Formula Student Netherlands	
2023 Inspection Sheet	
Electrical Inspection	
Car Number	
University	
ESF state	

	REQUIRED RESOURCES		
No.	Checkpoint	Checkbox	Comment
-	An ESO must attend		
-	LV battery or cell datasheet		
-	Samples of all wire types used for the tractive system		
-	Photographs of all inaccessible TS connections		
-	Fully assembled spare boards of all inaccessible TS boards		
-	For self developed LV battery packs: an opened battery pack, laptop and cables to display data of the AMS		
-	Laptop and cables to display data of the AMS		
-	Power Supply for TSAL test and connectors with shrouded banana jacks as in rule IN 4.2.1		
-	The connector to safely close the SDC while the HVD is removed		
-	Datasheets for used wiring, insulation materials, and TS components **NOT ON A CELL PHONE**		
-	Print-outs of Rule Requests, if applicable **NOT ON A CELL PHONE**		
-	At least all non-passed parts of the ESF **NOT ON A CELL PHONE**		
	LV BATTERY		
No.	Checkpoint	Checkbox	Comment
1	Voltage ≤ 60VDC	☐	
2	Rigid and sturdy casing	☐	
3	Only for wet-cell batteries: IPX7 rated and acid resistant casing if inside cockpit	☐	
4	Short circuit protection (e.g. fused)	☐	
5	Behind Firewall	☐	
6	Grounded to the chassis	☐	
7	Proper insulation of internal electrical connections	☐	
8	Proper mounting of cells	☐	
9	Complete battery pack inside rollover protection envelope	☐	
•	All following checks only needed for Li-Ion batteries (other than LiFePO4):		
10	UL94-V0 , FAR25 or equivalent casing	☐	
11	Overcurrent protection that trips below max. discharge current	☐	
12	Overtemperature protection of at least 30% of the cells (max. 60 C or datasheet, whichever is lower)	☐	
13	Voltage protection of all cells	☐	
14	Signal failures electrically disconnect the LV battery (SCS)	☐	
►	Disconnect one SINGLE voltage sense wire, if any wires used		
15	The LV battery is electrically disconnected	☐	
►	Disconnect one SINGLE temperature sense wire, if any wires used		
16	The LV battery is electrically disconnected	☐	
►	Ask the team to connect their laptop to the AMS		
17	Cell voltages can be displayed	☐	
18	Cell temperatures can be displayed	☐	
	SELF DEVELOPED PCBS		
No.	Checkpoint	Checkbox	Comment
►	Ask for spare PCB of self developed PCBs		
19	Sufficient spacing regarding system voltage and implementation	☐	
20	Sufficient insulation and temperature rating of coating if used, datasheet available	☐	
21	Coating process according to datasheet	☐	
22	The 1 min AC RMS isolation voltage is ≥ 3x max. TS voltage	☐	
23	BSPD PCB is standalone with only minimum interface	☐	
24	BSPD PCB(s) are directly supplied from the LVMS	☐	
	MASTER SWITCHES		
No.	Checkpoint	Checkbox	Comment
25	TSMS & LVMS installed on the right side of the vehicle and located next to each other	☐	
26	TSMS & LVMS are easily accessible	☐	
27	All master switches are located above 80% of shoulder height of percy	☐	
28	Rigidly mounted	☐	
29	Not mounted on removable bodywork	☐	
30	Rotary type with removable handle (50mm)	☐	
31	ON position in horizontal	☐	
32	"ON" and "OFF" positions marked	☐	
33	TSMS with locking mechanism for “OFF” position	☐	
34	LVMS marked with “LV” and symbol showing a red spark in a white edged blue triangle	☐	
35	LVMS mounted on an red circular area on high contrast background	☐	
36	Circular area diameter ≥50 mm	☐	
37	TSMS marked with “TS” and triangle with black lightning bolt on yellow background	☐	

38	TSMS mounted on an orange circular area on high contrast background	☐	
39	Circular area diameter ≥50 mm	☐	
	MEASURING POINTS		
No.	Checkpoint	Checkbox	Comment
40	Two TS voltage measuring points on orange background	☐	
41	A black LV ground measuring point installed	☐	
42	Next to the master switches	☐	
43	4mm shrouded banana jacks	☐	
44	Non conductive cover	☐	
45	Cover removable without tools	☐	
46	Correctly marked (TS+, TS-, GND)	☐	
	TS SHUTDOWN DEVICES		
No.	Checkpoint	Checkbox	Comment
47	Two shutdown buttons installed next to the main hoop	☐	
48	Right and left on the vehicle at approx. height of drivers head	☐	
49	Push-Pull or Push-Rotate-Pull functionality	☐	
50	Diameter > 39 mm	☐	
51	Marked with red sparked sticker	☐	
52	One cockpit shutdown button installed	☐	
53	Push-Pull or Push-Rotate-Pull functionality	☐	
54	Marked with red sparked sticker	☐	
55	Easy actuation by the driver	☐	
56	Diameter ≥24 mm	☐	
57	Inertia switch rigidly mounted to the chassis and can be demounted for functionality test	☐	
►	Check interlocks on ..		
58	TS accumulator container(s)	☐	
59	Inverters	☐	
60	HVD	☐	
61	Power distribution boxes	☐	
62	Energy meter box	☐	
►	Outboard wheel motors . . .		
63	. . . have a dedicated interlock wire routed along the TS wiring, must act before the TS wiring or its clamping fails	☐	
64	. . . have a dedicated interlock wire routed along a suspension member, must act if the suspension fails	☐	
65	. . . interlock(s) can opened for demonstration	☐	
	COCKPIT INDICATORS		
No.	Checkpoint	Checkbox	Comment
66	IMD and AMS indicator light illuminate for 1 to 3 s for visible check	☐	
•	AMS indicator light . . .		
67	. . . is inside the cockpit and marked with "AMS"	☐	
68	. . . is illuminated red and visible in bright sunlight, even from outside	☐	
69	. . . is visible for the driver	☐	
•	IMD indicator light . . .		
70	. . . is inside the cockpit and marked with "IMD"	☐	
71	. . . is illuminated red and visible in bright sunlight, even from outside	☐	
72	. . . is visible for the driver	☐	
•	TS Indicator . . .		
73	. . . is inside the cockpit and marked with "TS off"	☐	
74	. . . is illuminated green and visible in bright sunlight	☐	
75	. . . is visible for the driver	☐	
	TS VOLTAGE		
No.	Checkpoint	Checkbox	Comment
►	Measure voltage at TS measuring points.		
76	Equal or less than 60 VDC.	☐	
	TS WIRING		
No.	Checkpoint	Checkbox	Comment
77	All TS wiring and components (including the HVD) have to be in the envelope and behind the impact structures	☐	
78	TS connectors outside of enclosures cannot be physically connected other than the design intent configuration	☐	
79	TS wires of outboard wheel motors must not be able to reach the cockpit opening in case of a wire break	☐	
80	The wiring outside of the impact structure is the shortest possible distance	☐	
81	All TS wires and connectors have proper overcurrent protection	☐	
82	TS wiring channels are orange	☐	
83	No other wires than TS wires are orange	☐	
84	TS wiring outside electrical enclosures in seperate nonconductive enclosure or orange shielded cable	☐	
85	Securely anchored to withstand at least 200 N if outside of enclosure	☐	
86	Located out of the way of possible snagging or damage	☐	
87	Shielded against rotating/moving parts	☐	
88	No wire lower than the chassis	☐	
89	TS and LV wires separated (n/a for interlock)	☐	
90	Marked with gauge, temperature rating and voltage rating (max. TS voltage)	☐	
91	Suitable temperature rating for used position	☐	
92	Positive locking mechanism on every screwed connection (Photographs for all inaccessible TS connections)	☐	
93	TSMPs: positive locking mechanism on every connection (Photographs for all inaccessible TS connections)	☐	

94	Insulation is not insulating tape or rubber-like paint	☐	
	TS WARNING STICKERS		
No.	Checkpoint	Checkbox	Comment
►	Check for warning stickers on TS containing enclosures (triangle with black lightning bolt on yellow background)		
95	Inverter(s)	☐	
96	Motor(s)	☐	
97	Power Distribution box(es)	☐	
98	Energy meter box	☐	
99	HVD	☐	
100	Other TS containing enclosures	☐	
	TRACTIVE SYSTEM PROTECTION		
No.	Checkpoint	Checkbox	Comment
►	Check opening in TS enclosures, try to reach TS potentials with insulated test probe (100mm length, 6mm diameter)		
101	Not possible to reach any TS potentials	☐	
102	TS components and containers protected from moisture	☐	
	HIGH VOLTAGE DISCONNECT		
No.	Checkpoint	Checkbox	Comment
103	Clearly marked with "HVD"	☐	
104	Distance to ground greater than 350 mm	☐	
105	Inside roll-over protected envelope	☐	
106	Easily visible while standing behind the vehicle	☐	
107	No remote actuation (e.g. through wires)	☐	
108	Integrated interlock	☐	
►	Stand next to the vehicle, remove HVD		
109	Removed within 10 s without tools	☐	
110	TS protection still given (insulated test probe)	☐	
111	If a dummy connector for protection is used, it must be stored at the push bar	☐	
	TRACTIVE SYSTEM ACTIVE LIGHT		
No.	Checkpoint	Checkbox	Comment
112	Mounted below highest point of the main roll hoop and within the roll-over protected envelope	☐	
113	Fully illuminated surface	☐	
114	Visible by a person standing 3 m away from TSAL (1.6m eye height)	☐	
115	≤10° blocked by main hoop	☐	
	ENERGY METER		
No.	Checkpoint	Checkbox	Comment
116	Energy meter is fully enclosed in a housing	☐	
117	Energy meter is rigidly mounted	☐	
118	All energy from accumulator flows through the energy meter	☐	
	FIREWALLS		
No.	Checkpoint	Checkbox	Comment
•	Separates any point of the driver (less than 100mm above the bottom of the helmet of the tallest driver) from any TS component (including TS wiring) . . .		
119	. . . behind the driver's back	☐	
120	. . . at the sides of the driver	☐	
121	. . . at the front of the vehicle	☐	
122	First layer, facing TS must be made of Aluminum with a thickness of at least 0.5mm	☐	
123	Second layer, facing driver must be made of electrically insulated material (no CFRP)	☐	
124	Material meets UL94-V0, FAR25 or equivalent	☐	
125	TSAC cooling duct openings do not point towards the driver, although if behind a firewall	☐	
	ACCELERATION PEDAL POSITION SENSOR (APPS)		
No.	Checkpoint	Checkbox	Comment
126	Returns to original position if not actuated	☐	
127	At least two sensors with different transfer functions, each having a positive slope sense with either different gradients and/or offsets to the other(s) are installed (For digital sensors, a checksum is necessary)	☐	
128	Sensors do not share supply or signal lines	☐	
129	Sensors are protected from beeing mechanically overstressed (positive stop of pedal)	☐	
130	Minimum two springs installed to return pedal	☐	
131	Each spring still returns pedal with the second one disconnected (springs in the torque encoders not counted)	☐	
	BRAKE LIGHT		
No.	Checkpoint	Checkbox	Comment
132	Only one brakelight in red color	☐	
133	Clearly visible from behind the vehicle	☐	
134	Located on vehicle centerline	☐	
135	Height between wheel centerline and drivers shoulder	☐	
136	Round, triangle, or rectangular on black background	☐	
137	15 cm² minimum illuminated area OR LED strips with a total length greater than 150mm with elements closer than 20 mm apart	☐	
138	Sufficient brightness of the brake light even in bright sunlight	☐	
	ACCUMULATOR MANAGEMENT SYSTEM		
No.	Checkpoint	Checkbox	Comment
►	Disconnect TS accumulator		
139	AMS indicator light is illuminated red	☐	
►	Ask the team to connect their laptop to the AMS		
140	AMS data can be displayed	☐	
	DISCHARGE CIRCUIT AND BODY PROTECTION RESISTORS		

No.	Checkpoint	Checkbox	Comment
►	Switch off LV		
►	Measure resistance between TS+ and TS- Measuring Points		
141	Resistance is 30 kΩ + discharge resistor	☐	
142	Body protection resistor power and voltage rating is sufficient	☐	
143	Dis-charge power rating is sufficient for continuous dis-charge	☐	
	INSULATION MEASUREMENT TEST		
No.	Checkpoint	Checkbox	Comment
►	Choose test voltage to 500V		
►	Connect insulation tester to TS+ and LV ground		
►	Measure resistance: Riso+ = MΩ		
144	Resistance is much higher than (min. 500Ω/V*Umax)	☐	
►	Connect insulation tester to TS- and LVMP		
►	Measure resistance: Riso− = MΩ		
145	Resistance is much higher than (min. 500Ω/V*Umax)	☐	
146	Resistances are nearly equal	☐	
147	IMD chassis ground measurement line from TSAC connected to the main hoop by a separate wire	☐	
	Grounding Checks		
No.	Checkpoint		
•	EV 3.1 has been fully revised. Each TS enclosure must either contain a ≥0.5 mm properly grounded conductive layer or all materials must be electrically isolating for each own. Conductive seat, driver harness, and firewall mountings, as well as TS firewalls and conductive parts protruding through TS enclosures, must be properly grounded. A conductive part having ≤300 mΩ measured at 1 A and being able to continuously carry ≥10 % of the TS main fuse to LVS ground is properly grounded. Other conductive parts within 100 mm of any TS component must be ≤100 Ω to LVS ground.		
•	It is possible to join two TS enclosures one following EV 3.1.1 point 1 and the other one following EV 3.1.1 point 2 if each individual TS enclosure is fully closed.		
►	Check for each TS enclosure . . .		
148	. . . all materials used to build a TS enclosure separately have a resistance ≥2 MΩ @ 500 V ⇒ fully isolated TS enclose, no grounded layer needed	☐	
149	. . . expect e.g. screws, (shielded) connectors, backing plates isolating materials used ⇒fully isolated TS enclose, no grounded layer needed but protruding elements must be properly grounded	☐	
150	. . . at least one material has <2 MΩ ⇒ ≥0.5 mm thick solid grounded layer made of aluminium or better required and properly grounded	☐	
151	. . . a ≥0.9 mm thick steal layer might be used for TSAC as the grounded layer	☐	
►	Measure resistance of conductive parts to LVS ground(max. 300 mΩ @ 1 A) . . .		
152	. . . next to TSMPs	☐	
153	. . . main hoop	☐	
154	. . . seat mounting points	☐	
155	. . . driver harness mounting points	☐	
156	. . . firewall mounting points, also if not protruding through the firewall	☐	
157	. . . TS firewall	☐	
158	. . . TS accumulator container	☐	
159	. . . TS enclosures if applicable	☐	
160	. . . TS enclosure protruding parts if applicable	☐	
161	. . . parts protruding through TS enclosures	☐	
162	Each grounding is able to carry ≥10 % of TS main fuse	☐	
►	Measure resistance of conductive parts to LVS ground (max. 100 Ω @ 0 A) . . .		
163	. . . carbon fiber part within 10 cm around TS part	☐	
164	. . . suspension front left or right if applicable	☐	
165	. . . suspension rear left or right if applicable	☐	
	TEST AT HIGH VOLTAGE		
	TRACTIVE SYSTEM POWER UP		
No.	Checkpoint	Checkbox	Comment
►	All driven wheels are off the ground, driven wheels removed		
►	Connect multimeter between TS+ and TS-		
►	Switch on TSMS with LVMS deactivated		
166	Voltage at TS measurement points less or equal 60VDC	☐	
►	Switch on LVMS with TSMS deactivated		
167	Voltage at TS measurement points less or equal 60VDC	☐	
►	Switch on TSMS and all shutdown buttons		
►	Reset any IMD or AMS errors		
168	TS still deactivated	☐	
►	Activate TS, measure TS voltage during TS power-up. Use the team's multimeter and test leads from the push bar.		
169	System is precharged before second AIR closes	☐	
►	Switch off TSMS		
170	TS voltage decreases below 60VDC within 5 s	☐	
►	Try to power-up TS with switched off TSMS		
171	TS still deactivated	☐	
►	Switch on TSMS		
172	TS still deactivated	☐	
	TRACTIVE SYSTEM SHUTDOWN		
No.	Checkpoint	Checkbox	Comment
►	Connect multimeter between TS+ and TS-		
►	For every of the following switches, deactivation leads to TS shutdown, voltage decreases below 60VDC within 5 s		
173	LVMS	☐	

174	Shutdown button left	☐	
175	Shutdown button right	☐	
176	Cockpit shutdown button	☐	
177	Inertia switch (may be demounted for test)	☐	
178	Brake-over-travel switch	☐	
►	Show schematic of TS with all interlocks (ESF)		
179	Interlocks	☐	
	TRACTIVE SYSTEM INDICATORS		
No.	Checkpoint	Checkbox	Comment
►	Activate LV system		
180	TSAL and Cockpit Indicator(CI) is green only	☐	
►	Activate TS		
181	TSAL flashes red with freq 2 Hz - 5 Hz and CI is off	☐	
182	TSAL is clearly visible (horizontal position, entire illuminated surface)	☐	
►	Deactivate TS, disconnect AIR state detection circuitry, activate LV If activation of LV system is not possible skip test		
183	TSAL not illuminated and CI is off	☐	
►	If previous test succeeded, activate TS. If TS activation is not possible, skip test		
184	TSAL flashes red and CI is off	☐	
►	Deactivate TS, reconnect TSAC state detection, connect power supply >60 VDC to TS via dedicated connector but **NOT** TSMP, activate LVS		
185	TSAL is both green and red flashing simultaneously and CI is on	☐	
►	Disconnect power supply, remove HVD, override HVD interlock (!! cover HV potentials !!), activate LV and TS		
186	TSAL and CI is off	☐	
	INSULATION MONITORING DEVICE		
No.	Checkpoint	Checkbox	Comment
►	Determine Rtest = (max TS voltage * 250 Ω/V) - BPR		
►	Activate TS, connect RTest between TS+ and LV GND		
187	Shutdown circuits opens within 30 s	☐	
188	IMD indicator light illuminates	☐	
189	TS voltage decreases below 60VDC within 5 s after shutdown circuit opens	☐	
►	Try to activate the TS by the required additional action (EV5.11.2)		
190	Reactivation of TS is not possible	☐	
►	Push the reset button which is not accessible to the driver, if any		
191	Reactivation of TS is not possible	☐	
►	Remove RTest. Wait 40 s until IMD resets status output		
192	Reactivation of TS is not possible	☐	
►	Push all reset buttons in the cockpit, if any		
193	Reactivation of TS is not possible	☐	
►	Push the IMD reset button which is not accessible to the driver, if any		
194	Reactivation of TS is possible	☐	
►	Reset vahicle and activate TS. Push **and hold** the reset button which is not accessible to the driver, if any. Connect RTest between TS+ and LV GND		
195	Shutdown circuits opens within 30 s	☐	
196	IMD indicator light illuminates	☐	
►	Activate TS, connect RTest between TS- and LV GND		
197	Shutdown circuits opens within 30 s	☐	
	READY TO DRIVE ACTIVATION SEQUENCE		
No.	Checkpoint	Checkbox	Comment
►	Activate TS, press torque pedal		
198	No turning of motors	☐	
►	Let the team set the vehicle to ready to drive mode		
199	Pressing brake pedal WHILE activating is necessary	☐	
200	Ready to drive sound duration is 1 s to 3 s	☐	
201	Ready to drive sound is min 80 dBA (2m around the vehicle)	☐	
202	Ready to drive sound is easy recognizable and no animal sound or song part	☐	
►	Repeat the activation sequence, but push the brake pedal only once before finally pushing the activation button		
203	No ready to drive mode possible	☐	
►	Disconnect the brake sensor		
204	No ready to drive mode possible	☐	
►	Disconnect the second brake sensor if applicable		
205	No ready to drive mode possible	☐	
	IMPLAUSIBILITY CHECKS		
No.	Checkpoint	Checkbox	Comment
►	Set vehicle to ready to drive state. Press accelerator pedal >25 %. Push brake pedal		
206	Motors stop turning	☐	
►	Release brake, while accelerator pedal still activated		
207	Motors do not turn	☐	
►	Release accelerator pedal slowly		
208	Motors turn again when APPS position is <5 %	☐	
►	Get motors turning, disconnect ≥50% of APPS while motors turn		
209	Motors stop turning	☐	
►	Disconnect all APPS		
210	Motors do not turn	☐	
►	Reconnect all APPS, disconnect any communication connection between APPS and inverter while motors turn		
211	Motors stop turning	☐	

►	Disconnect Brake Pedal sensor		
212	Motors stop turning	☐	
►	Team simulates 5kW power, press brake representing hard braking (>0.5 s)		
213	TS shuts down	☐	
►	Reactivate TS, disconnect BSPD current sensor		
214	TS shuts down	☐	
•	Automatic BSPD reset installed?		
215	Reactivation of TS is only possible after 10 s without implausibility	☐	
	SEALING OF COMPONENTS		
No.	Checkpoint	Checkbox	Comment
►	After all tests have been passed successfully seal the inspected TS housings:		
216	Motor Controller housing	☐	
217	Energy Meter housing	☐	
218	IMD housing	☐	
219	TSAL circuitry housing	☐	
220	BSPD casing /BSPD calibration	☐	
221	Additional Part:	☐	
222	Additional Part:	☐	
	OTHER COMMENTS		