Formula-Hybrid 2018 Electrical Inspection

(Check box to the right when inspection is complete)

Note: Preliminary Electrical Inspection must be completed

before mechanical inspection or performing any work on the vehicle.

Team #	**School:**
	Vehicle Name:
	Team Leader(s):
	Faculty Advisor(s):
Rules and Safety Officer (RSO)	
	RSO Name:
	Cell Phone Number:
	Backup RSO:
	Backup RSO Cell Phone Number:
Date and Time	**Signoff By Inspector: *(Please PRINT Name)***
	Preliminary:
	Full Electrical (Documentation):
	Full Electrical (Accumulator Inspection):
	Full Electrical (Vehicle Inspection):
	Full Electrical (Pouch Cells):
	Full Electrical (Demonstration):
	Accum. Energy & Fuel Allocation:
	Safety & Charging (EV8 - Team Garage):
	Rain Test:
	Approved to Compete (Chief Inspector):

Notes

Preliminary Electrical Inspection (required prior to Mechanical Inspection)

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
Verify the following information is contained within the vehicle's <u>DOCUMENTATION/ESF</u> *[ESF paragraphs noted, as applicable]*				
Pre		1	N/A	Ensure that the team has a Tractive System Schematic. Each component of the Tractive System must be shown (Including the IMS and the AMD). Where possible, each wire in the schmatic should be marked with its wire gauge.
Pre		2	N/A	Ensure the team has dedicated Safety Circuit Schematic showing all switches, relays, and sources.
Pre		3	7.8.1	Ensure that the team has a Shutdown/Ready To Drive State Diagram (if different than Figure 40)
Operating Voltage: [ESF-2 Section 1]				
Pre		4	1.2.1	Maximum TSV operating voltage is 300V
Pre		5	1.2.1 4.1.1	GLV voltage is less than 30 Vdc or 25 Vac
Safety Circuit: [ESF-2 Section 6]				
Pre		6	7.1.3	TS shutdown circuit directly carries AIR coil current, including master, shutdown switches. A N.O. relay may be used to control AIR coils if approved by FHRC prior to event
Pre		7	7.1.1	The shutdown circuit consists of at least 2 master switches, 3 shut-down buttons, the brake-over-travel-switch, a N.O. relay controlled by the insulation monitoring device (IMD), a N.O. relay controlled by the accumulator management system (AMS), plus all required interlocks.
Pre		8	7.5.3 7.5.5 7.6.2	Big Red Buttons must be N.C., open the safety loop when pushed and must not act through logic or a microcontroller.
Pre		9	7.5.4 7.6.4	Pressing any shutdown button must open the shutdown circuit, open the AIRs, kill the engine and fuel pumps. Side mounted red buttons must shut down ALL electrical systems (with the exception of the engine starter). Control, telemetry, and instrumentation MAY remain energized if the cockpit BRB is depressed. (Refer to Figure 36)
Pre		10	2.8.1	When AIRs are open, no TS Voltage may be present outside container, including to TSMPs.
Pre		11	7.3.1 7.3.2	The GLVMS: (a) disables power to ALL electrical circuits, including the alternator, lights, fuel pump(s), ignition and electrical controls. (b) All GLV (i.e. battery, alternator) current must flow through this switch.
Pre		12	7.3.3	Vehicles with GLV charging systems such as alternators or DC/DC converters must use a multi-pole switch to isolate the charging source from the GLV (See Figure 35)
Pre		13	7.4.1 7.4.3	The TSMS must open the shutdown loop and be the last switch in the safety loop carrying the holding current to the AIRs.
Pre		14	7.2.4	The GLVMS and TSMS are direct acting, i.e. it cannot act through a relay or logic.
Pre		15	7.1.6	Electronic systems that contain internal energy storage (i.e. hold-up energy to allow an orderly shutdown of the system upon loss of the GLV) must be prevented from back-feeding power onto the GLV.
Indicator Operation: [ESF-2 Section 6]				
Pre		16	9.5.2	**REMOVABLE ACCUMULATOR CONTAINERS ONLY:** Accumulator Voltage indicator is directly controlled by HV, not software or the AIR control signal
Pre		17	9.1.1	The car is equipped with a TSAL which must be lit and clearly visible any time the AIR coils are energized
Pre		18	9.1.9 9.1.10	TSAL must be directly controlled by voltage being present at the output of the accumulator (no Software control is permitted). No TS voltage is present at the TSAL. If isolated DC/DC converter used, output of converter is ground referenced
TSMPs: [ESF-2 Section 4.3]				
Pre		19	10.3.4	The ESF shows where the TSMPs are connected to the positive and negative motor controller or inverter supply lines.
Pre		20	10.3.5	Each TSMP is protected with a 10kΩ current limiting resistor. Power rating must be 2*(Maximum_TSV^2/10k), but not less than 5W.
Pre		21		Ensure Fuse Table is attached to the ESF. Complete review will happen during the documentation stage in full inspection

Preliminary Electrical Inspection (required prior to Mechanical Inspection)

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
INSPECT *the vehicle for the following:*				
				Ground Low Voltage:
Pre		22	4.1.2	GLV battery is securely attached to frame
Pre		23	4.1.4 4.1.5	One terminal of the GLV battery or other GLV power source must be connected to the chassis by a stranded ground wire or flexible strap, with a minimum size of 12 AWG or equivalent cross-section. This ground wire must run directly from the GLV battery to the nearest frame ground and be secured at both ends.
Pre		24	6.1.6	GLV System is properly fused within close proximity to power sources (i.e. battery, alternator, etc.).
Pre		25	4.1.3	Non-grounded GLV battery terminal is insulated
				Vehicle Grounding:
Pre		26	8.1.1	Except for components of the GLV system, all metal parts accessible when the vehicle is configured for driving, maintenance, or charging have a resistance below 300 milliohm (measured at 1 amp) to the GLV system ground. This includes metal containers. Accessible parts are defined as those that are exposed in the normal driving configuration or when the vehicle is partially disassembled for maintenance or charging.
Pre		27	8.1.2	All accessible parts of the vehicle containing conductive material (including coated metal parts or carbon-fiber parts) which might contact a damaged wire or electrical part, have a resistance below 100 ohm to the GLV system ground. If no convenient conductive point is available for testing, then an area of coating may be removed to create one.
Pre		28	8.1.4	Conductors used for grounding shall be stranded and 16 AWG minimum.
				Tractive System Wiring:
Pre		29	T4.5.1 5.2.3	There are no HV components or TS wiring in the driver's compartment (Whether contained within conduit or not)
Pre		30	3.1.3	All parts of the TS circuity are protected by electrically insulating material. When the TS enclosures are in place, no conductive part of the TS circuitry can be touched with a 6 x 100 mm probe.
				TSMPs:
Pre		31	10.3.1 10.3.3	Two 4 mm, shrouded, banana-jack TSMPs are installed in an easily accessible well marked location. Access must not require the removal of body panels.
Pre		32	10.3.2	The TSMPs are protected by a non-conductive housing that can be opened without tools.
Pre		33	10.3.6	A shrouded, 4mm, banana-jack GLV ground terminal is available near the TSMP.
				Indicators and Safety Labels:
Pre		34	2.3.2	Each accumulator container MUST be prominently labeled with "ACCUMULATOR - ALWAYS ENERGIZED." Label must be 3"x9" with red letters on white background. One label MUST be visible when bodywork is in place
Pre		35	3.1.5	Every housing or enclosure containing parts of the tractive system (including accumulators) must be labeled with the words “Danger”, “High Voltage” and a black lightning bolt on a yellow background. The label must be at least 4 x 6 cm.
Pre		36	9.1.1 9.1.4	The TSAL is mounted under the highest point of the main roll hoop and helmet must not contact the TSAL
Pre		37	9.1.7	There are no other lights mounted in proximity to the TSAL.
Pre		38	9.5.1	**REMOVABLE ACCUMULATOR CONTAINERS ONLY:** There is a prominent indicator for voltage > 30V (LED or analog) when AIRs are closed. Analog electronics must be used for this indicator (no software)
				Safety Components:
Pre		39	7.2.1	There is both a Grounded Low Voltage Master Switch (GLVMS) and a Tractive System Master Switch (TSMS).
Pre		40	7.2.2	The GLVMS and TSMS are located on the right side of the vehicle, in proximity to the Main Hoop, at the driver’s shoulder height and is easily actuated from outside the car.
Pre		41	7.2.3	Both master switches must be of the rotary type, with a red, removable key (See Figure 38)
Pre		42	7.2.5	The master switches are not easily removable and not mounted onto removable body work, etc.
Pre		43	7.2.6	The function of both switches is clearly marked with “GLV” and “TSV”.
		44	7.4.2	The TSMS must be identified with a label containing a red lightning bolt in a blue triangle (see Figure 39)
Pre		45	7.5.1 7.5.2	One big red button is located on each side of the vehicle behind the driver’s compartment at approximately the level of the driver’s head. The minimum allowed diameter of the shutdown buttons on both sides of the car is 38 mm.
Pre		46	7.6.1 7.6.3	The cockpit-mounted master switch must be easily accessible by the driver in any steering wheel position. The minimum allowed diameter of the shutdown button in the cockpit is 24 mm.
Pre		47	7.5.6	Side Mounted BRBs are not easily removable and not mounted to removable body work, etc.

Preliminary Electrical Inspection (required prior to Mechanical Inspection)

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
The following is the Preliminary Demonstration. The team should be able to perform the following actions upon request. Ability to complete these actions constitute passing the applicable rules.				
Pre		48	5.1.1	Use TSMPs to check TS/GLV isolation (Resistance Check using DMM).
Pre		49	A6.4.2	Team should demonstrate their jack stand procedure. (Quick jack is not allowed for powered testing)
Pre		50	A6.4.2 12.1.1 2.9.7	RSO should explain and team should demonstrate their Lock-Out/Tag Out procedure
Pre		51	7.7.2	With meter attached to TSMPs, team should energize car. There should be a second action to put the car into “Ready-To-Drive” mode (Full demonstration of this requirement will happen during Full Inspection)
Pre		52	9.2.1 9.2.4	“Ready-To-Drive” Sound occurs (Note, dBA level will be checked at Noise Test). Vehicle makes not another sound similar to "Read-To-Drive" sound
Pre		53	9.1	TSAL is activated when AIR coils are energized: -Brightness (Visible in bright sunlight) -Color (Red) -Flash Rate (2-5 Hz) -Position (Roll Hoop) -Visibility (3m away at least 1.6m above ground - small angle blockages by roll hoop allowed) -Activated when accumulator voltage is greater than 32VDC or 1/3 max tractive
		54	12.2.15	Check that the charging port is only energized when the tractive system is energized and the TSAL is flashing. There must be no voltage present on the charging port when the tractive system is de-energized.
Pre		55	9.3	SSOK Light -Location (Near BRBs) -Color (Amber) -Label (SSOK)
Pre		56	7.2.7	Ensure both master switch handles are parallel to the fore-aft axis of the vehicle when "on"
Pre		57	2.8.3 7.5.3 7.6.2 7.6.4 9.3.3	Check operation of Side Mounted Big Red Buttons (repeat for each button) -Push-Pull or Push-Rotate Operation - Voltage should be <30V in less than 5 seconds. Time Measured _____ - Voltage meter or indicator on accumulator indicates HV until output is <30V - SSOK Lamp NOT illuminated when BRB is depressed
Pre		58	2.8.3 7.5.3 7.6.2 7.6.4 9.3.4	Check operation of Side Mounted Big Red Buttons (repeat for each button) -Push-Pull Operation ONLY - Voltage should be <30V in less than 5 seconds. Time Measured _____ - Voltage meter or indicator on accumulator indicates HV until output is <30V - SSOK Lamp remains illuminated when BRB is depressed
Pre		59	7.7.1 12.2.15	De-energize the car. While GLV is in the "OFF" position, ask team to energize TS system. TS System must NOT energize. There must be no voltage present on the charging port when the tractive system is de-energized.

Note: Preliminary Inspection Demonstration may be repeated during Full Inspection if there is any question of safety circuit operation

Notes/Actions

Full Inspection: Documentation/ESF

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
Verify the following information is contained within the vehicle's documentation/ESF: *[ESF paragraphs noted, as applicable]*				
				Fusing: [ESF-2 Section 2]
Doc		1	6.1.1 2.10.7	All electrical systems (with the exception of the pre-charge and discharge current paths) must be properly fused and adequately documented in ESF.
Doc		2	6.1.2	All conductors must be fused with a fuse rating <= current rating of conductor. (See Appendix E) Note: To know whether a vehicle passes this item, you do not need to consider the current that actually flows.
Doc		3	3.2.3 3.2.4	All wires, terminals and other conductors used in the tractive system must be sized appropriately for the continuous rating of the fuse which protects them. Insulation voltage ratings should be greater than the TS Maximum System Voltage for TS wiring. Minimum acceptable temperature rating for TS wiring is 90°C
Doc		4	6.1.3	All fuses and holders must be rated for the highest voltage in the system they protect
Doc		5	6.1.4	Fusing used for DC must be rated for DC (as noted in datasheet). Voltage rating >= maximum voltage of system used.
Doc		6	6.1.5	Interrupt rating of fuses must be greater than short circuit current.
Doc		7	6.1.7	Branch circuits must be fused if the branch wire is too small to be protected by the main fuse
Doc		8	12.2.14	The vehicle charging connection must be appropriately fused for the rating of its connector and cabling.
Doc		9	6.1.2	Series fuses must have lower rating than isolation relays (AIRs)
				Accumulator Fusing:
Doc		10	2.6.1	Each accumulator container contains at least one fuse in the high current TS path. Must be DC rated per EV6.1.4
Doc		11	2.6.2	All details and documentation for accumulator fusing, fusible links, and/or internal over current protection documented in ESF
		12	2.6.3 2.6.5 2.6.6	Are more than one cell or capacitor used to for a set of cells in parallel, and those parallel groups are then combined in series (i.e. Parallel then Series **nPmS**)? Yes [ ] No [ ]. If **Yes,** chech the following:
Doc		13		Each cell protected by fuse OR the cell/capacitor manufacturer must certify that it acceptable to use this configuration without additional fusing. Cell fuses must be rated for full TS voltage unless conditions in EV2.6.5 and EV2.6.6 are met (see rules). Cell Fuses have a current rating <= to maximum continuous discharge current of eaach cell/capacitor. High Current Series Fuse may be omitted if conductors carrying entire pack current are rated for sum of parallel fuse current rating AND cell fuses are rated to full TS voltage
		14	2.6.4	Are more than one cell or capacitor used to for a string of cells in series, and those string are then combined in parallel (i.e. Series then Parallel **nSmP**)? Yes [ ] No [ ]. If **Yes,** check the following:
Doc		15		Each string is individually protected with a fuse rated for the full pack voltage and meets EV 6.1 (General fusing rules). High Current Series Fuse may be omitted if conductors carrying entire pack current rated for sum of parallel fuse current rating.
				Motors: [ESF-2 Section 4.1]
Doc		16	A.2.1.1	Motor is electric
		17	3.1.8	Does the vehicle have outboard wheel motors completely outside the vehicle frame Yes [ ] No [ ]. If **Yes**, check the following:
Doc		18		Wheel motors interlocked into the shutdown curcuit such that it will be opened if any part of the motor is dislocated from the frame

Full Inspection: Documentation/ESF

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
				Isolation and Insulation: [ESF-2 Section 3]
Doc		19	5.1.1	All TS wiring and components must be galvanically (electrically) isolated from GLV by separation and/or insulation.
Doc		20	5.1.2 5.1.4	All isolation devices (opto-couplers, transformers, digital isolators or isolated dc-dc converters) must be rated for an isolation voltage of at least twice the maximum TS voltage.
Doc		21	3.7.5	GLV connections to the AMS are galvanically isolated.
Doc		22	5.1.3	External connections (i.e. laptop) to tractive system components are galvanically isolated with connection to frame ground. Documented in ESF
Doc		23	3.5.1	The tractive system motor(s) is connected to the accumulator through a motor controller.
Doc		24	5.4.2	Electrical insulating materials are UL (or equivalent) listed for TS insulation or TS/GLV isolation
Doc		25	3.2.6	All conduit (excluding Virtual Accumulator Conduit) must be non-metalic and UL Listed (UL recognized not acceptable). Acceptable Conduit must meet UL 1660, UL 651 or UL651A. UL 1696 Non-Metallic Protective Tubing (NMPT) is also acceptable
Doc		26	3.3.1	Conduit fitting must be designed for the conduit used. Cable glands are designed for use with shielded dual-insulated cable. Connectors used must be rated for the shielded-dual-insulated cable it terminate, latches in place to meet 200N pull test, and must meet or exceed IEC standards IP53 and IP20
				Printed Circuit Boards [ESF-2 Section 3.1]
Doc		27	5.5.1 5.5.4	Tractive system circuits and GLV circuits are on the same circuit board must be on separate, clearly defined areas of the board and clearly marked on the PCB. High resolution digital photos showing artwork AND/OR spare boards are available to certify rules complaince
Doc		28	5.5.2	Bare perforated boards may be used where both GLV and TS circuits are present on the same board IF the spacing and marking requirements in EV5.5.3 and EV 5.5.1 are met AND if the board is removable for inspection. Prototyping boards having plated holes and/or generic conductor patterns are not acceptable.
Doc		29	5.5.3	Required spacings for PCBs comply with Table 14. If a cut or hole in the PC board is used to allow the “through air” spacing, the cut must not be plated with metal and the distance around the cut must satisfy the “over surface” spacing requirement. *(See Reference Page for Table 14)*
Doc		30	5.5.5	Printed circuit boards located inside the accumulator container and having tractive system connections on them must be fused at 1 A or lower, with the exception of precharge and discharge circuits. If the fuses are located on the board, the spacing between tractive system conductors on the source side of the fuse must be at least 3.2 mm.
				IMD: [ESF-2 section 6.2]
Doc		31	7.9.1 7.9.2	IMD installed is a Bender A-ISOMETER ® iso-F1 IR155-3203 or -3204 or approved equivalent
Doc		32	7.9.3	The response value of the IMD is set to no less than 500 ohm / volt maximum tractive system operation voltage.
Doc		33	7.9.4	An insulation fault or IMD failure causes shut down of all electrical systems (with the exception of the engine starter, control, instrumentation and telemetry) and the interal combustion system. Action cannot be controlled via logic or microcontroller.

Full Inspection: Documentation/ESF

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
				AMS: [ESF-2 section 5.3]
Doc		34	2.11.1	Accumulator is monitored when both active and charging.
Doc		35	12.2.16	The external charging system must be disconnected if there is an AMS or IMD fault, or if one of the shutdown buttons is pressed.
Doc		36	2.11.4	AMS measures sufficient cell voltages (1 cell for lithium, 6 cells for PbA & NiMH)
Doc		37	2.11.5	AMS measures sufficient and representative cell temperatures per Table 11.
Doc		38	2.11.6	AMS voltage sense wires are appropriately protected by fuses or resistors. AMS boards may have integrated fuses if directly connected to cells.
Doc		39	2.11.7	Input channels of AMS used for different segments must be isolated from one another with a rating at least the maximun tractive voltage. Isolation is also requred between different sides of an SMD, HVD, fuse, or AIR.
Doc		40	2.11.8	Any GLV connection to the AMS must be galvanically isolated from the TSV
Doc		41	2.11.9	Is AMS team designed? If so, does it comply with all the the requirements of EV2.11.9? (Consult rule book)
				Accumulator and Accumulator Container: [ESF-2 Sections 5]
Doc		42	2.1.1	Acceptable technologies: Lithium Ion Batteries, NiMH Batteries, Lead Acid Batteries, or other Rechargable Batteries not listed below. Capacitors, Ultracaps, Supercaps Technologies NOT permitted: Molten Salt Batteries, Thermal Batteries, Fuel Cells, Atomic Batteries, Mechanical Flywheel Batteries
Doc		43	2.1.3	Accumulator cell quantity, configuration and manufactuer data sheets are documented
Doc		44	13.2.3	MSDS Sheets for Accumulator
Doc		45	1.2.1 2.2.1	Segment isolation meets requirements (<120V and 6MJ)? Note that this is rated energy, not FH capacity.
Doc		46	2.5.3 2.5.4 2.5.5	Mounting system for the Accumulator Container is designed to withstand 40g horizontal and 20g vertical deceleration (Min of 4, 8 mm Grade 8.8 or 5/16" Grade 5 bolts for for tube cars) see EV2.5.5 for monocoque)
Doc		47	2.4.2	Container material is fire-resistant (UL94-V0, FAR25, or equivalent).
		48	2.2.1	Segments are separated with an UL recognized (or equivalent) insulating barrier thermally rated for a minimum of 90°C and electrically rated for full TS voltage (per EV 5.4). For Lithium based cells, barrier must also be fire resistant according to UL94-V0, FAR25, or equivalent.
Doc		49	2.8.1	At least two isolation relays must be installed in every accumulator container
Doc		50	2.8.2 2.8.6	Isolation relays are of "normally open" type and held in the closed position by current flowing through the shutdown loop. Relays must open both poles of accumulator when shutdown loop current is interrupted. Relays containing mercury are not permitted
Doc		51	2.8.5	If the AIR coils are not equipped with transient supression by the manufacturer, transient supressor are added in parallel with the AIR coils
Doc		52	2.9.1	A High Voltage Disconnect (HVD) is provided to quickly disconnect the accumulator, independently of the AIR. Disconnection switch, disconnecting a main connector or removing an accessible element are all acceptable HVD implementations
				Pre-Charge/Discharge: [ESF-2 sections 4.4 and 4.5]
Doc		53	2.10.1 2.10.2	The vehicle has a means of pre-charging the intermediate circuit to at least 90% of the current accumulator voltage before closing the last AIR. A pre-charge sequence using time is acceptable (describe method).
Doc		54	2.10.4	If a discharge circuit is needed for EV2.8.3, the team has shown the calculations demonstrating that it is designed to handle the maximum discharge current for at least 15 seconds.
Doc		55	2.10.5	The discharge circuit is wired so it is always active whenever the shutdown circuit is open. The discharge circuit is fail-safe.
Doc		56	2.10.6	Pre-charge circuitry, always on discharge circuits, or components that disipate significant power must rated for maximum expected operating temperature and documented in ESF

Full Inspection: Documentation/ESF

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
				GLV/Torque Control: [ESF-2 Sections 4.2 and7]
Doc		57	4.1.7	GLV Battery Type: _____. Note: Lithium GLV batteries must be commerically assembled.
Doc		58	3.5.4	All acceleration controls signals must have error checking. All analog torque control signals must have continuous error checking which can detect open circuit, short to ground and short to sensor power and will shut down the torque production when a fault is detected. Digitial Plausibility must detect loss of communication.
		59	3.5.7 3.5.8	Are the motor controller inputs galvanically isolated from TSV? Yes [ ] No [ ].
Doc		60		If **Yes**: Motor controller input is positively bonded to GLV ground
Doc		61		If **No**: Motor controller inputs must not be in cockpit. This includes accelerator input, forward/reverse control, on/off swtiches, etc.
				General:
Doc		62	7.1.4	All components (AIR coils, switches, relay coils, etc) in the shutdown circuit must be rated for maximum continous current in the circuit
Doc		63	13.2.1	Electrical device layout is documented *accurately* in the ESF
Doc		64	13.3.1	FMEA is present and complete
Doc		65	13.2	Electrical design report is complete, understandable, and correct. (Use back for comments).

Notes/Actions

Full Electrical: Accumulator Inspection

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
Inspect the vehicle for the following:				
				Virtual Accumulator
		1	2.12	Does the vehicle have two or more accumulator containers AND does the team expect the containers to be inspected per the "Virtual Accumulator" rules? Yes [ ] No [ ] If **No**: Skip this sub-section and proceed to "Accumulator and Accumulator Container"
Accum		2	2.12.1	Each housing of the virtual accumulator must be permanently attached to the vehicle
Accum		3	2.12.2 2.12.3 2.12.4	The Interconnecting conduit(s) between housings containing accumulators must be RED (or painted red) flexible metallic liquid-tight steel electrical conduit (NEC type LFMC) securely fastened at each end with fittings rated for metallic LFMC. Use of connectors not rated for LFMC conduit between the interconnecting conduit and the housing containing accumulators, or along the length of the interconnecting conduit is not permitted.
Accum		4	2.12.5	Any unsupported length of the interconnect conduit may be no greater than 150 mm. I.e. it must be physically supported at least every 150 mm to ensure that it cannot droop or be snagged by something on the track.
Accum		5	2.12.6	Separate Conduit must be provided for individual tractive system conductors (i.e. only one high current conductor in a signal conduit and AMS wiring in a separate conduit from high current conductors) GLV may be run in its own conduit or outside of conduit
Accum		6	2.12.8	A 3-5mm drain hole must be in interconnecting conduit if it is the lowest point of the virtual accumulator
Accum		7	2.12.9	Segmentation requirements must be met considering the housings individually, and as an interconnected system. For example, AMS wires must be grouped according to segment and must maintain that grouping through to the AMS
Accum		8	2.12.10	Each individual housing must comply with TS fusing requirements. (Refer to EV 2.6)
				Accumulator and Accumulator Container
		9	2.3.5	Are there spare accumulators? Yes [ ] No [ ] If **Yes** then:
Accum		10		Are spare accumulators identical to vehicle units and presented for inspection?
		11	2.3.3	Are accumulator contents accessible? Yes [ ] No [ ] if **No** then:
Accum		12		Are adequate photos provided?
Accum		13	2.4.1 2.5.2	Container is rugged and rigidly-mounted. Materials are mechanically robust
Accum		14	2.5.1 2.12.7	Containers are within surface envelope (See IC1.5.1 for envelope). If RED Conduit is present due to a Virtual Accumulator, these conduits must also be within the surface envelope
Accum		15	2.4.8	Holes in container only for wiring, ventilation, cooling or fasteners.
Accum		16	2.4.9	An accumulator that can vent explosive gas must have a ventilation system
Accum		17	2.4.10	Sealed accumulators must have pressure release valves
Accum		18	2.4.5	External conductive container surfaces are grounded (<300mΩ to GLV Ground)
Accum		19	2.4.3	If any part of the container is made of electrically conductive material, a UL Recognized insulating barrier (thermally rated for 150°C and having minimum thickness of 0.25mm) is affixed to the inside of the container and provides 100% coverage over the conductive material.
Accum		20	2.4.4	If conductive penetrations of container are present (i.e. metal mounting hardware through plastic container wall), they are covered on the inside of the accumulator container by an UL Recognized (or equivalent) insulating material thermally rated for 150°C and is 0.25mm thick
Accum		21	2.3.1	All devices (i.e. batteries, supercaps, etc.) which store tractive system energy are enclosed within the accumulator container(s)
Accum		22	2.3.4	Accumulator Container(s) may not contain circuity or components other than the accumulator itself and necessary supporting circuitry (AIRS, AMS, Pre-charge, etc.). Teams may meet this requirement by dividing a large box into an accumulator section and non-accumulator section with an insulating barrier between them. In this case, it must be possible to open the non-accumulator section while keeping the accumulator section closed AND passing the "finger probe" test

Full Electrical: Accumulator Inspection

Complies		Line Item	Ref	Summary
Type	FH Inspector Initials			
Accumulator and Accumulator Container (Continued)				
Accum		23	2.6.1 3.2.3	Each accumulator container contains at least one fuse in the high current TS path. All TS wires, terminals and other conductors used in the accumulator must be sized appropriately for the continuous rating of the fuse which protects them. Wires must be marked with part number OR wire gauge, temperature rating and insulation voltage rating.
Accum		24	5.3.1 5.4.2	Tractive system wiring in the accumulator must be constructed using spacing, insulation, or both, in order to prevent short circuits between TS conductors. Minimum spacings are listed in Table 12. Insulation used to meet this requirement must be UL recognized (or equivalent), thermally rated for a minimum of 90°C and electrically rated for full TS voltage (per EV 5.4) *(See Reference Page for Table 12)*
Accum		25	3.2.2 3.4.1 3.4.2	Tractive system connections in the accumulator must be designed so that they use intentional current paths through conductors such as copper or aluminum (Steel is not permitted). Conductors and terminals cannot be modified from their original size/shape. Solder in the high current path is NOT permitted.
Accum		26	3.4.3	TS Connections in the accumulator must not include compressible material such as plastic or phenolic in the stack-up.
Accum		27	3.4.4	Bolts with nylon inserts (i.e. Nylocks) and thread locking compounds are not permitted in TS wiring connections in the accumulator. (All-metal positive locking nuts may be used) Metal lock washers or locking fasteners should be used if supplied or specified by the component manufacturer. Belleville (conical) metal locking washers may also be used.
Accum		28	5.4.3	Minimum Spacing/Creep Distance for conductive materials, including cell to cell connections in accumulator meets Table 12
Accum		29	2.4.6	All cells/segments must be appropriately secured against loosening inside the container
Accum		30	2.4.7	All accumulator devices are appropriately secured to the accumulator container using mechanical fasteners
Accum		31	3.6.1	At least two isolation relays must be installed in every accumulator container
Accum		32	10.4.4	AMS Test Port accessible for test and is Anderson 1327XXFP.
		33		Is the accumulator separated into multiple segments? Yes [ ] No [ ] If **Yes**, check the following:
Accum		34		Segment Maintenance Disconnects are installed between accumulator segments. HVD may serve as an SMD if it is located between segments
Accum		35	2.7.1 2.7.2 2.7.3	SMDs are switches or removable plugs that has positive means to ensure SMD remains in disconnected state. SMDs requiring tools are NOT permitted. Removable SMDs (such as a removable plug) must be non-conductive on external surfaces
Accum		36	2.7.4 2.2.1 2.12.9	Segments are separated with an UL recognized (or equivalent) insulating barrier thermally rated for a minimum of 90°C and electrically rated for full TS voltage (per EV 5.4). For Lithium based cells, barrier must also be fire resistant according to UL94-V0, FAR25, or equivalent.
Accum		37		**VIRTUAL ACCUMULATORS ONLY**: Segmentation requirements must be met considering the housings individually, and as an interconnected system. For example, AMS wires must be grouped according to segment and must maintain that grouping through to the AMS

Notes/Actions

Full Electrical: Vehicle Inspection

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
Inspect the vehicle for the following:				
				TS Wiring:
Insp		1	3.1.1	Nonconductive covers prevent inadvertent human contact with any TS circuitry. Covers are secure and rigid. No body panels function as the sole TS circuitry insulation.
Insp		2	3.2.1	All TS wiring technique is to professional standards and with adequate strain relief and protection from loosening due to vibration, etc.
Insp		3	5.3.1 5.4.2	Tractive system wiring must be constructed using spacing, insulation, or both, in order to prevent short circuits between TS conductors. Insulation used to meet this requirement must be UL recognized (or equivalent), thermally rated for a minimum of 90°C and electrically rated for full TS voltage (per EV 5.4) *(See Reference Page for Table 12)*
Insp		4	3.2.3 3.4.2	All wires, terminals and other conductors used in the tractive system must be sized appropriately for the continuous rating of the fuse which protects them. Wires must be marked with part number OR wire gauge, temperature rating and insulation voltage rating.
Insp		5	3.2.2 3.4.1 3.4.2	Tractive system connections must be designed so that they use intentional current paths through conductors such as copper or aluminum (Steel is not permitted). Conductors and terminals cannot be modified from their original size/shape. Solder in the high current path is NOT permitted.
Insp		6	3.4.3	Connections must not include compressible material such as plastic or phenolic in the stack-up.
Insp		7	3.4.4	Bolts with nylon inserts (i.e. Nylocks) and thread locking compounds are not permitted in TS wiring connections. (All-metal positive locking nuts may be used). Metal lock washers or locking fasteners should be used if supplied or specified by the component manufacturer. Belleville (conical) metal locking washers may also be used.
Insp		8	3.1.2	TS wiring must be mechanically shielded against damage from rotating or moving parts
Insp		9	3.1.6	All parts belonging to the tractive system including conduit, cables and wiring must be contained within the Surface Envelope of the vehicle such that they are protected against being damaged in case of a crash or roll-over situation or being caught (snagged) by road hazards.
Insp		10	3.1.7	Tractive system parts mounted in a position where damage could occur from a rear or side impact (below 350 mm from the ground) must be protected by a fully triangulated structure meeting T3.3 (or approved equivalents per T3.4 or T3.7)
Insp		11	3.1.9	No TS components project below the lower surface of the frame or monocoque, visible from the side or front.
Insp		12	3.2.5	All TS wiring running outside of electrical enclosures is EITHER: -Orange shielded double-insulated cable in accordance with ISO 6722 / ISO 14572 or equivalent; OR -Enclosed in orange non-conductive conduit (excluding virtual accumulator conduit)
Insp		13	3.2.8	Wiring to outboard wheel motors may be in conduit or may use shielded dual insulated cables. All other tractive system wiring that runs outside the vehicle frame (but within the roll envelope) must be within conduit.
Insp		14	3.2.9	If shielded double insulated cable used, all shields are properly terminated and grounded on both ends.
Insp		15	3.2.6	Conduit must be non-metallic and UL Listed (UL recognized not acceptable). Acceptable Conduit must meet UL 1660, UL 651 or UL651A. UL 1696 Non-Metallic Protective Tubing (NMPT) is also acceptable.
Insp		16	3.2.7	Conduit runs must be one piece. Conduit splices and/or transitions between conduit and shielded, dual-insulated cable may only occur within an enclosure and must comply with section EV3.3 (Strain Relief).
Insp		17	3.3.1 3.3.2	Cable or conduit exiting or entering a tractive system enclosure or the drive motor* must use a liquid-tight fitting proving strain relief to the cable or conduit such that it will withstand a force of 200N without straining the cable. Conduit fitting must be designed for the conduit used. Shielded dual-insulated cable must be terminated with EITHER a cable gland for the fitting used OR a connector rated for the cable used. *Drive motors that do not have provisions for conduit connections are allowed such that the TS wiring meets the finger probe probe test (EV3.1.3) AND 200N cable strain relief is within 15cm of motor terminals.
Insp		18	10.3.5	TSMP protection resistors must be located as close to the voltage source as practical.
Insp		19	3.1.10	TS components and their containers are protected from rain or splash moisture. (Visual inspection only - Will be fully tested during Rain Test)

Full Electrical: Vehicle Inspection

Complies Type	Complies FH Inspector Initials	Line Item	Ref	Summary
				TS/GLV Separation
		20	3.5.7 3.5.8	Is the motor controller inputs galvanically isolated from TSV? Yes [ ] No [ ]. *(See Documentation Section to answer)*
Insp		21		If **Yes**: Motor controller input is positively bonded to GLV ground
Insp		22		If **No**: Motor controller inputs must not be in cockpit. This includes accelerator input, forward/reverse control, on/off switches, etc.
Insp		23	5.2.1	Tractive system and GLV conductors do not run through the same conduit.
Insp		24	5.2.2	Tractive system and GLV wiring are not present together in one connector.
Insp		25	5.2.4	TS wiring is not present behind the instrument panel.
Insp		26	5.3.2 5.4.2	Where GLV and TS circuits are present in the same enclosure, they must be segregated (in addition to any insulating covering on the wire) by EITHER the distance specified in Table 12 OR a UL Recognized (or equivalent) barrier thermally rated for 150°C and is 0.25mm thick. *(See Reference Page for Table 12)*
Insp		27	5.3.3	All TS/GLV spacings must be clearly defined. Components and cables must be securely restrained to prevent movement and maintain spacing.
				HVD
Insp		28	2.9.5	The HVD is clearly marked "HVD".
Insp		29	2.9.6	Positive means of securing HVD in disconnected state exists (lockable switch, removable plug if it can't accidently connect). Procedure exist in ESF for the HVD
				Firewall:
Insp		30	T4.5.1 2.12.7	Firewalls separate driver's compartment from accumulators and lithium GLV batteries. Note: If there are RED conduits due to a Virtual Accumulator, firewall must also separate driver's compartment from these conduits
Insp		31	8.1.1 8.1.2	Firewalls comply with EV6.1.1/EV 6.1.2 grounding requirements (<300mOhm if metallic, <100 Ohm carbon fiber)
				Ground Low Voltage:
		32	4.1.6	Is the GLV Battery a Wet-Cell Battery AND located in the driver compartment? Yes [ ] No [ ] If **Yes,** check the follwing:
Insp		33		Wet-cell battery is enclosed in a nonconductive marine-type container or equivalent and include a layer of 1.5 mm aluminum or equivalent between the container and driver.
Insp		34	8.1.3	All external, uninsulated, heat sinks are grounded to the GLV system ground.
				General:
Insp		35	5.4.1 5.4.4	All electrical insulating material must be appropriate and adequately robust for the application in which it is used. Thermoplastic materials such as vinyl insulation tape may not be used. Thermoset materials such as heat-shrink and self-fusing tapes (typically silicone) are acceptable.
Insp		36	6.1.6	Fuses must be physically located at the end of the wiring closest to an uncontrolled energy source
Insp		37	6.1	Physically inspect key TS fuses
Insp		38	6.1	Physically inspect key GLV fuses

Notes/Actions

Full Electrical: Pouch Cells

Complies		Line Item	Ref	Summary
Type	FH Inspector Initials			
Note: Accumulators utilizing pouch type lithium ion cells are subject to the following rules. Do NOT complete this section if prismatic or cylindrical cells are used.				
Doc		1	2.1.2	Are pouch type lithium cells used? Yes [ ] No [ ]
Doc		2	2.1.2	Is the accumulator using pouch cells commercially constructed and specifically approved by the Rules Committee? Yes [ ] No [ ] If Yes, no further inspection needed. If No, continue inspecting pouch cells according to this inspection page.
Insp		3	11.1.1	Cells in a stack are arranged face-to-face (Edge-To-Edge is NOT allowed)
Insp		4	11.1.2	Mechanical restraining system of the pouch cell must -Be capable of applying >=10 psi without yielding for all temps <=150°C -Allow the stack to expand 8%-12% in volume before reaching 10 psi -Use fire retardant and creep immune materials -Not impinge on the cell separator internal to the cell -Be electrically insulated from the cells (if made of conductive materials) -Documented in the ESF Note: Variance may be granted against items in 11.1.2 if the team has a mechanical analysis of the proposed cell mounting structures AND EITHER -Datasheet from the manufacturer recommendations for assembly OR -A letter from the manufacturer with similar info.
Insp		5	11.1.3	A fire resistant soft elastic filler material is present between every cell. Material is evenly distributed through the stack and applying even pressure to each cell surface
Insp		6	11.1.4	Cell tabs are mechanically restrained and cannot move relative to the cell
Insp		7	11.1.4	Cell tabs are connected above the level of the tab insulator (metallic parts of the battery assembly may not bridge the insulation gap provided by the tab insulator)
Insp		8	11.1.4	Cell Tabs are insulated to prevent accidentally short circuit of adjacent cells
Insp		9	11.1.5	Cells held in position using a repeated frame (or equivalent). Frame does not change shape of the cell, impinge on the cell separator, or allow the edge of the cell to move in relation to the rest of the cell
Insp		10	11.1.6	No visible evidence of pouch cell damage due to handling or wear. No metal filing or other FOD near pouch cells
Insp		11	11.1.7	Entire stack is firmly anchored in the accumulator enclosure and clean of shavings or filings from manufacturer
Doc		12	11.1.8	All compliance information is in ESF

Notes/Actions

Demonstration (See attached procedure that covers these rules)

Complies		Ref	Summary
Type	FH Inspector Initials		
The following is the Final Demonstration. The team should be able to perform the following actions upon request. Ability to complete these actions constitute passing the applicable rules.			
Demo Step 1		A.6.4.2	Team should demonstrate their jack stand procedure. (Quick jack is not allowed for powered testing)
Demo Step 2		2.10.3 7.8.2 9.3.3	With meter attached to TSMPs, team should enable Tractive system but NOT make the car "Ready-To-Drive." Team must follow sequence of operation (Figure 40 or FHRC Approved diagram for team). Confirm Pre-Charge operated. Confirm SSOK Lights are illuminated
Demo Step 3		7.7.2 9.2.1	Ask team to slowly depress right foot pedal. Ensure the drive wheels do NOT rotate
Demo Step 4		7.7.2 9.2.1	Ask team to take second action to put the car into “Ready-To-Drive” mode. Ready-To-Drive sound must occur with second action and be audible for 1-3 seconds
Demo Step 5		3.5.2	Ask team to slightly depress the pedal to show drive wheel will rotate.
Demo Step 6		3.5.3	Ask team to release pedal to demonstrate pedal returns to original position. Ensure presence of positive stop.
Demo Step 7		3.5.4 3.5.5	Ask team to slightly depress the pedal to rotate drive wheel. Interrupt torque command signal. Torque production should stop within 1 sec . Power down the vehicle
Demo Step 8		N/A	Perform the steps 8-13 to demonstrate safety circuit operation. ***Note: Each time the car is energized, ensure two actions must be taken to achieve “Ready to Drive”***
Demo Step 9		3.5.9 7.1.1 9.3.3	Energize the vehicle. Slightly depress the right foot pedal to rotate wheels. Open the Brake Over Travel Switch (BOTS). AIRs should open and wheels should spin freely. Ensure the driver cannot reset the BOTS with foot or hand. Ensure SSOK Lights are NOT illuminated when BOTS is open
Demo Step 10		7.3.1 9.3.3	Reset Brake Over Travel Switch and energize the vehicle. Open the GLV Master Switch. AIRs should open. Ensure SSOK Lights are NOT illuminated when GLVMS is open
Demo Step 11		7.4.1 9.3.4	Close GLV Switch and energize the vehicle. Open the TSMS. Air should open. Ensure SSOK Lights remain illuminated when the TSMS is open
Demo Step 12		7.6.5 9.3.4	Close the TSMS and energize the vehicle. Ask the team to open the Big Red Button in the cockpit. AIRs should open. Ensure SSOK Lights remain illuminated when the Cockpit BRB is open
Demo Step 13		2.10.3 7.7.3	Close the Big Red Button in the cockpit. Confirm Precharge Operated. Confirm vehicle is NOT "Ready to Drive". Perform second action to achieve “Ready to Drive.”
Demo Step 14		2.10.1	Disable Vehicle and allow to complete discharge. Re-energize the vehicle, but open the cockpit big red button during the pre-charge stage. Ensure the Pre-charge is disabled.
Demo Step 15		2.11.2 9.3.3 10.4	With car de-energized, attach AMS test connector (Note: accumulator may need to be opened to access connector). Energize the vehicle. Induce an AMS fault using the AMS test setup using AMS trip levels from the ESF and within 60 seconds. AIRs should open. Ensure SSOK Lights are NOT illuminated when AMS is faulted
Demo Step 16		2.11.3 7.1.5 D7.13.7	Remove fault. Ask team to reset AMS. Ensure driver cannot reset AMS. Ensure AMS reset is properly labeled "AMS Reset"
Demo Step 17		N/A	Remove meter from TSMP and the AMS test connector. Connect GND side IMD test box
Demo Step 18		7.9.6 7.9.7 9.3.4 9.4.1 9.4.2 10.1.2	Induce fault to high pole of TS (level based on TS Voltage). Ensure shutdown occurs within 30 seconds. Fault light in cockpit labeled "IMD" or "GFD" should illuminate. Remove fault. Ensure the TS system does not re-energize (i.e. latches off due to fault). Ensure SSOK Lights are NOT illuminated while the IMD fault light is illuminated. Reset IMD (at least 1 minute after removal of fault should elapse before reset)

Demo Step 19		7.9.6 7.9.7 9.3.4 9.4.1 9.4.2 10.1.2	Induce fault to low side of TS (level based on TS Voltage). Ensure shutdown occurs within 30 seconds. Fault light in cockpit labeled "IMD" or "GFD" should illuminate. Remove fault. Ensure the TS system does not re-energize (i.e. latches off due to fault). Ensure SSOK Lights are NOT illuminated while the IMD fault light is illuminated. Reset IMD (at least 1 minute after removal of fault should elapse before reset)
Demo Step 20		7.1.5 7.9.5 D7.13.7	Ensure driver cannot reset IMD. Ensure IMD reset is labeled "IMD Reset" ***Note to Inspector: Label Vehicle with IMD Test Voltage and Shutdown Time near the TSMPs.***
Demo Step 21		N/A	Ensure vehicle is completely de-energized and remove vehicle from jack stands. All panels in the vicinity of the HVD should be attached.
Demo Step 22		2.9.2 2.9.3 2.9.4	Ask the team to designate someone other the RSO or Chief Engineer to remove the HVD in under 10 seconds from a starting position 10 feet away from the vehicle. Replace HVD
Demo Step 23		7.1	**HYBRIDS ONLY (to be performed at Noise Test after completion of Electrical Tech):** Enable the IC engine. Press the Cockpit BRBs. Ensure the IC engine turns off (Inspector optionally may also use a DMM to ensure fuel pump is disabled if it is easily accessible. Repeat for the other side mounted button and the cockpit BRB. ***Note to Inspector: If electric vehicle, mark as N/A. If hybrid, leave blank. Inspector conducting Noise Test will mark their initial after completion of Noise Test.***

The following is an optional test that <u>may</u> be performed at the discretion of the Inspector under advisement of the Chief Engineer to confirm insulation and isolation between GLV and TS			
Demo		10.2.1 10.2.2	**OPTIONAL TEST**: The insulation resistance between the tractive system and control system ground may be measured. The available measurement voltages are 250 V and 500 V. All cars with a maximum nominal operation voltage below 500 V will be measured with the next available voltage level. For example, a 175 V system will be measured with 250 V; a 300 V system will be measured with 500 V etc.
			The measured insulation resistance is >= 500 ohm/volt related to the maximum nominal tractive system operation voltage. Measurement:_____

Notes/Actions

Inspectors Reference

wire	Max fuse
24	5
22	7
20	10
18	14
16	20
14	28
12	40
10	55
8	80
6	105
4	140
3	165
2	190
1	220
1/0	260
2/0	300
3/0	350
4/0	405
250 cmils	455
300 cmils	505

Hybrid (and Hybrid In Progress)	
Endurance Energy Allocation	35.5 MJ
Maximum Accumulator Capacity	4,449 Wh
Electric	
Maximum Accumulator Capacity	5,400 Wh

Table 1 – 2017 Energy and Accumulator Limits

Chemistry	Maximum number of cells per voltage measurement
PbAcid	6
NiMh	6
Lithium based	1

Table 10 - AMS Voltage Monitoring

Formula Hybrid voltage and energy limits	
Maximum operating voltage[4] (TSV)	300 V
Maximum GLV	30 VDC or 25 VAC
Maximum accumulator segment voltage	120 V
Maximum accumulator segment energy[5]	6 MJ

Table 9 - Voltage and Energy Limits

Chemistry	Cells monitored
PbAcid	5%
NiMh	10%
Li-Ion	30%

Table 11 – AMS Temperature Monitoring

Note: C, V_{nom}, V_{peak} and Ah are device nameplate values at the 2C (0.5 hour) rate. To convert from manufacturer's data at other hour-rates, Peukert's equation should be used (see below).

Batteries:	$Energy(Wh) = (V_{nom})(Ah)(0.8)$
Capacitors:	$Energy(Wh) = \left(\frac{C(V_{peak}^{\ 2} - V_{min}^{\ 2})}{2}\right)/3600$ where V_{min} is assumed to be 10% of V_{peak}

Table 20 – Accumulator Device Energy Calculations

Liquid Fuels	Wh / Liter[26]
Gasoline (Sunoco[27] Optima)	2,343
Biodiesel (B100)	2,500±[28]
Ethanol (Sunoco E-85R)	1,718

Table 21 – Fuel Energy Equivalencies

For example, using 89 Maxwell MC 2600 ultracaps (2600 F, 2.7 V), the fuel equivalency would be 2.606 Wh per device, or 231.9 Wh for a bank of 89, resulting in a 99cc reduction of gasoline or 135cc reduction of E-85.

.he Peukert equation models how the capacity of a battery changes with its rate of discharge:

$$C_{0.5} / C_n = (I_{0.5} / I_n)^P$$

Where:

$C_{0.5}$ is the capacity at the 0.5 hour rate
C_n is the capacity at the "n" hour rate
$I_{0.5}$ is the current at the 0.5 hour rate
I_n is the current at the "n" hour rate, and
P is the "Peukert Number" which can be scaled from discharge curves for the battery when plotted on logarithmic axes.

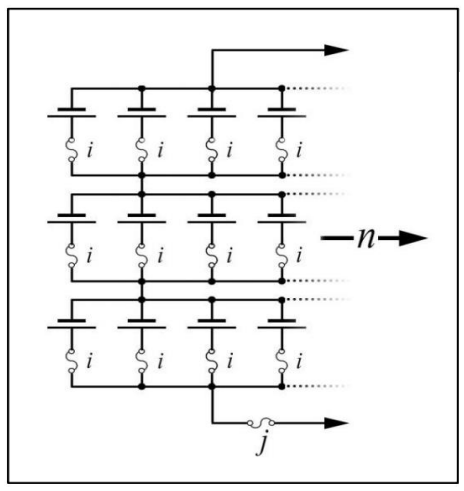

Figure 28 - Example nP3S Configuration

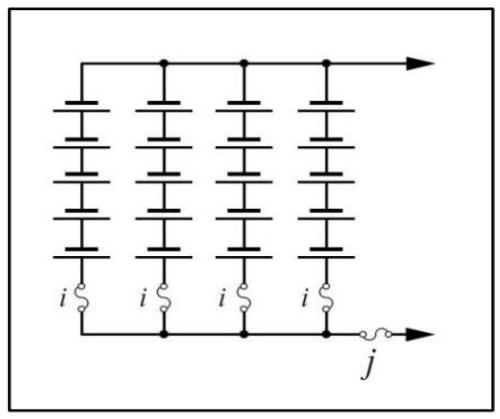

Figure 29 – Example 5S4P Configuration

		Controlled Systems				
		Engine Starter (High Current)	GLV Supply to: Instrumentation Data acquisition Computers Telemetry Etc.	I.C. Engine Ignition Fuel pumps Starter solenoid Etc.	AIRs (TS Voltage)	Fail indication extinguishes SSOK lamps
Shutdown Sources	TSMS				OFF	NO
	Cockpit BRB			OFF	OFF	NO
	Interlocks*			OFF	OFF	YES
	AMS			OFF	OFF	YES
	IMD			OFF	OFF	YES
	Brake Over-travel			OFF	OFF	YES
	Side-mounted BRBs		OFF	OFF	OFF	YES
	GLVMS	OFF	OFF	OFF	OFF	YES

*Optional interlocks as required (wheel motors, etc.)

Figure 36 - Priority of shutdown sources

Maximum Vehicle TS Voltage	TS/TS Within Accumulator Container[15]		TS/GLV
	Over Surface (Creepage)	Through Air	
V < 100 VDC	5.3 mm	2.1 mm	10.0 mm
100 VDC < V < 200 VDC	7.5 mm	4.3 mm	20.0 mm
V > 200 VDC	9.6 mm	6.4 mm	30.0 mm

Table 12 – Minimum Spacings[16]

Maximum Vehicle TS Voltage	Spacing	
	Over surface	Through air
0-150 V	6.4 mm	3.2 mm
150-300 V	8.5 mm	6.4 mm

Table 14 – PCB TS/GLV Spacings

Emergency

If an emergency crew is within sight, make contact.

Otherwise Dial 911