

**APPENDIX E
CSC 2014 INSPECTION FORMS FOR ZE SLEDS**

ZE Electrical Inspection Form

UNIVERSITY:		SLED NUMBER:	
ESF PASSED: <input type="checkbox"/> YES <input type="checkbox"/> NO		BODY PROTECTION RESISTOR:	
		TS VOLTAGE:	GLVS VOLTAGE:
IMPORTANT			
PRESENT THE VEHICLE FOR INSPECTION IN THE FOLLOWING ORDER			
<ol style="list-style-type: none"> 1. ELECTRICAL INSPECTION 2. RAIN TEST 3. MECHANICAL INPECTION 4. DYNAMIC 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	<input type="checkbox"/>	
GENERAL			
Identify Rules and Safety Officer	The RSO will be the central team contact during Electrical Inspection	Ask for the RSO	
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, rear of vehicle	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	
	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	

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	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 \leq ampacity of wire.		
	All fuses in HV system have appropriate DC voltage rating		
GLV Fusing	All wiring protected by fuse with current rating \leq 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	
	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.	
	It must be possible to operate the HVD without a tool.	Visible check	
	The HVD must have an interlock which breaks the current through the BIRs whenever the connector is removed.	Visible check	
Vehicle Energized Light	Vehicle Energized must be mounted on dash.	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	
TS Master switches	TS master switch at rear of snowmobile.	Visible check	
	Clearly marked with and red or black lightning bolt 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(s)	A firewall must separate the driver from the battery..	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	
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	
BATTERY CONTAINER			

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HV Battery(s) must be enclosed in container(s)	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)	
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 battery container must contain at least one fuse and at least two battery isolation 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.	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 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 BIRs.	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	
BATTERY MANAGEMENT SYSTEM			
Cell Voltage Monitoring	BMS must monitor the cell voltage of each cell	Activate GLVS and show measurement data of the BMS by connecting a laptop	
Cell Temperature Monitoring	BMS must monitor the temperature of at least 30% of the cells,		
AMS Indicator Light	A red LED marked “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	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:
Firewall(s)	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:
Battery container	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:
Conductive housings with TS parts inside	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:
Handle Bar surface	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:
Pedal box	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:
Driver Controls / Switches / Etc.	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:
External Heat Sink	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:

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Carbon fiber parts typically touched when trying to move the car with TS deactivated.:	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:	
Tractive System Component Data Connector:	<input type="checkbox"/>	<input type="checkbox"/>	[mΩ]:	
Additional Part:	<input type="checkbox"/>	<input type="checkbox"/>	[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				
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.		
Battery Indicator	Battery Indicator has to show if voltage above 40VDC is present outside of the container	Visible check		
Vehicle Energized Light	The VEL must be switched on whenever outside of accumulator container exceeds 40V DC or 25V AC RMS	Visible check / use multimeter		
	The VEL must be clearly visible, even in bright sunlight.	Visible check		
	The VEL must be green.	Visible check		
Calculate IMD Test-Resistor Value	R Test = (max. TS voltage * 250Ω/V) - BPR	R test [kΩ]:		
IMD	IMD indicator light on dash 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.		
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 --> Handlebar shutdown button off			
	All switches on --> tether switch off			
Charging	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		
	Charging --> Shutdown button off	TS voltage must be below 40VDC in 5 sec.		
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		
!!Test at High voltages completed!! TRACTIVE SYSTEM HAS TO BE SHUT-OFF!!				
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	visible check		

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	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 1m ² (36" x 36")	visible check	
NON-COMPLIANCE / COMMENTS:			
APPROVED BY:		DATE / TIME:	