Item 2 - Safety Loop Test

To: LFEVY42016 Team
From: Timothy Andrews
Date: 5/10/2016
Subject: Acceptance Test Report: Item 2

Item Overview

The test configurations show that the AIRs can be opened and closed with the presence of the 24V safety loop voltage. This safety loop voltage is monitored and can be controlled by scada and the external E-stop buttons. The safety system tests will also show that isolation is monitored between the low voltage systems and high voltage systems and safety loop voltage will be cut when isolation fails. And finally the TSI will be tested to insure minimal functionally for the motor controller. (open close pre-charge relay)

Requirements Analysis

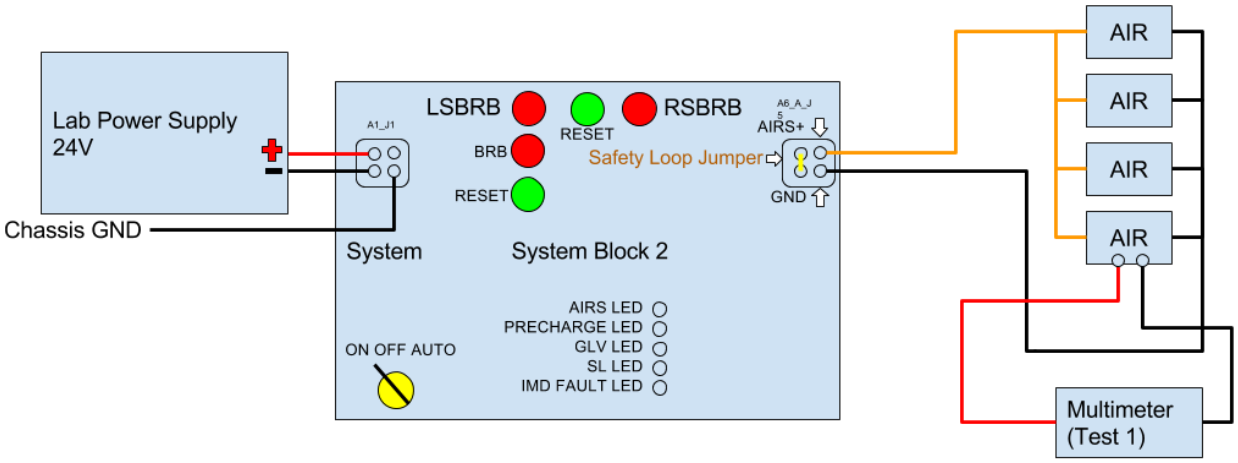
The following chart details the requirements that are tested with this item:

R001: TSV Battery Pack Accumulator					
SOW Req. #	Description	Team Member	ATP Item	P/F	Grade
R002b	Safety Loop Integration	Brendon	2	P	50%
R002m	Modular Data Acquisition System	Nick	1, 2	P	100%
R002o	Event Logging	Brendon	2	F	0%
R003b	GLV Safety Loop	Tim	2	P	100%
R003c	Vehicle User Interface Panels	Tim	1, 2	P	100%
R003d	Tractive System Interface	Brandon	1, 2	F	0%
R003e	VCI Hardware	Joe	2	P	100%

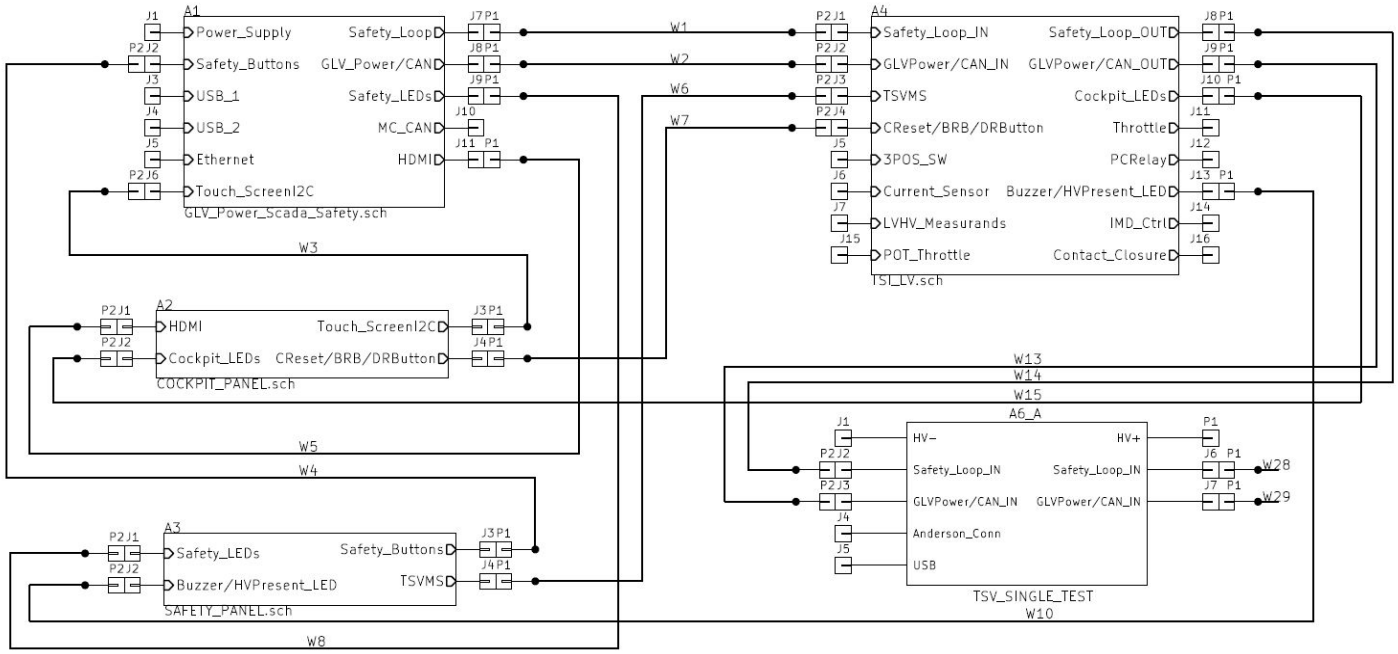
Total Number of Tests: 12
Total Number of Failed Tests: 3
Total Number of Passed Tests: 9
Grade for Item 2: Passed Tests/Total Test => 75% for Item 2

Configuration Diagram

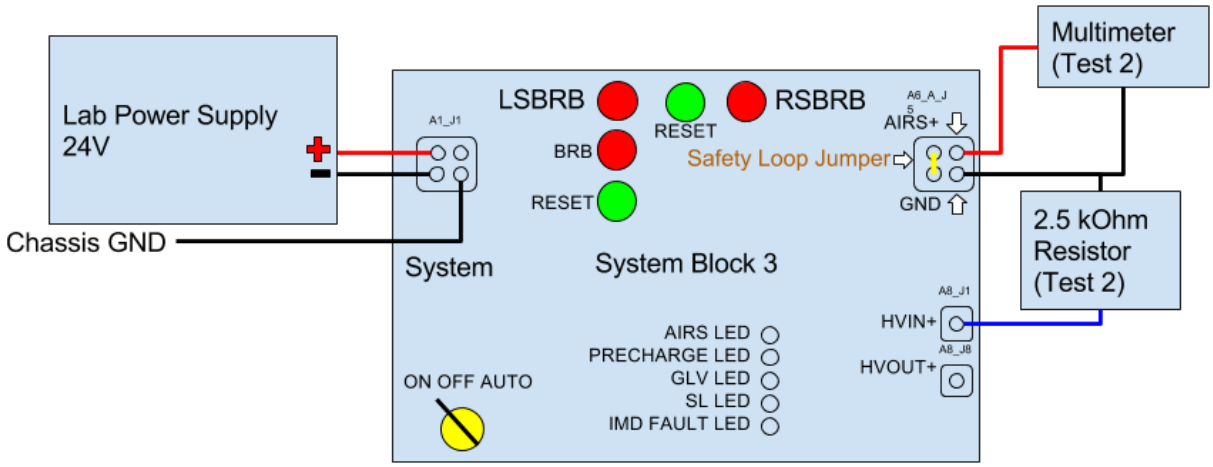
Test Configuration 1



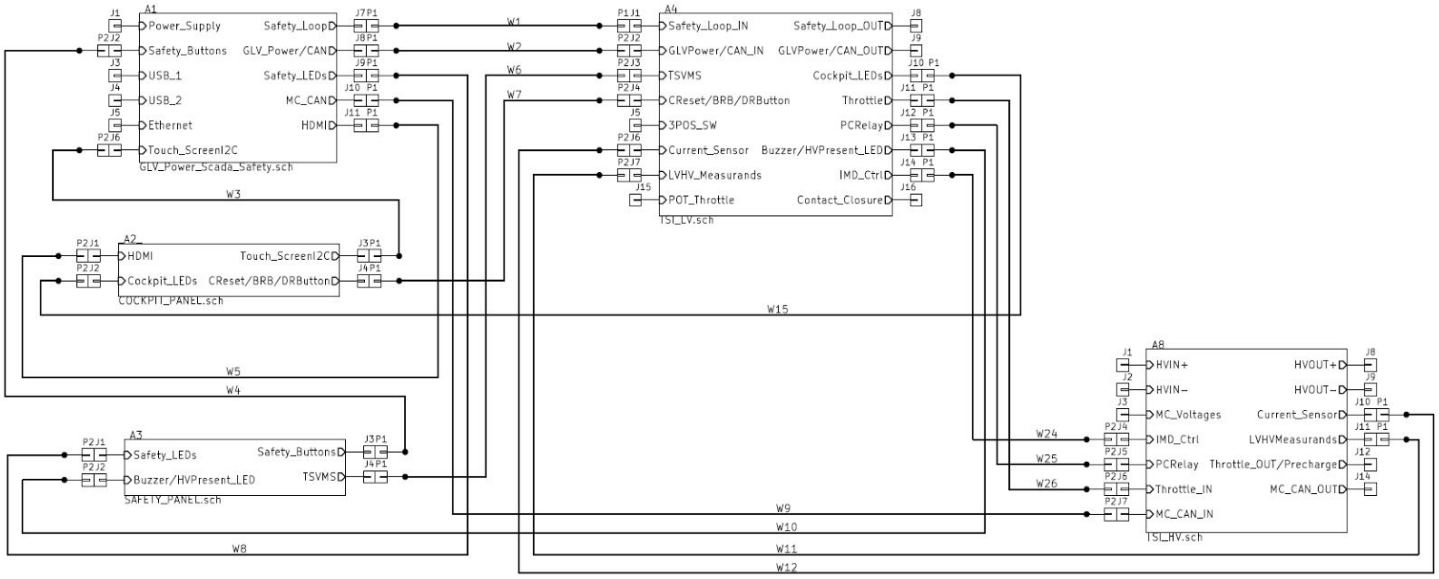
System Block 2



Configuration 1 involves the safety/VCI/power system boz, the safety panel, the cockpit panel, the TSI_LV and 1 pack. This configuration is used to test whether or not the system can close five AIR relays. One multimeter is used to check the continuity across a single AIR.

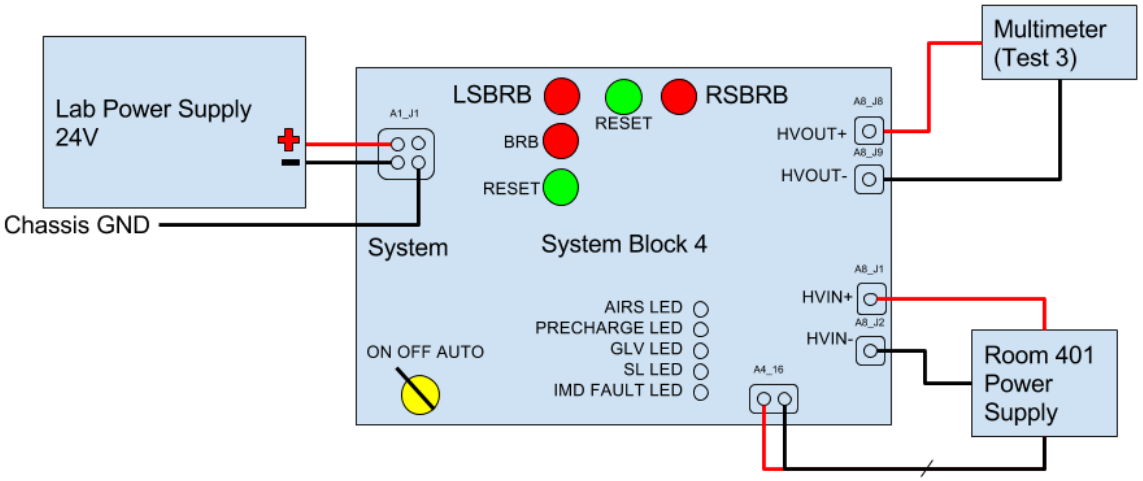


System Block 3

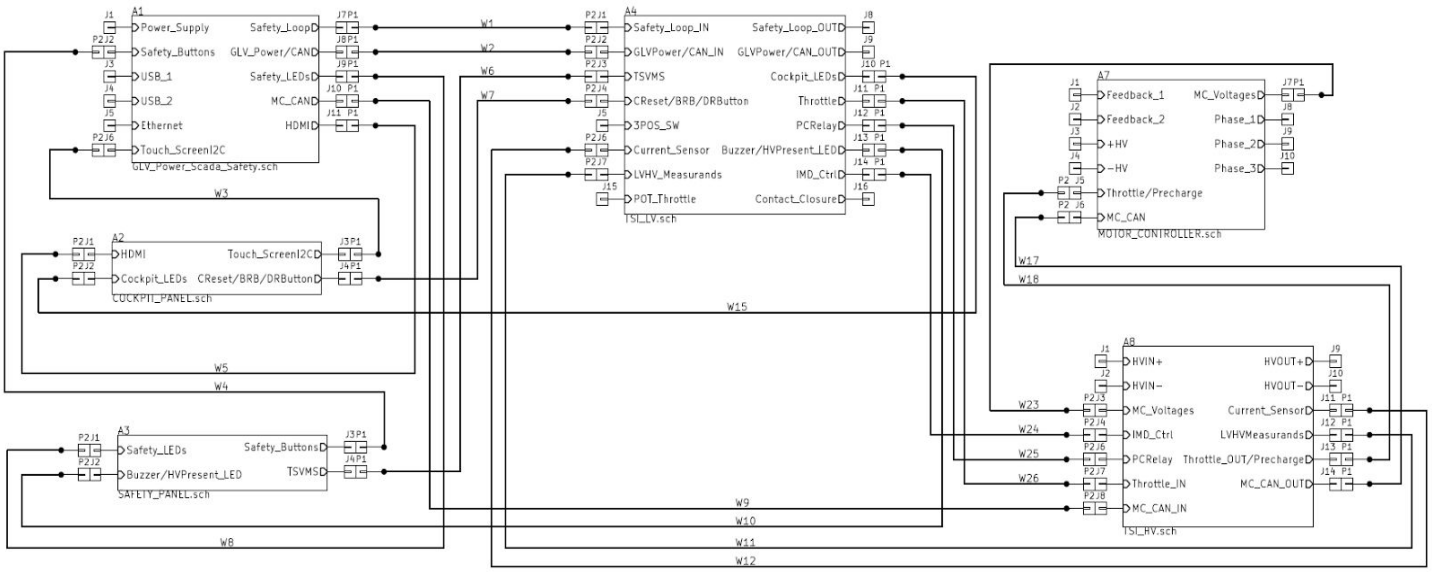


Configuration 2 is wired to test a ground fault. This setup includes the safety/VCI/power system boz, the safety panel, the cockpit panel, the TSI_HV and TSI_LV. Shorting the HVIN+ input to GLV ground will cause the safety loop to trip. The single multimeter monitors the presence of the AIRs voltage.

Test Configuration 3



System Block 4



Configuration 3 is wired to test the TSI, the configuration includes his setup includes the safety/VCI/power system boz, the safety panel, the cockpit panel, the TSI_HV and TSI_LV and the curtis motor controller. The purpose of the this test is to monitor the HVOUT+ and HVOUT- when the 3 position switch is move from ON to OFF to AUTO. This will show that the pre-charge relay can close in the ON position and remain open in the OFF position.

Detailed Procedure

All BRBs and master switches are to begin in their closed state for this test.

- The green reset button for the SCADA/GLV Power/Safety Box is pressed
- The green reset button for the cockpit panel is pressed, closing all five relays
    - The GLV LED, SL LED and the AIRs LED are all lit, proving the presence of GLV power in the system
- The BRB for the cockpit panel is pressed to open the AIRs (five relays)
    - The SL LED and AIRs LED turn off to indicate that this is the case
- The cockpit BRB is returned to its closed position and the cockpit reset button is pressed to restore power to the AIRS
- Either the LSBRB or the RSBRB are pressed to open the airs
- The system is reset by returning all buttons and switches to their closed positions and pressing both green reset buttons
- The switch for the TSI is set to its ON position (+24V)
- Continuity is checked across the precharge relay to confirm that it has closed
- The switch is set to its OFF position (GND)
- Continuity is checked again, but to confirm that the relay remains open
- The switch is set to its AUTO position (JGB ctrl)
- The TSILV is set to send a signal that closes the precharge relay when the motor controller is giving out +24V
- Continuity is checked across the relay to confirm that it is closed when the TSILV activates
- The switch is returned back to its ON position
- A resistance of 250 ohms/volt is applied between the GLV ground and the TSV+
    - The IMD is confirmed to open the safety loop within 30 seconds
- SCADA is checked to confirm that it logs the incidents of the safety loop tripping
- Total Current draw of the GLV is measured for future design work

AIRS STATE	Total GLV Current Draw (A)	GLV Voltage (V)	GLV Power (W)
OPEN	0.70	24.14	17.8
CLOSED	1.25	24.11	29.8

How and why requirements are met

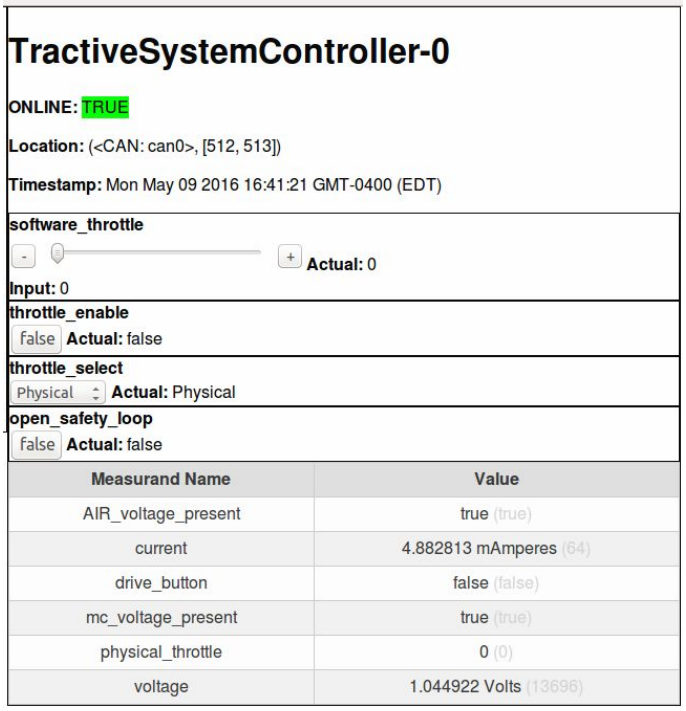
R002b: Safety Loop Integration

- VSCADA is capable of monitoring safety loop status
    - Pass/Fail: UI correctly displays when the loop is triggered

Safety Loop State	SCADA Displayed State
Triggered	See Picture Below(Figure 1)
Not Triggered	See Picture Below(Figure 2)

Timothy Andrews 05/10/16 Pass

Witness/Examiner Signature Date Pass/Fail



TractiveSystemController-0

ONLINE: TRUE

Location: (<CAN: can0>, [512, 513])

Timestamp: Mon May 09 2016 16:41:21 GMT-0400 (EDT)

software_throttle

\- + **Actual:** 0

Input: 0

throttle_enable

false **Actual:** false

throttle_select

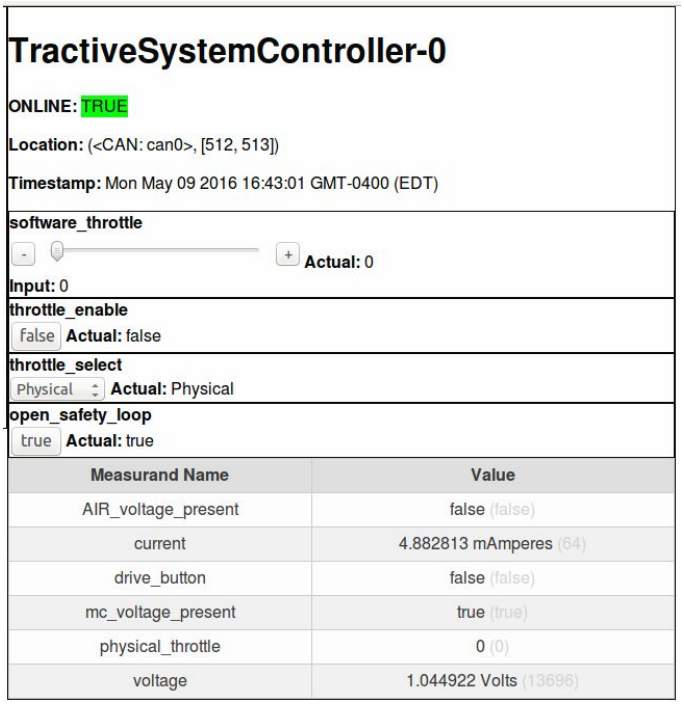
Physical **Actual:** Physical

open_safety_loop

false **Actual:** false

Measurand Name	Value
AIR_voltage_present	true (true)
current	4.882813 mAmperes (64)
drive_button	false (false)
mc_voltage_present	true (true)
physical_throttle	0 (0)
voltage	1.044922 Volts (13696)

FIGURE 2



TractiveSystemController-0

ONLINE: TRUE

Location: (<CAN: can0>, [512, 513])

Timestamp: Mon May 09 2016 16:43:01 GMT-0400 (EDT)

software_throttle

\- + **Actual:** 0

Input: 0

throttle_enable

false **Actual:** false

throttle_select

Physical **Actual:** Physical

open_safety_loop

true **Actual:** true

Measurand Name	Value
AIR_voltage_present	false (false)
current	4.882813 mAmperes (64)
drive_button	false (false)
mc_voltage_present	true (true)
physical_throttle	0 (0)
voltage	1.044922 Volts (13696)

FIGURE 1

- Pass/Fail: When safety loop is triggered a log of the triggering is created by SCADA

Log Line
N/A

Timothy Andrews 05/10/16 Fail

Witness/Examiner Signature Date Pass/Fail

*NOTE - The logs for this test were at one point operational but because they were proved to be unreliable this test has been marked as a failure.

R002m: Modular Data Acquisition System

- Met in R002b

R002o: Event Logging

- Met in R002b

R003b: GLV Safety Loop

- Various fault situations are able to successfully cut power to the majority of the safety loop
  Pass/Fail: All devices on the table below can trigger the safety loop

Device	Can Trigger Safety Loop
BRB	Yes
LSBRB	Yes
RSBRB	Yes
JGB	Yes
SCADA	Yes
AMS	Yes

Timothy Andrews	05/10/16	Pass
Witness/Examiner Signature	Date	Pass/Fail

Pass/Fail: A triggered safety loop can not be cleared until appropriate resets are done

- A cockpit loop trigger can be reset with just the cockpit reset button
- Outer safety loop must be reset by pressing both the cockpit and system reset buttons

Safety Loop Triggered	Reset Method Attempted	Expected	Clears Loop
Inner Loop	Cockpit Reset	No	No
Outer Loop	Cockpit Reset	Yes	Yes
Inner Loop	System Reset	No	No
Outer Loop	System Reset	No	No
Inner Loop	Cockpit and System Reset	Yes	Yes
Outer Loop	Cockpit and System Reset	Yes	Yes

Timothy Andrews	05/10/16	Pass
Witness/Examiner Signature	Date	Pass/Fail

*NOTE-The Inner loop refers to non-driver resettable faults. And the purpose of the test is to determine the correct order of the reset button presses to make sure that outer loop faults can be reset but the driver and inner faults can be reset by a combination of the the master reset button and the driver. As you can see here the cockpit reset button can reset the AIRs only when a outer loop fault has occurred. But any fault outer or inner can be reset by a master then cockpit reset button press. (If the fault is no longer present)

R003c: Vehicle User Interface Panels

- Pass/Fail: The interface includes the following LED indicators that function as listed in the below tables

Test Configuration 1 - Air Closure		
LED	Correct State	Observed State
GLV_Present	ON	ON
SL_LED	ON	ON
HV_Present	OFF	OFF
Pre-Charge	OFF	OFF
AIRs_Present	ON	ON

Test Configuration 2 - Ground Fault		
LED	Correct State	Observed State
GLV_Present	ON	ON
SL_LED	ON	ON
HV_Present	OFF	OFF
Pre-Charge	OFF	OFF
AIRs_Present	OFF	OFF

*NOTE - There is a known issue with the IMD and or the Motor Controller where the a ground fault is always detected. Although the system can not reliably determine when a ground fault is detected in this test the lights were tested in a simulated IMD ground fault state and the the light operate correctly. See QAR003d

Test Configuration 3 - Pre-charge Relay		
LED	Correct State	Observed State
		ON/OFF/AUTO
GLV_Present	ON	ON/ON/ON
SL_LED	ON	ON/ON/ON
HV_Present	ON	ON/OFF/ON
Pre-Charge	OFF	ON/OFF/ON
AIRs_Present	ON	ON/OFF/ON
TSI Selector	SWITCH STATE	ON/OFF/AUTO

*NOTE - The precharge no longer works as originally intended although the lights worked with the intended design the precharge is no wired directly to the main contactor and coil return line and controlled solely by the motor controller.

Timothy Andrews	05/10/16	Pass
Witness/Examiner Signature	Date	Pass/Fail

- The interface includes the GLVMS, TSVMS, BRBLS, BRBRS, and reset button.
  Proved to properly operate in the context of the safety loop by R003b

- Pass/Fail: All switches and buttons are integrated into the interface and labeled such that they can be identified at a glance.
  Pictures of switches will be here [Figure 3; Figure 4; Figure 5]

Timothy Andrews	05/10/16	Pass
Witness/Examiner Signature	Date	Pass/Fail

- Vehicle interfaces are designed such that they are capable of being housed and tested within a 19” rack cabinet, in addition to the car setup.
  Pass/Fail: Interface is seen mounted to the 19” rack cabinet
  - Picture will be here [Figure 3; Figure 4; Figure 5]

Timothy Andrews	05/10/16	Pass
Witness/Examiner Signature	Date	Pass/Fail

FIGURE 3

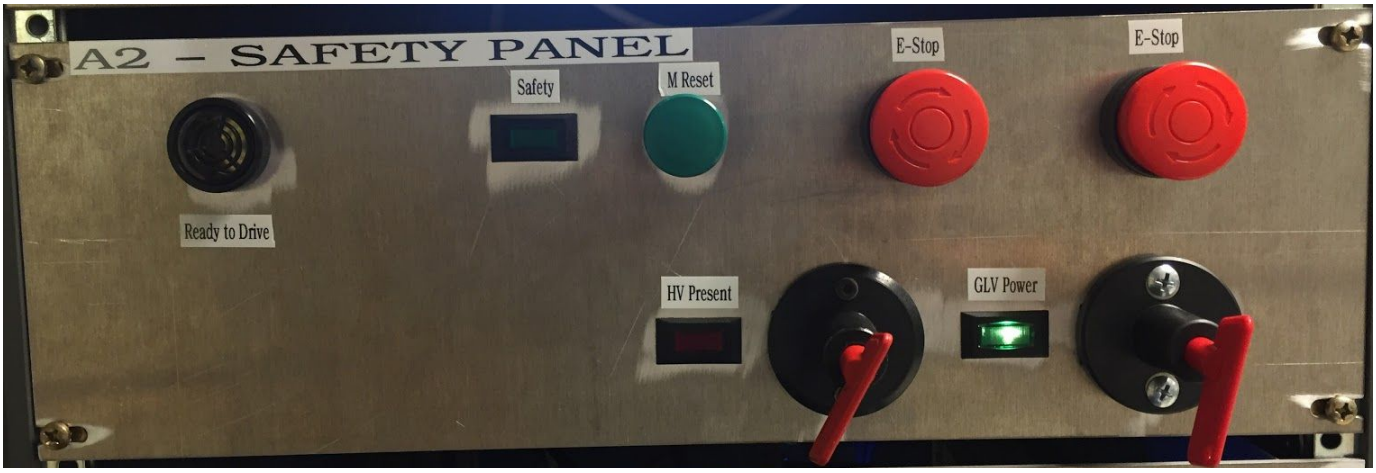


FIGURE 4

FIGURE 5

R003d: Tractive System Interface

- TSI monitors the TSV and GLV to ensure that they remain isolated from one another
    - Pass/Fail: When shorted together the IMD relay goes off triggering the safety loop within 30 seconds

Observed Time	FAIL

Timothy Andrews	05/10/16	Fail
Witness/Examiner Signature	Date	Pass/Fail

- TSI is capable of disabling the safety loop and motor controller under system faults or driver input
    - Pass/Fail: R003b TSI section has passed

R003e: VCI Hardware

- Support all needs of SCADA to make sure all parts that exist on the car are supplied power via GLV. SCADA is powered on and fully functional
  Pass/Fail: If at least one test relying on VSCADA communication passes

TEST	Pass/Fail	TEST	Pass/Fail
R002a: Car dash Display	Pass	~~R002m: Modular Data Acquisition System~~	
R002c: VCI	Pass	R002b: Safety Loop Integration	Pass
~~R002l: Monitoring and Data Acquisition~~		R003b: GLV Safety Loop (VSCADA pass)	Pass
~~R002h: Drive Mode~~			

Timothy Andrews	05/10/16	Pass
Witness/Examiner Signature	Date	Pass/Fail

- User interface hardware such as dashboard is demonstrated.

QA Tests and Test Memos

~~QAR002b - Safety Loop Integration~~

1. ~~Ensure that when safety loop is triggered and only when its triggered the UI displays it as such~~

~~QAR002o - Event Logging~~

1. ~~Show logs of events such as safety loop trigger with expected times of recording~~

~~QAR003b - GLV Safety~~

1. ~~Test for safety loop operation under system faults~~

~~QAR003c - Vehicle User Interface Panels~~

1. ~~Test that buttons and interfaces operate as expected~~

QAR003d - Tractive System Interface

1. Test that the TSI interacts properly with the safety loop and trips it as needed
2. Monitor that TSV remains isolated from the GLV and ground
3. Test that the Motor/Motor Controller can be engaged and disengaged from driver input

Recorded Software Versions

Software	Description	Version Used
Scada-d	Python program that talks CAN on the network and collects and logs the data on the the CAN network	Githash fc843de2
Scada-d Configuration File	Config file that describes system topology loaded by Scada-d	SEE FIGURE 6
Scada-ui	Javascript program that generates all the user interfacing	Githash aec7c6cd9
PACMAN	Software that speaks over CAN and monitors the PAC	0.14
JGB	Embedded Device that talks CAN and controls throttle	Githash 6d8f7e11
AMS	Responds to I2C messages from PACMAN to report measurands	3.0

FIGURE 6

```
"physical":
 "can0":
   "[0x601, 0x602]": "MotorController"
   "[0x500, 0x0501, 0x0502]": "BatteryPack"
   "[0x510, 0x0511, 0x0512]": "BatteryPack"
   "[0x520, 0x0521, 0x0522]": "BatteryPack"
   "[0x530, 0x0531, 0x0532]": "BatteryPack"
   "[0x200, 0x201]": "TractiveSystemController"
   "[0x250, 0x251]": "DynomometerController"


 "fake0": "GPS"

"virtual":
   - ["Dashboard"]
   - ["BatteryManager"]
```