**Coversheet**

**The Coversheet must contain the following:**

* **Heading “Hybrid System Form 2025”**
* **University Name and Team Name**

Feel free to add your team logo, car picture, and the like to the cover page

1. **Requirements (delete this section after you have read and understood it):**
2. Complete all sections and tables of the HSF. If a section is not applicable to your design state that in the document, do not delete any sections unless it is explicitly mentioned in the instructions.
3. Remove instructions (orange) from the document as you complete the sections by writing in black.
4. Provide hyperlinks to all datasheets.
5. If you are unsure concerning the reviewer's feedback, do not hesitate to ask questions at: hybrid@fs-world.org
6. Parts of the HSF that are changed after your initial upload **must be marked in red**.
7. Following these guidelines will guarantee a swift review process.

We are aware that this HSF template is quite detailed. We want to give you support in your journey towards a Hybrid Combustion Vehicle and going through all the components will give you the best chance of a system that is safe and rules compliant, ensuring a swift Tech Inspection process.

Also: Feel free to use this document for the Engineering Design event!

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# System Overview

Include a brief description of the vehicle (1 paragraph).

Complete the information in the table below.

|  |  |
| --- | --- |
| Maximum Hybrid System Voltage | 40VDC |
| Nominal Hybrid System Voltage | 30VDC |
| Grounded Low Voltage System Voltage | 24VDC |
| Number of Hybrid Storage Containers | 2 |
| Total Hybrid Storage Energy | 500Wh |
| Motor Type | AC Induction |
| Number of Motors | Total 1 |
| Maximum Combined Motor Power | 5kW |

*Table 1-1 - High Level Specifications*

Insert a system overview block diagram showing major electrical components and system interactions

*Figure 1-2 – System Overview Block Diagram*

# Hybrid System Schematics

## Hybrid System Schematic (Power Electronics ONLY)

Insert a large (full page) schematic of the Hybrid System. This schematic should focus on the components that are not within the HSC. Provide boxes and 1st level interfaces, when details will be provided later in this document. Some details of components within the HSC may be included for better understanding (i.e. AIR).

The figure must include the following:

* Wire Size (AWG or mm2)
* Relative location of overcurrent protection (end of wire vs middle)
Note: Fuses are typically used as overcurrent protection
* Overcurrent protection rating (Amperage and Voltage)
* Motor controller (1st level interfaces...inputs & outputs)
* Motor
* Connection to GLVS (if any)
* Connectors and interfaces for charging
* Show enclosures as dashed lines

*Figure 2-1 – Hybrid System Schematic*

### Overcurrent Protection Specifications

Complete the information in the table below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Location** | **Current Rating** | **Voltage Rating** | **Interrupt Rating** | **Datasheet** |
|  |  |  |  |  |
|  |  |  |  |  |

*Table 2-2 - Overcurrent Protection Specifications*

### Conductor Specifications

Complete the information in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Conductor Location** | **Size** | **Voltage Rating** | **Ampacity** | **Rating of Relevant Overcurrent Protection** | **Datasheet** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

*Table 2-3 - Conductor Specifications*

### Connector Specifications

Complete the information in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Connector Location** | **Ampacity** | **Voltage Rating** | **Includes Interlock** | **Accepted Wire Gauge** | **Wire Gauge Connected** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

*Table 2-4- Connector Specifications*

# Shutdown Circuit

## Shutdown Circuit Schematic

Insert a large (full page) schematic of the shutdown circuit.

The schematic must include the following:

* All shutdown circuit switches/devices (indicate Normally Open or Closed)
* Hybrid control system connection to shutdown circuit
* BSPD connection to shutdown circuit
* BOTS
* Inertia switch
* AIR coils
* Pre-charge relay coil (if used)
* GLV battery
* Overcurrent protection(s)
* Wire size (AWG or mm2)

Explain how you meet the following requirement: The hybrid system may only be activated when the combustion engine is running or during engine start.

*Figure 3-1 – Shutdown Circuit Schematic*

# Hybrid Storage Container

## Hybrid Storage Container

Insert a large image (top or nearly top view) of the complete Hybrid Storage Container assembly without cover.

Figure must include the following:

Attachment points to the chassis

Electronics for the cell monitoring (at least one PCB mock-up)

AIR

Overcurrent protection device (typically: fuses)

All electrical connections for the high current path

Main power connector

(additional images may be needed to provide clear views of all elements)

*Figure 4-1 – Hybrid Storage Container Overview*

## Cutout Area in HSC Walls

Insert images to show compliance with the following requirement:

Holes, both internal and external, in the HSC, are only allowed for the wiring harness, ventilation, cooling, or fasteners. The total cutout area must be below 25 % of the area of the respective single wall.

Figure must include the following:

Measurement of total area of respective single wall (including cutouts)

Measurement of cutout area of respective single wall

*Figure 4-2 – Proof for Cutout Area*

Complete the information in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Respective Single Wall | Total Area | Cutout Area | Cutout Percentage |
| Bottom | 60 000 mm² | 0 mm² | 0 % |
| Frontal Wall | 30 000 mm² | 600 mm² | 2 % |
| Left Side Wall | 20 000 mm² | 5 000 mm² | 25 % |
| Right Side Wall | 20 000 mm² | 5 000 mm² | 25 % |
| Rear Wall | 30 000 mm² | 0 mm² | 0 % |
| Top *(typically: cover)* | 60 000 mm² | 0 mm² | 0 % |
| Internal Walls *(if applicable)* | 30 000 mm² | 6000 mm² | 20 % |

*Table 4-3 – Cutout Area Calculation*

## Hybrid Storage Container Attachments

Insert calculations showing that the following criteria are being met: The HSC itself, the mounting of the HSC to the chassis, and the mounting of each cell to the HSC must be designed to withstand the following accelerations:

* 40 g in the longitudinal direction (forward/aft)
* 40 g in the lateral direction (left/right)
* 20 g in the vertical direction (up/down)

## Segments

### Segment Overview

Insert a large image of the complete segment assembly. Describe segment materials and how the design provides a safe environment when working on the HSC, with regards to dropped tools.

*Figure 4-4 – Segment Overview*

### Segment Specifications

Complete the information in the table below.

|  |  |
| --- | --- |
| # of Segments: | 5 |
| Cells per segment: | 15 |
| Cell configuration in segment: | 5S3P |
| Energy in segment: | 2.8MJ / 0.78 kWh |

*Table 4-5 - Segment Specifications*

### Cell Connections

Describe how the electrical connections are made to the cells (welded/bolted/clamped)? Define what kind of weld (resistance/laser), what kind of bolt (copper w/deforming nut), and the material of the clamp. If bus bars are used what is the cross-sectional area and ampacity?

## Cells

### Cell Specifications

Complete the information in the table below.

|  |  |
| --- | --- |
| Cell Make / Model / Style | Kokam XYZ- pouch, cylindrical, or metal can |
| Cell Nominal Capacity | 5.4 Ah |
| Maximum Voltage | 4.2 V |
| Nominal Voltage | 3.7V |
| Minimum Voltage | 2.8V |
| Maximum Output Current | 12A for 10s |
| Maximum Continuous Output Current | 5A |
| Maximum Charging Current | 1A |
| Maximum Cell Temperature (discharging) | 65°C |
| Maximum Cell Temperature (charging) | 55°C |
| Cell Chemistry | LiFePO4 |
| Cell Weight | 65g (+/-5%) |
| Total Number of Cells in HSC(s) | 42 |
| Total Weight of Active Material | 2730 g (+/-5%) |
| Datasheet | [Datasheet](http://www.fsaeonline.com) |

*Table 4-6 - Cell Specifications*

Explain how the power sinking elements of the precharge circuit (if present) are cooled.

## HSC Monitoring System

### Monitoring System Overview

Describe the system that has been selected for voltage and temperature monitoring of the HSC(s). Provide a datasheet, and show the position of the measurement system in your HSC.

*Figure 4-7 –Monitoring System Overview*

### Voltage Monitoring

Provide details of the voltage measurement system (accuracy, acquisition frequency, …).

Describe how and where the voltage sense leads are overcurrent protected (fused). What size are the sense leads? What is their ampacity? If your sense leads are not fused, please reason why and how your system detects a malfunction of one of the measurements. Also, include an error calculation of how precise your system is.

### Temperature Monitoring

Provide details of the temperature measurement system (accuracy, acquisition frequency, …). Give details of the temperature sensors used. Also, include an error calculation of how precise your system is.

Provide images showing the position of the temperature sensors describe how you meet the following requirements:

The HSC must include overtemperature protection of at least 30 % of the cells that trips when any cell leaves the allowed temperature range according to the manufacturer’s datasheet, but not more than 60 ◦C, for more than 1 s and disconnects the battery.

Cell temperature must be measured at the negative terminal of the respective cell. The sensor used must be in direct contact with the electrically exposed negative terminal or less than 10 mm along the high current path away from the terminal in direct contact with the respective busbar. It is acceptable to monitor multiple cells with one sensor if this requirement is met for all cells sensed by the sensor.

*Figure 4-8 – Temperature Sensors Location*

### HSC Monitoring System Limits

Complete the table below.

|  |  |
| --- | --- |
| Max Cell Voltage: | 6.8V |
| Min Cell Voltage: | 4.2V |
| Max Temperature: | 60°C |
| Min Temperature: | -5°C |

*Table 4-9 – HSC Monitoring System Limits*

## Charging

### Charger Specifications

Complete the information in the table below.

|  |  |
| --- | --- |
| Make / Model | ElectronPusher Inc 100V200 |
| Power | 0.082kW |
| Output Voltage | 30V |
| Output Current | 0.273A |
| Input Voltage | 120V |
| Input Current | 1A |
| Datasheet | [Datasheet](http://www.fsaeonline.com) |

Table 4-10 - Charger Specifications

Provide images of the charger assembly and charging setup as it will be used during the events

*Figure 4-11 – Charger Assembly and Charging Setup*

### Charger Control

Describe how the charging process is controlled (voltage, current and temperature monitoring)
If there is a connection between the HSC monitoring system and the charger, please explain.

### Charger Demonstration

Describe numbered steps you would use to demonstrate the safe operation of charging, including how to connect, and how to disconnect. Include any safe use practices, as well as what to look for proper operation vs. a faulted condition.

# Motor controller

## Motor controller 1

### Description, type, operation parameters

Describe important functions.

Describe how you have implemented the requirement, that hybrid system may only be activated when the combustion engine is running or during engine start.

Fill out the following table:

|  |  |
| --- | --- |
| Motor Controller Type | ABC Controller |
| Maximum Continuous Power | 60kW |
| Maximum Peak Power | 75kW for 10s |
| Maximum Input voltage | 600VDC |
| Output voltage | 250VAC |
| Maximum continuous output current | 100A |
| Maximum peak current | 200A for 5s |
| Control method | PWM, analog signal... |
| Cooling method | Air, water, oil... |
| Auxiliary supply voltage | 24VDC |
| Datasheet (if not self-developed) | [Datasheet](http://www.fsaeonline.com) |

*Table 5.1 –Motor Controller Specifications*

### Position in car

Provide CAD-renderings showing the relevant parts. Mark the parts in the rendering, if necessary.

*Figure 5.2 – Motor Controller Position*

## Motor Controller 2

If multiple identical motor controllers are used, you can delete this section. If different motor controllers are used, please provide the same information as for motor controller 1.

# Electric Motors

## Electric Motor 1

### Description, type, operating parameters

Describe the motor used, the casing and if the casing rotates the finger guards used.

Provide a picture of the Electrical Motor.

*Figure 6.1 –Electric Motor*

Fill out the table:

|  |  |
| --- | --- |
| Motor Manufacturer and Type | ABC Motor |
| Motor Principle | Asynchronous, permanently excited |
| Maximum Continuous Power | 25kW |
| Peak Power | 70kW for 5s |
| Input Voltage | 250VAC |
| Nominal Current | 50A |
| Peak Current | 70A |
| Maximum Torque | 60Nm |
| Nominal Torque | 20Nm |
| Cooling Method | Water / oil / air |
| Datasheet *(if not self-developed)* | [Datasheet](http://www.fsaeonline.com) |

*Table 6.2 –Electric Motor Specifications*

Give a plot of power vs. rpm including a line for nominal and maximum power.

Give a plot of torque vs rpm including a line for nominal and maximum torque.

*Figure 6.3 –Electric Motor Power and Torque*

### Position in car

Describe how do you integrate the electrical motor into your System. Provide CAD renderings showing all relevant parts. Mark the parts in the rendering, if necessary, and identify the structure used to protect all relevant parts.

*Figure 6.3 –Electric Motor Integration and Protection*

## Electric Motor 2

If multiple identical motors are used, you can delete this section. If different motors are used, please provide the same information as for motor 1.

# Other Items

## Firewall

### Firewall Specifications

Provide a Screenshot from your SES Tab “T1.2.1 T4.6 T4.8 Firewall” showing the following cells:



*Table 7-1 - Firewall Specifications*

Provide a Datasheet for the fire-resistant material (same as in SES):[Datasheet](http://www.fsaeonline.com)

### Firewall Location

Provide CAD rendering(s) or photographs showing the firewall components. Mark the parts that the firewall is protecting from (HSC, fuel, oil, and cooling system components) in the pictures, if necessary. (same information as in lower part of the respective SES tab)

*Table 7-2 – Firewall Location*

## Other Components

If your Hybrid System has other components, please document them here.

If there are no other components, you can delete this section.

If there are multiple different other components, please copy and paste this section.