

# GLV User Manual

ECE 492 - Spring 2015

## Abstract

This user manual is a high level document that explains all operational procedures and techniques needed to operate the GLV system in a safe and effective manner. Anyone operating the GLV system should be familiar with this document, and this document should be referred back to in the event of a problem with the system. This document is broken up by GLV subsystem, and each section contains an introduction, instructions on getting started, and an operational procedure. The operational procedure will include a detailed explanation of all functions and controls, user level troubleshooting, calibration, and maintenance.

Revision 2.0.0  
GLV Team

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# Document Introduction

This document will outline how to set up all of the subsystems of the GLV system and how each system will work if it is properly functioning. The specific subsystems included in this document are the Power Box, TSI Box, VCI Box, and the safety loop. It also lists some basic troubleshooting methods for simple errors within the system. For issues that cannot be resolved from this manual, please reference the GLV maintenance manual.

# User Breakdown

## Driver

The only piece of equipment in the GLV system that the driver uses is the Cockpit Panel. Please see the [Cockpit Panel](#) normal operation subsection and the VSCADA user manual for help using the panel and its GUIs.

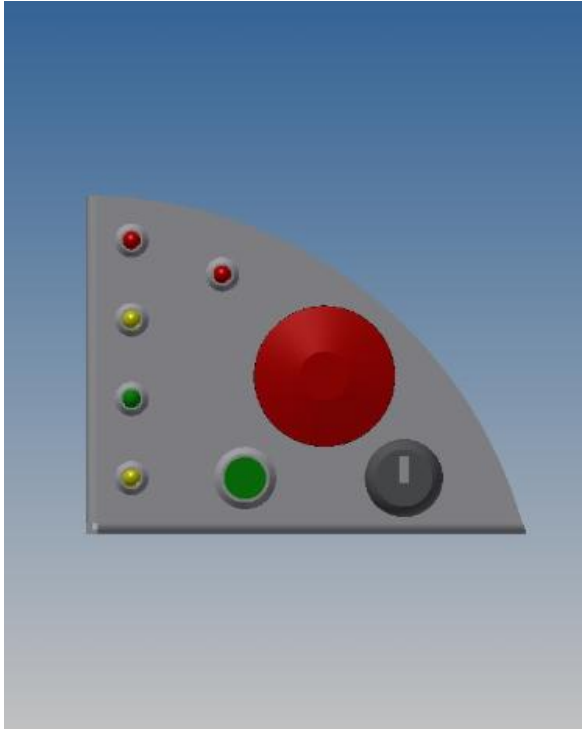
## Pit Crew

The crew will have access to all vehicle components, though some may require some minor disassembly for access. The crew is responsible for problem diagnosis and will have access to each BRB for emergencies.

## System Integrator

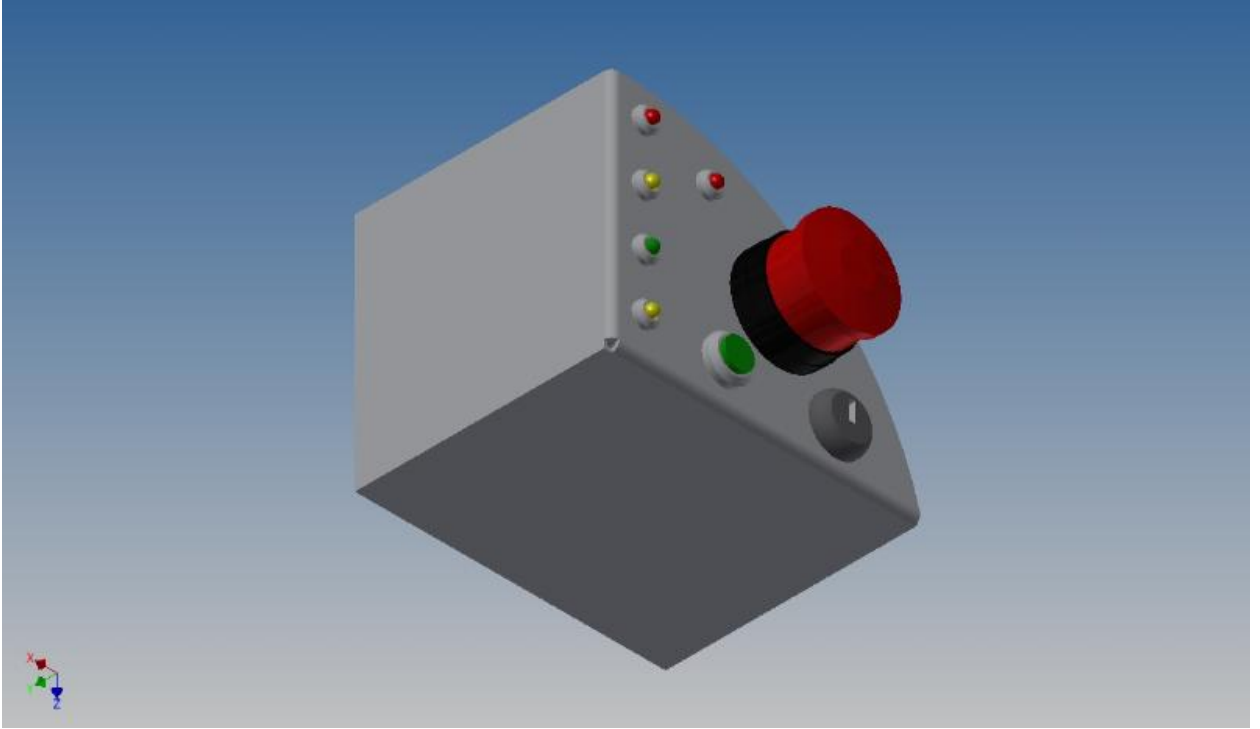
The system integrator will be responsible for all components within the GLV system.

# Cockpit Panel



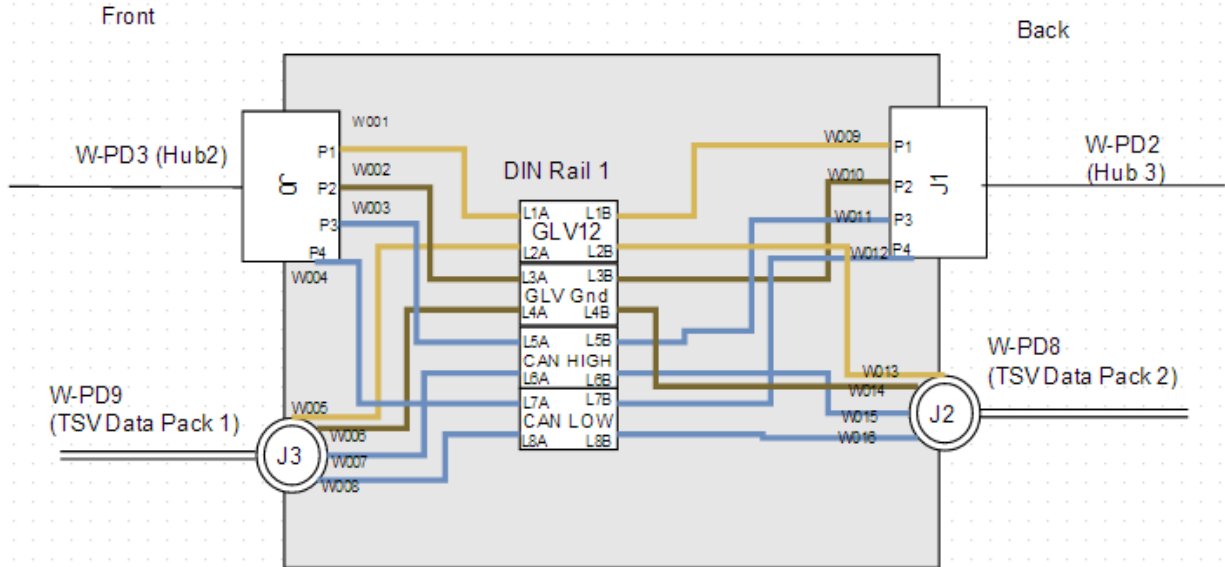
## Material List and Description:

- Aluminum Panel - mounting platform
- Cockpit Reset Button (CPR) - second method for driver reset
- Cockpit BRB - emergency stop for driver
- Red 'Safety' LED - indicates that the system has shutdown
- Amber 'Warning' LED - indicates a problem within the system
- Green 'OK' LED - indicates full normal functionality in the Safety Loop
- Amber Indicator LED
- Ready To Drive Key - ignition system for the car once all prior start protocol has taken place



# GLV Hub

## GLV Hub 1 (A12-1)



### Wire Connections:

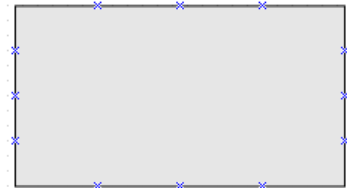
#### Hub 1

- From J0 Pin 1 connect W001 to port L1A on the DIN Rail
- From J0 Pin 2 connect W002 to port L3A on the DIN Rail
- From J0 Pin 3 connect W003 to port L5A on the DIN Rail
- From J0 Pin 4 connect W004 to port L7A on the DIN Rail
- W005 connect to port L2A on the DIN Rail
- W006 connect to port L4A on the DIN Rail
- W007 connect to port L6A on the DIN Rail
- W008 connect to port L8A on the DIN Rail
- From J1 Pin 1 connect W009 to port L1B on the DIN Rail
- From J1 Pin 2 connect W010 to port L3B on the DIN Rail
- From J1 Pin 3 connect W011 to port L5B on the DIN Rail
- From J1 Pin 4 connect W012 to port L7B on the DIN Rail
- W013 connect to port L2B on the DIN Rail
- W014 connect to port L4B on the DIN Rail
- W015 connect to port L6B on the DIN Rail
- W016 connect to port L8B on the DIN Rail

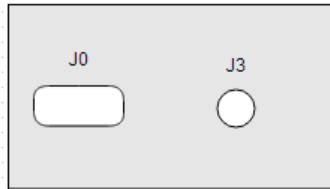
Left Side



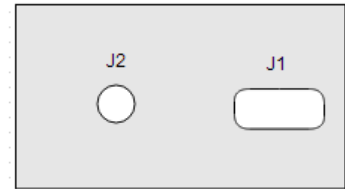
Right Side



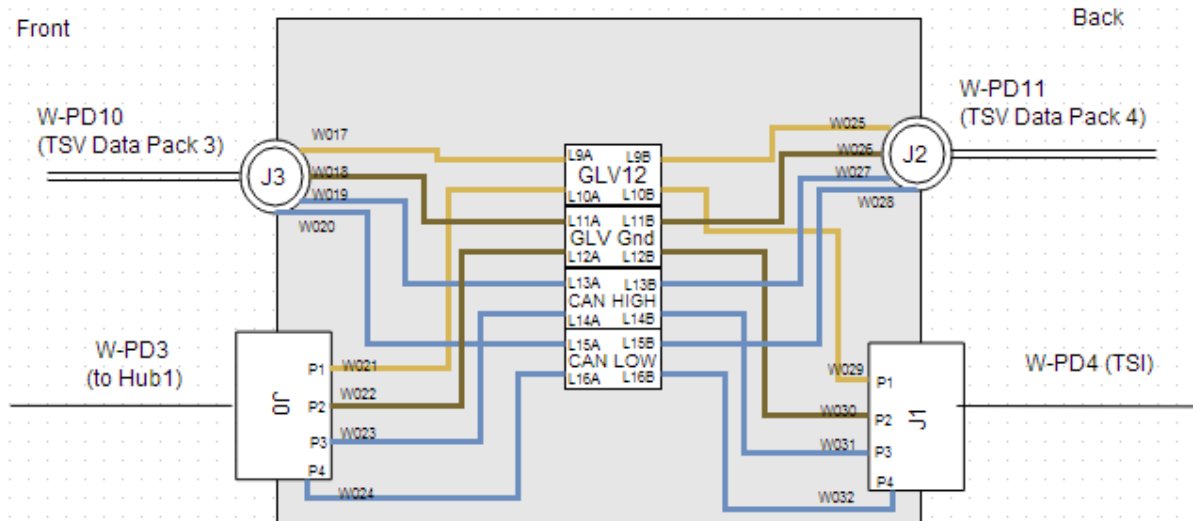
Front



Back



## GLV Hub 2 (A12-2)

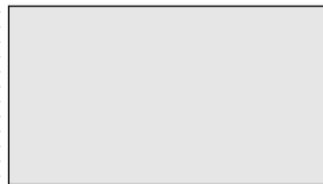


### Wire Connections:

#### Hub 2

- W017 connect to port L9A on the DIN Rail
- W018 connect to port L11A on the DIN Rail
- W019 connect to port L13A on the DIN Rail
- W020 connect to port L15A on the DIN Rail
- From J0 Pin 1 connect W021 to port L10A on the DIN Rail
- From J0 Pin 2 connect W022 to port L12A on the DIN Rail
- From J0 Pin 3 connect W023 to port L14A on the DIN Rail
- From J0 Pin 4 connect W024 to port L16A on the DIN Rail
- W025 connect to port L9B on the DIN Rail
- W026 connect to port L11B on the DIN Rail
- W027 connect to port L13B on the DIN Rail
- W028 connect to port L15B on the DIN Rail
- From J1 Pin 1 connect W029 to port L10B on the DIN Rail
- From J1 Pin 2 connect W030 to port L12B on the DIN Rail
- From J1 Pin 3 connect W031 to port L14B on the DIN Rail
- From J1 Pin4 connect W032 to port L16B on the DIN Rail

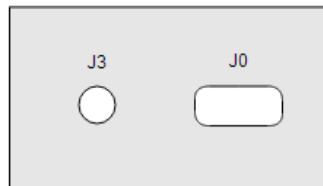
#### Left Side



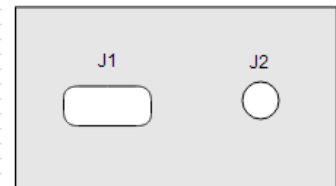
#### Right Side



#### Front

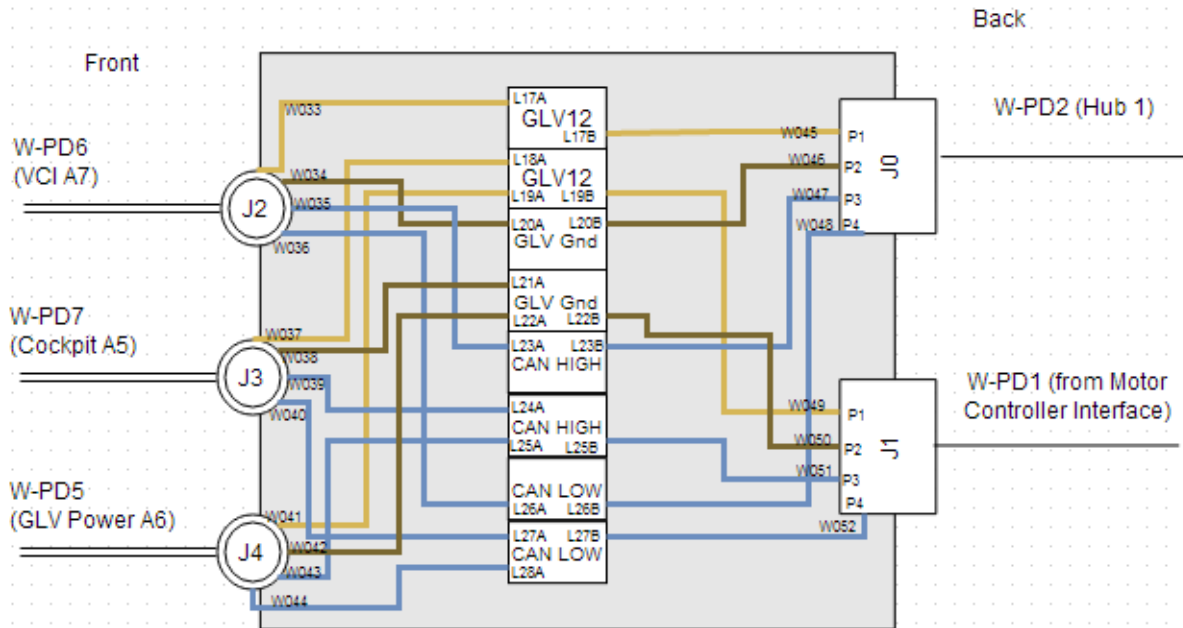


#### Back





## GLV Hub 3 (A12-3)

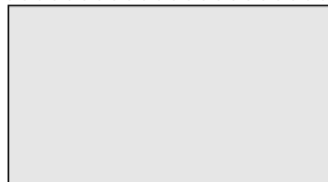


### Wire Connections:

#### Hub 3

- W033 connect to port L17A on the DIN Rail
- W034 connect to port L20A on the DIN Rail
- W035 connect to port L23A on the DIN Rail
- W036 connect to port L26A on the DIN Rail
- W037 connect to port L18A on the DIN Rail
- W038 connect to port L21A on the DIN Rail
- W039 connect to port L24A on the DIN Rail
- W040 connect to port L27A on the DIN Rail
- W041 connect to port L19A on the DIN Rail
- W042 connect to port L22A on the DIN Rail
- W043 connect to port L25A on the DIN Rail
- W044 connect to port L28A on the DIN Rail
- From J0 Pin 1 connect W045 to port L17B on the DIN Rail
- From J0 Pin 2 connect W046 to port L20B on the DIN Rail
- From J0 Pin 3 connect W047 to port L23B on the DIN Rail
- From J0 Pin 4 connect W048 to port L26B on the DIN Rail
- From J1 Pin 1 connect W049 to port L19B on the DIN Rail
- From J1 Pin 2 connect W050 to port L22B on the DIN Rail
- From J1 Pin 3 connect W051 to port L25B on the DIN Rail
- From J1 Pin 4 connect W052 to port L27B on the DIN Rail

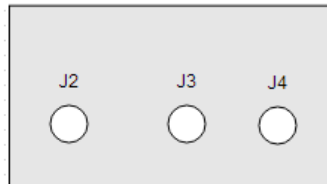
Left Side



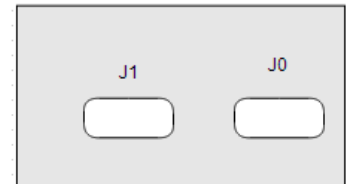
Right Side



Front



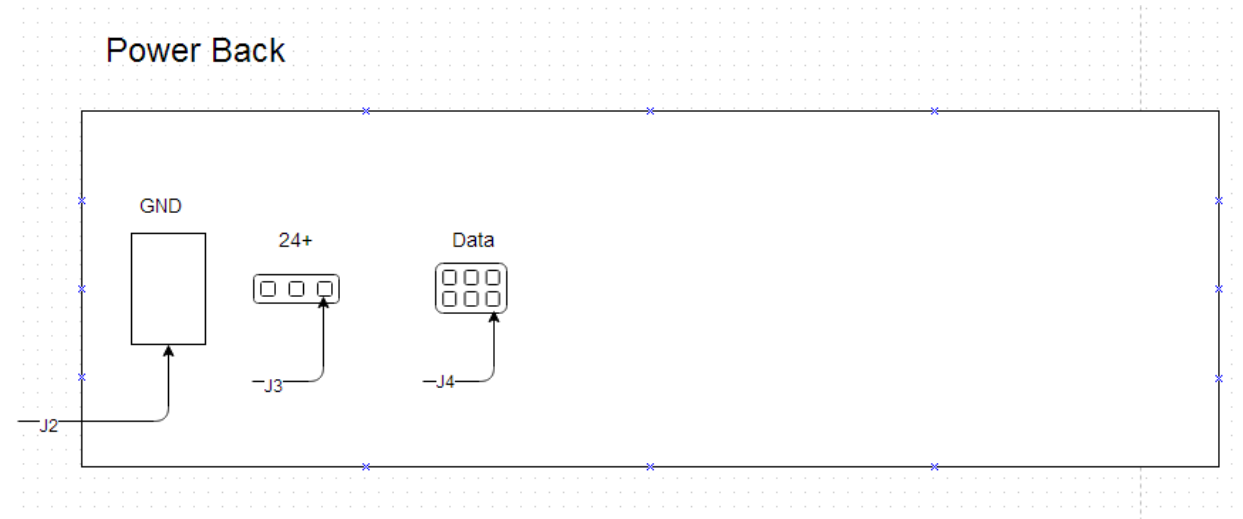
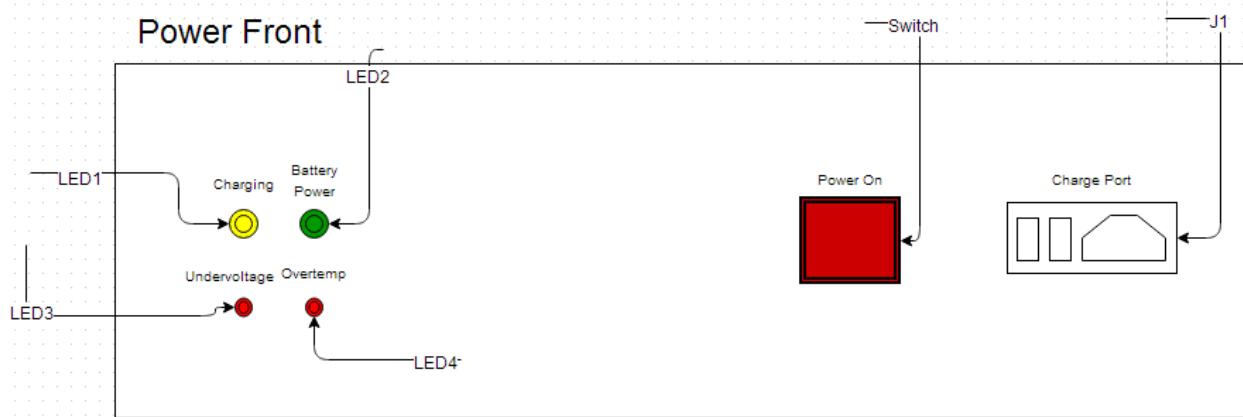
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# GLV Power

The GLV Power subsystem provides power to all of the non-tractive systems in the electric vehicle. This includes the rest of the GLV subsystem, TSV AIRS, and VSCADA computer. The Power subsystem consists of a Power Box, which houses the battery, a DC-to-DC converter, and a PCB. This Power Box has a Charging Port, four LEDs, GLV24B output, and GLVPD output. The function of all of these will be explained in the following sections. Explanations for important buttons and switches on the Side Panel of the car will also be provided.

## Power Box Panels



## Setting Up the Power System

The GLV Power System is located in the rear of the car with the Motor System and TSI. The GLV Power System supplies power to the rest of the vehicle, but starting the Power System is dependent upon the Side Panel, Safety Loop, and Charging Port. In order for the user to activate the Power System, the Side Big Red Buttons (BRBs) must be closed and the GLV battery must have sufficient charge. If these criteria are met, then the user will use the GLV Master Switch (GLVMS) to activate the entire system. When the GLV battery is supplying power to the system, the GLV24 LED on the Side Panel will be active. This light can be found on the front face of the Power Box as a Green LED next to the Charge Port. The two physical connections to the other parts of the vehicle are the GLV 24V Line and the Power and Data Line. These connections are located on the rear face of the Power Box. The GLV24 port is a 3-Pin Molex that must be connected to the Side Panel. The GLVPD is a 9-Pin D-Sub that must be connected to P4 of the GLV Hub.

There is also a setup procedure for the charger of the GLV battery. The charger is made up of a 24vdc Power Supply, 6' AC North American Cord, and a two wire cable with a 4-Pin Square Molex connector on one end. The following are the steps for setting up the GLV charger.

1. Attach the green wire of the 6' AC North American Cord to the middle screw of the Power Supply (Ground).
2. Attach the blue wire of the 6' AC North American Cord to the second screw of the Power Supply (Neutral).
3. Attach the brown wire of the 6' AC North American Cord to the leftmost screw of the Power Supply (Live).
4. Attach the black wire of the charging cable to the fourth screw of the Power Supply (DC Output -).
5. Attach the red wire of the charging cable to the rightmost screw of the Power Supply (DC Output +).

## GLV Power Operational Procedures

The GLVMS is the Pit Crew's on/off switch for the GLV Power System. All battery current flows through this switch; when deactivated, the GLVMS will disable power to all electrical circuits and electrical controls. The GLVMS is a red, rotary switch located on the Side Panel. The GLVMS is located next to the TSV Master Switch (TSVMS), which is discussed in Safety Loop section. Each Master Switch is clearly marked with the letters "GLV" or "TSV". There is a GLV24 light located next to the GLVMS that indicates whether the GLV Power system is actively powering the vehicle.

Also located on the Side Panel are the Side BRBs. Each BRB is labelled either “Left” or “Right” indicating where they would be located on the electric vehicle. Each of these buttons will be a red push-rotate switch that separates the GLV battery from the rest of the GLV power lines. The BRBs will also kill the Accumulator Isolation Relays (AIRS). If a BRB is activated and the system is shutdown, the user must reset the BRB and then press the overall Reset to restore the state of the Safety Loop. The Reset button is located on the Side Panel. There is also a BRB reachable by the driver in the cockpit. The function of this BRB is detailed in the Cockpit Box section.

The GLV battery is made up of 8 3.3V, 10Ah,  $LiFePo_4$  Battery Pack. The battery will be located in the Power Box which is in the rear of the car. It is here that the user can find the Charging Port, which is a 4-Pin Square Molex clearly labelled with “Charging Port”. A 24vdc Power Supply will be used to charge the battery. This power supply will deliver a 2.2A current to the Power Box. There are also two LEDs located on the front face of the Power Box that indicate levels of charge. The charging process is as follows:

1. Plug the charger into the 120VAC wall socket.
2. Plug the 4-Pin Square Molex into the Charge Port on the Power Box.
3. The yellow “Charging” LED will activate when the charger is properly connected and the battery is charging.
4. When the battery is fully charged, the green “Charged” LED will activate.
5. Remove the charger from the Charge Port and the 120VAC wall socket.

According to the estimation Charging time (hours) =  $1.2 \times \text{battery capacity (Ah)} / 2.2$ , the 10Ah battery will take ~5.45 hours to charge.

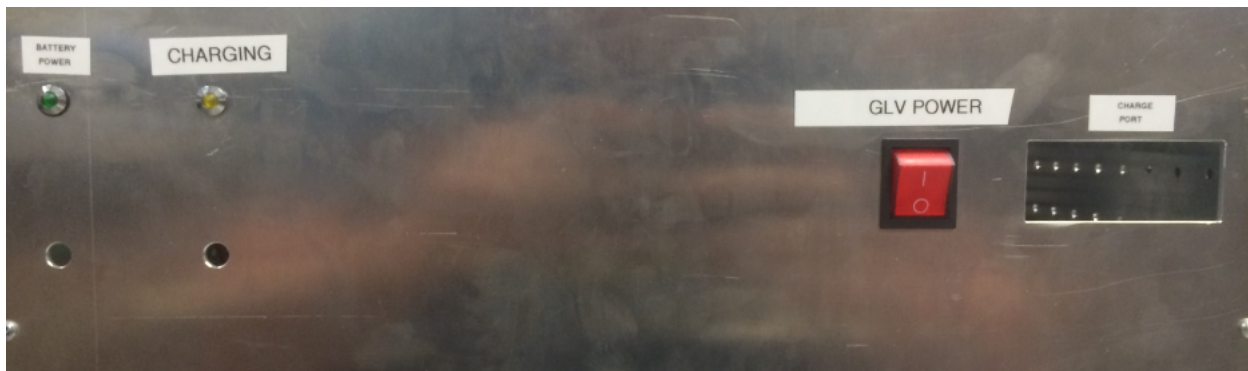
The Power Box also contains a DC-to-DC converter which protects the battery from short circuit, overload, and overvoltage. There is a Charge Monitor located between the Charge Port, battery leads, and DC-to-DC converter. This Charge Monitor is a PCB that also includes circuitry for data collection which will be sent to the VSCADA computer. There are also two more LEDs on the Power Box, next to the charging LEDs and the Charge Port. One indicates overtemperature, and the other indicates undervoltage.

## Troubleshooting the Power System

If the GLV Power System is active, the battery is supplying power to the low-voltage systems on the vehicle, and the GLV24 LED will be on. If this light is ever off and the user desires the system to be active, the following steps should be taken.

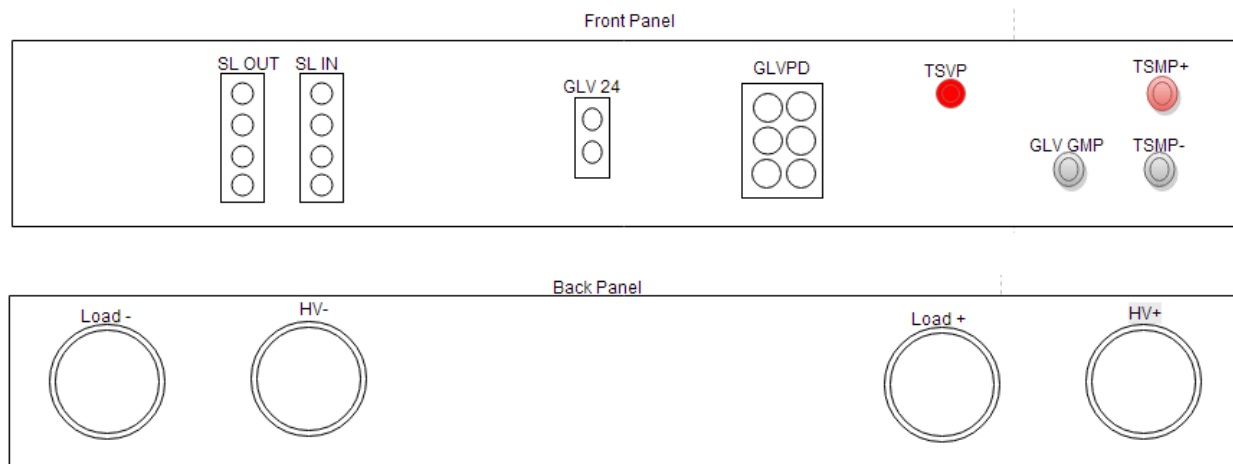
1. Check the GLV Master Switch on the Side Panel. If the switch is vertical, then it is off. Push and rotate the switch clockwise ninety degrees so that it remains horizontal.

2. Check the Side BRBs on the Side Panel. If a BRB is pushed in, the Shutdown Circuit is active. Rotate the deactivated BRB clockwise until it “pops” out of the off position.
3. Check the Undervoltage LED on the Power Box. If this light is active, the user should charge the battery according to the charging protocol listed in the previous section.
4. Check the Overtemp LED on the Power Box. If this light is active, the user should turn off the GLVMS and determine why the battery is overheating.
5. If none of these solves the problem, there is a more serious issue present. Turn off the GLV Power system at the Master Switch and consult an expert



# TSI

The load controller serves as a high voltage interface between the TSV battery packs and the motor controller. The isolation relay acts as a final switch in the high voltage line. The VSCADA system controls a precharge circuit which safely provides current to the motor controller. The isolation monitoring device is used to monitor galvanic isolation between the high and low voltage components and it will trip the safety loop whenever the IMD detects a fault. The TSI also contains TSVP lamp which turns on whenever there is greater than 18V across the high voltage ports. There is a voltage measuring system which measures the voltage across the battery packs.



## Setting up the TSI

In this section we outline the steps that should be taken when setting up and connecting the load controller. These steps should be executed in the order that they are listed.

1. **SL IN:**  
The safety loop in should be connected into the safety loop (see the Safety Loop section of this document). The four pin socket connector that is used is a TE 350780-1 and should be connected using a TE 350779-1.
2. **SL Out:**

The safety loop out should be connected into the safety loop (see the Safety Loop section of this document). The four pin socket connector that is used is a TE 350780-1 and should be connected using a TE 350779-1.

3. **GLVPD:**  
The grounded low voltage power and data bus must be connected to the GLV power box. This connection provides the power for the low voltage circuits in the load controller as well as a connection to the CAN data line. The six pin connector mounted on the load controller is a Mouser 571-14807050 and should be connected using a Mouser 571-14807040.
4. **GLV24:**  
The GLV24 cable supplies the TSI with 24V from the GLV power box. The GLV24 connector mounted on the TSI is a two pin female Mouser connector and the cable used to connect to is a two pin male Mouser connector.
5. **HV+:**  
High voltage plus is the positive high voltage line from the TSV battery pack. The other side of this cable must be a power lock connection to the positive side of the battery pack.
6. **Load+:**  
Load plus is the positive high voltage line out of the load controller. The Load+ terminal will be connected directly the motor controller via screw and nut connection. Voltage will only be present if the isolation relay is closed.
7. **HV-:**  
High voltage minus is the negative high voltage line into the load controller. The Other side of this wire should be a power lock connection the pack.
8. **Load-:**  
Load minus is the negative high voltage line out of the load controller. The Load-terminal will be connected directly the motor controller via screw and nut connection. Voltage will only be present if the isolation relay is closed.

## External Components of the TSI

In this section we list and describe the external signals and components that are used by the TSI box. We describe how the signals should be interpreted and how the components should be used.

1. **TSVP:**

Tractive system active light is the red LED indicator. It turns on when the tractive system is active. This is defined as whenever there is 18V or greater outside the accumulator isolation relays.

2. **GLV GMP:**  
Ground low voltage ground measuring point is a banana jack connection directly to the low voltage system ground. This measuring point is required by the specifications and can be used in conjunction with the TSMP- to create a ground fault error.
3. **TSMP+:**  
Tractive system measuring point plus is a banana jack connection directly to the positive high voltage line. This measuring point is required by the specifications and can be used in conjunction with the TSMP- to measure voltage across the high voltage system.
4. **TSMP-:**  
Tractive system measuring point minus is a banana jack connection directly to the negative high voltage line. This measuring point is required by the specifications and can be used in conjunction with the TSMP+ to measure voltage across the high voltage system. It can also be used in conjunction with the GLV GMP to create a ground fault.

## Normal TSI Use

In typical operation for discharging, the system will start up when GLV 24 is provided. At this point the Safety Loop will be open as well as the AIRs (accumulator isolation relays), so there will be no high voltage present in the TSI. When the safety loop is closed, the AIRs close and high voltage is now present at the HV+ terminal of the load controller. Since the AIRs are closed the TSVP light will turn on provided there is greater than 18V across all the packs. When the user is ready to drive, the user must press the drive button on the SCADA interface. This will start the precharge circuit. If the Safety Loop was tripped by a fault detection in the IMD, then the IMD Indicator LED in the cockpit will turn on. Under normal shutdown procedures, the drive would not be able to reset the error from within the car. During shutdown the Safety Loop will open and the red LED should turn off. If any indication happens other than this normal use case, there may be an issue and the user is advised to consult an expert.

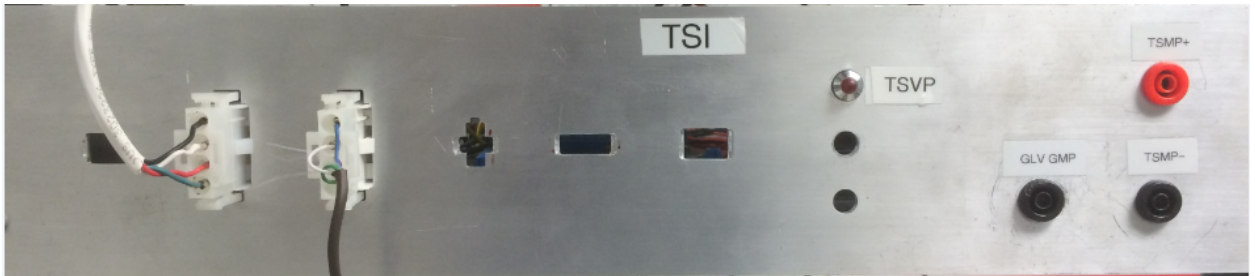
## Troubleshooting the TSI

Any errors in the TSI need the consultation of an expert and reference to the maintenance manual. Issues to look out for are the following:

1. If any plastic connectors on the outside of the box break or get pushed into the box, refer to the maintenance manual.

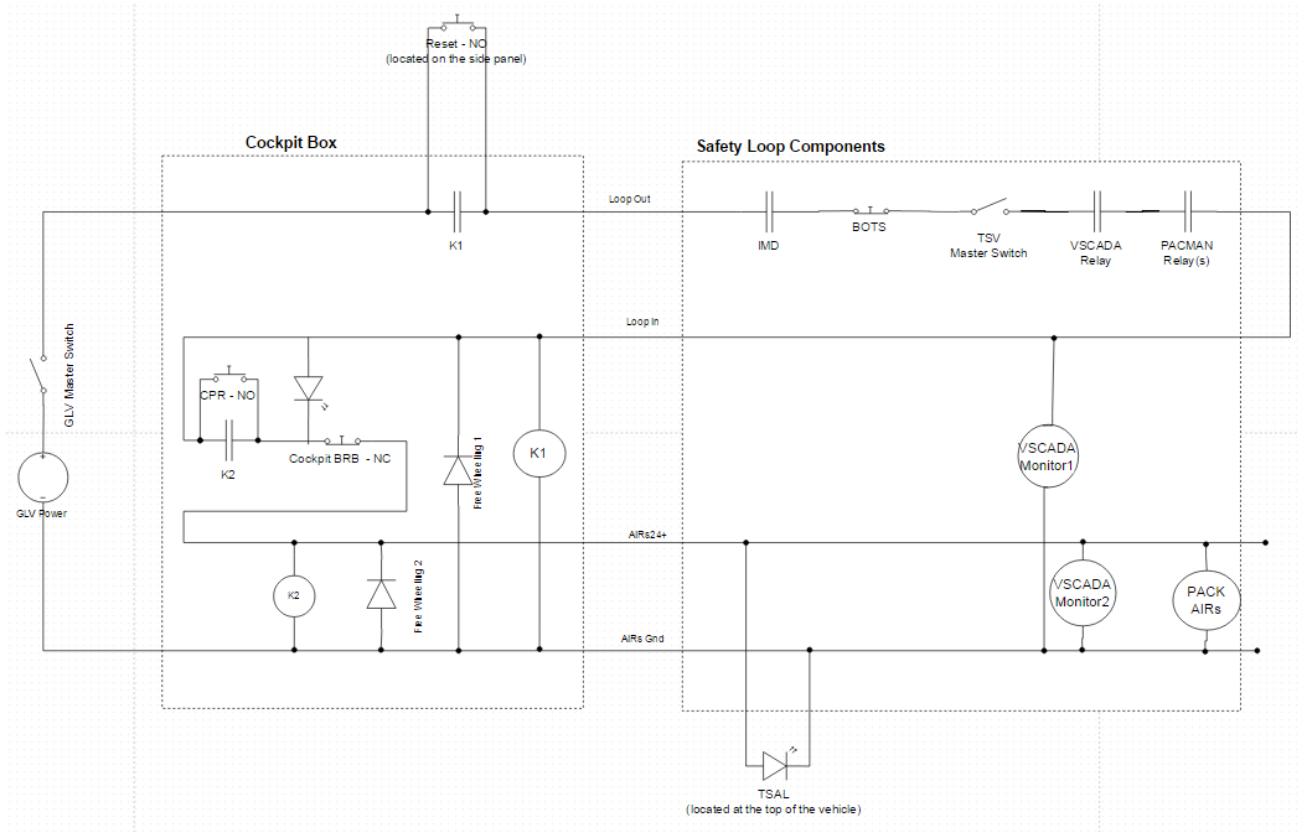


2. If any smoke is seen coming from the load controller or if the box has gotten unusually hot (>40 degrees Celsius), refer to the maintenance manual.
3. If it has been noticed that the isolation monitoring device has been constantly tripping or if a test has shown that it does not trip (indicated by the status of the of the safety loop), consult the maintenance manual.



# Safety Loop

The Safety Loop keeps the electric vehicle in a state of safe operation and allows the driver, surrounding personnel, and system components to shutdown the system in case of emergency or system failure. This user's manual will detail the connections of the Safety Loop, and the processes involved in engaging and disengaging the Safety Loop.



## Setting Up the Safety Loop

The Safety Loop starts with the Safety Circuit. The Safety Circuit is housed behind the Cockpit Panel. From here the Safety Loop flows throughout the entire system. It must connect with each of the following vehicle systems:

- Vehicle Computer Interface Cockpit Box (VCI)
- Brake Over Travel Switch (BOTS)
- Tractive System Battery Packs (all four)
- Tractive System Master Switch
- Motor System

Each of the components have two Safety Loop connects. This lets the Safety Loop run serially through each of the required systems. The Safety circuit must begin behind the Cockpit Panel and terminate with the safety loop cap. The specific order of these connections does not matter as long as each is connected to the line and the final system has a safety loop cap.

## Engaging the Safety Loop

There are multiple checks that need to be looked over before the Safety Loop can be properly engaged. Once the system is wired as described above, check that the GLV Power light, the BOTS, and Master Switches to ensure that they are all in their proper state. The VSCADA safety loop relay needs to be closed and the TSI will need to indicate that the IMD is in its proper state. Once these have been verified the Safety Loop is ready to be engaged. The user can now press and hold the green reset button for one second. If the safety loop is fully closed, a green safety loop LED will be lit.

If this light does not come on, recheck the status of the wiring, the IMD, BRBs, BOTS, and Master Switches. If the problem persists, simply replacing the fuse (2AG 6A fuse) is another option. If this does not engage the green LED, there is another maintenance issue that should be explored.

## Opening the Safety Loop

The Safety Loop should only be opened in case of emergency while energized. If the Safety Loop is opened repeatedly while current is flowing through it, the life of the AIRs is shortened. The fastest way to open the Safety Loop is by pressing one of the BRBs. Make sure to properly reset the BRB and any fault in the system before resetting the safety loop itself.

If there is a fault in the system in the IMD, tractive system cells, VSCADA, BOTS, or motor controller, the safety loop will shutdown automatically open as per the specifications.

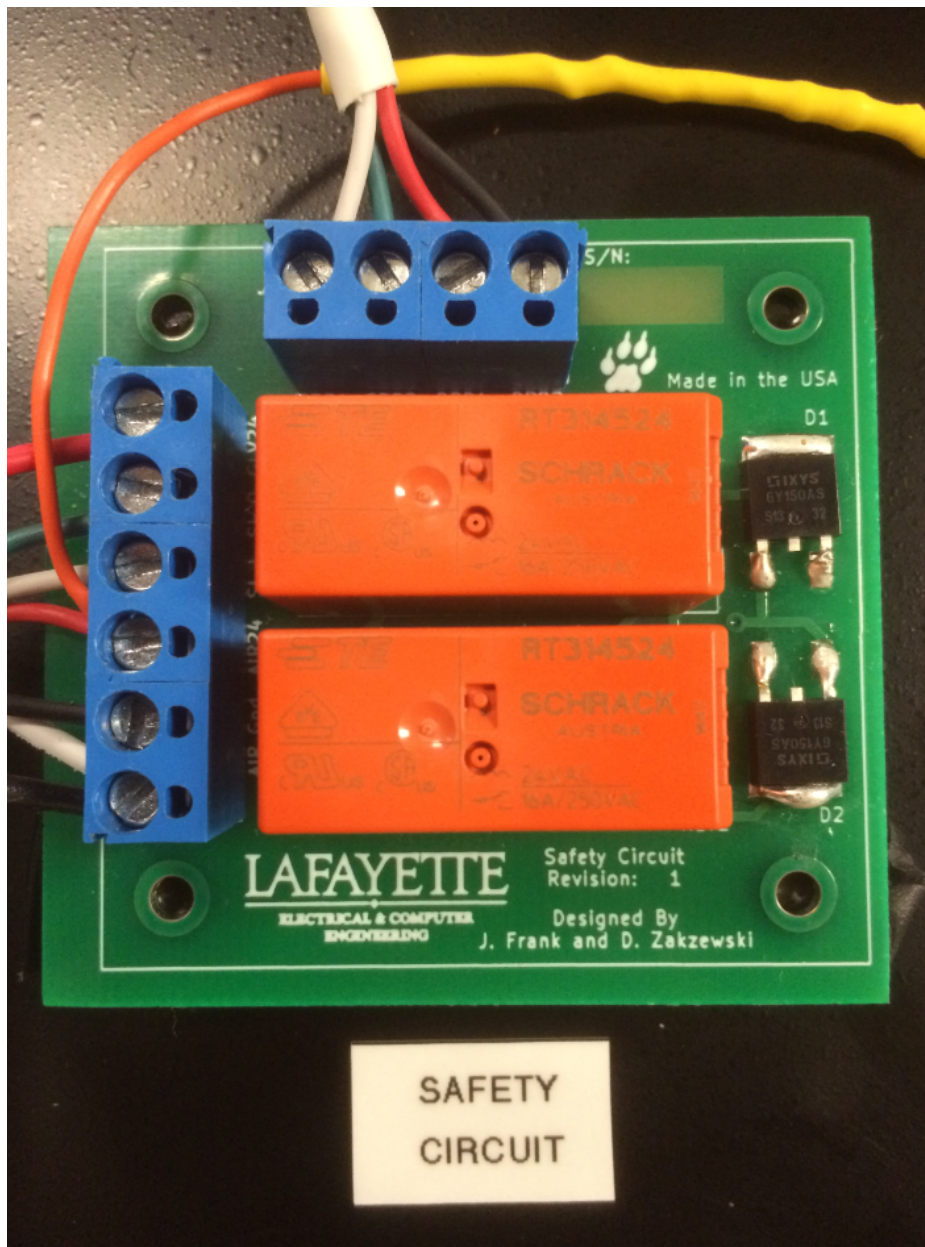
## After Opening the Safety Loop

If the Safety Loop is ever opened, the user should find the source of the failure. Sources of failures include:

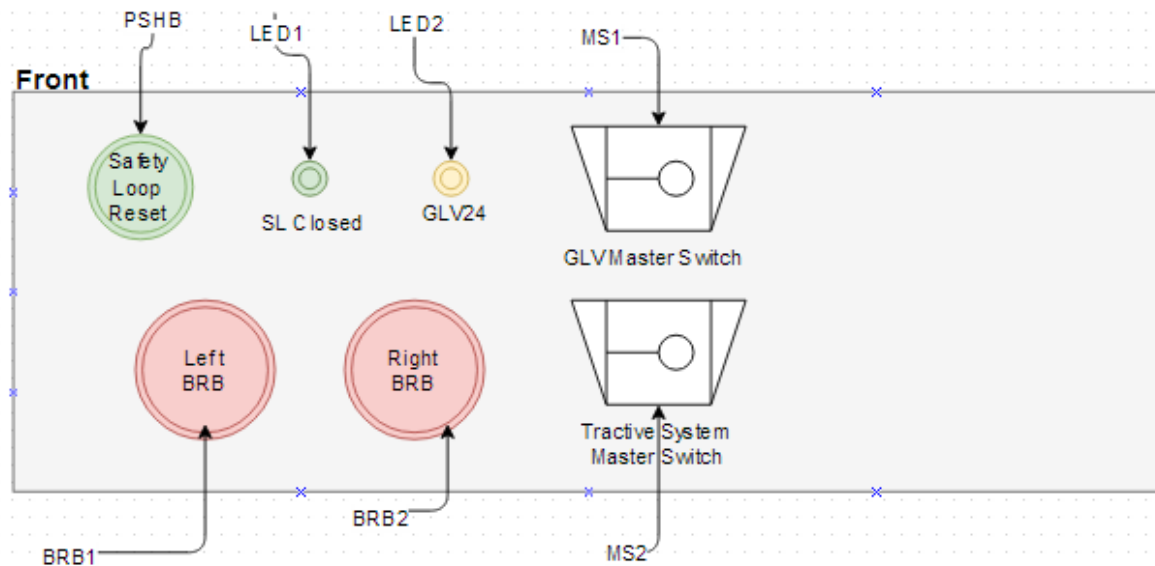
- IMD Fault
- AMS Fault
- BOTS flipped
- VSCADA error

- Motor Controller
- Safety Loop physically disconnected
- Loss of power from the GLV
- Master Switches

Before resetting the Safety Loop, the user should fully inspect each element to determine the cause of the Safety Loop opening. Do not simply reset the system with the green button without determining the original source of fault.



# Side Panel



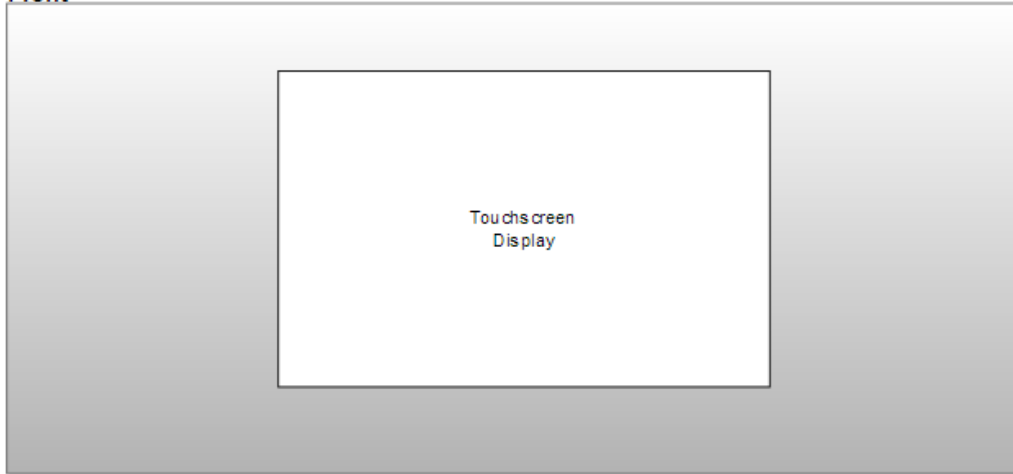
The GLV Master Switch (GLVMS) is a red, rotary switch located on the Side Panel. The GLVMS is located next to the TSV Master Switch (TSVMS), which is discussed in the Safety Loop section. Each Master Switch is clearly marked with the letters “GLV” or “TSV”. There is a GLV24 light located next to the GLVMS that indicates whether the GLV Power system is actively powering the vehicle. Also located on the Side Panel are the Side BRBs. Each BRB is labeled either “Left” or “Right” indicating where they would be located on the electric vehicle. Each of these buttons will be a red push-rotate switch that separates the GLV battery from the rest of the GLV power lines. The BRBs will also kill the Accumulator Isolation Relays (AIRS). If a BRB is activated and the system is shutdown, the user must reset the BRB and then press the overall Reset to restore the state of the Safety Loop. The Reset button is located on the Side Panel. The light next to the Reset button, labeled SL Closed, will light up when the Safety Loop is completely closed. There is also a BRB reachable by the driver in the cockpit. The function of this BRB is detailed in the Cockpit Box section.



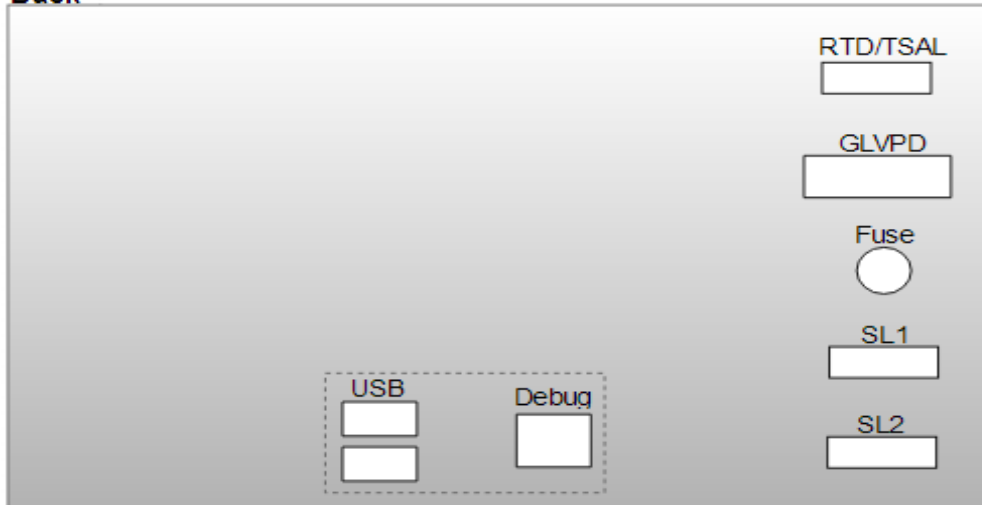
# VCI

The Vehicle Computer Interface will deliver data from sensors located throughout the car to the VSCADA system. Data from these sensors will be converted from analog to digital data using microprocessors and then formatted for the cockpit display by the VSCADA computer. The Ready-to-Drive sound speaker will also be designed and implemented as a safety feature for the electric car. This user's manual will detail the connections of the Vehicle Computer Interface, and some troubleshooting assistance.

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## Setting Up the VCI Box

In order for proper operation of the Vehicle Computer Interface, the VCI box must be set up as follows in the specific order noted.

1. Connect the box to the cockpit via the Cockpit Bus port.
2. Connect the box to the TSV system via the TSV Data ethernet connector.
3. Connect the box to the TSI box via the Load Controller 3-pin Molex connector.
4. Integrate the box into the safety loop via both Safety Loop (SL) 4-pin Molex connectors.
5. Connect the box to the GLV power and data line via the GLV24 6-pin Molex connector.

## Normal VCI Operation

In normal operation the VCI system, a green power light will appear when the system is properly powered. Data from the VSCADA computer will be displayed on the cockpit display. The Safety Loop light should not be lit, if no critical errors were found.

## Troubleshooting

If the cockpit display and/or VSCADA computer are not starting:

- Check connection to the GLV24 line and that the line is supplying power
- Check that the cockpit display bus is connected properly
- Reset the VSCADA computer

If the Ready-To-Drive sound is inaudible or quiet:

- Use a voltmeter to make sure the subsystem is receiving power
- If the speaker is emitting a low volume sound then adjust the amplifier as needed
- If no sound is being emitted remove the speaker from the system and test to see if it is still working
- If the speaker is operating properly then reinstall the speaker and replace the amplifier
- If there is no improvement of the system then further analysis of the circuit by an engineer is required

If the displayed measurements are no longer working or noticeably inaccurate



- Ensure that the system is properly connected to GLV24
- No change in the output, check the microprocessor to see if it is correctly converting the data, if it is not replace the microprocessor