FULL GLV SAFETY LOOP: MEMO-03

Abstract

This document describes the purpose, design, and functionality of the full GLV safety loop for ECE492's electric formula vehicle project. The safety loop was designed using a slightly modified version of the past year's safety loop, manufactured on a rack mount panel, wired, and tested. The full safety loop functioned as expected.

April 20, 2017

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Introduction

One of the responsibilities of the GLV team was to provide 24V DC to power all low voltage electrical systems as well as the five AIRs on the four TSV battery packs. In order to accomplish this, a safety loop was designed in order to safety provide GLV power to the necessary systems in accordance with the Formula Hybrid Rules. The safety loop was integrated in the dyno room on two rack mount panels, and it interfaced with the BoB within the GLV enclosure.

The Design

The design of the full GLV safety loop is shown in the schematic in appendix A. A list of safety loop components and their descriptions can be found in Appendix B. Optoisolators were used to monitor the safety loop and send data to VSCADA as shown in Appendix C. The GLV system contains several pushbuttons and switches as well as four LEDs: GLV, SAFETY, FAULT, and AIRs. Dyno room panel layouts including all the safety loop I/O are shown in appendix D and E.

Safety Loop 1: The safety loop has two purposes. It needs to provide GLV power to all systems requiring it as well as apply power to the AIRs when conditions were safe. For GLV power to be provided to the car subsystems, the circuit breakers, GLV master switch, left side E-stop, and right side E-stop must be closed. This is all accessible from the exterior of the car (or on the exterior panel in the dyno room). When power is provided to the car subsystems, the GLV LED on the interior panel will turn on.

Safety Loop 2: After the first part of the safety loop is active, additional actions must be taken to energize the AIRs in the TSV battery packs. First, each of the GLV subsystems must be closing the safety loop. This includes a cooling controller fault switch, TSI IMD fault switch, and packman fault switches. If these are all closed, the SAFETY LED (on the interior panel) will turn on, but if there is a fault in any one of these, the FAULT LED (on the interior panel) will turn on instead. Following this, the Master Reset button (exterior panel) must be pressed, and the driver E-Stop (interior panel) must be closed. The Crash Protection (interior panel) must then be pressed, and the TSV Master Switch (exterior panel) must be switched on. If all of these actions are taken, the AIRs will become energized, and the AIRs LED will turn on. In the car, a Tractive System Energized Light (TSEL) will be wired in parallel with the AIRs LED and placed on top of the car.

Car Operation: The safety loop was designed in this way to abide with formula vehicle rules. This design allows an operator on the outside of the car to turn off the GLV system entirely or turn off power to the AIRs using the exterior E-stops and master switches. It also requires the outside operator to press the Master Reset before the car can start. The Driver only has access to the driver E-stop so that the driver can turn off the AIRs if needed, but the driver cannot cut power to the entire GLV system or power down subsystems. The safety loop requires the driver to press the crash protection reset after the Master Reset is pressed to start the car. There is also an inertia switch in the cockpit which will open the safety loop if the car crashes. The driver can press the inertia switch and the Driver Reset to reenergize the AIRs after a crash, if desired.

Design Verification

Description	Test Method	Detailed Results
1.) Energize Subsystems-24V Power Supplied to GLV Subsystems.	Supplied 24V of power to the GLV system using an external power supply. The 15A circuit breaker, GLVMS, BRBRS, BRBLS, and 8A circuit breaker were closed. The 24V output was measured on J10 (6 pins of GLV power and CanBus line) on the GLV enclosure.	24V was measured on J10. The GLV LED turned on. PASS
2.) Energize AIRS-Power supplied to Accumulator AIRs.	Supplied 24V of power to the GLV system using an external power supply. The GLVMS, BRBLS, BRBRS, TSVMS, circuit breakers, and driver BRB were closed. The exterior master switch and driver reset were pressed.	The GLV LED turned on. The SAFETY LED turned on. The AIRs LED turned on. The FAULT LED did not turn on. The AIRs in the packs closed. PASS
3.) Shutdown- All GLV power turns off when the GLVMS or exterior BRBs turn off.	Power was supplied to the AIRs following the procedure in test 2. The GLVMS was opened, while checking the output to the J10 pin on the GLV enclosure. This was repeated for both exterior BRBs.	All LEDs turned off. 0V was measured on J10. GLV Subsystems deenergized. The AIRs deenergized. PASS
4.) Fault- GLV System stops supplying power to the AIRs in the following situations.	The AIRs were energized following the procedure described in test 2. The following faults will be tested. The Master Reset and Drive Reset were pressed at the end of each test to ensure these inputs do not reenergize the AIRs during a fault.	PASS
4a.) Subsystem Fault	Had a subsystem break the safety loop. This was tested by removing the final jumper on the TSV battery packs.	The GLV LED remained on. The SAFETY LED turned off. The AIRs LED turned off. The FAULT LED turned on. The AIRs deenergized. PASS
4b.) Driver E-Stop Fault	The Driver E-Stop was pressed.	The GLV LED remained on. The SAFETY LED remained on. The AIRs LED turned off. The FAULT LED remains off. The AIRs deenergized. PASS
4c.) Crash Fault	The Inertia switch was triggered.	The GLV LED remained on. The SAFETY LED remained on. The AIRs LED turned off. The FAULT LED remains off. The AIRs deenergized. PASS
4d.) TSVMS Fault	The TSVMS was turned off.	The GLV LED remained on. The SAFETY LED remained on. The AIRs LED turned off. The FAULT LED remains off. The AIRs deenergized. PASS

5.) Reenergize AIRs after fault.	The faults in test 4 should be resettable in the following ways so that the AIRs can be reenergized without cutting power to the GLV powered subsystems.	PASS
6a.) AIRs Reenergize after Subsystem Fault	Ran test 4a. Fixed the safety loop fault in the subsystem. This was done by plugging the safety loop jumper back into the TSV battery packs, closing the safety loop. Pressed the Master Reset and then the Crash Protection Reset.	The GLV LED remains on. The SAFETY LED turned on. The AIRs LED turned on. The FAULT LED turned off. The AIRs in the packs closed. PASS
6b.) AIRS Reenergize after Driver E-Stop Fault	Ran test 4b. Closed the Driver E-Stop. Pressed the Master Reset and then the Crash Protection Reset.	The GLV LED remains on. The SAFETY LED remained on. The AIRs LED turned on. The FAULT LED did not turn on. The AIRs in the packs closed. PASS
6c.) AIRS Reenergize after Crash Fault	Ran test 4c. Pressed the Inertia Switch. Pressed the Master Reset and then the Crash Protection Reset.	The GLV LED remains on. The SAFETY LED remained on. The AIRs LED turned on. The FAULT LED did not turn on. The AIRs in the packs closed. PASS
6d.) AIRs Reenergize after TSVMS Fault	Ran test 4d. Reengaged TSVMS. Pressed the Master Reset and then the Crash Protection Reset.	The GLV LED remains on. The SAFETY LED remained on. The AIRs LED turned on. The FAULT LED did not turn on. The AIRs in the packs closed. PASS
6.) Connectivity- The safety loop is wired as shown by the schematic in Appendix A.	The safety loop circuit was traced with an ohmmeter to ensure each connection occurred expected.	Each component was connected as expected. PASS
7.) Unexpected Input- The reset buttons should not have any effect on the system if pressed at an unexpected time or in the wrong order.	The following unexpected inputs did not affect the system.	PASS
7a.) Master Reset or Driver Reset pressed after AIRs energized.	Followed procedure in test 2 to energize the AIRs. Pressed the Master Reset. Pressed the Driver Reset.	No changed occurred. PASS
7b.) Driver Reset pressed before master reset when energizing AIRs after startup.	Followed procedure in test 1 to energize GLV powered subsystems. Ensured there were no subsystem safety loop faults as indicated by on SAFETY LED. Pressed Driver Reset.	The GLV LED remains on. The SAFETY LED remained on. The AIRs LED did not turn on. The FAULT LED did not turn on. The AIRs were not energized. PASS
In submitting this checklist as part of our report, I/We certify that the tests described above were conducted and that the results of these tests are accurately described and represented. I/We understand that any misrepresentation of the tests or the results constitutes a violation of the College policy on academic dishonesty.		
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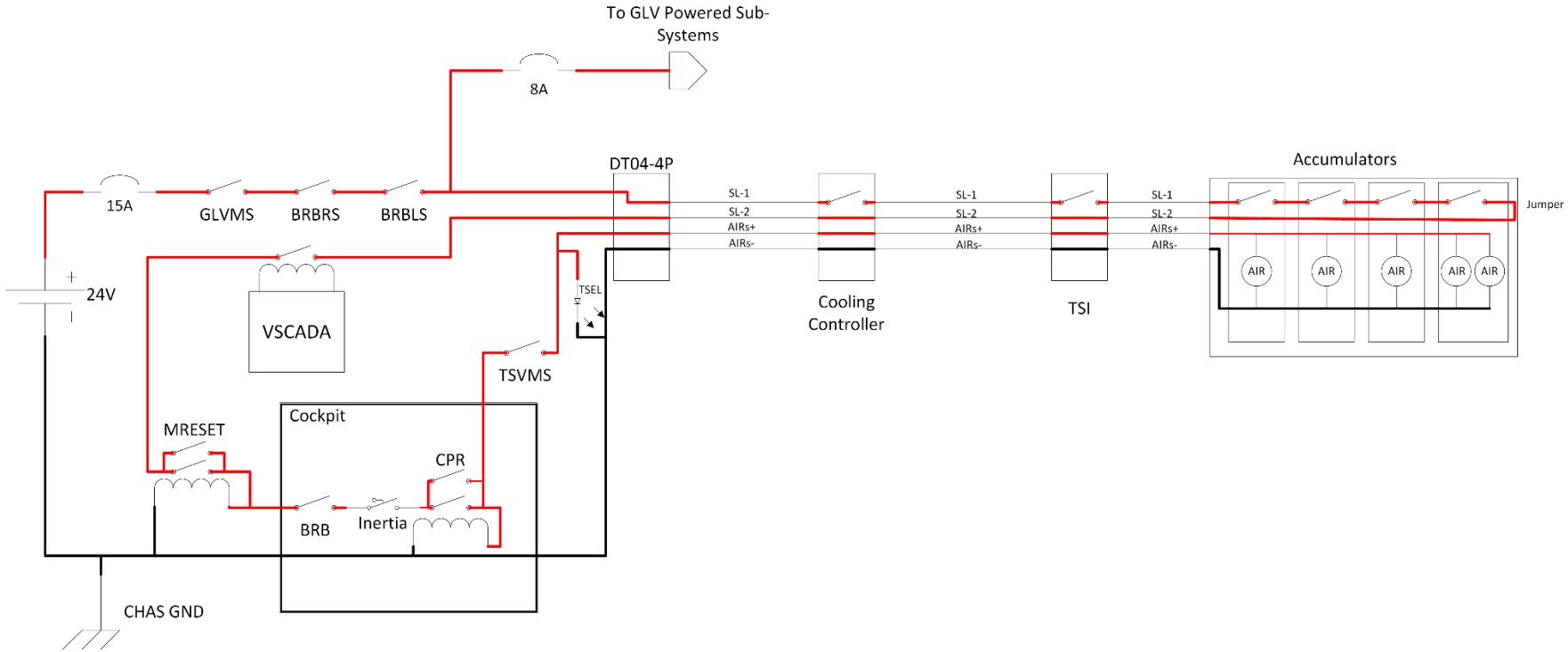
Conclusion

Upon the completion of the full safety loop, the GLV team had provided a functioning safety system that was successfully integrated in the dyno room.

References

The GLV safety loop design from the class of 2016 created by Tim Andrews was referenced for the design of the full safety loop.

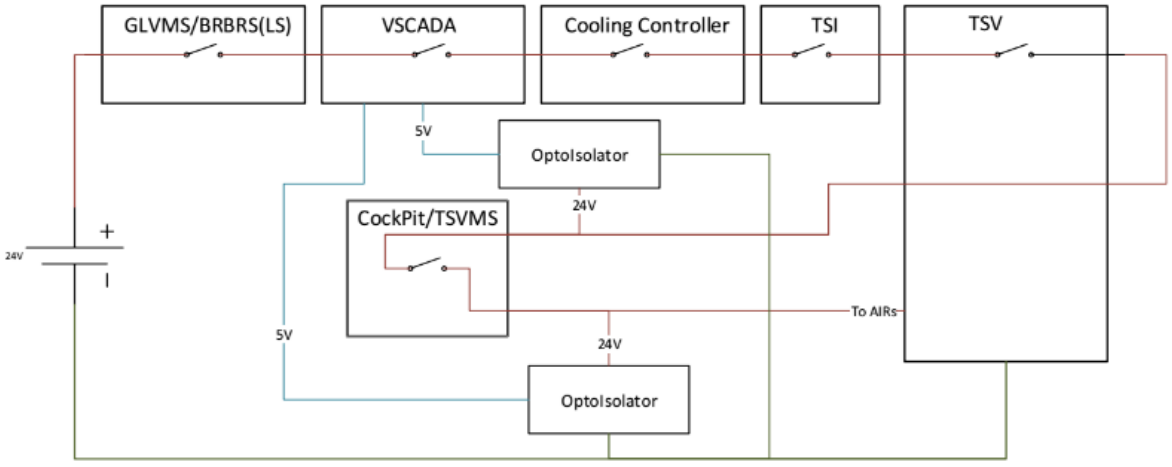
Appendix A – Full Safety Loop Schematic Diagram



Appendix B – GLV Component List

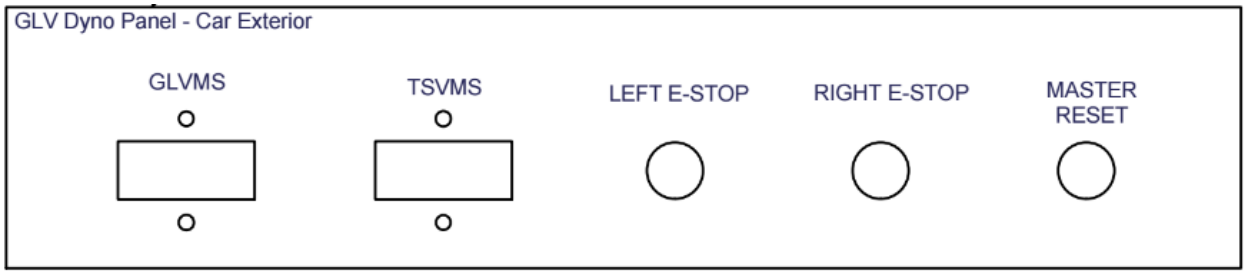
Switch	Description	Effect
Circuit Breaker	A basic resettable circuit breaker	GLV LED turns on. Powers Cooling System, Dashboard, VSCADA, and TSI
GLVMS	Grounded Low Voltage Master Switch	
BRBLS	Big Red Button Left Side	
BRBRS	Big Red Button Right Side	
Cooling System Fault Switch	Allows Cooling System to trigger fault	SAFTEY LED turns on.
IMD Switch	Insulation Monitoring Device, triggers fault if HV and GLV are galvanically isolated	
PACKMAN Fault Control	Allows PACKMAN board on any pack to trigger a fault	
SCADA Relay	Allows SCADA computer to trigger fault	
MRESET (Latching)	Exterior Master Reset Button	AIRs LED turns on. 24V to Accumulator Isolation Relays
BRB (Car Dash)	Driver accessible Big Red Button	
Inertia Switch	Driver accessible Inertial switch, opened by a 6g+ collision.	
CPR(Latching)	Driver accessible Collision Protection Reset Latching Relay.	
TSVMS	Tractive System Voltage Master Switch	

Appendix C – Safety Loop Monitoring



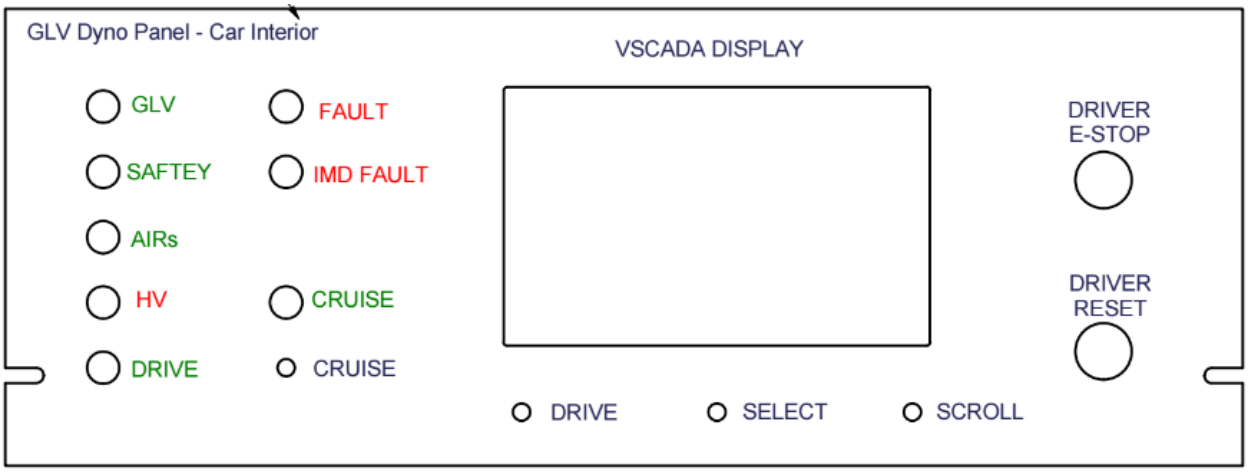
Optoisolators monitor the safety loop and send fault data to the VSCADA system in the configuration shown above. More information about these can be found in GLV Memo-02 (GLV Break Out Board).

Appendix D – GLV Dyno Roo Panel - Car Exterior



The Exterior Dyno Room Panel includes I/O in the GLV system which the driver will not have access to.

Appendix E – GLV Dyno Room Panel - Car Interior



The Interior Dyno room panel includes LED indicators and several buttons. The GLV, SAFETY, and AIRs LED are part of the GLV system while the HV and DRIVE LED are part of the TSI. These will turn on sequentially from top to bottom as the car starts up and goes into drive.

The FAULT LED, Driver E-Stop, and Driver Reset are part of the GLV system. The Select Button, Scroll Button, and VSCADA Display are provided by GLV for the driver to interface with VSCADA.

The Cruise control LED and button are part of the TSI.