2017 Electrical Inspection Form

UNIVERSITY:	TSMP PROTECTION RESISTOR (TPR):
TS VOLTAGE:	
GLVS VOLTAGE:	ESF PASSED: □ YES □ NO

IMPORTANT

PRESENT THE VEHICLE FOR INSPECTION IN THE FOLLOWING ORDER:

1. ELECTRICAL INSPECTION
2. MECHANICAL INSPECTION
3. RAIN TEST
4. DYNAMIC INSPECTION

PART 1	**ELECTRICAL INSPECTION**		
Inspector name:			
GENERAL			
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 switch.	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 by bare hands/fingers once the housing is opened. 4mm shrouded banana jacks rated to an appropriate voltage level have to be used.	Visible check	
	The TSMPs must be marked with HV+ and HV-, the ground point must be labeled GND.	Visible check	
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 non-conductive conduit or use a 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.	Visible check / Manual Check	
	Tractive system wiring must be protected against damage by rotating/moving parts, snagging and/or chaffing.	Visible check	
	No wires are allowed to run lower than the lower surface of the tunnel.	Visible check	
	TS wires and GLVS wires must be clearly separated such that they do not run directly next to each other, in the same conduits or in the same connectors. Allowed only for 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 vehicle (e.g. next to hot components)	Visible check	
TS Fusing	All wiring protected by fuse with current rating <= ampacity of wire.	Visible check	
	All fuses in HV system have appropriate DC voltage rating	Visible check	
GLV Fusing	All wiring protected by fuse with current rating <= ampacity of wire.	Visible check	
HV wiring / Connections	Wiring to professional standards: terminals correct size, intentional current path on bolted connections	Visible check	
	Bolted connections in the high current path must have a positive locking mechanism.	Visible check	
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	
	Using only insulating tape or rubber-like paint for insulation is prohibited.	Visible check	
	Tractive System components and containers must be protected from moisture in the form of snow, rain or puddles.	Visible check	
High Voltage Disconnect	The HV disconnect must be clearly marked with "HVD"	Visible check	
	HVD must require removing an element. Switches are not allowed to be used as the HVD.	Visible check	
	In fully assembled condition it must be possible to disconnect the HVD within 10 seconds.	The team must demonstrate how to operate the HVD within 10 seconds.	
	An interlock line must be implemented which breaks the current through the BIR coils whenever the HVD is removed.	Visible check	
Shutdown Buttons	One shutdown button on the right handle bar configured such that up is on and down is off.	Visible check	
	Vehicle is equipped with disconnect tether, max length of 5ft.	Visible check	
	Shutdown circuit carries current of precharge and BIRs.	Demonstrated by team	
TS Master switch	TS master switch at the rear of the vehicle.	Visible check	
	Clearly marked with a red or black lightning bold on a yellow background or red lightning bolt on a white background.	Visible check	
	Switch must be a rotary type with a removable handle.	Visible check	
	TSMS must be fitted with a "lockout/tagout" capability.	Visible check	
Firewall	A firewall must separate the driver from all components of high voltage system (including HV wiring).	Visible check	
	The firewall must be 1.5mm alluminum (or equivalent) with an electrically insulating material between all the tractive system components and the firewall.	Visible check	
Accelerator Lever Position Sensor	Must have at least two sensors not sharing supply or signal lines	Visible check	
	Two springs must be used to return the sensor to the off position and each spring must work with the other disconnected. NOTE: The springs in the ALPS are not acceptable return springs.	Visible check / Manual check	
Brake System Encoder	A brake lever position sensor or brake pressure switch must be fitted to check for plausibility.	Visible check	
Charger	Chargers must be accredited to a recognized standard e.g. 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 connector must incorporate an interlock such that the connectors only become live if is correctly connected.	Visible check	
	HV charging leads must be orange.	Visible check	
ACCUMULATOR CONTAINER			
Battery Container	The poles of the battery stack(s) and/or cells must be insulated against the inner wall of the battery container if the container is made of electrically conductive material.	Visible check (photos taken during assembly are acceptable)	
	Battery is removable while remaining rules compliant.	Visible check	
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 EV6.1.6 met.	Visible check	
BIR / Fuse	Every battery container must contain at least one fuse and at least two BIRs. These must be separated from the cells with an insulating, fireproof barrier.	Visible check (photos taken during assembly are acceptable)	
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 6MJ. The separation has to affect both poles of the stack.	Visible check (photos taken during assembly are acceptable)	
	Maintenace plugs must have a positive locking mechanism.	Visible check	

	Maintance plugs must not be able to be connected incorrectly.	Visible check	
Cell stacks	Each stack has to be electrically insulated by the use of suitable materials 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)	
	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.	Visible check (photos taken during assembly are acceptable)	
Indicator Light	Each container must have an indicator showing that voltages greater than 60V DC are present outside of the container.	Visible check	
Battery Container Connectors	If HV-connectors of the battery containers can be removed without the use of tools, a pilot contact/interlock line has to be implemented which breaks the current through the BIR coils.	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	
Spare accumulator(s)	Must have the same size, weight and type	weight, visible check, mark	
BMS	Temperature sensor must be in direct contact with negative terminal or <10mm away on the bus bar	Visible check	
	A red light marked "BMS" must be installed in the dash 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 driver controls must have a resistance below 300 mOhms (measured with a current of 1A) to GLV system ground.

Part (only if applicable)	conductive (max. 300 mOhm)	may become conductive/coated (max 5 Ohm) .		
Frame	☐	☐	[mΩ]:	
Firewall(s)	X		[mΩ]:	
Battery container	☐	☐	[mΩ]:	
Conductive housings with TS parts inside	☐	☐	[mΩ]:	
Handle bar surface	☐	☐	[mΩ]:	
Pedal box	☐	☐	[mΩ]:	
Driver controls	☐	☐	[mΩ]:	
External heat sink(s)	☐	☐	[mΩ]:	
Carbon fiber parts typically touched when moving vehicle		X	[mΩ]:	
BMS data connector		X	[mΩ]:	
Additional Part	☐	☐	[mΩ]:	

Measurements

Dis-charge Circuit and TSMP 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*TPR+Discharge Resistor	
GLVS voltage	Measure GLVS Voltage between GLVS battery plus or DC/DC converter plus and chassis.	Must be <= 60VDC.	

!!TEST AT HIGH VOLTAGE!!
Track must be off the ground and someone must be holding the teather.

Insulation Measurement Test	Measure isolation between TSMP and chassis ground. Choose next voltage level above TS voltage (250V or 500V) R iso >= 500 * TS Voltage + TPR	HV+ Measured resistance:	
		HV- Measured resistance:	
Tractive System Voltage	Measure HV during following tests. Must be less than or equal to 300VDC	TS Voltage:	
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 last BIR closes.	
Battery Indicator	Battery indicator has to show if voltage above 60VDC is present outside of the container.	Visible check	
Vehicle Energized Light	The VEL must be switched on whenever the voltage outside of the battery container exceeds 60V DC or 25V AC RMS	Visible check / use multimeter	
	The VEL on dash must be green, labeled "Vehicle Energized" and clearly visible even in bright sunlight.	Visible check	
BMS	BMS must monitor the cell voltage of: PbAcid or NiMh - every 6 cells LiIon - every cell	Show measurement data of the BMS by connecting a laptop or other display.	
	BMS must monitor the temperature of at least 30% of the cells		
Calculate IMD Test-Resistor Value	R_Test = (max. TS voltage * 250Ω/V) - TPR	R test [kΩ]:	
IMD Test	Activate tractive system, Connect R_Test between HV+ and GLVS measurement points	IMD may take up to 30s to react, TS voltage must decrease below 60VDC in 5sec	
	Activate tractive system, Connect R_Test between HV- and GLVS measurement points	IMD may take up to 30s to react, TS voltage must decrease below 60VDC in 5sec	
IMD	IMD indicator light on dash must be marked with "IMD", must be red and must be visible in bright sunlight.	Visible check	
IMD or BMS Error disables TS	The tractive system may not automatically return to active state after the IMD test resistor is removed or a BMS error disables it. The driver must not be able to reactive the tractive-system.	Demonstrated by the team	
TS master switch, shutdown buttons and interlocks	All switches on --> TS master switch off	TS voltage must decrease below 60VDC in 5 sec	
	All switches on --> handlebar shutdown button off		
	All switches on --> tether switch off		
Activating the TS	Key must be turned to "crank" to enable HV.	All shutdown switches on, key in run - measure NO HV Turn key to crank - measure HV Press and release shutdown switch - measure NO HV	
Charging	Charger shutdown button shuts down tractive system.	TS voltage must decrease below 60VDC in 5 sec	
	IMD active during charging	Team must demonstrate IMD is active	
	When charging, the BMS 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 BMS is active.	
Ready-To-Drive-Sound Test	The vehicle 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 80dBA, fast weighting, in a radius of 2m around the vehicle. The used sound must be easily recognizable.	Measure sound level:	

ALPS / Brake Pedal Plausibility Check	ALPS 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 ALPS signals less than 5% pedal travel, no matter whether the brake pedal is still actuated or not.	Check that track moves with ALPS > 25%. Then additionally activate the brake-motors must stop. Release brake -> motor is still shutdown. Slowly drop ALPS until it is below 5%. Motors are allowed to move again after ALPS has gone below 5%.	
ALPS Implausibility Check	If implausibility occurs between the values of two ALPSs power to the motor(s) has to be immediately shut down completely. It is not necessary to completely deactivate the tractive system.	Check that track moves, 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 track is moving.	
Brake System Plausibility Device	A standalone non-programmable circuit must be used on the vehicle such that braking hard when a positive current is delivered from the motor controller, the BIRs will be opened. The current limit for triggering the circuit must be set at a level equal to 5kW at the nominal battery voltage. The action of opening the BIRs must occur if the implausibility is persistent for more than 0.5 sec.	The team must provide a test. The preferred method is to "fake out" the current sensor with a signal equivalant to > 5kW.	
	The brake plausibility device may not be reset by a driver accessible control.	Check that the driver controls do not reset the BSPD	

!! Test at High Voltages Completed !!

Seal important parts after the TS tests have been passed successfully	Battery container(s) including spares	Part sealed:	
	Motor Controller housing	Part sealed:	
	IMD housing	Part sealed:	
	Additional Part:	Part sealed:	
	Additional Part:	Part sealed:	
Basic set of HV-proof tools	Insulated cable shear	Visible check	
	Insulated screw drivers/wrenches for battery	Visible check	
	Multimeter with protected probe tips	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	

NON-COMPLIANCE / COMMENTS: (on back)

APPROVED BY: **DATE/TIME:**