UNIVERSITY:		CAR NUMBER:	
SES PASSED: ☐ YES ☐ NO	IADR PASSED: ☐ YES ☐ NO	BODY PROTECTION RESISTOR:	
ESF PASSED: ☐ YES ☐ NO	FMEA PASSED: ☐ YES ☐ NO	TS VOLTAGE:	GLVS VOLTAGE:

IMPORTANT

PRESENT THE VEHICLE FOR INSPECTION IN THE FOLLOWING ORDER

1. ELECTRICAL INSPECTION
2a. SAFETY GEAR CHECK (Bring **all items** from "DRIVER'S EQUIPMENT" section below, plus **rain tires**)
2b. MECHANICAL TECHNICAL INSPECTION
3. TILT TABLE INSPECTION
4. RAIN TEST
5. BRAKING PERFORMANCE INSPECTION

THIS FORM MUST STAY WITH THE CAR UNTIL THAT SPECIFIC PART OF INSPECTION HAS BEEN COMPLETED
NOTE - IF THERE IS A CONFLICT BETWEEN THIS FORM AND THE RULES, THE RULES PREVAIL

PART 1 ELECTRICAL INSPECTION

Scrutineer name:	**Start time:**	**End time:**

Check that ESF and FMEA are **available printed on paper**:

Available? Check if yes	ESF	☐	FMEA	☐

GENERAL

Identify Electrical System Officer	The ESO will be the central team contact during Electrical Inspection	Ask for the ESO	
Separation of TS and GLVS on self-developed PCBs	Check that on self-developed PCBs TS and GLVS are clearly separated. Check spare PCBs or photographs, if available. Otherwise check built-in PCBs.	Visible check	
Tractive System measuring points	Two tractive system voltage measuring points and a GLVS ground point must be installed directly next to the master switches, right side of the vehicle, shoulder height of the driver.	Visible check	
	The measuring points must be protected by a non-conductive housing that can be opened without tools.	Visible check	
	The measuring points must be protected from being touched with the bare hand / fingers, once the housing is opened. 4mm shrouded banana jacks rated to an appropriate voltage level have to be used.	Visible check	
Tractive System measuring points	The TSMPs must be marked with HV+ and HV-	Visible check	
GND measuring point	Must be positioned next to the TSMPs and must be marked with GND.	Visible check	
GLVS Voltage	Measure GLVS Voltage between GLVS battery plus or DC/DC converter plus and chassis.	Must be equal to or less than 40VDC.	
Dis-charge Circuit and Body Protection Resistors	The discharge circuit has to be wired in a way that it is always active whenever the shutdown circuit is open. If a discharge circuit is used a low resistance can be measured between HV+ and HV- whenever the tractive system is de-activated.	Measure resistance between HV+ and HV- with multi-meter. Result must be 2*BPR+ Dis-Charge Resistor	
HV wiring	All visible HV wiring or their cable channels must be orange	Visible check	
	All tractive system wiring that runs outside of electrical enclosures must either be enclosed in separate orange non-conductive conduit or use an orange shielded cable.	Visible check	
	The conduit or shielded cable must be securely anchored at least at each end so that it can withstand a force of **200N** without straining the cable and crimp and must be located out of the way of possible snagging or damage.	Visible/Manual check	
	Tractive system wiring must be shielded against damage by rotating and / or moving parts.	Visible check	
	No wires are allowed to run lower than the chassis	Visible check	
	TS wires and GLVS wires are clearly separated / do not run directly next to each other / bounded together by cable rods or in the same cable channel !!! **ALLOWED ONLY INTERLOCK SIGNALS !!!**	Visible check	

	Wires must be marked with gauge, temperature rating and voltage rating, serial number or norm is also sufficient, if the team shows the datasheet in printed form	Visible check	
	Wire temperature rating must be suitable for position of the wire in the car (e.g. next to hot components)	Visible check	
HV wiring / Connections	Using only **insulating tape** or **rubber-like paint** for insulation is **prohibited**.	Visible check	
	Bolted connections in the high current path must have a positive locking mechanism.		
TS Fusing	All wiring protected by fuse with current rating <= ampacity of wire.		
	All fuses in HV system have appropriate DC voltage rating		
GLV Fusing	All wiring protected by fuse with current rating <= ampacity of wire.		
HV warning stickers	Each housing/enclosure containing HV parts (except motor housings) must be labeled with a HV-sticker.	Visible check	
Tractive System protection	It must not be possible to touch any tractive system connections with a 100 mm long, 6 mm diameter insulated test probe when the tractive system enclosures are in place.	Check with probe	
	Tractive System components and containers must be protected from moisture in the form of rain or puddles.	Visible check	
High Voltage Disconnect	The HV Disconnect is clearly marked with "HVD".	Visible check	
	It must be possible to disconnect the HVD without removing any bodywork.	Visible check	
	In ready to race condition it must be possible to disconnect the HVD within 10 seconds.	The team must demonstrate how to operate the HVD within 10s.	
	If opening the HVD is possible without the use of tools, a pilot contact/interlock line has to be implemented which breaks the current through the AIRs whenever the connector is removed.	Visible check	
Outboard Wheel Motors	Outboard wheel motors require an interlock is added such that the Shutdown Circuit is opened if the wheel assembly is damaged or knocked off the car.	Visible check	
Energy Meter Wiring	All energy from accumulator containers must flow through a single point, the Energy Meter connection point for energy measuring.	Visible check	
Tractive System Active Light	Tractive system active light must be mounted under the highest point of the main roll hoop	Visible check	
	The TSAL must be visible by a person standing up to 3m away from the TSAL. The person's minimum eye height is 1.6m.	Visible check	
Shutdown Buttons	One shutdown button, push-pull or push-rotate-pull on each side behind the drivers compartment (height approx. driver's head), one in the cockpit and easily accessible by the driver in any steering wheel position.	Visible check	
	Minimum diameter of shutdown buttons on the side = 40mm. Minimum diameter of shutdown button in the cockpit = 24mm.	Visible check	
	The shutdown buttons are not easily removable, e.g. mounted onto a removable body work.	Visible check	
	The international electrical symbol consisting of a red spark on a white-edged blue triangle must be affixed in close proximity to three switches	Visible check	
Brake-over-travel-switch	Brake-over-travel-switch must be positioned behind the brake pedal	Visible check	
TS and GLVS Master switches	TS and GLVS master switch on the right side of the vehicle, approx. At the height of the drivers shoulders. The ON position must be in horizontal position.	Visible check	
	Clearly marked with HV and LV respectively and red or black lightning bolt on a yellow background or red lightning bolt on a white background marks TSMS.	Visible check	
	Both switches must be a **rotary type** with a removable handle	Visible check	
	TSMS must be fitted with a "lockout/tagout" capability	Visible check	
Inertia switch	The device must be mechanically attached to the vehicle, however it must be possible to demount the device so that its functionality can be tested by shaking it.	Visible check	
Firewall(s)	A firewall must separate the driver compartment from all components of high voltage system (including HV wiring).	Visible check	
	The firewall must be made from or coated with an electrically insulating material or there must be an electrically insulating barrier between all the tractive system components and the firewall.	Visible check	

	The firewall must be fire resistant according to UL94-V0, FAR25 or equivalent.	Visible check	
	The firewall must be puncture and scratch resistant.	Visible check	
Torque Encoder	At least two sensors must be fitted and not sharing supply or signal lines.	Visible check	
	The foot pedal must have a positive stop to prevent sensors from being mechanically overstressed	Visible/Manual check	
	Two springs must be used to return the throttle pedal to the off position and each spring must work with the other disconnected. NOTE: The springs in the torque encoders/sensors are not acceptable return springs.	Visible/Manual check	
Brake System Encoder	A brake pedal position sensor or brake pressure switch must be fitted to check for plausibility.	Visible check	
Brake System Master Cylinder	The brake system master cylinder must be actuated directly or by a mechanical connection. The use of bowden cables or push-pull bowden cables is not allowed. The first 90% of the brake pedal travel may be used to regenerate brake energy without actuating the hydraulic brake system. The remaining brake pedal travel must directly actuate the hydraulic brake system, but brake energy regeneration may remain active.	Visible/Manual check	
Charger	Chargers must be accredited to a recognized standard eg. CE. When built by the team they must be built to high standards and conform with all electrical requirements for the vehicle TS.	visible check and mark	
	Charger must incorporate an interlock such that the connectors only become live if is correctly connected to the accumulator	Visible check	
	HV charging leads must be orange	Visible check	
ACCUMULATOR CONTAINER			
HV Accumulator(s) must be enclosed in container(s)	The poles of the accumulator stack(s) and/or cells must be insulated against the inner wall of the accumulator container, if the container is made of electrically conductive material.	visible check (photos taken during assembly are acceptable)	
Internals – Cell connection	Contacting / interconnecting the single cells by **soldering** in the high current path is **prohibited**. Soldering wires to cells for the voltage monitoring input of the BMS is allowed.	visible check (photos taken during assembly are acceptable)	
	Parallel (strings of) batteries must be individually fused to protect all the components on that string. Fusible links acceptable if EV6.1.5 met.	Visible check	
Internals – AIR / Fuse	Every accumulator container must contain at least one fuse and at least two accumulator insulation relays	visible check (photos taken during assembly are acceptable)	
Internals - Maintenance plugs	Maintenance plugs or similar measures have to be taken to allow separating the internal cell stacks. Cell stacks must have a voltage less than **120VDC** and a maximum energy of **12MJ**. The separation has to affect both poles of the stack.	visible check (photos taken during assembly are acceptable)	
Internals – Cell stacks	Each stack has to be electrically insulated by the use of suitable material towards other stacks in the container and on top of the stack. Air is not considered to be a suitable insulation material in this case.	visible check (photos taken during assembly are acceptable)	
Internals – Cell stack barriers	The contained cell stacks must be separated by an insulating and fire resistant (according to UL94-V0, FAR25 or equivalent) barrier in a way, that no single cell stack contains more than **6MJ** energy, if fully charged. These barriers are only needed, if cells are used, which are not LiFePO4.	visible check (photos taken during assembly are acceptable)	
Indicator Light / Voltmeter	Each container must have an indicator showing that voltages greater than 40V DC are present outside of the container.	visible check	
Accumulator Container Connectors	If HV-connectors of the accumulator containers can be removed without the use of tools, a pilot contact/interlock line has to be implemented which breaks the current through the AIRs.	visible check	
Openings in container	Holes in the container are only allowed for the wiring-harness, ventilation, cooling or fasteners. These holes must be sealed against water.	visible check	
Equalizing Valve	If the container is completely sealed, it must have an equalizing valve	visible check	
Spare accumulator(s)	Must have the same size, weight and typ	weight, visible check, mark	

ACCUMULATOR MANAGEMENT SYSTEM			
Cell Voltage Monitoring	AMS must monitor the cell voltage of each cell	Activate GLVS and show measurement data of the AMS by connecting a laptop	
Cell Temperature Monitoring	AMS must monitor the temperature of at least 30% of the cells, if a cell chemistry is used, which is not LiFePO		
AMS Indicator Light	A red LED marked “AMS” or “BMS” must be installed in the cockpit that lights up, if the BMS shuts down the car.	Visible check (function must not be demonstrated)	

All electrically conductive parts of the vehicle (e.g. parts made of steel, (anodized) aluminum, any other metal parts, etc.) which are within 100mm of any tractive system or GLV component , and any driver harness mounting points, seat mounting points and driver controls must have a resistance below 300 mOhms (measured with a current of 1A) to GLV system ground.

All parts of the vehicle which may become electrically conductive (e.g. completely coated metal parts,carbon fibre parts, etc.) which are within 100mm of any tractive system or GLV component, must have a resistance below 5 Ohm to GLV system ground.

Part (only if applicable)	conductive (max. 300 mOhm)	may become conductive / coated (max 5 Ohm)		
Frame / Monocoque	☐	☐	[mΩ]:	
Firewall(s)	☐	☐	[mΩ]:	
Accumulator container	☐	☐	[mΩ]:	
Seat mounting points	X		[mΩ]:	
Driver harness mouting points	X		[mΩ]:	
Conductive housings with TS parts inside	☐	☐	[mΩ]:	
Steering wheel surface	☐	☐	[mΩ]:	
Pedal box	☐	☐	[mΩ]:	
Main Roll Hoop	☐	☐	[mΩ]:	
Suspension Front left	☐	☐	[mΩ]:	
Suspension Front right	☐	☐	[mΩ]:	
Suspension Rear left	☐	☐	[mΩ]:	
Suspension Rear right	☐	☐	[mΩ]:	
Driver Controls / Switches / Etc.	☐	☐	[mΩ]:	
External Heat Sink	☐	☐	[mΩ]:	
Carbon fiber parts typically touched when trying to move the car with TS deactivated.:	☐	☐	[mΩ]:	
Accumulator Management System Data Connector:	☐	☐	[mΩ]:	
Additional Part:	☐	☐	[mΩ]:	

Measure the isolation between HV measuring points and chassis ground, choose next voltage level above the tractive system voltage level, (either 250V or 500V whichever is the next higher value to the tractive-system voltage)

Insulation Measurement Test	R iso+ [kΩ] (min 0.5 kOhm/Volt + BPR)	HV+ Measured resistance:	
	R iso+ [kΩ] (min 0.5 kOhm/Volt + BPR)	HV- Measured resistance:	

!!TEST AT HIGH VOLTAGE!!

All driven wheels have to be off the ground! Car has to be jacked up with driven wheels removed

TS only allowed to be powered up, when GLVS is powered up	Try to switch on Tractive System with GLVS Master switch in Off-Position	No voltage above 40VDC allowed at measurement points	
	Switch on Tractive System and then switch off GLVS Master switch.	Tractive system must switch off as well	
Tractive System Voltage	Measure HV during following tests. Must be less than or equal to **300VDC**	[V]:	
Pre-Charge Circuit	A circuit that is able to pre-charge the intermediate circuit to **90% of the current accumulator voltage** before closing the second AIR has to be implemented.	Check with multimeter during power up of the tractive system that the system is pre-charged before the second AIR closes.	
Accumulator Indicator	Accumulator Indicator has to show if voltage **above 40VDC** is present outside of the container	Visible check	

Tractive system active light	The TSAL must be switched on whenever outside of accumulator container **exceeds 40V DC or 25V AC RMS**	Visible check / use multimeter	
	The TSAL must be clearly visible from every horizontal direction, even in bright sunlight. Small angles of invisibility may be caused by the main roll hoop.	Visible check	
	The TSAL must be red.	Visible check	
	The TSAL has to flash continuously with a frequency between 2Hz and 5Hz.	Visible check	
Calculate IMD Test-Resistor Value	**R_Test = (max. TS voltage * 250Ω/V) - BPR**	R test [kΩ]:	
IMD	IMD indicator light inside the cockpit must be marked with "IMD" and must be RED	visible check	
	IMD status must be shown to the driver (visible in bright sunlight)	visible check	
IMD Test	Activate Tractive System, Connect R_Test between HV+ and GLVS ground	TS voltage must decrease below 40VDC in 5 sec, IMD may take up to 30s to react	
	Activate Tractive System, Connect R_Test between HV- and GLVS ground	TS voltage must decrease below 40VDC in 5 sec, IMD may take up to 30s to react	
IMD or BMS Error disables TS	The tractive system may not automatically return to active state after the IMD test resistor was removed or a BMS error disabled it. The Driver must not be able to reactivate the tractive-system.	Demonstrated by the team.	
Seal all important parts after the IMD test was passed successfully	Accumulator container, Motor Controller Housing, etc.		
Tractive System master switch, shutdown buttons and brake-over-travel-switch and interlocks	All switches on --> TS master switch off	TS voltage must decrease below 40VDC in 5 sec	
	All switches on --> CS master switch off		
	All switches on --> left shutdown button off		
	All switches on --> right shutdown button off		
	All switches on --> Cockpit shutdown button off		
	All switches on --> brake-over-travel-switch off		
	All switches on --> Open Interlock(s) of outboard wheel motor (if applicable)		
Inertia switch	Unmount inertia switch. Activate TS and measure HV voltage. Shake the switch and check if TS is shutdown. TS is not allowed to reactivate without a manual reset e.g. by the driver.	TS voltage must decrease below 40VDC in 5 sec	
Charging	When charging, the AMS must be live and must be able to turn off the charger in the event that a fault is detected.	Set vehicle to charge. Team must demonstrate AMS is active	
	Charging --> Emergency stop button on charger pressed	Charging current must decrease to 0.	
	Charging --> Shutdown button off	TS voltage must be below 40VDC in 5 sec.	
Ready-To-Drive-Mode	Only closing the shutdown circuit must not set the car to ready-to-drive mode. The car is ready to drive as soon as the motor(s) will respond to the input of the torque encoder / acceleration pedal.	Check that car is not automatically Ready-To-Drive, when TS is activated	
	Additional actions are required by the driver to set the car to ready-to-drive-mode e.g.pressing a dedicated start button, after the tractive system has been activated. One of these actions must include the brake pedal being pressed as ready-to-drive-mode is entered.	The team must demonstrate how the car is set to Ready-To-Drive-mode by the driver (pressing the brake pedal is mandatory)	
Ready-To-Drive-Sound-Test	The car must make a characteristic sound, once but not continuous, for at least 1 second and a maximum of 3 seconds when it is ready to drive. The sound level must be a minimum of 70dBA, fast weighting, in a radius of 2m around the car. The used sound must be easily recognizable.	Check/measure during Ready-To-Drive-Mode test	
Torque Encoder / Brake Pedal Plausibility Check	Torque encoder is at more than 25% and brake is actuated simultaneously. The motors have to shut down. The motor power shut down has to remain active until the torque encoder signals less than 5% pedal travel, no matter whether the brake pedal is still actuated or not.	Check that driven axles turn with torque encoder > 25%. Then additionally activate the brake-Motors must stop. .Release brake-> motor is still shutdown. Slowly drop torque encoder until it is below 5%. Motors are allowed to move again after torque encoder has gone below 5%	

Torque Encoder Implausibility Check	If implausibility occurs between the values of two torque encoder sensors the power to the motor(s) has to be immediately shut down completely. It is not necessary to completely deactivate the Tractive System. Implausibility is defined as a deviation of more than 10% pedal travel between the sensors. If three sensors are used at least two sensors have to be within 10% pedal travel, etc.	Check that driven axles turn, then disconnect at least 50% of the sensors and check that the power to the motors is shut down. The sensor should be disconnected while the axles are turning!	
Brake System Plausibility Device	A standalone non-programmable circuit must be used on the car such that when braking hard (without locking the wheels) and when a positive current is delivered from the motor controller (a current to propel the vehicle forward), the AIRs will be opened. The current limit for triggering the circuit must be set at a level where 5kW of electrical power in the DC circuit is delivered to the motors at the nominal battery voltage. The action of opening the AIRs must occur if the implausibility is persistent for more than 0.5sec.	The team must devise a test to prove this required function during Electrical Tech Inspection. However it is suggested that it should be possible to achieve this by sending an appropriate signal to the non-programmable circuit that represents the current to achieve 5kW whilst pressing the brake pedal to a position or with a force that represents hard braking.	
Brake System Plausibility Device	The Brake Plausibility Device may only be reset by power cycling the GLVS Master Switch.	Check that TS is only re-activated, after the GLVS has been cycled.	
Regenerating Energy	Regenerating energy is not allowed below a vehicle speed of 5kph.	Set car to ready-to-drive-mode and actuate the brake pedal slightly without activating the hydraulic brake circuit. Turning a driven wheel/axle by hand must be possible.	
Brake Light	One RED brake light, clearly visible from the rear; on vehicles centerline; height between wheel centerline & driver's shoulders. Round, triangle, or rectangular on black background. 15cm² minimum illuminated area. Sufficient brightness for visible activation in bright sunlight.	Visible check during the tests containing brake pedal actuation.	

!!Test at High voltages completed!! TRACTIVE SYSTEM HAS TO BE SHUT-OFF!			
Seal important parts after the TS tests have been passed successfully	Accumulator container(s) including spares	Part sealed:	
	Motor Controller housing	Part sealed:	
	Energy Meter housing	Part sealed:	
	IMD housing	Part sealed:	
	TSAL circuitry housing	Part sealed:	
	Additional Part:	Part sealed:	
	Additional Part:	Part sealed:	
Car movement	Check car movement with all electrical systems deactivated	try to move the car manually with deactivated TS	
Basic set of HV-proof tools	Insulated cable shear	visible check	
	Insulated screw drivers	visible check	
	Multimeter with protected probe tips	visible check	
	Insulated spanners, if screwed connections are used in the Tractive System	visible check	
	Face Shield	visible check	
Safety Glasses		Visible check	
HV isolating gloves	Test date within last 12 months	visible check	
HV isolating blanket(s)	At least 1m² (36” x 36”)	visible check	
Push Bar	A pair of high-voltage insulating gloves, a multimeter and a fire extinguisher have to be attached to the push bar.	visible check	
	If a tool is needed to open the HVD, this tool has also to be attached to the push bar.	visible check	

NON-COMPLIANCE / COMMENTS:	
APPROVED BY:	**DATE / TIME:**