Formula SAE-A 2017 ELECTRIC VEHICLE (EV) TECHNICAL INSPECTION SHEET

UNIVERSITY:	**CAR NUMBER:**
TS VOLTAGE:	**GLVS VOLTAGE:**

VEHICLE MUST HAVE HVD DISCONNECTED AND TSMS KEY REMOVED AND LOCK IN PLACE AT ALL TIMES UNTIL INSTRUCTED BY SCRUITENEERS

PRESENT THE VEHICLE FOR INSPECTION IN THE FOLLOWING ORDER

1. Electrical Inspection PART 1
2. Mechanical Inspection
3. Electrical Inspection PART 2
4. Tilt Table Inspection
5. Braking Performance Inspection

Note: If there is a conflict between this form and the rules, the rules prevail.

ELECTRICAL INSPECTION PART 1 - VISUAL INSPECTION

Lead Scrutineer Name:		**Part 1 Start date/time:**		
		Part 1 Pass date/time:		

GENERAL:			
Identify Electrical Systems Officer (ESO)	The ESO will be the central team contact during Electrical Inspection	Ask for ESO	
Check that ESF and FMEA are available and printed on paper	The team should have copies of their ESF and FMEA for reference during the scrutineering process	Ask for copies of ESF and FMEA	
Disable HV systems	Check HVD is removed and TSMS lock is in place	Visual Check	

SAFETY:			
Teams are expected to have appropriate safety equipment to allow them to work on their vehicle All safety equipment should be in good condition			
Basic set of HV-proof tools	Insulated cable shear	Visual Check	
	Insulated screw drivers	Visual Check	
	Multimeter with protected probe tips. CATIII or better	Visual Check	
	Insulated spanners or insulated socket set if screwed connections are used in the tractive system	Visual Check	
	Other insulated tools if required for tractive system maintenance	Visual Check	
	Face Shield	Visual Check	
Safety Glasses		Visual Check	
HV isolating gloves		Visual Check	
HV isolating blanket(s)	At least $1m^2$	Visual Check	
Push Bar	A pair of high-voltage insulating gloves, a multimeter and a fire extinguisher have to be attached to the push bar.	Visual Check	
	If a tool is needed to open the HVD, this tool has also to be attached to the push bar.	Visual Check	

GENERAL:			
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, if they are easily accessible.	Visual 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.	Visual Check	
Tractive System Measuring Points	The measuring points must be protected by a nonconductive housing that can be opened without tools.	Visual Check	
Tractive System Measuring Points	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.	Visual Check	
Tractive System Measuring Points	The TSMPs must be marked with HV+ and HV-	Visual Check	
GND measuring Point	Must be positioned next to the TSMPs and must be marked with GND.	Visual Check	
GLVS voltage	Measure GLVS Voltage between GLVS battery positive or DC/DC converter plus and chassis	Must be equal to or less than 60Vdc	
TS voltage	Measure TS voltage at measurement points	Must be equal to or less than 60Vdc	
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 (GLVS must be off)	

GENERAL:			
HV wiring	All visible HV wiring or their cable channels must be orange.	Visual Check	
HV wiring	All tractive system wiring that runs outside of electrical enclosures must either be enclosed in separate orange nonconductive	Visual Check	
HV wiring	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.	Visual Check. Pull on conduits with reasonable force	
HV wiring	Tractive system wiring must be shielded against damage by rotating and / or moving parts.	Visual Check	
HV wiring	No wires are allowed to run lower than the chassis.	Visual Check	
HV wiring	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 FOR PILOT CONTACTS OR INTERLOCK SIGNALS !!!	Visual Check	
HV wiring	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	Visual Check	
HV wiring	Wire temperature rating must be suitable for position of the wire in the car (e.g. next to hot components)	Visual Check	
HV wiring/Connections	Using only insulating tape or rubber-like paint for insulation is prohibited.	Visual Check	
HV warning stickers	Each housing/enclosure containing HV parts (except motor housings) must be labeled with a HV-sticker.	Visual 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 protection	Tractive System components and containers must be protected from moisture in the form of rain or puddles.	Visual Check	

GENERAL:			
High Voltage Disconnect	The HV Disconnect has to be clearly marked with "HVD".	Visual Check	
High Voltage Disconnect	It must be possible to disconnect the HVD without removing any bodywork.	Visual Check	
High Voltage Disconnect	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.	
High Voltage Disconnect	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.	Visual Check	
Outboard Wheel Motors	Outboard wheel motors are allowed if an interlock is added such that the Shutdown Circuit is opened if the wheel assembly is damaged or knocked off the car.	Visual Check	
Energy Meter Wiring	All energy from accumulator containers must flow through a single point, the Energy Meter connection point for energy measuring.	Visual Check	
Tractive System Active Light	Tractive system active light (TSAL) must be mounted under the highest point of the main roll hoop	Visual Check	
Tractive System Active Light	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.	Visual 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.	Visual Check	
Shutdown Buttons	Minimum diameter of shutdown buttons on the side = 40mm. Minimum diameter of shutdown button in the cockpit = 24mm.	Visual Check	
Shutdown Buttons	The shutdown buttons are not allowed to be easily removable, e.g. mounted onto a removable body work.	Visual Check	

GENERAL:			
Cockpit Shutdown Button	The international electrical symbol consisting of a red spark on a white-edged blue triangle must be affixed in close proximity to this switch	Visual Check	
Brake-over-travel-switch	Brake-over-travel-switch must be positioned behind the brake pedal	Visual 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.	Visual Check	
TS and GLVS Master switches	Clearly marked with HV and LV respectively and indicated "ON" position	Visual Check	
TS and GLVS Master switches	Both switches must be a rotary type with a removable key / handle	Visual Check	
TS master switch	TSMS must be fitted with a "lockout/tagout" capability to prevent accidental activation of the tractive system.	Visual 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.	Visual check / Manual Check	
Torque Encoder	Torque Encoder must return to original position, if not actuated.	Visual check / Manual Check	
Torque Encoder	At least two sensors must be fitted as torque encoder not sharing supply or signal lines.	Visual Check	
Torque Encoder	The foot pedal must have a positive stop to prevent sensors from being mechanically overstressed	Visual check / Manual Check	
Torque Encoder	Two springs must be used to return the throttle pedal to the off position and each spring must work with the other disconnected.	Visual check / Manual Check	
Brake System Encoder	A brake pedal position sensor or brake pressure switch must be fitted to check for plausibility	Visual check	

GENERAL:			
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.	Visual check	
ACCUMULATOR CONTAINER			
Accumulators	HV Accumulator(s) must be enclosed in container(s)	Visual Check	
Accumulators	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.	Visual Check (detailed photographs taken during assembly may be 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.	Visual Check (detailed photographs taken during assembly may be acceptable)	
Internals - AIR / Fuse	Every accumulator container must contain at least one fuse and at least two accumulator insulation relays	Visual Check (detailed photographs taken during assembly may be acceptable)	
Internals - Maintenance plugs	Maintenance plugs or similar measures have to be taken to allow separating the internal cell stacks in a way, that the separated cell stacks carry a voltage of less than 120VDC and a maximum energy of 12MJ. The separation has to affect both poles of the stack.	Visual Check (detailed photographs taken during assembly may be acceptable)	
Internals – Cell stack barriers	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	Visual Check (detailed photographs taken during assembly may be acceptable)	

ACCUMULATOR CONTAINER			
Indicator Light / Voltmeter	Each container must have an indicator light or an analogue voltmeter showing that voltages greater than 60V DC are present outside of the container.	Visual 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 whenever the connector is removed.	Visual Check	
Openings in container	Breakthroughs or holes in the container are only allowed for the wiring-harness, ventilation, cooling or fasteners. These holes must be sealed against water.	Visual Check	
Equalizing valve	If the container is completely sealed, it must have an equalizing valve	Visual Check	
Spare accumulator(s)	Must have the same size, weight and type Only applicable if spare accumulators are used.	Weight, visual check, mark	
FIREWALLS			
Vehicle must be reassembled and firewalls checked in place			
Firewall(s)	A firewall must separate the driver compartment from all components of high voltage system (including HV wiring).	Visual Check	
Firewall(s)	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.	Visual Check	
Firewall(s)	The firewall must be fire resistant according to UL94-V0, FAR25 or equivalent.	Visual Check / Teams to Produce datasheet for material used	
Firewall(s)	The firewall must be puncture and scratch resistant.	Visual check / Manual Check	

GROUNDING

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 fiber 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 / is coated (max 5 Ohm)**	**Measurement**
Frame Monocoque (measure in several locations)	[ ]	[ ]	(mΩ)
Firewalls	[ ]	[ ]	(mΩ)
Accumulator container	[ ]	[ ]	(mΩ)
Seat mounting points	[X]		(mΩ)
Driver Harness mounting points	[X]		(mΩ)
Conductive housings with TS parts inside	[ ]	[ ]	(mΩ)
Motor inverter housings	[ ]	[ ]	(mΩ)
Steering wheel surface	[ ]	[ ]	(mΩ)
Pedal Box	[ ]	[ ]	(mΩ)
Main Roll Hoop	[ ]	[ ]	(mΩ)
Forward Roll Hoop	[ ]	[ ]	(mΩ)

GROUNDING			
Part (only if applicable)	**Conductive (max 300 mOhm)**	**May become conductive / is coated (max 5 Ohm)**	**Measurement**
Suspension Front Left Upper	[ ]	[ ]	(mΩ)
Suspension Front Left Lower	[ ]	[ ]	(mΩ)
Suspension Front Right Upper	[ ]	[ ]	(mΩ)
Suspension Front Right Lower	[ ]	[ ]	(mΩ)
Suspension Rear Left Upper	[ ]	[ ]	(mΩ)
Suspension Rear Left Lower	[ ]	[ ]	(mΩ)
Suspension Rear Right Upper	[ ]	[ ]	(mΩ)
Suspension Rear Right Lower	[ ]	[ ]	(mΩ)
Driver Controls/switches	[ ]	[ ]	(mΩ)
Exposed heatsinks/radiators	[ ]	[ ]	(mΩ)
Carbon Fiber parts typically touched when trying to move the car wit TS disabled	[ ]	[ ]	(mΩ)
Additional parts:	[ ]	[ ]	(mΩ)
Additional parts:	[ ]	[ ]	(mΩ)
Additional parts:	[ ]	[ ]	(mΩ)

EV SCRUITEENERING PART 1 COMPLETE	
Approved by:	**Date/time:**

Once all items are passed, give team EV Scrutineering PART 1 sticker. Team may proceed to mechanical scrutineering.

NON-COMPLIANCES / COMMENTS:

ELECTRICAL INSPECTION PART 2 - FUNCTIONAL DEMONSTRATION

Lead Scrutineer Name:	**Part 2 Start date/time:**
	Part 2 Pass date/time:

ACCUMULATOR MANAGEMENT SYSTEM			
Cell Voltage Monitoring	AMS must monitor the cell voltage of each cell	Activate AMS system and show measurment data of the AMS for each cell. (eg. via laptop)	
Cell Temperature Monitoring	AMS must monitor the temperature of at least 30% of cells in pack.		
AMS indicator light	A red LED marked “AMS” or “BMS” must be installed in the cockpit that lights up, if the AMS shuts down the car.	Visual Check (function must not be demonstrated)	
CHARGER			
Check and mark Charger	Charger needs to be professionally built, e.g. no damaged insulation on cables etc.	Visual Check	
Check and mark Charger	Charger must have current electrical 'test and tag' tag	Visual Check	
!!! 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 60VDC allowed at measurement points.	
TS only allowed to be powered up, when GLVS is powered up	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 600VDC	Measured Voltage [V]:	
Pre-Charge Circuit	A circuit that is able to pre-charge the intermediate circuit to at least 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 Light / Voltmeter	Accumulator Indicator Light or analogue voltmeter has to show if voltage above 60VDC is present outside of the container	Visible check	

!!! TEST AT HIGH VOLTAGE !!! All driven wheels have to be off the ground! Car has to be jacked up with driven wheels removed			
Tractive system active light	The TSAL must be switched on whenever outside of accumulator container exceeds 60V DC or 40V AC RMS or when the accumulator insulation relays are closed	Visual check / use multimeter	
Tractive system active light	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.	Visual Check	
Tractive system active light	TheTSAL must be red.	Visual Check	
Tractive system active light	The TSAL has to flash continuously with a frequency between 2Hz and 5Hz.	Visual Check	
IMD	IMD indicator light inside the cockpit must be marked with "IMD" and must be RED	Visual Check	
Calculate IMD Test-Resistor Value	R_Test = (max. TS voltage * 250Ω/V) - BPR	R test [kΩ]:	
IMD Test Note: Teams should have a test lead manufactured with insulated bananna plugs and with approporate resistor in place.	Activate Tractive System, Connect R_Test between HV+ and GLVS ground	TS voltage must decrease below 60VDC in 5 sec, IMD may take up to 30s to react	
	Activate Tractive System, Connect R_Test between HVand GLVS ground	TS voltage must decrease below 60VDC in 5 sec, IMD may take up to 30s to react	
IMD	IMD status must be shown to the driver (visible in bright sunlight)	Visual Check	
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.		

!!! TEST AT HIGH VOLTAGE !!! All driven wheels have to be off the ground! Car has to be jacked up with driven wheels removed			
Prove correct function of all shutdown devices. **Note: Care must be taken not to overheat pre-charge or discharge resistors during tests. Allow cooling off time if required.**	All switches on --> GLVS master switch off	Voltage at TS test points must fall to below 60VDC within 5 seconds	
	All switches on --> TS master switch off	Voltage at TS test points must fall to below 60VDC within 5 seconds	
	All switches on --> Left Shutdown button off	Voltage at TS test points must fall to below 60VDC within 5 seconds	
	All switches on --> Right Shutdown button off	Voltage at TS test points must fall to below 60VDC within 5 seconds	
	All switches on --> Cockpit Shutdown button off	Voltage at TS test points must fall to below 60VDC within 5 seconds	
	All switches on --> Brake -Over Travel Switch off	Voltage at TS test points must fall to below 60VDC within 5 seconds	
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.	Voltage at TS test points must fall to below 60VDC within 5 seconds	
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	
Ready-To-Drive-Mode	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)	

!!! TEST AT HIGH VOLTAGE !!! All driven wheels have to be off the ground! Car has to be jacked up with driven wheels removed			
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. No animal voices, song parts or sounds that can be interpreted as offensive will be accepted.	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 an 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, the motor controller(s) shutting down the power to the motor(s) is sufficient. 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!	

!!! TEST AT HIGH VOLTAGE !!! All driven wheels have to be off the ground! Car has to be jacked up with driven wheels removed			
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 or via a RESET button, located out of reach from the driver.	Check that TS is only reactivated, after the GLVS has been cycled or reset button pressed.	
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.	

COMPLETION AND SIGNOFF			
VEHICLE MUST HAVE TS SHUTDOWN, HVD DISCONNECTED AND TSMS KEY REMOVED AND LOCK REINSTALLED			
Car movement	Check car movement with all electrical systems deactivated	Try to move the car manually with deactivated TS (press throttle)	
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:	

EV SCRUITEENERING PART 2 COMPLETE	
Approved by:	**Date/time:**

Once all items are passed, give team EV Scrutineering PART 2 sticker. Team may proceed to Tilt Table Test

NON-COMPLIANCES / COMMENTS: