Electrical System Form

FSG24 - IT Ancon U | Car 104

Table Of Content

TS Accumulator (el.)

SUBMITTED

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.

TS Accumulator (el.) - Cell

Describe the cell type used and the chemistry, provide table with main parameters. Enter all values as specified in the data sheet.

Attribute	Value
Cell Name:	Melasta SLPB9270175HV
Cell Data Sheet:	ESF_12112_6375_1709154228.pdf
Cell Nominal Capacity:	14.00 Ah
Maximum Voltage	4.35 V
Nominal Voltage:	3.80 V
Minimum Voltage:	3.00 V

Max. Continuous Discharge Current:	108.000 A
Cell Peak Discharge Current:	162.000 A
Peak Discharge Current Time:	4.00 s
Maximum Cell Temperature (discharging):	60.0 °C
Max. Continuous Charge Current:	14.000 A
Peak Charge Current:	21.000 A
Maximum Cell Temperature (Charging):	45.0 °C
Cell Chemistry:	LiCoO2
Description:	

TS Accumulator (el.) - Accumulator

Describe the cell configuration of the TS accumulator.

Attribute	Value
Accumulator configuration (parallel)	1
Accumulator configuration (series)	138
Maximum Voltage:	600.3 V
Nominal Voltage:	524.4 V
Minimum Voltage:	414 V
Max. Continuous Discharge Current:	108 A
Peak Discharge Current:	162 A
Max. Continuous Charge Current:	14 A
Peak Charge Current:	21 A
Total numbers of cells:	138
Total Capacity:	30.25512 MJ

Number of TS accumuator segments	6
Every TS accumulator segment is below < 120VDC and 6 MJ.	Yes
Answers to reviewer comments (optional)	

TS Accumulator (el.) - Cell Temperature Monitoring:

Attribute	Value
Is an offset for the maximum and minimum temperature threshold included?	Yes
Temperature measurement error	1.1 °C
Please provide a error calculation of your measurement system.	ESF_12112_6326_1711535396.pdf
Total number of temperature sensors:	48
How many cells are measured by one temperature sensor?	1
Total numbers of cells:	138
Max. distance from monitored negative cell terminal to sensor	0 mm
CAD Rendering - Position of Cell Temperatur Sensor on Cell	ESF_12112_6308_1711360719.pdf
Descripe how you make sure to measure the temperature of at least 30% of lithium based cells:	There are 48 temperature sensors and 138 cells, so that 34.8% of the cells are monitored. Specifically, each module contains 23 cells and 8 out of those 23 have temperature sensors on them.
Provide a drawing or CAD rendering of the temperature sensors equally distributed over all cells.	ESF_12112_6310_1711360719.pdf
Maximum Cell Temperature (Charging):	45 °C
AMS opens AIRs during charging, if sensor temperature above:	40 °C
Maximum Cell Temperature (discharging):	60 °C
AMS opens AIRs during discharging, if sensor temperature above:	55 °C
Describe how faults within temperature monitoring can be detected (e.g. missing power line etc.)	The code checks the readings of the ADC. BMS detect a fault if the readings are inconsistent (varying too fast) or out of the range of valid value, for example reading 0V means that is missing power or there is an open wire (the ADC input is pulled down with

	100k resistor), also reading a value above 1500mV is not a valid value.
Please state the sampling rate of your temperature measurement system	25 Hz
Descripe where you will place the official cell temperature logger and why this is the warmest cell in the container.	It will be placed on one of the cells which are on the last row of the rear most modules so that, being an aircooled battery pack, the recorded temperature will be the highest due to the air absorbing the heat of all the cells which come before down the flow path.
CAD Rendering and additional Documents - Position of Cell Temperatur Logger in Accumulator Container, Cooling Simulation of Accu Container	ESF_12112_6323_1711466661.pdf
Time to detect an open wire in cell temperature monitoring and open AIRs:	0.30 s
Time to detect a short to supply voltage in cell temperature monitoring and open AIRs:	0.20 s
Time to detect a short to GND in cell temperature monitoring and open AIRs:	0.30 s
Time to detect an implausibility due to out of range in cell temperature monitoring and open AIRs:	0.30 s
Time to detect failure of digitally transmitted signals in cell temperature monitoring and open AIRs:	0.20 s
Total Capacity:	30.25512 MJ

TS Accumulator (el.) - 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
Voltage measurement error	0.003 V
Please provide a error calculation of your measurement system.	ESF_12112_6300_1711535396.pdf
AMS opens AIRs, if highest single cell voltage is above:	4.3 V
AMS opens AIRs,if lowest single cell voltage is below:	3.2 V
Please state the sampling rate of your voltage measurement system	25 Hz
Time to detect an open wire in cell voltage monitoring and open AIRs:	0.20 s
Time to detect a short to supply voltage in cell voltage monitoring and open AIRs:	0.10 s

Time to detect a short to GND in cell voltage monitoring and open AIRs:	0.10 s
Time to detect an implausibility due to out of range in cell voltage monitoring and open AIRs:	0.30 s
Time to detect failure of digitally transmitted signals in cell voltage monitoring and open AIRs:	0.10 s

TS Accumulator (el.) - 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)

SUBMITTED

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.

TS Accumulator (charging) - Accumulator Charging

Attribute	Value
Upload schematic of the full electrical setup during charging.	ESF_12254_6188_1711380911.pdf
Upload datasheet of your charger	ESF_12254_6191_1709830439.pdf
Maximum Charging Power:	3 kW
Input Voltage:	230 VAC
Input Current (for fusing):	16 A
Description (optional):	Shutdown: Yes the shutdown board is outside the TSAC and is the same used in the car.

The AMS input is pulled UP and the IMD input is pulled down, so if there is a broken wire or a signal loss on one of them it will go in an error state and open the circuit. Power and fusing: we want to stay under the 3kW for using the charger everywhere also if is not available more power than 3.3kW, so a current of 16A is OK for fusing.

TS Accumulator Indicator

PASSED

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

TS Accumulator Indicator - 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	Status	Reviewer Comment
Upload a schematic/Datasheet	ESF_12689_6353_1711467112.pdf	PASSED	
Threshold accumulator indicator onset	60.00 V	PASSED	
Threshold accumulator indicator turns off	60.00 V	PASSED	
CAD Rendering:	ESF_12689_6354_1711013058.pdf	PASSED	

TS overcurrent protection

SUBMITTED

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

TS overcurrent protection - General

What is the schematic about?

- all TS components
- mark all TS components with their respective current and voltage rating
- 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
  - searchable / machine readable
- 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_12622_5950_1721729694.pdf
All TS components are marked with current rating Manufacturer + Part No. 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 overcurrent protection - 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 edge 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)	bel 0AKK-K100-BB
TS Accumulator Fuse Data Sheet	ESF_12622_5982_1711359878.pdf
DC Voltage rating fuse	1000 V
Sufficient voltage rating of fuse& rated for DC (EV 3.2.4)	Yes
Short circuit current	2420 A
Provide calculation of the short circuit current of the accumulator	ESF_12622_5973_1711387359.pdf
Fuse maximum interrupt current	50000 A
Sufficient interrupt current rating (EV 3.2.3)	Yes
AIR	TE Connectivity 1-2071567-1
AIR Data Sheet	ESF_12622_5999_1711359878.pdf
Voltage rating AIR	1000 V
Sufficient AIR voltage rating and overload current capability	Yes
Maintenance Plugs	Amphenol RL00801-50
Maintenance Plugs Data Sheet	ESF_12622_5977_1711359878.pdf
TS high current path Connector	Amphenol UPCR012ALS1
Voltage rating connector	1000 V
Sufficient connector voltage rating	Yes
TS high current path Wire	Coroflex 9-2652
TS High Current Path Wire Data Sheet	ESF_12622_5969_1710867289.pdf
Fuse is the weakest point (EV 3.2.2)	Yes
Description (inconsistencies), if necessary or required	
optional Document, if necessary or required	**NOT SET**

TS overcurrent protection - 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. **In case of two or more unequal inverter systems either provide the worst-case parts and/or use the TS schematic to show the position of those parts and their interconnection.**

Attribute	Value
Additional TS high current path fuse	**NOT SET**
DC Voltage rating fuse	1000 V
Sufficient voltage rating of fuse & rated for DC (EV 3.2.4)	Yes
Inverter	AMK GmbH Co KG
Inverter datasheet when selected other	**NOT SET**
Inverter maximum input current	48 A
Fuse is the weakest point (EV 3.2.2)	Yes
Overcurrent protection suitable for at least 0 °C to 85 °C (EV 3.2.6)	Yes
If inverter is selected as "other ..." upload page of overcurrent protection. If inverter is selfbuild, add schematic and calculations of the overcurrent protection.	**NOT SET**
Description (inconsistencies), if necessary or requested	
optional Document	**NOT SET**

TS overcurrent protection - 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. **In case of two or more unequal motor systems either provide the worst-case parts and/or use the TS schematic to show the position of those parts and their interconnection.**

Attribute	Value
There is a dedicated overcurrent protection on the motor side of the inverter	Yes
Motor	AMK GmbH Co KG
Motor datasheet	ESF_12622_5920_1710867289.pdf
Motor maximum inout current	41 A
Overcurrent protection is the weakest point (EV 3.2.2)	Yes
Overcurrent protection suitable for at least 0 °C to 85 °C (EV 3.2.6)	Yes
Description (inconsitencies)	
optional Document, if necessary or requested	**NOT SET**

TS overcurrent protection - 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
Data Logger (voltage measurement positive input)	Fuse 200mA Bel 0ADBP0200-RE
DC/DC converter	
Optional Document	**NOT SET**

TS overcurrent protection - 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

PASSED

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.

Shutdown Circuit - Concept

Attribute	Value	Status	Reviewer Comment
Schematic (Example Schematic)	ESF_12214_5853_1723734228.pdf	PASSED	Can't find your BSPD
Description (optional)		PASSED	
Answers to reviewer comments (optional)			

Shutdown Circuit - 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	Status	Reviewer Comment
Accumulator Insulation Relay Type:	TE connectivity - 1-2071567-1	PASSED	
Nominal Coil Current	0.13 A		
Nominal Coil Voltage:	12 V		
Total Number of AIRs:	2	PASSED	
Additional parts consumption	0.150 A	PASSED	
Total current through the shutdown circuit:	0.41 A		
All power stages are able handle the current	Yes	PASSED	
The voltage drop accross all power stages is small enough to maintain AIRs minimum voltage requirements	Yes		

Shutdown Circuit - AMS & IMD Latching

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

Attribute	Value	Status	Reviewer Comment
Show how the AMS is able to open the shutdown circuit and drive the AMS indicator light. (Example Schematic)	ESF_12214_6258_1711014652.pdf	PASSED	
IMD Type	Bender A-ISOMETER ® iso-F1 IR155-3204	PASSED	
Response Value	330 kΩ	PASSED	
Show how the IMD is able to open the shutdown circuit and drive the IMD indicator light. (Example Schematic)	ESF_12214_6060_1711014652.pdf	PASSED	

Shutdown Circuit - Inertia Switch

Attribute	Value	Status	Reviewer Comment
Inertia Switch Type	Sensata Technologies' 360° Resettable Crash Sensors	PASSED	

Shutdown Circuit - Extra Information (by request)

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

Attribute	Value	Status	Reviewer Comment
Document upload by request	**NOT SET**		

Brake System Plausibility Device (BSPD)

PASSED

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

Brake System Plausibility Device (BSPD) - 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	Status	Reviewer Comment
Provide schematic (Example Schematic)	ESF_12245_6229_1711015684.pdf	PASSED	
Datasheet of used TS current sensor	ESF_12245_6221_1709805530.pdf		
All components consist of hard wired electronics (NO software) - Read T11.6.1	Yes	PASSED	
Reset either power cycling LVMS or self reset after more than 10s - Read T11.6.1	Yes	PASSED	
Max. 500ms implausibility until opening the shutdown circuit - Read T11.6.2	Yes	PASSED	
Directly supplied from LVMS - Read T11.6.3	Yes	PASSED	
Standalone - NO additional functionality on BSPD PCBs - Read T11.6.4	Yes	PASSED	
Interfaces are reduced to the minimum necessary - Read T11.6.4	Yes	PASSED	
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	PASSED	
SCS failures are detected for all wired connections - Read T11.6.8 Usually wired connections: Connections to sensors (including short to sensor supply	Yes	PASSED	

failure) Additional wired connections Normally opened power stage for shutdown circuit			
No part inside the accumulator container - Read T11.6.10	Yes	PASSED	

Brake System Plausibility Device (BSPD) - Extra Information (by request)

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

Attribute	Value	Status	Reviewer Comment
Document upload by request	ESF_12245_6101_1720468851.pdf		

Discharge Circuitry

SUBMITTED

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

Discharge Circuitry - Discharge Ciruitry

The reviewer might check additional points.

Attribute	Value
Upload a schematic (Example Schematic)	ESF_12213_6162_1722155692.pdf
Relay/MOSFET (or equivalent) datasheet	ESF_12213_6158_1711382459.pdf
Resistor (or equivalent) datasheet	ESF_12213_6154_1711382459.pdf
For PTC resistors: At least three subsequent discharges within 15s before exceeding 5s discharge time - Read EV 4.9.1	No
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

Discharge Circuitry - 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)

SUBMITTED

Please see the example schematic for reference. Use graphic symbols of electrical components that are covered by international standards (e.g. IEC 60617).
Keep a clear structure in your uploaded documents. Avoid text and use graphs to underline the concept of your logic and logic levels. Label each schematic clearly, regarding the funtion, PCB and housing. Provide a logic table to your TSAL logic.

Following parts will be checked:
- Voltage measurement across DC-link capacitors
- Evaluation of voltage measurement for red flashing TSAL
- AIR and pre-charge relay stete detection
- Acumulator vehicle side voltage measurement
- Evaluation for green TSAL light
- SCS compliance of TSAL circuitry

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

Tractive System Active Light (TSAL) - 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)	ESF_12690_5824_1722085738.pdf
What happens if any wired connection needed for the TSAL breaks?	RED TSAL CIRCUIT: the leds will not light up. GREEN TSAL CIRCUIT: The leds will light up only if all signal wires are low and the ts voltage is under 60V. First of all, if the 12V or GND wires break the leds will not light up. For the signal's ones, on the other hand, if only one wire breaks there are some ways to detect the malfunction. If the ts connection breaks and the ts voltage is over 60V also the tsal red led light up. Moreover,

	the precharge signals depends on the air's and vice versa, so if one of them is cutted the other should avoid a misleading led activation.
Hard wired electronics for TSAL - cockpit indicator light might be programmable logic	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	No
SCS failures are detected for connection to any additional circuitry, e.g. if TSAL is split to multiple PCB	No
Answers to reviewer comments (optional)	

Tractive System Active Light (TSAL) - 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

PASSED

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

TS and LVS Measurement points - 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	Status	Reviewer Comment
Value for Current Limiting Resistor	15 kΩ	PASSED	
Calculation of Power Rating for Current Limiting Resistor	(600^2/(15000*2))/2 = 6W	PASSED	
Please upload the datasheet of the body protection resistor	ESF_12246_5815_1709805684.pdf	PASSED	
Answers to reviewer comments (optional)			

TS and LVS Measurement points - Extra Information (by request)

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

Attribute	Value	Status	Reviewer Comment
Document upload by request	**NOT SET**		