety measures to prevent issues such as overcharging. This integrated approach, where the BMS actively monitors and manages the charging, contributes to the overall safety, efficiency, and performance of the battery system.

Complete the table

Charger Manufacturer and model:	N/A
Maximum charging power:	N/A
Isolation	N/A
Do you have a waiver from the FI rules committee?	N/A
Maximum charging voltage:	N/A
Maximum charging current:	N/A
Interface with accumulator (e.g. CAN, relay etc)	
Input voltage:	VAC single phase
Input current:	A

Table 23- Charger data

7. 5-G) Accumulator Container/Housing



The Battery and accumulator are placed as shone in the diagram.

5. SECTION VI – SAFETY CONTROLS

1. 6-A) Shutdown Circuit

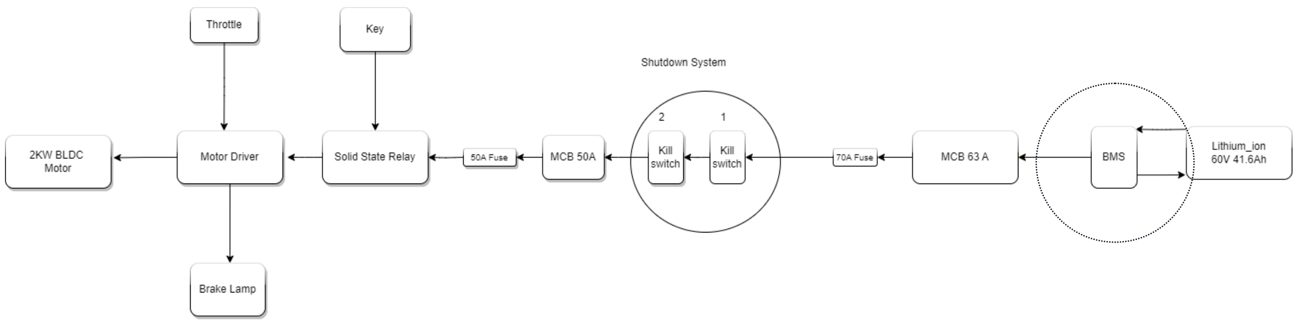


Figure 7 – Safety Shutdown Circuit Schematic

The primary shutdown system that we are using is kill switches. The BMS will also act as shutdown system the operating parameters exceeds its limits

Part	Function (Momentary, Normally Open or Normally Closed)
Brake over-travel switch (BOTS)	N/A
Shutdown buttons (BRB)	Kill Switch
Battery Management System (AMS)	
Interlocks (if used)	N/A

Table 24- Switches& devices in the shutdown circuit.

SECTION VII - GLV SYSTEM

Person primarily responsible for this section:

Name: Dayas A Dixen

e-mail: dayasadixen2002@gmail.com

2. 7-A) GLV System Data

GLV System Voltage	12 V
GLV Main Fuse Rating	15 A
Is a Li-Ion GLV battery used?	Yes
If yes, is a firewall provided?	No
Is a dc-dc converter used from TSV?	Yes
Is the GLV system grounded to chassis?	Yes
Does the design comply with **EV3.3**?	No

Table 27- GLV System Data

6. SECTION VII - APPENDICES

Include only highly-relevant data. Data Sheets (click here to access data sheets).

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