LFEV-Y5 v0.6

Acceptance Test Plan: v0.6

Greg Flynn

This document outlines all of the tests required to deliver LFEV-Y5. The plan is presented as an overview with the ATP number next to the test. This refers to the document that describes the test procedure. The requirements are from the SoW for 2017

Table of Contents

ATP overviews

None of these tests can be viewed as completed until appropriate documentation has been uploaded to the webpage.

Item	Item description	Demonstrated Requirements	Successful Test Criteria	Verification Method
ATP-01	Accumulator integration	R001a R001c R001d R001e R002a R002c R004a (TSV part) R005a R005b (Manual)	Packs power motor and all telemetry is recorded by VSCADA. Control by using the throttle. Verify by accelerating and looking at dash, pack screens, and log files remotely	Test
ATP-02	Charging Accumulator	R001b R001g R002b R002h	Packs charge by the charging port and open the safety loop VSCADA reacts correctly Verify by looking at the dash	Test
ATP-03	CAN Bus link	R002a R002c R002d R002e R002f R002g R002j R002k R003a(8) R003d R004a (CAN Bus part) R005a (CAN Bus part) R005c (CAN Bus part) R007c R007d	DAQ by VSCADA of TSI, GLV, TSV, Cooling. Verify by looking at cell phone and looking at dash and remote computer in each mode of VSCADA. All DAQ methods should happen simultaneously	Test
ATP-04	Safety loop	R001g R002b	Fault by: Crashing	Test

		R002c R002d R002k R002m R003b R003c R003d R004a (Safety loop part) R005c (IMD fault) R007b	BRB IMD Cooling VSCADA limit Pack fault Throttle fault Brake fault User defined limit (warn) User defined limit (halt) Pack charging Verify by looking at the dash, the remote computer and the cellphone	
~~**ATP-05**~~	~~Cruise Control~~	~~R002l~~ ~~R005b (Software)~~	~~Motor can maintain desired speed~~ ~~Verify by checking motor speed compared to target~~	~~Test~~
~~**ATP-06**~~	~~24h endurance test~~	~~GPR006~~	~~At the end of all other tests leave the car running for 24h~~	~~Test~~
ATP-07	Shutdown	R002k R002i	VSCADA works after unexpected GLV shutdown All hardware in safe state Packs stop powering motor with GLV shutdown TSI works after unexpected TSV shutdown	Test
ATP-08	GLV grounding	R003a(2)	Ensure that there is only 1 connection between ground and chassis ground	Inspection
ATP-09	Documentation	GRP001	Complete and accurate documentation	Inspection
ATP-10	Hazmat	GPR004	No hazardous materials used	Analysis
ATP-11	Safety practice	GPR005	Good practice used for safety	Inspection

ATP-12	Maintainability	GPR007	Ensure that the project is maintainable	Analysis and test
ATP-13	Demonstration	GPR011	Have a video and demo setup	Inspection
ATP-14	Disposal	GPR012	Dispose of all materials as required	Inspection

Compliance Matrix

All requirements should also have a QA by each subsystem before integration.

Requirement	Test(s) to demonstrate acceptance
R001a	ATP-01
R001b	ATP-02 OR https://sites.lafayette.edu/ece492-sp16/files/2016/05/QAR001b.pdf
R001c	ATP-01
R001d	ATP-01
R001e	ATP-01
R001f	https://sites.lafayette.edu/ece492-sp16/files/2016/05/QAR001e.pdf
R001g	ATP-02
R002a	ATP-01 or ATP-03
R002b	ATP-02
R002c	ATP-01 OR ATP-03 OR ATP-04
R002d	ATP-01 OR ATP-03 OR ATP-04
R002e	ATP-03
R002f	ATP-03
R002g	ATP-03
R002h	ATP-02 OR ATP-03
R002i	ATP-02
R002j	ATP-03
R002k	ATP-03
R002l	Waived
R002m	ATP-04
R003a(1)	Any ATP
R003a(2)	ATP-08
R003a(3)	QA by GLV
R003a(4)	ATP-02
R003a(5)	ATP-02
R003a(5)	ATP-02
R003a(6)	ATP-02
R003a(7)	ATP-02
R003a(8)	ATP-03
R003b	ATP-04
R003c	QA by GLV
R003d	ATP-03
R004a	ATP-01 AND ATP-03 AND ATP-04
R004b	QA by Interconnect
R005a	ATP-01 AND ATP-03
R005b	ATP-01 AND ATP-07
R005c	ATP-04
R005d	QA by TSI
R006	Any ATP
R007a	QA by Cooling

R007b	ATP-04
R007c	ATP-03
R007d	ATP-03
R007e	Waived
R007f	QA by Cooling
R007g	QA by Cooling
GPR001	ATP-09
GPR003	Waived
GPR004	ATP-10
GPR005	ATP-11 (MTBF + power waived)
GPR006	ATP-06 and ATP-11
GRP007	ATP-12
GPR008	ATP-09
GPR011	ATP-13
GPR012	ATP-14

Deliverables

D000: PDR

https://sites.lafayette.edu/ece492-sp17/files/2017/01/PDR_Presentation_v2.pdf

D001: CDR

https://sites.lafayette.edu/ece492-sp17/files/2017/02/2017_CDR_Presentation.pdf

D002: User Manuals

Note this is a checklist for the video

System	Getting started	FAQ	Functions and controls	Troubleshooting calibration and maintenance
TSI				
TSV				
GLV				
Cooling				
VSCADA				
Dyno room				

Attach link to each of the videos to demonstrate competing the deliverable.

D003: Final Report and Maintenance Manual

Final report

Check	Completed
Maintenance manuals completed	
3x DVD presented (or flash drive)	
DVD artwork	
ATP-09 completed	

Attach image of DVD or flash drive. Attach link to the final report with all of the documentation.

Maintenance manual

Part	TSI	TSV	GLV	Cool	VSCADA	Dyno	Andriod
Maintenance							
Calibration							
PCB schematic							
PCB BOM							
Mechanical drawing							
Mechanical BOM							
Block diagram							
Wiring diagram							
Gerber files							
QA testing							
Principal of operation							
Software binaries							
Software source							
Software make file							
ATP-12 completed							

Attach link to each of the maintenance manuals for this document.

D004: ATP

Check	Completed
Compliance matrix	
Forms present	

http://sites.lafayette.edu/ece492-sp17/testing/atp/

D005: ATR

Check	Completed
All tests included	
Test date for all tests	
Photos as required	
Tester named	
Witness signature if available	
Test results	

Attach link to the ATR.

D007: Project Website

Check	Completed
All documents as portable static documents (PDF/TXT/XML)	
Original version present	
Links to any cloud storage	

Attach link to the site for each document required.

D008: Final Presentation and Delivery

Check	Completed
GPR006	
GPR007	
GPR008	
GPR011	
D010	
Video for D009	
Video of GPR011	
Delivered per GPR012	
Any other items disposed per GPR012	

Links to the final presentation provided. Link to the video.

D009: Conference Paper, Presentation, and Video

Check	Completed
Conference video compiled	
Conference paper submitted	
Conference delivered	

Link to the paper. Link to the video.

D010: Project Poster

Check	Completed
Poster dimensions 47"x35"	
QR code to webpage	
Web link present	

Link to the poster provided.

D012: Software Maintainability Plan

https://sites.lafayette.edu/ece492-sp17/files/2017/02/MaintainabilityPlanFinal.pdf

D013: Purchasing Report

Check	Completed
Table for all purchases	
Summary based on team	
Summary based on week	

Link to purchasing reports provided.

D014: Project Management and Status Letters

Check	Completed
Status letter submitted	
WBS delivered	

Link to WBS and status letter provided.

Waived or modified requirements and questions

Requirement	Reason
R003a(4)	Cannot tell if GLV is from the battery or 24VDC
R002h	Cannot tell if GLV is from the battery or 24VDC
R007e	Waived
R005d	We've changed the switches
R002l	Waived
GPR003	Waived
GPR005	(Power and MTBF/MTTR waived)

ATP-01 checklist: Accumulator integration

Test	Pass
a) Packs can deliver 200A through TSI	
b) Voltage measured at TSVMP is as expected	
c) Throttle controls RPM	
d) Throttle implausibility causes exit of drive mode	
e) Two moves required to enter drive mode	
f) Throttle and brake together prevent drive mode from starting	
g) Throttle and brake together exit drive mode	
h) TSAL lights come on when HV present outside packs	
i) TSEL lights come on when AIRS closed	
j) RTDS come on for 1-3 seconds when drive mode entered	
k) HV present light comes on when HV present	
l) Packs display telemetry on screen	
m) VSCADA can set the throttle	
n) VSCADA can set the valve on the dyno	

Pass count: /14

(Test) Variable to measure	Value
(a) Current according to current sensor	
(a+l) Current according to pack 1	
(a+l) Current according to pack 2	
(a+l) Current according to pack 3	
(a+l) Current according to pack 4	
(a) Current according to TSI	
(b) Voltage at TSVMP with 50A load	
(b) Voltage at TSVMP with no draw	
(c) Max RPM	
(d) APPS1 voltage at implausibility	
(d) APPS2 voltage at implausibility	
(m) Max RPM	
(n) Max torque	

ATP-02 checklist: Charging Accumulator

Test	Pass
a) Safety loop opens when charging	
b) Dash board shows that packs are charging	
c) Packs can be left charging after they are full	
d) VSCADA can acquire charging graphs	

Pass count: /4

Attach VSCADA data dump showing voltage and current with respect to time. This should be an excel document with data as well as a graph.

ATP-03 checklist: CAN Bus link

Test	Seen by VSCADA	Seen by Remote	Seen by android
Cell Temperature	/28	/28	/28
Cell Voltage	/28	/28	/28
Pack Current	/4	/4	/4
Pack SoC	/4	/4	/4
Pack Status	/4	/4	/4
Pack Voltage	/4	/4	/4
GLV Voltage			
GLV SoC			
GLV Current			
GLV Temperature			
Safety loop status			
RPM gauge (Dyno)			
Strain gauge			
Throttle position			
Brake status			
IMD resistance			
FWD/REV status			
Precharge status			
MC temp			
MC current			
Cooling temp in			
Cooling flow			
Cooling temp out			
TSI temp			
Speed			
Safety loop status			

Pass count: /78

Attach excel document of data for VSCADA receiving data. Attach graphs from the android application. Attach screen shots of the remote computer in operation.

ATP-04 checklist: Safety loop

Fault	Safety loop trip (Fault lit)	Seen on VSCADA	Seen on Remote	Seen on Android
Driver resettable BRB				
Non driver resettable BRB				
Crash protection				
Over temperature cooling				
Under flow cooling				
IMD fault				
Cell overtemp				
Cell overcurrent				
Cell overvoltage				
Cell undervoltage				
Brake overtravel				
VSCADA defined violation				

Pass count: /48

Add logs from VSCADA showing faults. Add screen shots from the remote computer showing the faults. Add screen shots from the android application showing the faults.

ATP-07 checklist: Shutdown

Test	Pass
VSCADA powers up with no user input	
GLV shutdown prevents TSV being present at TSVMP	
TSVMS shutdown prevents TSV being present at TSVMP	
VSCADA has recorded data up to the shutdown	
TSVMS shutdown while under load does not create any issues	

Pass count: /5

Shutdown time (yyyy-mm-dd hh:mm:ss UTC):

Attach log from VSCADA showing data up until GLV shutdown.

ATP-08 checklist: GLV grounding

Attach image of the grounding connection.

ATP-09 checklist: Documentation

For every subassembly in a subsystem this checklist should be completed. I have attempted to capture them all but if there are parts not included they need to be added. Part numbers should go in a tree structure all the way down to commercial parts.

TSV: Pacman

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSV: AMS

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSV: Pack

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSV: Pack panel

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSV: Bus bar

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSV: Control panel PCB

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSI: Container

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSI: Front Panel

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSI: Back Panel

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSI: Bus bar 1 (AIR to connector)

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSI: Bus bar 2 (connector to connector)

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSI: PCB

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

TSI: Dyno panel

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

GLV: Container

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

GLV: Front panel

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

GLV: Back panel

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

GLV: PCB

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

GLV: Dyno panel

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

Cooling: Assembly

Check	Pass
Unique part number	
Document delivered to instructor	
Document uploaded to website	
Units defined on diagram clearly	
Have a complete BOM with document if required	
Part number on title block	
Part number on file name	
Part number on fabricated object	
Lafayette Electrical and Computer Engineering marked	
BOM had alternative or justification of only 1 supplier	

Pass count: /10
Part number:
Link:

ATP-10 checklist: Hazmat

Check	Pass
All PCBs are RoHS	
No NiCd/Pb-Acid batteries	
Dispose pre 2002/96/EC WEEE Directive	

Attach link to hazmat documentation.

ATP-11 checklist: Safety practice

Wires

Internal wiring

System	Clean cabling	No rats-nest	Color coded	Labeled
TSI				
TSV				
GLV				
Cooling				

Attach pictures of the inside of each system to document.

W1

Count: 3

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /9

Attach image as evidence

W2

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W3

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W6

Count: 6

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /18

Attach image as evidence

W7

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W11

Count: 5

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /15

Attach image as evidence

W12

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W13

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W15

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W18

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W20

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W21

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W22

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W23

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W24

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W25

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W26

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W28

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W31

Count: 7

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /21

Attach image as evidence

W32

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W33

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W34

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W35

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

W36

Count: 1

Check	Pass
Wires correctly color coded	
Cable labeled with gauge/max temperature/max voltage	
Cable labeled with reference designator	

Pass count: /3

Attach image as evidence

Indicators

IMD fault light

Check	Pass
Clear indicator of function	
Red LED	
Located in cockpit	
Illuminates when IMD resistance is low	

Pass count: /4
Attach image of illuminated light

Fault light

Check	Pass
Clear indicator of function	
Red LED	
Located in cockpit	
Illuminates when fault detected	

Pass count: /4
Attach image of illuminated light

AIRs Light

Check	Pass
Clear indicator of function	
Green LED	
Located in cockpit	
Illuminates when AIRs closed detected	

Pass count: /4
Attach image of illuminated light

Drive light

Check	Pass
Clear indicator of function	
Green LED	
Located in cockpit	
Illuminates when Drive mode entered	

Pass count: /4
Attach image of illuminated light

Safety light

Check	Pass
Clear indicator of function	
Green LED	
Located in cockpit	
Illuminates when safety loop closed	

Pass count: /4
Attach image of illuminated light

Cruise light

Check	Pass
Clear indicator of function	
Green LED	
Located in cockpit	
Illuminates when cruise mode entered	

Pass count: /4
Attach image of illuminated light

High Voltage Present light

Check	Pass
Clear indicator of function	
Red LED	
Located in cockpit	
Illuminates when HV outside of packs	

Pass count: /4
Attach image of illuminated light

Grounded Low Voltage Present light

Check	Pass
Clear indicator of function	
Green LED	
Located in cockpit	
Illuminates when GLV powered	

Pass count: /4
Attach image of illuminated light

Tractive System Energized Light

Check	Pass
2Hz-5Hz frequency when on	
Amber strobe	
Located on dyno specific panel (will be on car in future)	
Illuminates when AIRs closed	

Pass count: /4
Attach image of illuminated light

Tractive System Active Light

Check	Pass
2 lights present (LHS + RHS)	
Red lights	
Located on dyno specific panel (will be on car in future)	
Illuminates when HV present outside of car	

Pass count: /4
Attach image of illuminated light

Brake light

Check	Pass
1 light present	
Red light	
Located on dyno specific panel (will be on car in future)	
Illuminates when brake pressed and GLV on	

Pass count: /4
Attach image of illuminated light

Buttons and switches

FWD/REV switch

Check	Pass
Clearly labeled	
Key switch 2 position	
Key can be removed in either state	
Mounted on TSI box	

Pass count: /4
Attach image of button/switch:

Driver Reset

Check	Pass
Clearly labeled	
Green button	
Momentary switch	
Mounted in cockpit	

Pass count: /4
Attach image of button/switch:

Driver BRB

Check	Pass
Clearly labeled	
Red button	
Latching button, twist to unlatch	
Mounted in cockpit	

Pass count: /4
Attach image of button/switch:

Inertial switch

Check	Pass
Clearly labeled	
Inertial switch	
Resettable by driver	
Mounted in cockpit	

Pass count: /4
Attach image of button/switch:

Drive button

Check	Pass
Clearly labeled	
Tactile switch	
Momentary button	
Mounted in cockpit	

Pass count: /4
Attach image of button/switch:

Cruise button

Check	Pass
Clearly labeled	
Tactile switch	
Momentary button	
Mounted in cockpit	

Pass count: /4
Attach image of button/switch:

Scroll button

Check	Pass
Clearly labeled	
Tactile switch	
Momentary button	
Mounted in cockpit	

Pass count: /4
Attach image of button/switch:

Select button

Check	Pass
Clearly labeled	
Tactile switch	
Momentary button	
Mounted in cockpit	

Pass count: /4
Attach image of button/switch:

GLV Master Switch

Check	Pass
Clearly labeled	
Red key switch	
2 position	
Mounted on RHS panel	

Pass count: /4
Attach image of button/switch:

TSV Master Switch

Check	Pass
Clearly labeled	
Red key switch	
2 position	
Mounted on RHS panel	

Pass count: /4
Attach image of button/switch:

RHSBRB

Check	Pass
Clearly labeled	
Red button	
Latching button, twist to unlatch	
Mounted on RHS panel	

Pass count: /4
Attach image of button/switch:

RHS MReset

Check	Pass
Clearly labeled	
Green button	
Momentary switch	
Mounted on RHS panel	

Pass count: /4
Attach image of button/switch:

LHSBRB

Check	Pass
Clearly labeled	
Red button	
Latching button, twist to unlatch	
Mounted on LHS panel	

Pass count: /4
Attach image of button/switch:

PCBs

AMS

Check	Pass
Silkscreens marking reference designators	
Silkscreens marking power and critical signals	
Silkscreen showing Lafayette College, Made in USA, Electrical and Computer Engineering, part number	
Space for serial number	
Bottom copper has part number and rev	

Pass count: /5
Attach picture of front and back of PCB.

Pacman

Check	Pass
Silkscreens marking reference designators	
Silkscreens marking power and critical signals	
Silkscreen showing Lafayette College, Made in USA, Electrical and Computer Engineering, part number	
Space for serial number	
Bottom copper has part number and rev	

Pass count: /5
Attach picture of front and back of PCB.

TSI PCB

Check	Pass
Silkscreens marking reference designators	
Silkscreens marking power and critical signals	
Silkscreen showing Lafayette College, Made in USA, Electrical and Computer Engineering, part number	
Space for serial number	
Bottom copper has part number and rev	

Pass count: /5
Attach picture of front and back of PCB.

GLV PCB

Check	Pass
Silkscreens marking reference designators	
Silkscreens marking power and critical signals	
Silkscreen showing Lafayette College, Made in USA, Electrical and Computer Engineering, part number	
Space for serial number	
Bottom copper has part number and rev	

Pass count: /5
Attach picture of front and back of PCB.

Fuses

Accumulator fuse

Check	Pass
UL listed socket as a holder	
5 spares	
Easy to access	

Pass count: /3
Holder part number:
Fuse part number:
Attach image of fuse location

Pacman fuse

Check	Pass
UL listed socket as a holder	
5 spares	
Easy to access	

Pass count: /3
Holder part number:
Fuse part number:
Attach image of fuse location

TSI precharge relay fuse

Check	Pass
UL listed socket as a holder	
5 spares	
Easy to access	

Pass count: /3
Holder part number:
Fuse part number:
Attach image of fuse location

GLV high current fuse

Check	Pass
UL listed socket as a holder	
5 spares	
Easy to access	

Pass count: /3
Holder part number:
Fuse part number:
Attach image of fuse location

GLV low current fuse

Check	Pass
UL listed socket as a holder	
5 spares	
Easy to access	

Pass count: /3
Holder part number:
Fuse part number:
Attach image of fuse location

Enclosures

Pack

Check	Pass
Access panel present	
Pilot lights and indicators present	
All interconnect cables have at least 1 return signal	
PCBs are not mounted directly to enclosure	
Enclosures are grounded if they are conductive	
Labeled internally and externally	

Pass count: /6

Attach 6 images of enclosures (All views)

TSI

Check	Pass
Access panel present	
Pilot lights and indicators present	
All interconnect cables have at least 1 return signal	
PCBs are not mounted directly to enclosure	
Enclosures are grounded if they are conductive	
Labeled internally and externally	

Pass count: /6

Attach 6 images of enclosures (All views)

GLV

Check	Pass
Access panel present	
Pilot lights and indicators present	
All interconnect cables have at least 1 return signal	
PCBs are not mounted directly to enclosure	
Enclosures are grounded if they are conductive	
Labeled internally and externally	

Pass count: /6

Attach 6 images of enclosures (All views)

ATP-12 checklist: Maintainability

Software

Pacman code

Check	Pass
Version controlled	
Can startup with no input from the user	
Have an install script (.exe/make/RPM)	
Configurable without requiring a recompile	
Data stored in a well-supported format	
Any files that grow should be automatically trimmed	
A procedure for backing up data	
Passwords should be avoided	
If a port is needed it should enumerate automatically	

Pass count: /9

AMS code

Check	Pass
Version controlled	
Can startup with no input from the user	
Have an install script (.exe/make/RPM)	
Configurable without requiring a recompile	
Data stored in a well-supported format	
Any files that grow should be automatically trimmed	
A procedure for backing up data	
Passwords should be avoided	
If a port is needed it should enumerate automatically	

Pass count: /9

VSCADA code

Check	Pass
Version controlled	
Can startup with no input from the user	
Have an install script (.exe/make/RPM)	
Configurable without requiring a recompile	
Data stored in a well-supported format	
Any files that grow should be automatically trimmed	
A procedure for backing up data	
Passwords should be avoided	
If a port is needed it should enumerate automatically	

Pass count: /9

Cell application code

Check	Pass
Version controlled	
Can startup with no input from the user	
Have an install script (.exe/make/RPM)	
Configurable without requiring a recompile	
Data stored in a well-supported format	
Any files that grow should be automatically trimmed	
A procedure for backing up data	
Passwords should be avoided	
If a port is needed it should enumerate automatically	

Pass count: /9

TSI code

Check	Pass
Version controlled	
Can startup with no input from the user	
Have an install script (.exe/make/RPM)	
Configurable without requiring a recompile	
Data stored in a well-supported format	
Any files that grow should be automatically trimmed	
A procedure for backing up data	
Passwords should be avoided	
If a port is needed it should enumerate automatically	

Pass count: /9

Remote software code

Check	Pass
Version controlled	
Can startup with no input from the user	
Have an install script (.exe/make/RPM)	
Configurable without requiring a recompile	
Data stored in a well-supported format	
Any files that grow should be automatically trimmed	
A procedure for backing up data	
Passwords should be avoided	
If a port is needed it should enumerate automatically	

Pass count: /9

Hardware

Packs

Check	Pass
Recommended list of spare hardware	
Basic troubleshooting guidelines for a beginner	
Advance troubleshooting for an expert	
A beginner can diagnose a simple problem (loose connector)	
An expert can diagnose a complex problem (TBA)	

Pass count: /5
Link to documentation:

TSI

Check	Pass
Recommended list of spare hardware	
Basic troubleshooting guidelines for a beginner	
Advance troubleshooting for an expert	
A beginner can diagnose a simple problem (loose connector)	
An expert can diagnose a complex problem (TBA)	

Pass count: /5
Link to documentation:

GLV

Check	Pass
Recommended list of spare hardware	
Basic troubleshooting guidelines for a beginner	
Advance troubleshooting for an expert	
A beginner can diagnose a simple problem (loose connector)	
An expert can diagnose a complex problem (TBA)	

Pass count: /5
Link to documentation:

Cooling

Check	Pass
Recommended list of spare hardware	
Basic troubleshooting guidelines for a beginner	
Advance troubleshooting for an expert	
A beginner can diagnose a simple problem (loose connector)	
An expert can diagnose a complex problem (TBA)	

Pass count: /5
Link to documentation:

ATP-13 checklist: Demonstration

Check	Pass
1080p compressed video supplied	
Video ~5min in length	
Slideshow of final project	
Demonstration of final project	
Standalone self-contained display provided	

Pass count: /5

Attach link to video, slides and image of display.

ATP-14 checklist: Disposal

Check	Pass
All materials stored in the same room	
Webpage updated to a final version	
Old material removed from webpage	
Test equipment returned	
Trash cleaned in 400 and 401	
Items disposed in accordance with Hazmat procedures	
Paper recycled	
Webpage matches demonstration	

Pass count: /8

Attach link to disposal procedure. Attach image of clean lab at the end.

FORMULA HYBRID THE FUTURE ON TRACK.	Formula-Hybrid 2016 Electrical Inspection
Note: Preliminary Electrical Inspection must be completed before mechanical inspection or performing any work on the vehicle.	
Team #	**School:**
Date Started:	**Vehicle Name:**
Time Started:	**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
	Preliminary:
	Accum. Energy & Fuel Allocation:
	Safety & Charging (EV8 - Team Garage):
	Documentation: ESF & FMEA
	Full Electrical (Documentation):
	Full Electrical (Inspection):
	Full Electrical (Pouch Cells):
	Full Electrical (Demonstration):
	Rain Test:
	Approved to Compete (Chief Inspector):

Notes

Accumulator Data

ACCUMULATOR DATA FOR BATTERIES		
Chemistry:	**Manufacturer:**	**Part/Model number:**
Nominal Cell Voltage	Datasheet Value _____V. At 2C rate: V@80%soc= _____V V@20%soc=_____V Average =_____ V	
Nominal Cell AH	AH at 2C Rate _____AH (2C is twice the cell capacity in Amps, or the current for a discharge time of 0.5h)	
	Nominal Cell Capacity _____Wh using [ ] Datasheet or [ ] Average V	
Configuration	P/S Code: In Series: In Parallel: Total Cells:	
Total Rated Capacity: _____Wh FH Fuel Equivalency Capacity (Wh x 0.8):_____Wh (FH Rules Appendix A)		
Battery chemistry: Does cell contain metallic Li? Yes[ ] No [ ]		
Segment Energy Limit (EV3.3.3, Table 9): _____MJ _____Wh Number of Cells in Segment_____		

ACCUMULATOR DATA FOR CAPACITORS		
Chemistry:	**Manufacturer:**	**Part/Model number:**
Capacity Per Unit	**[Cell] / [Module]** Capacity (F): Maximum Operating Voltage (V):	
Configuration	P/S Code: In Series: In Parallel: Total [Cells]/[Modules]:	
Overall Capacity	# Strings Farads per String: String Max Voltage (V)	
FH Fuel Equiv. Rating	Rated Capacity: _____Wh See FH Rules Appendix A.	
Segment Energy Limit (EV3.3.3, Table 9): _____MJ _____Wh Number of Cells in Segment_____		

Notes/Actions

Preliminary Electrical Inspection (required prior to Mechanical Inspection)

Complies		Ref	Summary
Type	FH Inspector Initials		
Verify the following information is contained within the vehicle's documentation/ESF: *[ESF paragraphs noted, as applicable]*			
Operating Voltage: *[ESF Section 1]*			
Pre		1.2.1	Maximum operating voltage is 300V
Pre		1.2.2	GLV voltage is less than 30 Vdc or 25 Vac
Safety Circuit: *[ESF Section 6.1]*			
Pre		5.1.1	TS shutdown circuit directly carries AIR coil current, including master, shutdown switches.
Pre		5.1.2	The shutdown circuit consists of at least 2 master switches, 3 shut-down buttons, the brake-over-travel-switch, the insulation monitoring device (IMD), all required interlocks and the accumulator management system (AMS).
Pre		5.5.2 5.5.4	Big Red Buttons must open the safety loop when pushed and must not act through logic or a microcontroller. Normally-closed, push-pull or push-rotate are all acceptable BRBs.
Pre		5.5.3	Pressing any shutdown button must open the shutdown circuit, open the AIRs, kill the engine and fuel pumps (See Table 37 for Shutdown Priority Table).
Pre		5.6.2 5.7.2 5.7.3	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 Table 16
Pre		5.3.1 5.3.2	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		5.4.1 5.4.2 5.4.3	The TSMS: (a) must be the last switch in the safety loop carrying the holding current to the AIRs. (b) must be identified with a sticker of a red lightning bolt in a blue triangle (see Figure 34)
Pre		5.5.6	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 Sections 5.10, 6.6, 6.7]*			
Pre		3.4.7 3.4.8	**REMOVABLE ACCUMULATOR CONTAINERS ONLY:** Accumulator Voltage indicator is directly controlled by HV, not software or the AIR control signal
Pre		4.10.1	The car is equipped with a TSEL which must be lit and clearly visible any time the AIR coils are energized
Pre		4.12.3	TSVP 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 TSVP. If isolated DC/DC converter used, output of converter is ground referenced
TSMPs: *[ESF Section 1]*			
Pre		4.4.5	The ESF shows where the TSMPs are connected to the positive and negative motor controller or inverter supply lines.
Pre		4.4.6	Each TSMP is protected with an appropriately rated current limiting device (e.g., fuse or resistor).
Pre			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	Ref	Summary
Inspect the vehicle for the following:			
			Ground Low Voltage*:*
Pre		1.2.3	The GLV system is grounded to the chassis
Pre		6.1.5	GLV System is properly fused within close proximity to power sources (i.e. battery, alternator, etc).
Pre		3.8.1	GLV battery is securely attached to frame
Pre		3.8.5	One terminal of GLV battery securely fastened to frame using adequate size/length wire and robustly connected?
Pre		3.8.3	Non-grounded GLV battery terminal is insulated
			Vehicle Grounding*:*
Pre		4.3.1	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.
Pre		4.3.2	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		4.3.3	Conductors used for grounding shall be stranded and 16 AWG minimum.
			Tractive System Wiring*:*
Pre		T4.5.1	There is no HV or TS wiring in the driver's compartment (Whether contained within conduit or not)
Pre		4.5.1	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		4.4.1 4.4.4	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		4.4.2	The TSMPs are protected by a non-conductive housing that can be opened without tools.
Pre		4.4.3	The TSMP must be protected from being touched with the bare hand / fingers, even when the housing is opened.
Pre		4.4.8 4.4.9	A shrouded, 4mm, banana-jack GLV ground terminal is available near the TSMP.
			Indicators and Safety Labels*:*
Pre		4.6.1	A High Voltage sticker is applied to every container if TS voltage is > 30 Vdc
Pre		4.10.1 4.10.4	The TSEL is mounted under the highest point of the main roll hoop and helmet must not contact the TSEL
Pre		4.10.7	There are no other lights mounted in proximity to the TSEL.
Pre		3.4.7	**REMOVABLE ACCUMULATOR CONTAINERS ONLY:** There is a prominent indicator for voltage > 30V (LED or analog) when AIRs are closed
			Safety Components*:*
Pre		5.2.1	There is both a Grounded Low Voltage Master Switch (GLVMS) and a Tractive System Master Switch (TSMS).
Pre		5.2.2	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		5.2.4	The GLVMS and TSMS are direct acting, i.e. it cannot act through a relay or logic.
Pre		5.2.3	Both master switches must be of the rotary type, with a red, removable key.
Pre		5.2.5	The master switches are not mounted onto removable body work, etc.
Pre		5.2.6	The function of both switches is clearly marked with "GLV" and "TSV".
Pre		5.5.1	Three shut-down buttons are installed on the vehicle (left, right and cockpit).
Pre		5.6.1	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 40 mm.
Pre		5.7.1 5.7.5	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		5.5.5	The shutdown buttons are not to be mounted onto removable body work,etc.

Preliminary Electrical Inspection (required prior to Mechanical Inspection)

Complies Type	Complies FH Inspector Initials	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 constitutes passing the applicable rules.			
Pre		A6.4.2	Team should demonstrate their jack stand procedure. (Quick jack is not allowed for powered testing)
Pre		A6.4.2 4.7.5	RSO should explain and team should demonstrate their Lock-Out/Tag Out procedure
Pre		4.8.2	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		4.11	"Ready-To-Drive" Sound occurs
Pre		4.10	TSEL is activated when AIR coils are energized: -Brightness -Color -Flash Rate -Position
Pre		4.12	TSVP light -Location -Color -TSVP is activated when accumulator voltage is greater than 32VDC or 1/3 max tractive system bus voltage (whichever is higher)
Pre		5.2.7	Ensure both master switches are parallel to the fore-aft axis of the vehicle
Pre		5.1.3 5.5.2 5.5.3 5.7.4	Check operation of Big Red Buttons (repeat for each button) - Voltage should be <30V in less than 5 seconds. Time Measured _____ - Voltage meter or indicator on accumulator indicates HV until output is <30V -Cockpit button is resettable

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

The following is for REFERENCE ONLY with regards to demonstration requirements.			
		A6.4.2	Jack Stand Procedure (Quick Jack is not permitted for powered testing)
		A6.4.2 4.7.5	RSO can explain and team should demonstrate their Lock-Out/Tag-Out Procedure
Ready to Drive Sound			
		4.11.1	The car must make a characteristic sound, for a minimum of 1 second and a maximum of 3 seconds, when it is ready to drive.
		4.11.2	The sound emitting device must produce a tone between 2500-3500Hz at 68dB(A) at 2Ft, or be a Mallory Sonalert SC648AJR or equivalent.
Indicators:			
		4.10.5	The TSEL is clearly visible from all horizontal directions even in bright sunlight.
		4.10.2 4.10.3	The TSEL is amber and flashes continuously with a frequency of 2-5 Hz.
		4.10.6	The TSEL must be visible from a person standing up to 3m away from the TSAL itself. The person's minimum eye height is 1.6m.
		4.12	Two TSVP lights are present. Each TSVP must be each side of the roll bar near the shutdown buttons and easily seen from the side of the vehicle
		4.12.1	TSVP must be red and comply with DOT FMVSS 108 for trailer clearance lamps
		4.12.2	TSVP must be lit and visible any time the voltage outside of the accumulator container exceeds 32VDC or 1/3 maximum tractive bus voltage (whichever is higher)

Preliminary Electrical Inspection (required prior to Mechanical Inspection)			
Complies			
Type	FH Inspector Initials	Ref	Summary
Safety Circuit:			
		5.2.7	The “ON” position of both master switches is parallel to the fore-aft axis of the vehicle
		5.5.2 5.5.3	Side mounted red buttons must shut down all electrical systems. Buttons must be push pull or push-rotate where pushing the button opens the shutdown circuit.
		5.1.3	If the shutdown circuit is opened/interrupted the tractive system must be shut down by opening all accumulator isolation relays. The voltage in the tractive system must drop to under 30 VDC or 25 VAC RMS in less than five seconds.
		5.1.3	Voltage decay to under 30 VDC or 25 VAC in less than 5 seconds. Time measured_____
		5.7.4	The cockpit-mounted shutdown button must be driver resettable. If the driver disables the system by pressing the cockpit shutdown button, the driver must then be able to restore system. Restoring the system must include pulling the button back out, taking the "additional action" to re-activate motor control and make the vehicle ready to drive sound.

Notes/Actions

Full Inspection: Documentation/ESF

Complies Type	Complies FH Inspector Initials	Ref	Summary
Verify the following information is contained within the vehicle's documentation/ESF: *[ESF paragraphs noted, as applicable]*			
			Fusing:
Doc		6.1.1	All electrical systems must be properly fused
Doc		6.1.2	All conductors must be fused with a fuse rating <= current rating of conductor. Note: to know whether a vehicle passes this item, you do not need to consider the current that actually flows.
Doc		6.1.3	All fuses and holders must be rated for the highest voltage in the system they protect
Doc		6.1.4	Interrupt rating of fuses must be greater than short circuit current.
Doc		6.1.6	Branch circuits must be fused if the branch wire is too small to be protected by the main fuse
Doc		3.6.5	Series fuses must have lower rating than isolation relays (AIRs)
Doc		6.1.7	Parallel cells in a battery or cap bank individually fused or certification from mfr. attached.
Doc		6.1.8	Parallel strings in a battery or capacitor bank individually fused; full-current conductors sized for sum of ratings or separately fused.
Doc		6.1.9 6.1.10	Are any fusible links OR internal cell protection used for paralleling? If so attach documentation of 6.1.7 a,b,c.
Doc		6.1.11	Attach fusing table. All pertinent fuse information is in ESF
			Motors: [ESF Section 4.1]
Doc		A.2.1.1	Motor is electric
		4.2.3	Does the vehicle have outboard wheel motors Yes [ ] No [ ]. If Yes:
Doc			Are the wheel motors interlocked for damage scenarios.
			Isolation and Insulation:
Doc		1.2.4 1.2.5	The Tractive System is galvanically isolated from the GLV system and chassis and other conductive parts of the car.
Doc		3.7.5	GLV connections to the AMS are galvanically isolated.
Doc		4.5.4	All controls, indicators and data acquisition connections or similar must be galvanically isolated from the TS.
Doc		3.7.6	External connections (i.e. laptop) to tractive system components are galvanically isolated with connection to frame ground. Documented in ESF
Doc		2.3.1	Accelerator/Motor Controller Inputs are galvanically isolated from TS
Doc		1.2.6	The tractive system motor(s) is connected to the accumulator through a motor controller.
Doc		1.3.1	Electrical insulating materials are UL (or equivalent) listed.
Doc		4.5.10	Conduit is UL Listed for conduit. Not UL Recognized, and not sleeving. (NMPT-B is allowable only in limited situations)
Doc		1.3.1 1.3.2	Insulating material temperature rating is appropriate for location AND greater than 90C. Isolation between GLV and TS is rated for 150C
Doc		4.5.5	Appropriately insulation materials have been used for the intended vehicle location. None are below 90C. No electrical tape or coatings are used alone for insulation.
Doc		4.5.6	All wires, terminals, and conductors used in the HV are appropriate for the application and thus marked: (1) sized appropriately for the continuous current rating of the fuse protecting them and marked with the current or wire gauge, (2) temperature rated for their environment (at least 90C) (3) insulation voltage rating. The lowest insulation voltage is _____ V. Part numbers or standards designations printed on parts are documented in the Electrical design report, if needed.
Doc		4.1.1	The electrical design report contains PCB TS-GLV isolation information, including photographs if necessary.
Doc		4.1.7 4.1.8	On each **team designed PCB**, TS and GLV circuits are on separate, clearly-marked areas of the board. Spacing complies with the FH rules. Samples or photos are provided in Electrical design report. All mixed HV-GLVS PCBs are accessible for inspection.

Full Inspection: Documentation/ESF

Complies		Ref	Summary
Type	FH Inspector Initials		
			IMD: [ESF section 6.2, 6.3]
Doc		5.9.1 5.9.2	IMD installed is a Bender A-ISOMETER ® iso-F1 IR155-3203 or -3204 or approved equivalent
Doc		5.9.3	The response value of the IMD is set tono less than 500 ohm / volt maximum tractive system operation voltage.
Doc		5.9.4	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 internal combustion system. Action cannot be controlled via logic or microcontroller.
Doc		5.9.8	IMD ground connection must be wired according to MFG instructions so the ground detector is functional
			AMS: [ESF section 5.8]
Doc		3.7.1	Accumulator is monitored when both active and charging.
Doc		3.7.2	AMS measures sufficient cell voltages (1 cell for lithium, 6 cells for PbA & NiMH)
Doc		3.7.3 3.7.7	AMS measures sufficient and representative cell temperatures per Table 12.
Doc		3.7.4	AMS voltage sense wires are appropriately protected by fuses or resistors
Doc		3.7.9	Is AMS team designed? If so, does it comply with all the requirements of EV3.6.9? (Consult rule book)
			Accumulator and Accumulator Container: [ESF Sections 5]
Doc		3.1.1	Acceptable technologies: Lithium Ion Batteries, NiMH Batteries, Lead Acid Batteries, Rechargeable Batteries not listed below, Capacitors, Ultracaps, Supercaps Technologies NOT permitted: Molten Salt Batteries, Thermal Batteries, Fuel Cells, Atomic Batteries, Mechanical Flywheel Batteries
Doc		3.1.2	Have manufacturer's data sheets showing accumulator rating been submitted?
Doc		App F	MSDS Sheets for Accumulator
Doc		3.4.3	Segment isolation meets requirements (<120V and 6MJ)? Note that this is rated energy, not FH capacity. No tools required to isolate the segments
Doc		3.5.2	Mounting system is designed to withstand 20g horizontal and 10g vertical (Min 4 Bolts for tube cars, see 3.5.2 for monocoque)
Doc		3.5.5	Container material is fire-resistant
Doc		3.5.7	Segments are separated with insulating barrier. For all Lithium based cells, must also be fire-resistant
Doc		3.4.2	Each accumulator container contains at least one fuse?
Doc		3.6.1	At least two isolation relays must be installed in every accumulator container
Doc		3.6.2	Relays must open both poles of accumulator
Doc		3.6.4	Isolation relays are of "normally open" type.
Doc		3.6.6	Relays containing mercury are not permitted
Doc		4.7.1	An HVD is provided to quickly disconnect the accumulator, independently of the AIR.
Doc		3.4.10	There are no unnecessary GLV circuits in the accumulator container. AMS and AIR circuitry is acceptable. Must explain in ESF.
			Pre-Charge/Discharge: [ESF sections 5.11]
Doc		4.9.1	The vehicle has a means of precharging the intermediate circuit to at least 90% of the current accumulator voltage before closing the last AIR.
Doc		4.9.2	A pre-charge sequence using time is acceptable (describe method).
Doc		4.9.3	If a discharge circuit is needed for EV5.1.3, the team has shown the calculations demonstrating that it is designed to handle the maximum discharge current for at least 15 seconds.
Doc		4.9.4	The discharge circuit is wired so it is always active whenever the shutdown circuit is open. The discharge circuit is fail-safe.
Doc		4.9.6	Pre-Charge circuitry always on discharge circuits, or components that dissipate significant power must rated for maximum expected operating temperature and documented in ESF

Full Inspection: Documentation/ESF

Complies		Ref	Summary
Type	FH Inspector Initials		
GLV/Torque Control: [ESF Sections 7]			
Doc		3.8.4	Is GLV battery team-built lithium? If so, is protection described in ESF? Battery must have OV/UV/SC and Over Temp protection (Review)
Doc		2.2.1	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
		2.3.2	Accelerator/Motor Controller bonded to GLV Ground (i.e. negative/common tied to ground)
		…	Digital pedal position encoders must incorporate error checking
		…	All digital communications directly controlling torque production must have a timeout such that is a valid command is not received, torque production in shut down
General:			
Doc		4.1.1	Electrical device layout is documented *accurately* in the ESF
Doc		9.1	FMEA is present and complete
Doc		4.1.1	Electrical design report is complete, understandable, and correct. (Use back for comments).

Notes/Actions

Full Electrical: Inspection

Complies		Ref	Summary
Type	FH Inspector Initials		
Inspect the vehicle for the following: *Note: Those items with an * require special attention to ensure safety of tractive system.*			
			TS Wiring:
Insp*		4.5.2	Nonconductive covers prevent inadvertent contact with any TS circuitry. Covers are secure and rigid. No body panels function as the sole TS circuitry insulation.
Insp*		4.5.7	All TS wiring technique is to professional standards and with adequate strain relief and protection from loosening due to vibration, etc. Conductors and terminals have not been modified from their original size and shape and are appropriate for the use.
Insp*		4.5.15	All HV circuitry uses current paths through conventional conductor materials, such as copper or aluminum. No structural components or fasteners are used as primary conductors. No clamped connections in stressed, statically indeterminate stack-ups include materials subject to creep or plastic deformation.
Insp*		4.5.17	TS wiring must be mechanically shielded against damage from rotating or moving parts
Insp		4.2.1	All TS parts, cables, and wiring are contained within the frame, and protected from crash or roll-over per rule 4.2.1
Insp		4.2.2	If subject to potential side or rear impact, TS parts must be protected per T3.3.
Insp		4.2.4	No TS components project below the lower surface of the frame or monocoque, visible from the side or front.
Insp*		4.5.8 4.5.9	All TS wiring running outside of electrical enclosures is shielded, double insulated cable or enclosed in separate, orange, nonconductive conduit. Tractive System wiring greater than 25mm^2 may be run outside of conduit if shielded and properly terminated.
Insp		4.5.13	If shielded double insulated cable used, location of cabling is within the frame of the vehicle. Cabling outside the frame but within the surface envelope of the vehicle must be in conduit or connected to wheel motors
Insp*		4.5.16	If shielded double insulated cable used, all shields are properly terminated on both ends and connected to chassis.
Insp		4.5.10	Conduit is UL Listed for conduit. Not UL Recognized, and not sleeving. (NMPT-B is allowable only in limited situations)
Insp		4.5.12	TSV Conduit or cable is securely anchored at least at each end so that it can withstand a force of 200N without straining the cable, and must be located out of the way of possible snagging or damage.
Insp		4.5.12	Fittings/connectors must be appropriate for the conduit/cable used for the TSV. See EV4.5 for special exceptions for wheel motors
Insp		4.5.3	TS components and their containers are protected from rain or splash moisture.
			TS/GLV Separation
Insp		4.1.2	There is no connection between the frame or other conductive surface and the TS circuits.
Insp		4.1.3	There are no GLV circuits in the HV conduit or connector (except interlock connections).
Insp		4.1.5	Within each enclosure, TS and GLV circuits are separated by UL recognized 150° C insulating barriers or maintain spacing (See Table 15).
Insp		4.1.6	TS and GLV spacing is clearly evident. Parts and wires are positively secured to maintain spacing.
Insp		4.1.9 4.1.10	Bare perforated boards with both TS and GLV are inspectable and meet spacing requirements. Plated perforated board or generic conductor patterns may not be used.
			HVD
Insp		4.7.3	The HVD is clearly marked "HVD".
Insp		4.7.4	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		T4.5.1	Firewalls separate driver's compartment from accumulators and lithium GLV batteries
Insp		4.3	Firewalls comply with EV4.3 grounding requirements (<300mOhm if metallic, <100 ohm carbon fiber)
Insp		T4.5.1	Firewalls separate the driver compartment from all HV components.
Insp		4.2.5	There is insulating material between tractive system terminals and firewall if within 2"

		Accumulator and Accumulator Container	
Insp		3.2.1	Accumulator is segmented and enclosed?
		3.2.2	Are there spare accumulators? Yes [ ] No [ ] If Yes then:
Insp			Are spare accumulators identical to vehicle units and presented for inspection?
		3.2.3	Are accumulator contents accessible? Yes [ ] No [ ] if No then:
Insp			Are adequate photos provided?
Insp		3.4.1	Is cell to container (if conductive) insulation adequate?
Insp		3.4.1	External conductive container surfaces are grounded?
Insp		3.4.1	If conductive penetration of container are present, they are located outside of and cannot penetrate insulative barrier
Insp		3.4.4 3.4.5	SMD Connect (if needed) is a switch or a removable plug and has positive means to ensure SMD remains in disconnected state Note: Use of Tools to isolate segments in NOT acceptable
Insp		3.4.3	Segment isolation means meets requirements (<120V and 6MJ energy)? Note that this is rated energy, not FH capacity.
Insp		3.4.6	There are no soldered connections to cells in the high current path
Insp		3.4.9	Minimum Spacing/Creep Distance for conductive materials, including cell to cell connections in accumulator meets Table 10
Insp		3.5.1	Container is rugged and rigidly-mounted.
Insp		3.5.3	Containers are within surface envelope (See IC1.5.1 for envelope)
Insp		3.5.4	Materials are mechanically robust
Insp		3.5.6	Cells are appropriately secured using mechanical fasteners
Insp		3.5.7	Segments are separated with insulating barrier. For Lithium based cells, must also be fire resistant
Insp		3.5.8	Holes only for wiring, ventilation, cooling or fasteners. See EV4.5
Insp		3.4.9	Container must adequately enclose accumulator
Insp		3.5.10	An accumulator that can vent explosive gas must have a ventilation system, or..
Insp		3.5.11	Sealed accumulators must have pressure release valves
Insp		3.6.1	At least two isolation relays must be installed in every accumulator container
Insp		3.6.3	When open, no TS Voltage may be present outside container, including to AMS.
Insp		4.1.4	There are no unnecessary GLV circuits in the accumulator container. AMS and AIR circuitry is acceptable. Must explain in ESF.
Insp		3.5.9	Accumulator is marked "High Voltage" sticker. See 3.5.9 for sticker guidelines
		Ground Low Voltage:	
Insp		3.8.2	Wet cell GLV batteries in driver's compartment must have container and barrier
Insp		4.6.3	All external, uninsulated, heat sinks are grounded to the GLV system ground.
		General:	
Insp		4.6.1	Every housing or enclosure containing parts of the TS (except motor housings) is labeled with a "High Voltage" sticker.
Insp		4.6.2	All electrically conductive or potentially conductive TS housing materials have a low-resistance (under 300 milliohm) connection to GLV system ground.
Insp		4.5.14	Wheel Motors ONLY: at least one wire of the interlock system must accompany each conduit or cable to wheel motor
Insp		3.7.10	AMS Test Port accessible with jumper/connector for normal operation installed?(Molex or 4 Shrouded Banana)?
Insp		1.3.3	Vinyl electrical tape and rubber-like paints and coatings are not used for insulating materials.
Insp		6.1.5	Fuses must be physically located at the end of the wiring closest to an uncontrolled energy source
Insp		6.1	Physically inspect key TS fuses
Insp		6.1	Physically inspect key GLV fuses

Notes/Actions

Full Electrical: Pouch Cells (Not applicable)

Complies		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		3.9	Are pouch type lithium cells used? Yes [ ] No [ ]
Insp		3.9.1	Cells in a stack are arranged face-to-face (Edge-To-Edge is NOT allowed)
Doc		3.9.2	Did team request variance from 3.8.2 from rules committee? Yes [ ] No [ ]. If No, then review documentation for compliance to 3.8.2 below:
		-	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
Insp		3.9.3	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		3.9.4	Cell tabs are mechanically restrained and cannot move relative to the cell
Insp		3.9.4	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		3.9.4	Cell Tabs are insulated to prevent accidentally short circuit of adjacent cells
Insp		3.9.5	Cells held in position using a repeated frame (or equivalent). Frame does not change shape of the cell, inpinge on the cell separator, or allow the edge of the cell to move in relation to the rest of the cell
Insp		3.9.6	Entire stack is firmly anchored in the accumulator enclosure and clean of shavings or filings from manufacture

Full Electrical: Virtual Accumulator

Complies		Ref	Summary
Type	FH Inspector Initials		
Note: Vehicles with multiple interconnected accumulator containers may be considered as a single "Virtual Accumulator Container" if the			
Doc		3.3	Does the vehicle has multiple interconnected containers and does team desire for the vehicle for the accumulators to be considered as a "Virtual Accumulator Container? Yes [ ] No [ ]. If yes, continue with the following inspection
Insp		3.3.5	All accumulators are NOT removable
Insp		3.3.1 3.3.2	The interconnecting conduit that contain high current tractive wiring is red (or painted red) flexible metallic liquid tight steel electrical conduit (NEC type LFMC). Conduit containing GLV, AMS wiring, etc may be red or orange non-metallic conduit
Insp		3.3.1	The interconnecting conduit is securely fastened at each end with fitting rated for metallic LFMC and are properly grounded to the GLV ground (<300mOhm)
Insp		3.3.3	The interconnecting conduit is supported every 150mm (~6 in)
Insp		3.3.4	Separate interconnecting conduit are used for the following: (a) Individual Tractive System Conductors (one conductor per "high-current" TSV conductor) (b) GLV level wiring (c) AMS wiring (i.e. sense wires that are at TS potential)
Insp		3.3.7	If an interconnecting conduit is the lowest point in the virtual accumulator housing, it has a 3-5mm drain hole in its lowest point
Insp		3.3.8	Accumulator segmentation is satisfied at the individual accumulator level AND at the virtual accumulator level

Notes/Actions

Final Demonstration (See attached procedure that covers these rules)

Complies		Ref	Summary
Type	FH Inspector Initials		
The team should be able to perform any of the following actions upon request. Ability to complete these actions constitutes 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		4.7.5	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)
Demo Step 3		2.1.1	Ensure torque control is actuated by a right foot pedal.
Demo Step 4		N/A	Ask team to slightly depress the pedal to show drive wheel will rotate.
Demo Step 5		2.1.2	Ask team to release pedal to demonstrate pedal returns to original position. Ensure presence of positive stop.
Demo Step 6		2.2	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 7		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 8		5.1.6 5.8	Energize the vehicle. Slightly depress the right foot pedal to rotate wheels. Open the Brake Over Travel Switch. AIRs should open and wheels should spin freely. Ensure the driver cannot reset the brake over travel switch with foot or hand
Demo Step 9		1.2.7	Reset Brake Over Travel Switch and energize the vehicle. Open the GLV Master Switch. AIRs should open.
Demo Step 10		5.4.1	Close GLV Switch and energize the vehicle. Open the TSMS. Air should open
Demo Step 11		4.8	Close the TSMS and energize the vehicle. Ask the team to open the Big Red Button in the cockpit. AIRs should open. Close the Big Red Button in the cockpit. AIRs should NOT close. Perform second action to achieve "Ready to Drive." AIRs should close.
Demo Step 12		4.9	Open any big red button during the pre-charge stage. Ensure the Pre-charge is disabled.
Demo Step 13		3.7	With car de-energized, attach AMS test connector. Energize the vehicle. Induce an AMS fault using the potentiometer based on the ESF. AIRs should open. Remove fault. Ask team to reset AMS. Ensure driver cannot reset AMS.
Demo Step 14		N/A	Remove meter from TSMP and the AMS test connector. Connect IMD test box
Demo Step 15		5.9	Induce fault to high pole of TS (level based on TS Voltage). Ensure shutdown occurs within 30 seconds. Fault light in cockpit should illuminate. Remove fault. Ensure the TS system does not re-energize (i.e. latches off due to fault)
Demo Step 16		5.9	Induce fault to low side of TS (level based on TS Voltage). Ensure shutdown occurs within 30 seconds. Fault light in cockpit should illuminate. Remove fault. Ensure the TS system does not re-energize (i.e. latches off due to fault)
Demo Step 17		5.9.5	Ensure driver cannot reset IMD
Demo Step 18		4.7	Remove the HVD in under 10 seconds (Ensure no panels could interfere with the HVD removal). Replace HVD
Demo Step 19		5.5.3	**HYBRIDS ONLY (to be performd in a designated area):** With the vehicle on the jack stands, enable the IC engine. Press one of the side mounted BRBs. Ensure the IC engine turns off (Inspector optionally may also use a DMM to ensure fuel pump is disabed if it is easily accessible. Repeat for the other side mounted button and the cockpit BRB.

The following is for REFERENCE ONLY with regards to demonstration requirements.			
Torque Control:			
Demo		2.1.1	Torque control sensor actuated by a right foot pedal
Demo		2.1.2	Foot pedal returns to original position when not actuated and has positive stops to protect sensor
Demo		2.2.1	All plausibility detections schemes must detect and shutdown torque production within 1 second of the errors first occurrence or loss of communication.
Demo		2.2.2	Teams must be prepared to demonstrate error detection at Electrical Tech Inspection. Unplugging a connector is an acceptable method of demonstration
Safety Circuit/Shutdown			
Demo		5.8.1	The brake over-travel switch shuts down the tractive system, the IC engine and the fuel pumps
Demo		5.8.2	The brake over-travel switch is not driver-resettable
Demo		5.1.6	Check that motor spins freely when TS is deactivated.
Demo		1.2.7	The GLV system must be energized in order to activate the tractive system. If the GLV system shut down, the tractive system must de-activate immediately.
Demo		4.7.6 4.7.6 4.7.7	The team can remove the HVD in under 10 seconds, from the ready-to-drive condition, without the use of tools
Demo		4.8.1	The driver can make the car ready to drive without assistance. For AMS, IMD, or other inaccessible shutdown circuit opens, the drives alone cannot make the car ready-to-drive.
Demo		4.8.1	The driver must be able to re-activate or reset the tractive system from within the cockpit without the assistance of any other person except for situations in which the AMS or IMD have shut down
Demo		4.8.2	At least one action in addition to enabling the shutdown circuits is required to set the car to ready-to-drive mode. A start button shall not be such that it can inadvertently be left in the “on” position.
Demo		4.9.1	The precharge is disabled by an opened shutdown circuit.
Demo		4.9.5	Pre-Charge circuit must operate regardless of the sequence of operation used to energize the vehicle (i.e. restarting after automatic shut down of safety circuit
Demo		5.1.7 5.1.8	Shutdown circuit operates to state diagram in Figure 31
AMS			
Demo		3.7.8	AMS disables all electrical systems, disables IC drive system, and opens AIRs until manually reset by other than driver.
Demo		3.7.10	Does AMS trip at level documented in ESF?
IMD			
Demo		5.1.5	The driver must not be able to re-activate the tractive system from within the car in case of an AMS or IMD fault. Wireless reset shutdown circuit is not permitted
Demo		5.9.5	TS remains inactive until manually reset by other than the driver (IMD Fault). Driver must not be able to reset an IMD fault from within the car.
Demo		5.9.6 5.9.7	A red indicator light in the cockpit indicates IMD status. It is visible in bright sunlight, and marked "IMD" or "GFD".
		7.1	The IMD test is passed if the IMD shuts down the tractive system within 30 seconds at a fault resistance of 250 ohm/volt (50% below the response value) - Note: Proper wiring proven through successful testing of the IMD
Demo			IMD test. Shuts down HV?_____ Latches off?_____ Labeled cockpit light?_____
Demo		7.2	The insulation resistance between the tractive system and control system ground will be measured during Electrical Tech Inspection. 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.
Demo			The measured insulation resistance is >= 500 ohm/volt related to the maximum nominal tractive system operation voltage

Notes/Actions

EV8 - High Voltage Procedures and Tools

This form is completed in the team's garage.

Complies		Ref	Summary
Type	FH Inspector Initials		
Charging Systems			
S&C		8.1.1	Team knows the location of the designated charging area
S&C		EV3.4.3	Are the accumulator energy and voltage levels below the segmentation limit? Yes [ ] No [ ]. Complete Table on Page EV3.
S&C		8.1.2	Vehicle has maintenance plugs
S&C		8.1.3 8.1.4	Team has appropriate insulated tools for working on the accumulator. Visible "High Voltage" sign displayed when working on the accumulator
S&C		8.2.5	Has a label prepared complying with EV8.2.4: Team name and Safety Officer phone number(s).
S&C		8.2.6	No exposed connections during charging
S&C		8.2.9	Review Charging Process with Inspector
S&C		8.2.11	High voltage wiring to/from an off board charger is UL listed. All flexible cables comply with NEC Article 400; double insulated.
S&C		8.2.12	Charger is UL listed (or waiver approved by FHRC)
S&C		8.2.14	Charging port is only energized when the tractive system is energized and TSEL is flashing. Charging system is disconnected if safety circuit is opened
Accumulator Hand Cart			
S&C		8.3.1	Team has accumulator hand cart? Yes [ ] No [ ]. If Yes, then:
S&C		8.3.2	Cart has dead man's switch
S&C		8.3.3	Brake capable of full stop when loaded with accumulator
S&C		8.3.4	Hand cart rated for accumulator load
Required Tools			
S&C		8.4	**Tools required:**
S&C			a. Insulated screw drivers
S&C			b. Multimeter with protected probe tips
S&C			c. Insulated wrenches, if screwed or bolted connections are used in the tractive system
S&C			d. Face shield which meets ANSI Z87.1-2003
S&C			e. HV insulating gloves which are within test date and protective outer glove
S&C			f. 2 HV insulating blankets of sufficient size to cover accumulator
S&C			g. Safety glasses with side shields for all team members which meet ANSI Z87.1-2003
S&C		Appendix F	Fire Extinguishers
S&C		Appendix F	Chemical Spill Absorbent & MSDS for Accumulator
S&C		Appendix F	Describe team response to an accumulator fire and to an electrolyte spill

Notes/Actions

Inspectors Reference

Enclosure segregation:			
Barrier rated for electrical insulation, 150 C or higher OR			
Spacing of		**Voltage between**	
1 cm	0.4 inch	0	100
2 cm	0.75 inch	100	200
3 cm	1.2 inch	200	

Circuit boards			
Voltage	**Over Surface**	**Thru Air**	**Under Coating**
		(Cut in board)	
0-50	1.6 mm (1/16”)	1.6 mm (1/16”)	1 mm
50-150	6.4 mm (1/4”)	3.2 mm (1/8”)	2 mm
150-300	9.5 mm (3/8”)	6.4 mm (1/4”)	3 mm
300-400	12.7 mm (1/2”)	9.5 mm (3/8”)	4 mm

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

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 – 2016 Energy and Accumulator Limits

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 22 – Accumulator Device Energy Calculations

Liquid Fuels	Wh / Liter[15]
Gasoline (Sunoco[16] Optima)	2,343
Biodiesel (B100)	2,500±[17]
Ethanol (Sunoco E-85R)	1,718

Table 23 – 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.

6.10.5 Any time a vehicle is energized and capable of electric motion (See section 3.1.5) the drive wheels must be supported clear of the ground or removed, complying with the requirements of Section 6.10.6.

6.10.7 Safety glasses must be worn at all times while working on a vehicle, and by anyone within 10 ft. (3 meters) of a vehicle that is being worked on.

4.11 Energized electrical work is any work to be performed where energized high voltage will be exposed and present and the vehicle will be energized for testing. Teams must receive approval from an electrical safety inspectors prior to any energized electrical work being performed. Inspectors will review the work to be done with the team and upon approval place a "Danger High Voltage" work sign outside the pit. During the energized electrical work the number of people in the pit area may be limited by the electrical inspectors. Failure to follow this rule will result in disqualification from the event in progress.

Charging must be attended by someone knowledgeable, no other work

on car (elec or mech) Medical emergency procedure (direct ambulance

crew contact during hours they are on site)

If an emergency crew is within sight, make contact. Otherwise Dial 911

Maximum Vehicle TS Voltage	Spacing	
	Over Surface	Through Air
0-150 VDC	6.4 mm (1/4")	3.2 mm (1/8")
150-300 VDC	9.5 mm (3/8")	6.4 mm (1/4")

Table 10 - Accumulator spacing

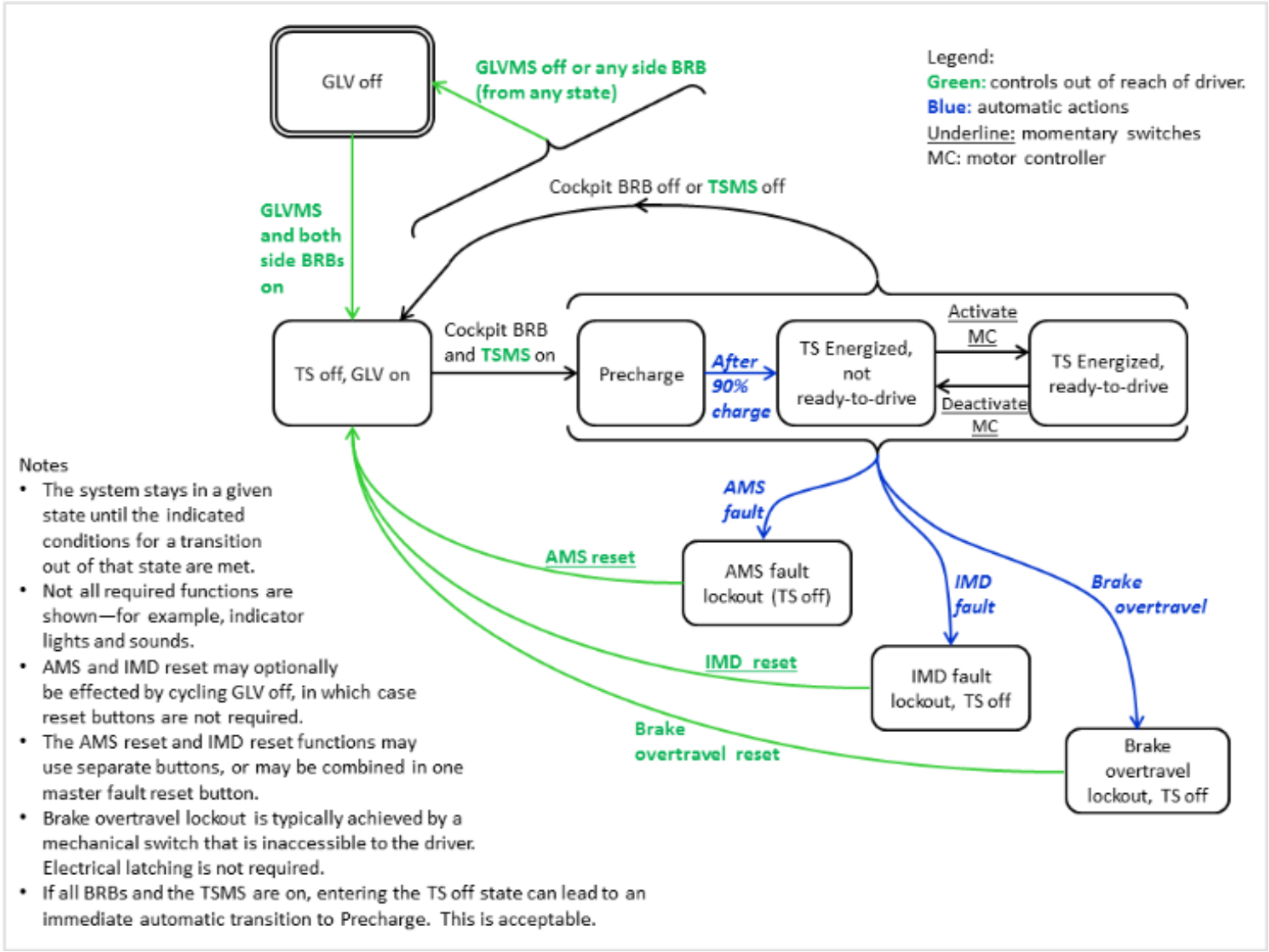

Figure 1 - FSM for TSI

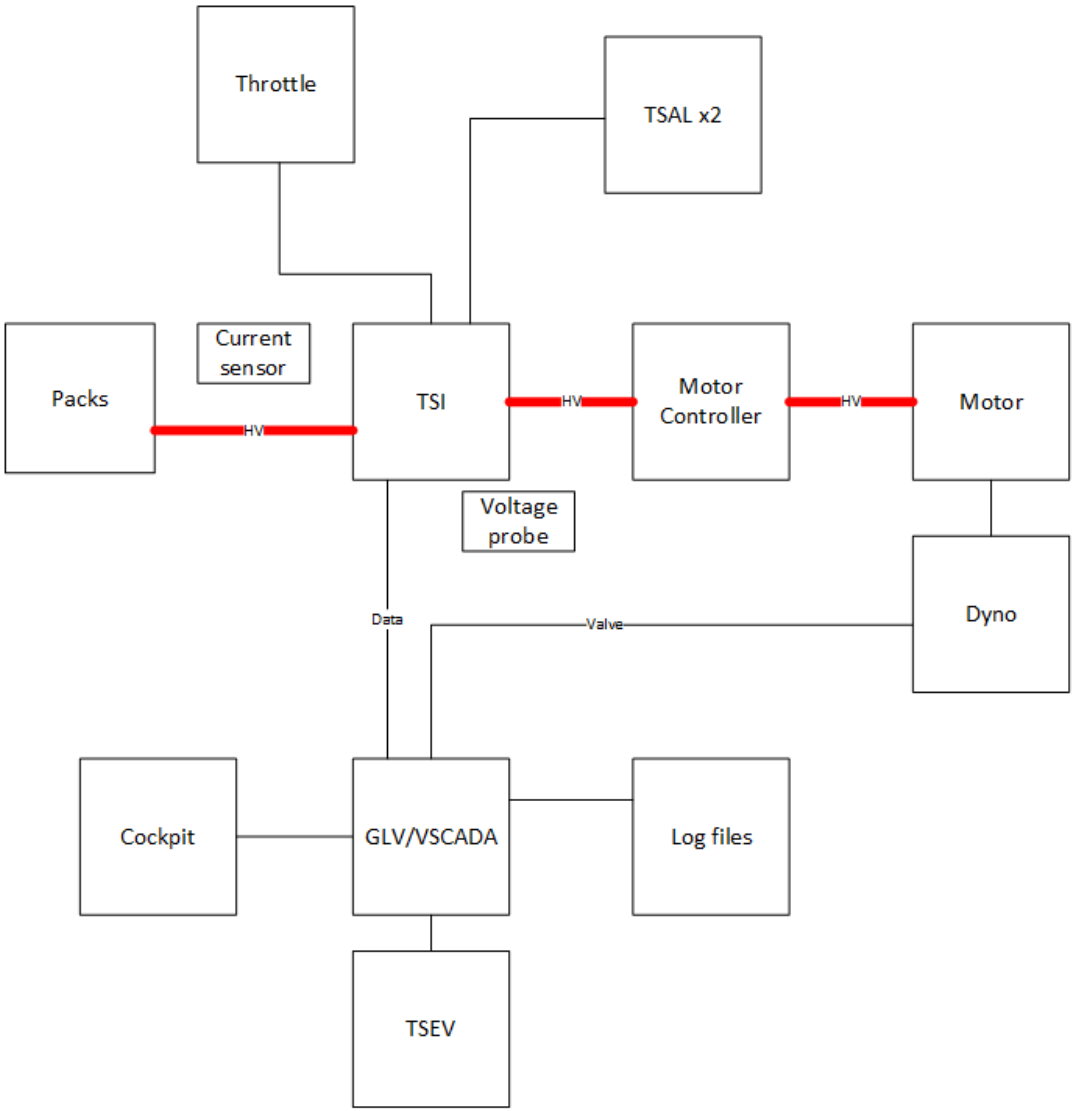

Figure 2 - ATP-01 block diagram

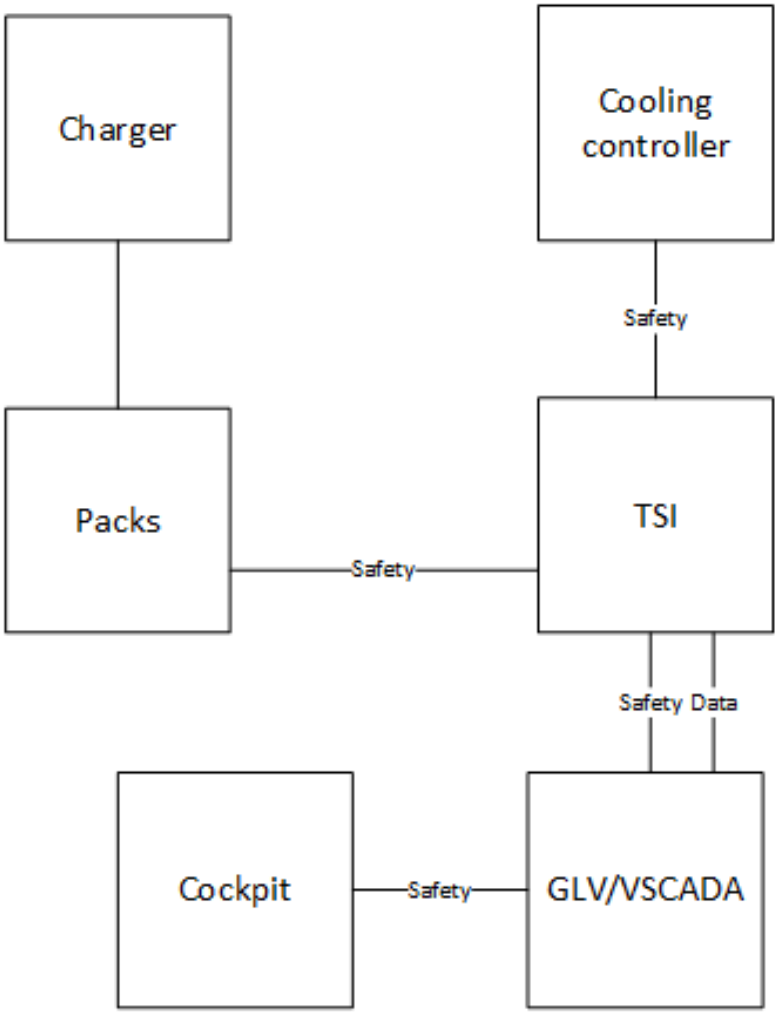

Figure 3 - ATP-02 block diagram

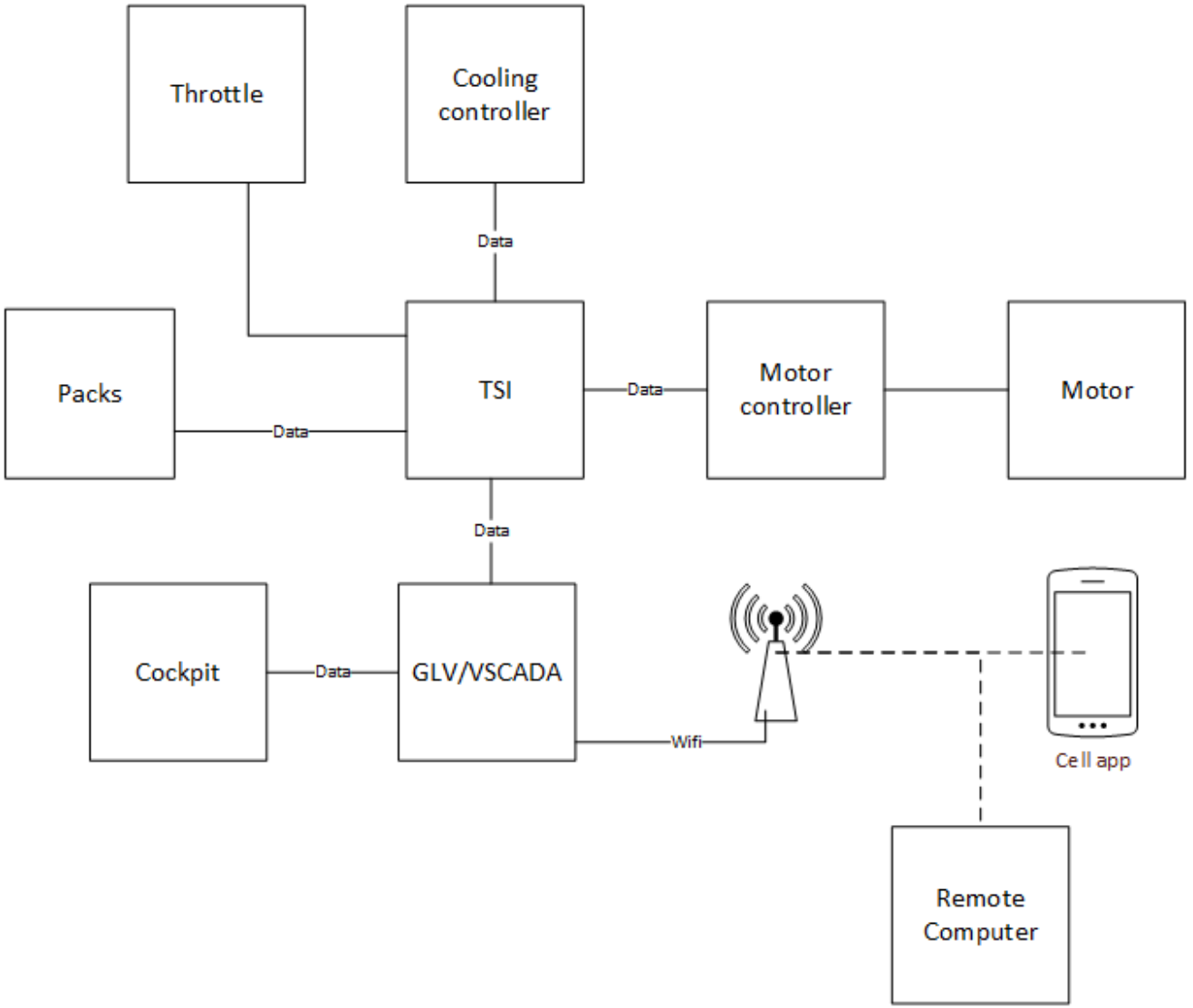

Figure 4 - ATP-03 block diagram

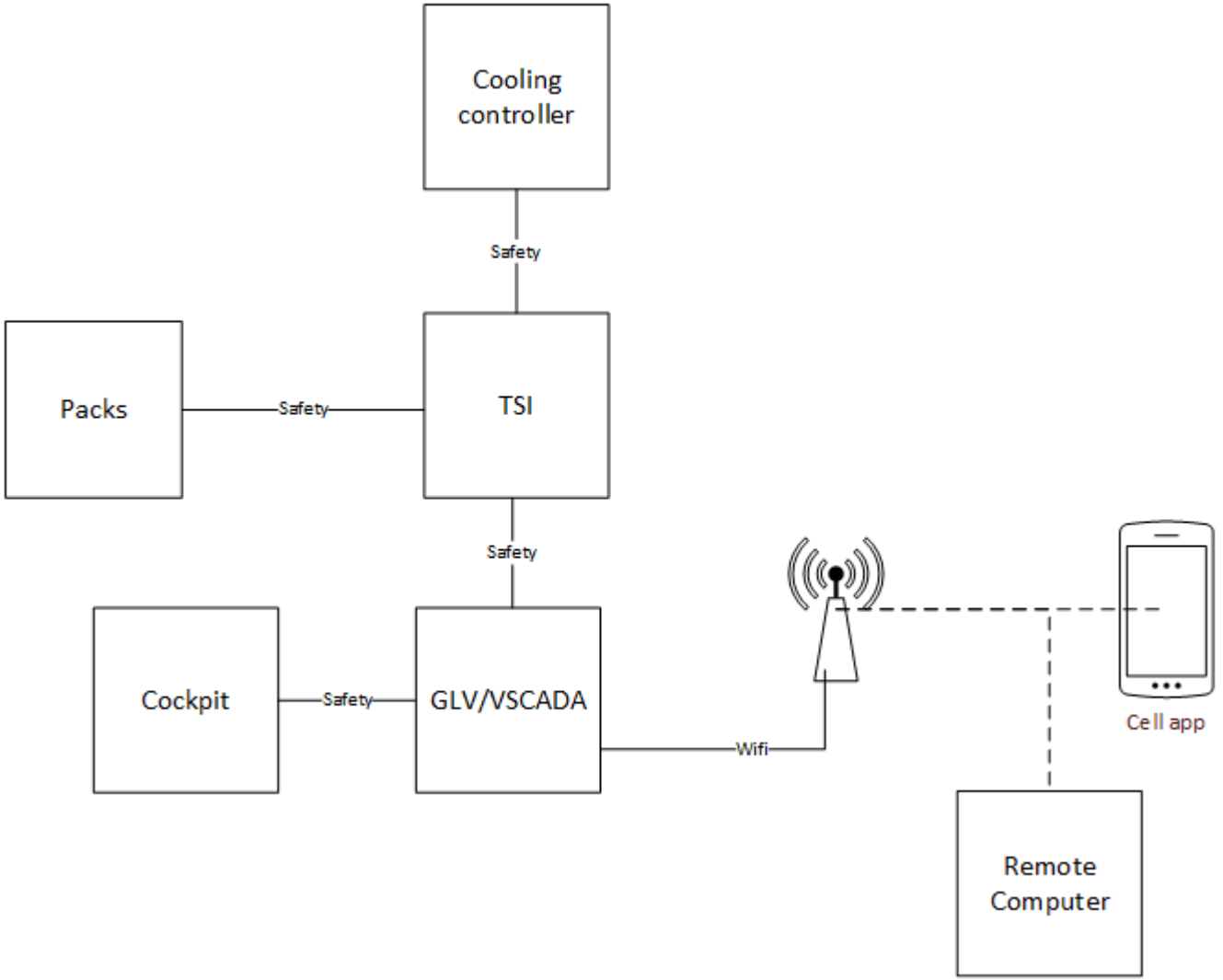

Figure 5 - ATP-04 block diagram