

**IMPORTANT**

PRESENT THE VEHICLE FOR INSPECTION IN THE FOLLOWING ORDER:

1. SAFETY GEAR CHECK (Bring all items, plus rain tires)
2. ACCUMULATOR INSPECTION
3. ELECTRIC VEHICLE INSPECTION
4. MECHANICAL TECHNICAL INSPECTION
5. TILT TABLE INSPECTION
6. RAIN TEST
7. BRAKING PERFORMANCE INSPECTION

**THIS FORM MUST STAY WITH THE CAR UNTIL THAT SPECIFIC PART OF INSPECTION HAS BEEN COMPLETED**

| <b>ACCUMULATOR INSPECTION</b>     |   |  |  |
|-----------------------------------|---|--|--|
| UNIVERSITY:                       |   | INSPECTOR(s):  |  |
| Identify team/design information  | The ESO will be the central team contact during Electrical Inspection   | Name:  |  |
|                                   | The designed maximum TS voltage.  | _____ [V]  |  |
|                                   | ESF Accepted  | <input type="checkbox"/> YES <input type="checkbox"/> NO       |  |
| <b>DESIGN</b>                     |   |  |  |
| TSMP                              | TSMP body protection resistor value.  | _____ [kΩ]   |  |
| TS Fusing                         | All wiring protected by overcurrent protection with current rating $\leq$ ampacity of wire.   | Visible check of documentation                                 |  |
|                                   | All overcurrent protection in TS must have DC voltage rating $\geq$ max TS voltage  | Visible check of documentation                                 |  |
|                                   | Precharge and discharge circuits must not be fused.   | Visible check of documentation                                 |  |
| Accumulator                       | Maintenance plugs must separate 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. | Per Stack:<br>Max Voltage: _____ [V]<br>Max Energy: _____ [MJ] |  |
|                                   | AMS must monitor the temperature of at least 30% of the cells   | Visible check  |  |
|                                   | Temperature sensor must be in direct contact with negative terminal or <10mm away on the bus bar  | Visible check  |  |
| Shutdown/Safety Circuits          | Shutdown buttons directly carry current of AIRs   | Visible check of documentation                                 |  |
|                                   | IMD, BMS, and BSPD have independent relays or transistors to open the shutdown circuit.   | Visible check of documentation                                 |  |
|                                   | An interlock line opens the AIRs whenever the HVD is removed.   | Visible check  |  |
|                                   | TSAL must be controlled by >60V voltage present in TS, <b>not shutdown circuit voltage.</b>   | Visible check of documentation                                 |  |
| APPS                              | Must have at least two sensors not sharing supply or signal lines.  | Visible check  |  |
|                                   | The transfer functions of the two sensors must not cross.   | Visible check  |  |
| <b>ACCUMULATOR</b>                |   |  |  |
| HV warning stickers               | Accumulator housing must be labeled with "High Voltage" and<br>  | Visible check  |  |
| Separation on self-developed PCBs | GLV and TS circuits have at least the spacing specified in EV4.1.7.   | Visible check  |  |
| HV Wiring                         | 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. <b>Lock washers, nyloc's and thread locking compound are NOT allowed.</b>                                 | Visible check  |  |
|                                   | Soldering is not allowed in the high current path. It is acceptable to solder sense wires.  | Visible check  |  |
|                                   | TS wires and GLVS wires are clearly separated: not run directly next to each other, in the same conduit or connector. Does not apply to interlock wires.                                      | Visible check  |  |

|                                      |  |   |  |
|--------------------------------------|--|---|--|
| TS Fusing                            | All wiring has overcurrent protection with current rating $\leq$ ampacity of wire.   | Visible check   |  |
|                                      | AMS cell voltage sense leads have overcurrent protection. Distributed AMS with leads $<25\text{mm}$ are exempt. Voltage rating $\geq$ cell voltage and must occur in conductor attached to cell.           | Visible check   |  |
|                                      | Parallel cells or strings of cells must be individually fused to protect all the components on that string. Fusible links acceptable if EV6.1.5 met.   | Visible check   |  |
| Internals                            | The poles of the accumulator stack(s) and cells must be insulated against the inner wall of the accumulator container if the container is made of electrically conductive material.                        | Visible check   |  |
|                                      | Every accumulator container must contain at least one fuse and at least two accumulator insulation relays (1 on each pole).  | Visible check   |  |
|                                      | Fuse and AIRs must be separated from the rest of the enclosure by an electrically insulating fireproof material.   | Visible check   |  |
| Maintenance Plugs                    | Maintenance plugs can be removed without tools.  | Visible check   |  |
|                                      | Surfaces of the maintenance plugs must be non-conductive except as required to make the electrical connection.   | Visible check   |  |
|                                      | Maintenance plugs cannot be incorrectly installed.   | Visible check   |  |
| Internals - 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. <b>Air is not a suitable insulation material in this case.</b> | Visible check   |  |
|                                      | The contained cell stacks must be separated by an insulating and fire resistant (according to UL94-V0, FAR25 or equivalent) barrier.   | Visible check   |  |
| Indicator Light                      | Each container must have an indicator showing that voltages greater than 60V DC are present outside of the container. <b>Indicator must function with accumulator removed from vehicle.</b>                | Visible check   |  |
| Accumulator Container Connectors     | If HV-connectors of the accumulator containers can be removed without the use of tools, an interlock line has to be implemented which opens the AIRs.  | Visible check   |  |
| AMS                                  | AMS must monitor the voltage of every cell.  | Visible check   |  |
| Spare accumulator(s)                 | Must have the same size, weight and type   | Visible check   |  |
| Accumulator Removal                  | Accumulator can be removed while rules compliant   | Visible check   |  |
| Hand Cart                            | Accumulator is removable while remaining rules compliant.  | Visible check   |  |
|                                      | Hand cart has dead man's switch capable of stopping fully loaded cart.   | Visible check   |  |
| Chargers                             | 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   |  |
| <b>!!TEST AT HIGH VOLTAGE!!</b>      |  |   |  |
| <b>Pack removed on charging cart</b> |  |   |  |
| Charging                             | Emergency stop button on charger stops charging  | Check that current goes to 0.                               |  |
|                                      | IMD active during charging   | Team must demonstrate IMD is active                         |  |
|                                      | 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. |  |

## ELECTRIC VEHICLE INSPECTION

UNIVERSITY: \_\_\_\_\_

INSPECTOR(s): \_\_\_\_\_

**CHECK THAT HVD IS REMOVED FROM VEHICLE.**

## GENERAL

|                              |   |                              |  |
|------------------------------|---|------------------------------|--|
| Required Safety Equipment    | Insulated cable cutter  | Visible check                |  |
|                              | Insulated screw drivers/wrenches for accumulator  | 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                |  |
|                              | Electrically insulating blanket at least 1m <sup>2</sup> (36" x 36")  | Visible check                |  |
|                              | Push bar has 2 pairs of high-voltage insulating gloves, a multimeter and a fire extinguisher attached.  | Visible check                |  |
| HV wiring                    | All HV wiring or their conduit must be orange.<br>GLV wiring must not be orange.  | Visible check                |  |
|                              | TS wiring outside of electrical enclosures must either be enclosed in non-conductive conduit or use a shielded cable with the shield grounded.  | Visible check                |  |
|                              | The conduit or shielded cable must be securely anchored at least at each end to withstand a force of 200N without straining the cable and crimp.  | Visible check / Manual Check |  |
|                              | TS wiring protected against damage. No TS wires or components are allowed to be lower than the chassis.   | Visible check                |  |
|                              | TS wires and GLVS wires are clearly separated: not run directly next to each other, in the same conduit or connector. Does not apply to interlock wires.  | 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.<br><b>Lock washers, nyloc's and thread locking compound are NOT allowed.</b>                                      | Visible check                |  |
| GLV Fusing                   | All wiring protected by overcurrent protection with current rating <= ampacity of wire.   | Visible check                |  |
| Energy Meter wiring          | All energy from accumulator containers must flow through the Energy Meter for energy measuring.   | Visible check                |  |
| Tractive System protection   | It must not be possible to touch any TS connections with a 100 mm long, 6 mm diameter insulated test probe when the TS enclosures are in place.   | Check with probe             |  |
|                              | Using only tape or rubber-like paint for insulation is prohibited.  | Visible check                |  |
| HV warning stickers          | Each housing/enclosure containing HV parts (except motor housings) must be labeled with "High Voltage" and<br>     | Visible check                |  |
| High Voltage Disconnect      | The HVD must be actuated by removing/disconnecting an element.  | Visible check                |  |
|                              | The HVD is clearly labeled with "HVD"   | Visible check                |  |
|                              | The HVD must be accessible without removing bodywork and located >350mm from the ground.  | Visible check                |  |
|                              | In ready to race condition it must be possible to disconnect the HVD within 10 seconds.   | Team Demonstration           |  |
|                              | HVD must remain fingerproof when disconnected. <b>A dummy connector may be used to restore to fingerproof.</b>  | Visible check                |  |
| Tractive System Active Light | The TSAL must be mounted under highest point of main roll hoop and visible from every horizontal direction by a person standing up to 3m away from the TSAL. The person's minimum eye height is 1.6m. | Visible check                |  |
| AMS Indicator                | A red light marked "AMS" or "BMS" must be installed in the cockpit that lights up, if the AMS shuts down the car.   | Visible check                |  |

|                          |  |                              |  |
|--------------------------|--|------------------------------|--|
| Measurement Points       | TS+, TS- and GLVS ground shrouded banana jack must be installed on the right side of the vehicle at the shoulder height of the driver.   | Visible check                |  |
|                          | The TSMPs must be protected by a non-conductive housing that can be opened without tools.  | Visible check                |  |
|                          | The TSMPs must be protected from being touched with the bare hand/fingers, once the housing is opened.   | Visible check                |  |
|                          | The measurement points must be marked with HV+, HV-, and GND.  | Visible check                |  |
| Master Switches          | TS and GLVS master switch on the right side of the vehicle at the height of the drivers shoulders.   | Visible check                |  |
|                          | GLVMS labeled "LV" and TSMS labeled "HV" and    | Visible check                |  |
|                          | On and Off position of each switch is labeled.   |                              |  |
|                          | Both switches must be a rotary type with a removable handle. <b>The ON position must be in horizontal position.</b>  | Visible check                |  |
| Shutdown Buttons         | One shutdown button on each side of drivers compartment (height of drivers head). Minimum diameter = 40mm. Push pull or push-rotate style.   | Visible check                |  |
|                          | One shutdown button in cockpit. Minimum diameter = 24mm. Push pull or push-rotate style.   | Visible check                |  |
|                          | Three switches labeled with   | Visible check                |  |
| Outboard Wheel Motors    | Outboard wheel motors require an interlock such that the shutdown circuit is opened if the wheel assembly is damaged or knocked off the car.   | Visible check                |  |
| Brake-over-travel-switch | Brake-over-travel-switch must actuate if brake pedal overtravels <b>and not be damaged.</b>  | Visible check                |  |
| APPS                     | The foot pedal must have a positive stop to prevent sensors from being mechanically overstressed.  | Visible check / Manual check |  |
|                          | Two springs must be used to return the accelerator pedal to the off position and each spring must work with the other disconnected. The springs in the APPS are not acceptable return springs. | Visible check / Manual 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 coated with an electrically insulating material on the driver side  | Visible check                |  |
|                          | The insulating material must be puncture and scratch resistant.  | Visible check                |  |

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| <b>DEMONSTRATION</b> |
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**CAR MUST BE JACKED UP WITH DRIVEN WHEELS REMOVED.**

|   |   |   |
|---|---|---|
| UNIVERSITY:   | INSPECTOR(s):   |   |
| <b>Measurements</b>   |   |   |
| Discharge Circuit and Body Protection Resistors                               | If used, the discharge circuit must always be active when the shutdown circuit is open.<br>1. Measure resistance between TSMP HV- and TSMP HV+ Measurement must be $2 * \text{body protection resistor} + \text{Discharge}$ .   | _____ k $\Omega$  |
| GLVS voltage  | Measure GLVS voltage, must be $\leq 60\text{VDC}$   | _____ V   |
| GLVS ground   | Measure GLVS gnd for conductive surface $< 100\text{mm}$ from GLV component, must be $< 300 \text{ m}\Omega$ .  | _____ m $\Omega$  |
| <b>!!TEST AT HIGH VOLTAGE!!</b>   |   |   |
| Insulation Measurement Test   | Measure isolation between TSMP and chassis ground. Choose next voltage level above TS voltage (250V or 500V)<br>$R_{iso} \geq 500 * \text{TS Voltage} + \text{BPR}$   | HV+ _____ M $\Omega$  |
|   |   | HV- _____ M $\Omega$  |
| TS only on when GLVS powers up  | Try to switch on TS with GLVS Master Switch in off position   | No voltage above 60VDC allowed at measurement points  |
| Tractive System Voltage   | Measure HV during following tests. Must be less than or equal to 300VDC   | _____ V   |
| Pre-Charge Circuit  | Intermediate circuit must be precharged to $\geq 90\%$ of the current accumulator voltage before closing the second AIR.  | Observe precharge with multimeter.  |
| Accumulator Indicator   | Accumulator Indicator indicates if voltage above 60VDC is present outside of the container.   | Visible check   |
| Tractive System Active Light  | The TSAL must be switched on whenever the voltage outside of accumulator container exceeds 60V DC.  | Visible check   |
|   | The TSAL must be red and clearly visible even in bright sunlight.   | Visible check   |
| IMD Test  | IMD must open shutdown circuit in 30 seconds when isolation fault is present.<br>1. Activate Tractive System<br>2. Connect IMD test box between TSMP and GLVS Ground.<br>3. IMD must trip in 30 seconds and TS voltage must decrease below 60VDC in 5 sec.                    | HV+   |
|   |   | HV-   |
| IMD   | IMD indicator light inside the cockpit 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 was removed or a BMS error disabled it. The driver must not be able to reactive the tractive-system.   | Demonstrated by the team  |
| master switches, shutdown buttons and brake-over-travel-switch and interlocks | All switches on --> TS Master switch off  | TS voltage must decrease below 60VDC in 5 sec   |
|   | All switches on --> GLV 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  |   |
| Inertia switch  | All switches on --> Open Interlock(s) of outboard wheel motor (if applicable)   | TS voltage must decrease below 60VDC in 5 sec   |
|   | Unmount inertia switch. Activate TS and measure HV voltage. Shake the switch and check if TS is shutdown.   |   |
| AMS Data Check  | Team demonstrates that the AMS monitors all cell voltages and temperatures.   | Team must demonstrate live AMS data.  |
| 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 accelerator pedal.  | Check that car is not automatically Ready-To-Drive, when shutdown ckt 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 80dBA, fast weighting, in a radius of 2m around the car. The used sound must be easily recognizable.  | Check for Ready-To-Drive sound when team starts vehicle.  |  |
| APPS / Brake Pedal Plausibility Check | Torque production must stop when accelerator and brake pedal are pressed simultaneously<br>1. Press accelerator to show that axle turns.<br>2. With accelerator > 25%, press brake pedal. <b>Axle must stop</b><br>3. Keeping accelerator >25%, release brake pedal. <b>Axle must remain stopped.</b><br>4. Slowly release accelerator, <b>axle may turn again once &lt; 5% pedal position.</b> | Team demonstration per procedure  |  |
| APPS Implausibility Check             | Torque production must stop if >= 50% of APPS are implausible.<br>1. Press accelerator to show that axle turns.<br>2. Unplug >= 50% of APPS.<br>3. Press accelerator, <b>axle must not turn.</b>  | Team demonstration per procedure  |  |
| Brake System Plausibility Device      | A standalone non-programmable circuit must open the AIRs when braking hard and a positive current is delivered from the motor controller. The current limit must be set at a 5kW at the nominal battery voltage. The action of opening the AIRs 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 equivalent to > 5kW. |  |
|                                       | The BSPD 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 | 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: |  |

APPROVED BY:

DATE/TIME: