Electrical System Form

Team: DE Stralsund UAS Car122

Competition: FSE22

Table Of Content

TS Accumulator (el.)

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

What will be checked:

- Cell configuration and maximum accumulator voltage
- Temperature monitoring and tolerances
- Voltage monitoring and tolerances

The reviewer might check additional points.

Status: NONE

Accumulator

Select your cells and check if the calculated values are correct.

Attribute	Value
Cell /Accumulator:	Sony - US18650 VTC6
Accumulator configuration (parallel)	5
Accumulator configuration (series)	132
Maximum Voltage:	554.4 V
Nominal Voltage:	475.2 V
Minimum Voltage:	330 V
Max. Continuous Discharge Current:	150 A
Peak Discharge Current:	150 A
Peak Discharge Current Time:	0 s
Max. Continuous Charge Current:	25 A
Peak Charge Current:	25 A
Peak Charge Current Time:	0 s
Total numbers of cells:	660
Total Capacity:	29.9376 MJ
Every cell stack of the accumulator is below < 120VDC and 6 MJ.	Yes
Answers to reviewer comments (optional)	

Cell Temperature Monitoring:

Attribute	Value
Is an offset for the maximum and minimum temperature threshold included?	Yes
Total number of temperature sensors:	132
Total numbers of cells:	660
Max. distance from monitored negative cell terminal to sensor	10 mm
Descripe how you make sure to measure the temperature of at least 30% of lithium based cells	at the middle of every stack of five cells that are connected in parralel a SMD thermistor is mounted on a flex PCB which is attached to the busbar. This Thermistor measures the temperature of the cell that it is on and the temperature of both adjacent cells as thex are within 10mm of the thermistor. This makes it possible to measure the temperature of 3/5 of all cells.
AMS opens AIRs during charging, if sensor temperature above:	58.5 °C
AMS opens AIRs during dis-charging, if sensor temperature above:	58.5 °C
Maximum Cell Temperature (Charging):	60 °C
Maximum Cell Temperature (discharging):	60 °C
Please provide a error calculation of your measurement system.	ESF_9715_5050_1648140034.pdf
Describe how faults within temperature monitoring can be detected (e.g. missing power line etc.)	A short circuit of the temperature sensor reads as out of range. Open circuit of the sensor reads as out of range as well because of the voltage divider working as a pull-up. A power fault of the sensor therefore also reads as out of range. A power fault for the slave results in incorrect CRCs in master slave communication. If a slave is disconnected, the CRC of the slave will be invalid. Analog Digital converting all cells takes approx. 3ms in total, limiting the minimum cycle time to 3ms. The BMS runs a cycle time of 10ms and activates the SC after an error has sustained for a total of 20cycles. Problematic conversions or values add to the error count while successful conversions substract from it. (if errorcount>=20, open SC)
Please state the sampling rate of your temperature measurement system	100
CAD Rendering - Position of Cell Temperatur Sensor on Cell	ESF_9715_5040_1647850488.pdf
Descripe where you will place the official cell temperature logger and why this is the warmest cell in the container.	The CTMD will be place under the AMS Slave in the middle at the most center stacks of the accumulator. We do not plan to flow Air throuh the accumulator so the most inner part of the accumulator should be the warmest. We are closest to the upper cells of the stack as the heat should rise up through the conatiner through convection resulting in the the top cells being the warmest. The CTMD is directly screwed to the busbar with Nylon screws. It can be inserted with the AMS Slave removed. We also attached a flow simulation out of our early development that led us to abandoning a forced cooling. We simulated with 50m^3/h and you can see that the pressure drop is enormous. We still run cooling slids in the case as we plan to still do testing on that matter with different fans to see wether our conclusion holds that forced cooling is not effective.
CAD Rendering and additional Documents - Position of Cell Temperatur Logger in Accumulator Container, Cooling Simulation of Accu Container	ESF_9715_5047_1648139632.pdf

Cell Voltage Monitoring:

Describe how the AMS is connected to the cells. Describe the sense wiring and show schematics, cover additional parts, etc.

Attribute	Value
AMS opens AIRs, if highest single cell voltage is above:	4.2 V
Maximum Voltage:	4.2 V
AMS opens AIRs,if lowest single cell voltage is below:	2.5 V
Minimum Voltage:	2.5 V
Please provide a error calculation of your measurement system.	ESF_9715_5033_1648121359.pdf
Please state the sampling rate of your voltage measurement system	100
Describe how faults within voltage monitoring can be detected (e.g. missing power line etc.)	The LTC6811-X has open circuit detection and short circuits can be detected by out of range measurements. The balancing can be activated, this should cause a voltage drop in the cell measurement so we can test whether balancing works or not. If a slave is disconnected, the CRC will be invalid. Analog Digital converting all cells takes approx. 3ms in total, limiting the minimum cycle-time to 3ms. The BMS runs a cycle time of 10ms and activates the SC after an error has sustained for a total of 20cycles Problematic conversions or values add to the error count while successful conversions substract from it. (if errorcount>=20, open SDC)

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET

TS Accumulator (mech.)

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event! What will be checked:

- All components according to the rules section "Accmulator Container" are described
- position/mounting in the car
- internal configuration
- cell stack configuratio
- cooling concept
- weight of the accumulator(s) with container(s)
- hard-cart with safety functions

The reviewer might check additional points.

Status: NONE

Accumulator Container:

Attribute	Value
Show how the container is mounted to the car and how it is sealed against water etc.	ESF_9717_4904_1647880331.pdf
Accumulator container internal configuration:	The container is divided into 14 compartments. Twelve of which are used to house the accumulator stacks and 2 of which are used to house the accumulator electronics. The from the front view left compartment houses the AMS IMD and our HVDCDC and the right compartment houses the AIR`s, Fuse and a Current Measurement Device. The Container and all internal walls are made from Aluminium in 2,5 and 3,5mm thickness respective and is welded. The aluminium is covered wit aramid paper to electrically insulate the container. The high current path starts at the rightmost stack and goes in a circle and ends at the stack left to the rightmost one. An isolated SPI bus is used to connect the slaves and the Master together in a line topology.
Accumulator container internal configuration:	ESF_9717_4908_1647880331.pdf
Does the mounting of each cell meet EV 5.5.9?	Yes
Do all used screws within the cell stack have a positive locking mechanism?	No
Cell Stack Configuration:	ESF_9717_4913_1647884649.pdf
Total weight of the accumlator/accumulators (with container)	45000 g

Hand-Cart:

Describe how the accumulator is secured on the hand-cart. Also how the cart is fulfilling the requirements.

Attribute	Value
Description of the safety function of the cart:	The Container is screwd down just like it is in the CAR
Pictures of the Hand-Cart	ESF_9717_4954_1648152544.pdf

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET

TS Accumulator (charging)

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

What will be checked:

- No live contacts outside of Accumulator or Charger during charging
- Galvanic separation between TS and GLVS
- Shutdown Circuit includes AMS, IMD and emergency stop button
- TSMP and current limiting resistors
- Charger Power Supply (for Charging Tent)

The reviewer might check additional points.

Status: NONE

Accumulator Charging

Attribute	Value
How will the charger be connected to the Accumulator?	It will use the Connector for the Car. For HV as well as LV
Upload schematic of the full electrical setup during charging.	ESF_9718_4927_1648234159.pdf
Upload datasheet of your charger	ESF_9718_4930_1647863879.pdf
Maximum Charging Power:	15 kW
Input Voltage:	400 VAC
Input Current (for fusing):	32 A
Description (optional):	

TS Accumulator Indicator

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

Status: NONE

Accumulator Indicator

What will be checked?

- hard wired electronics for complete indicator
- indicates any voltage >60V or half the max. TS voltage, whichever is lower
- only connected to vehicle side of the AIR (which implies power supply by TS)
- clearly visible while disconnecting the TS accumulator container from the vehicle

The reviewer might check additional points.

Attribute	Value
Upload a schematic/Datasheet	ESF_9848_5076_1648148752.pdf
Voltage the Indicator signals TS on	45 V
Voltage the Indicator signals TS off	25 V
CAD Rendering:	ESF_9848_5077_1648298127.pdf

TS overcurrent protection

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

Status: NONE

General

What is the schematic about?

- all TS compoents
- mark all TS components with their respective current rating and EAIR ID if applicable
- mark all TS enclosures
- format:
  - 1 to 2 pages
  - A3
  - title block with at least vehicle number, revision, and date
  - correctly rotated
  - vector graphics, not pictures
- keep in mind:
  - you'll only get comments on things you show us
  - location of the overcurrent protection matters, so show the TS enclosures and connectors
  - overcurrent protection includes more than fusing
  - use some white space for structure

The reviewer might request additional points.

Attribute	Value
TS Schematic (Example Schematic)	ESF_9719_4694_1648237719.pdf
All TS components are marked with - current rating - EAIR ID if applicable - wire cross-section if applicable TS enclosurres are marked	Yes
Accumulator contains - cells - AMS - accumulator fuse - AIRs - precharge - IMD - TSAL voltage measurement - voltage indicator - wires - accumulator connector	Yes
Inverter & motor contains - fuses/OCP measures - wires - connectors - HVD - Data Logger - TSMPs - discharge - TSAL voltage measurement - BSPD - inverters - motors	Yes
All electrical systems have appropriate overcurrent protection (EV 3.2.1)	Yes
Continuous current rating of the overcurrent protection is not greater than protected components (EV 3.2.2)	Yes
Each accumulator container has a fuse (EV 3.2.7 & EV 5.4.2)	Yes
Each accumulator container has 2 AIRs (EV 5.4.2)	Yes
Data Logger TS+ is fused if dedicated OCP is needed	Yes
IMD connected to the vehicle side of the AIRs (EV 6.3.4)	Yes
TSMPs are not fused (EV 4.7.6)	Yes
Discharge is not fused (EV 4.9.3)	Yes
Answers to reviewer comments (optional)	

TS Accumulator

What will be checked?

- the TS Accumulator fuse is able to protect
  - the cells (cont. discharge current)
  - the AIR (cont. current and short circuit current)
  - the maintenance plugs
  - the high current path wiring
  - the high current path connectors
- scope: the high current path from cells to the TS Accumulator outlet

If you have any special design, right on the edgle calculations, or more than one item of a type with different ratings use the schmatic of general section to show/explain/proof your design. But please keep it short and stick to the basic math. The reviewer might request additional points.

Attribute	Value
TS Accumulator Fuse (acc. EV 3.2.7)	Adler Electric - Adler AE72800i25
DC Voltage rating fuse	700 V
Sufficient voltage rating of fuse& rated for DC (EV 3.2.4)	Yes
TS Accumulator cell	Sony - US18650 VTC6
no. of parallel cells	5
Short circuit current	2636 A
Provide calculation of the short circuit current of the accumulator	ESF_9719_4716_1647867771.pdf
Fuse breaking capacity	50000 A
Sufficient interrupt current rating (EV 3.2.3)	Yes
AIR	Littlefuse - DCNEV150-MA
Voltage rating AIR	900 V
Overload current AIR	500 A
overload time AIR	8 s
Sufficient AIR voltage rating and overload current capability	Yes
Maintenance Plugs	Molex - 2032630001
TS high current path Connector	TE Connectivity - HDP2X-18-6
Voltage rating connector	707 V
Sufficient connector voltage rating	Yes
TS high current path Wire	Lapp - Ölflex Train 340 600V 2*16mm^2
Current rating fuse	80 A
Accu Pack Current rating	150 A
Current rating AIR	150 A
Current rating maintenance plugs	200 A
Current rating connector	100 A
Current rating wire	94 A
Fuse is the weakest point (EV 3.2.2)	Yes
Description (inconsistencies), if necessary or required	
optional Document, if necessary or required	NOT SET

Inverter

What will be checked?

- scope: the high current path from the TS Accumulator outlet to the inverter
- if the TS Accumulator fuse is used for overcurrent protection keep the fuse field empty
- the overcurrent protection is able to protect
    - the wires (high current path only)
    - the connectors (high current path only, including HVD)

The reviewer might request additional points.

Motor

What will be checked?

- scope: the high current path from the inverter to the motor
- there must be a dedicated overcurrent protection
- if the overcurrent protection is done by the inverter upload the respective pages of the datasheet and keep the fuse empty (there is a dedicated field for the datasheet)
- the overcurrent protection is able to protect
    - the wires (high current path only)
    - the connectors (high current path only)
    - the motor

The reviewer might request additional points.

Auxiliaries

What will be checked?

- proper overcurrent protection on all TS components which are not part of the high current path
- briefly state how the overcurrent protection is done e. g. fusing
- keep in mind that overcurrent protection includes more than just fusing

Markdown can/should be used for text formating.

The reviewer might request additional points.

Attribute	Value
TSAL (HV voltage measuring input)	The voltage dividers of all measurement circuits have an input impedance of 12MOhm. This protects against short circuits inside the isolation amplifiers.
TS Accumulator Indicator Light	The TSAL has a fuse located inside the fusebox the fusebox
BSPD power measurement	The BSPD`s has an onboard fuse for power supply. The power measurement happens by means of an isolated current sensor and hence needs no further fusing.
Precharge Circuitry (wire, connectors, relay/mosfet)	The low voltage side of the circuit is fused by the SC fusing. The high voltage side uses the precharge resistor as protection as it is a metaloxide- type resistor and act's like a PTC.
Discharge Circuitry (wire, connectors, relay/mosfet)	It is input current protected by the discharge resistors and the MOSFET voltage divider.
Data Logger (voltage measurement positive input)	A 250mA Fuse of the type 0ADBC0250-BE or similar is located between the Logger Input and the High Voltage Bus.
DC/DC converter	The DCDC converter has an onboard fuse that is used to disconnect the HV+ line in case of a foult. Datasheet of the fuse is given below.
Optional Document	ESF_9719_4705_1648210021.pdf

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET

Shutdown Circuit

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

What will be checked:

- All components according to the rules section "Shutdown Circuit" are in schematic
- (Re-)activation prevention is implemented
- IMD- and AMS latching is rules conform
- Powerstages are not overloaded
- IMD connected to vehicle side of the AIRs
- IMD ground lines connected to chassis ground and accumulator container separately

The reviewer might check additional points.

Status: NONE

Concept

Attribute	Value
Schematic (Example Schematic)	ESF_9720_4605_1648226488.pdf
Description (optional)	
Answers to reviewer comments (optional)	

Current consumption

Please give information about the additional parts consumption and add your used powerstages (MOSFETs and/or relays) used in your shutdown circuit.

Attribute	Value
Accumulator Insulation Relay Type:	Littlefuse - DCNEV150-MA
Nominal Coil Current	0.07 A
Nominal Coil Voltage:	24 V
Total Number of AIRs:	2
Additional parts consumption	0.100 A
Total current through the shutdown circuit:	0.24 A
All power stages are able handle the current	Yes
The voltage drop accross all power stages is small enough to maintain AIRs minimum voltage requirements	Yes

AMS & IMD Latching

Describe how AMS & IMD error signals are latched within the shutdown circuit.

Attribute	Value
Show how the AMS is able to open the shutdown circuit and drive the AMS indicator light. (Example Schematic)	ESF_9720_4997_1648150176.pdf
IMD Type	Bender A-ISOMETER ® iso-F1 IR155-3203
Response Value	330 kΩ
Show how the IMD is able to open the shutdown circuit and drive the IMD indicator light. (Example Schematic)	ESF_9720_4799_1648150176.pdf

Inertia Switch

Attribute	Value
Inertia Switch Type	Sensata Technologies' 360° Resettable Crash Sensors

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET

Brake System Plausibility Device (BSPD)

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector during technical inspection!

Status: NONE

Description

Each check is listed as a separate check point. You must make sure, that each check is possible with the provided schematic!

Attribute	Value
Provide schematic (Example Schematic)	ESF_9857_4968_1648300508.pdf
Datasheet of used TS current sensor	ESF_9857_4960_1648205796.pdf
All components consist of hard wired electronics (NO software) - Read T11.6.1	Yes
Reset either power cycling LVMS or self reset after more than 10s - Read T11.6.1	Yes
Max. 500ms implausibility until opening the shutdown circuit - Read T11.6.2	Yes
Directly supplied from LVMS - Read T11.6.3	Yes
Standalone - NO additional functionality on BSPD PCBs - Read T11.6.4	Yes
Interfaces are reduced to the minimum necessary - Read T11.6.4	Yes
Practical proof of functionality must include all needed circuitry of the BSPD except for commercially available current sensors + threshold <= 5kW + analog sensor input must be used - Read T11.6.6/T11.6.9	Yes
SCS failures are detected for all wired connections - Read T11.6.8 Usually wired connections: Connections to sensors (including short to sensor supply failure) Additional wired connections Normally opened power stage for shutdown circuit	Yes
No part inside the accumulator container - Read T11.6.10	Yes

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET

Discharge Circuitry

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

Status: NONE

Discharge Ciruitry

The reviewer might check additional points.

Attribute	Value
Upload a schematic (Example Schematic)	ESF_9849_4901_1648149835.pdf
Relay/MOSFET (or equivalent) datasheet	ESF_9849_4897_1648208605.pdf
Resistor (or equivalent) datasheet	ESF_9849_4893_1648208605.pdf
For PTC resistors: At least three subsequent discharges within 15s before exceeding 5s discharge time - Read EV 4.9.1	Yes
Discharge relay/MOSFET (or equivalent) can handle the current at maximum TS voltage continuously - Read EV4.9.1	Yes
Discharge resistor can handle current at maximum TS voltage continuously - Read EV4.9.1	Yes
Discharge resistor/MOSFET (or equivalent) has sufficient cooling - Read EV4.9.1	Yes
Discharge circuit connected to shutdown circuit (after last component) - Read EV 4.9.2	Yes
Discharge relay/MOSFET (or equivalent) is normally closed/conducting - Read 4.9.2	Yes
No fuse in discharge circuit - Read 4.9.3	Yes
Discharge time < 5s - Read 6.1.5	Yes
Discharge circuit connected to DC link capacitors not passing interlocked connectors - Read EV 6.1.5	Yes

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET

Tractive System Active Light (TSAL)

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

Status: NONE

Description/circuitry:

Each check is listed as a separate check point. You must make sure, that each check is possible with the provided schematic!

Attribute	Value
Provide a schematic (Example Schematic) Attention, the example schematic does not comply with the rules 2022!	ESF_9850_4573_1648149919.pdf
What happens if any wired connection needed for the TSAL breaks?	(open circuit) or short to ground -> TSAL light off (safe mode)
Hard wired electronics for TSAL - cockpit indicator light might be programmable logic	Yes
TSAL is functional without accumulator container if LV system is powered	Yes
TS voltage is measured at vehicle side of the AIRs inside the accumulator container	Yes
TS voltage is measured directly at the inverter input without any connector between measurement location and inverter	Yes
SCS failures are detected for connection to parts in accumulator container	Yes
SCS failures are detected for connections to relays for relay state detection. Does not need to detect an open circuit when the intentional state of the relay is opened	Yes
SCS failures are detected for connection to cockpit indicator light	Yes
SCS failures are detected for connection to any additional circuitry, e.g. if TSAL is split to multiple PCB	Yes
Answers to reviewer comments (optional)	

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET

TS and LVS Measurement points

Passing the ESF does not imply full rules compliance. The final decision will be made by the technical inspector on the event!

Status: NONE

Description, Wiring, Calculations

What will be checked?

- TSMPs are directly connected to positive and negative motor controller supply
- if multiple motor controller with separate TS supply are used: TSMPs must be wired in a way that a wire failure to any motor controller is detectable
- correct current limiting resistor value used
- current limiting resistor power rating is higher than dissipated power while short circuiting both TSMPs
- current limiting resistors are placed within the same casing where the TSMP wires are connected to the DC-link (TS supply of the inverters) --> overcurrent protection

The reviewer might check additional points.

Attribute	Value
Value for Current Limiting Resistor	15 kOhm
Calculation of Power Rating for Current Limiting Resistor	P_TSMP=I_TSMP^2*R_TSMP R_ges=2*R_TSMP R_ges=30kOhm I_TSMP=U_max/R_ges U_max=554,4V I_TSMP=0,01848A P_TSMP=5,122656W
Please upload the datasheet of the body protection resistor	ESF_9858_4563_1648209302.pdf
Answers to reviewer comments (optional)	

Extra Information (by request)

Field for additional Information if requested by reviewer. Not necessary for initial upload

Attribute	Value
Document upload by request	NOT SET