GROUNDED LOW VOLTAGE (GLV) MAINTENANCE MANUAL

Abstract

This document describes maintenance for the GLV system.

May 4, 2017

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Note 1: There is no Software is involed in the GLV System

Note 2: GLV Gerber files are attached.

Note 3: Mechanical Parts and Drawings are attached.

Maintenance

Being that the GLV system is implemented entirely in hardware, maintenance of the system generally involves ensuring the wiring is correct throughout the system (see GLV Wire List). It is also important to ensure that the chips on the GLV PCB are functioning properly (see GLV PCB Q/A Testing Procedures). The mechanical components of the GLV system do not require regular maintenance.

Charging the GLV Battery

The GLV Battery must be charged for proper operation of the GLV system. The GLV battery can be charged using a PST-G100-24F8 charger. This charger charges the 24V battery at 1.5A, and it includes a plug and forget algorithm which allows it to be plugged in without the possibility of overcharging the battery. The charger has lights which indicate when the battery has finished charging.

Calibration

The chips on the GLV PCB are calibrated using specific resistors and capacitors. Resistors are clearly labeled in the PCB Schematic.

A 0.01Ω resistor (R3) is used for current sensing. When testing on board, this resistor was be measured to be 0.02Ω, so when calibrating the ina226 chip, specify a shunt resistance of 0.02Ω. Two 2.2KΩ resistors (R7 and R8) used for current limiting into the opto-isolator. There is a 120Ω terminating resistor (R6) between the positive and negative CAN lines. Two 20kΩ pull-up resistors (R4 and R5) are used as pull-up resistors for I2C. Current limiting resistors are sized at 1kΩ (R9 and R10), with one 200Ω limiting resistor (R20). All resistors used with the buffering op amps are sized at 10kΩ, and all caps on the board are .1uF decoupling caps.

Principal of Operation

The GLV system provides 24V DC to power all low voltage electrical systems as well as the five AIRs on the four TSV battery packs. The GLV system includes a safety loop was designed accordance with the Formula Hybrid Rules. The safety loop was I/O integrated in the dyno room on two rack mount panels. The safety loop is implemented on a PCB which interfaces with the safety loop I/O and provides GLV battery data to VSCDA. The PCB is housed on an aluminum place in the mechanical enclosure along with the VSCADA Raspberry Pi, and mechanical connector panels were mounted on the GLV enclosure to hold connectors extending wires to other electrical systems.

Safety Loop 1

The safety loop is composed of two loops. For GLV power to be provided to the car subsystems, safety l must be closed. This loop is composed of the circuit breakers, GLV master switch, left side E-stop, and right side E-stop. 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 – Starting GLV

The GLV system requires an operator on the outside of the car to turn the master switches and press Master Reset before the car can start. The driver is required to press the crash protection reset after the Master Reset is pressed to start the car. This will energize the AIRs if there are no safety loop faults in the GLV powered subsystems. 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.

Car Operation – Operator Cutting Power

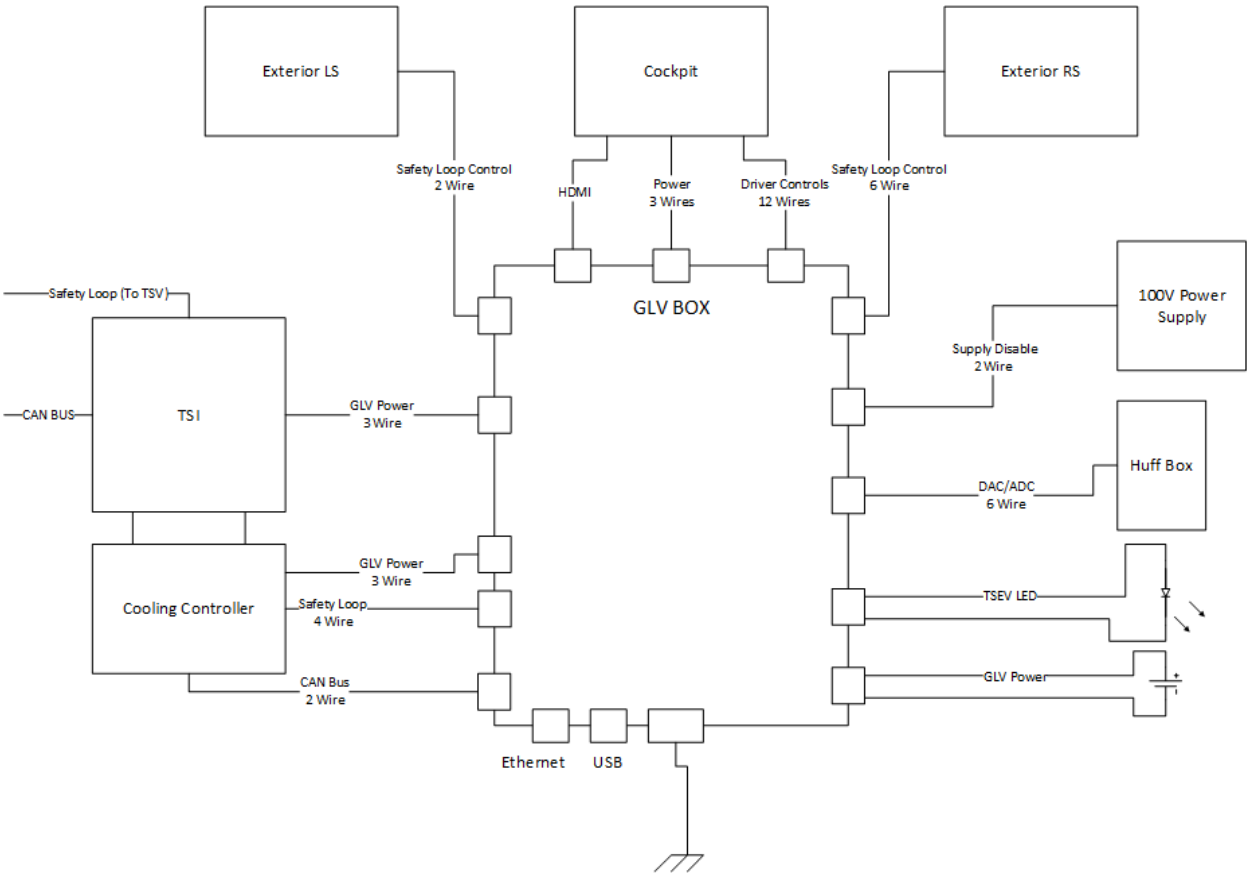
This GLV safety loop allows an operator on the outside of the car to turn off the GLV system entirely or turn off power to the AIRs using the exterior E-stops and master switches. The Driver only has access to the driver E-stop so that the driver can turn off the AIRs if needed, but the driver cannot cut power to the entire GLV system or power down subsystems.

GLV PCB Operation

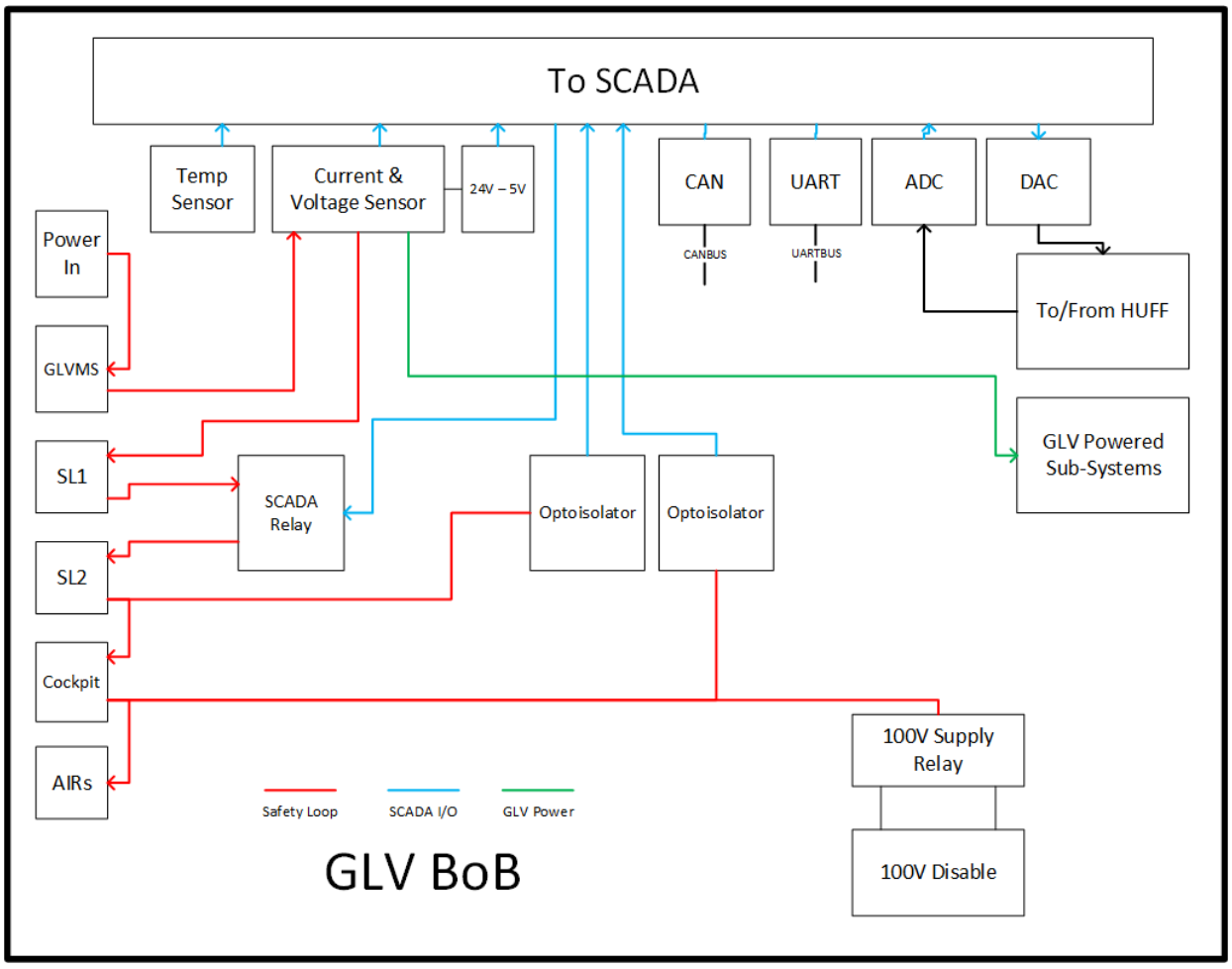
The GLV PCB encompasses most of the routing for the safety loop, and it provides data to the Raspberry Pi (VSCADA) through CAN, UART, and I2C. CAN is routed to VSCADA through the GLV PCB so that TSV, Cooling, and TSI can relay information to VSCADA. UART is also routed to VSCADA through the GLV PCB so that TSI can communicate motor data such as torque, rpm, and load. On board chips communicate through I2C to relay the voltage and current of the GLV battery as well as the temperature of the PCB to VSCADA. These each will be displayed on the VSCADA display. There is a 24V to 5V DC/DC converter used to power the Raspberry Pi as well. There is a 5V relay on the GLV PCB which allows VSCADA to trip the safety loop, and there are additional 24V relays allowing the GLV system to trip the safety loop.

Block Diagrams

GLV Systems Block Diagram

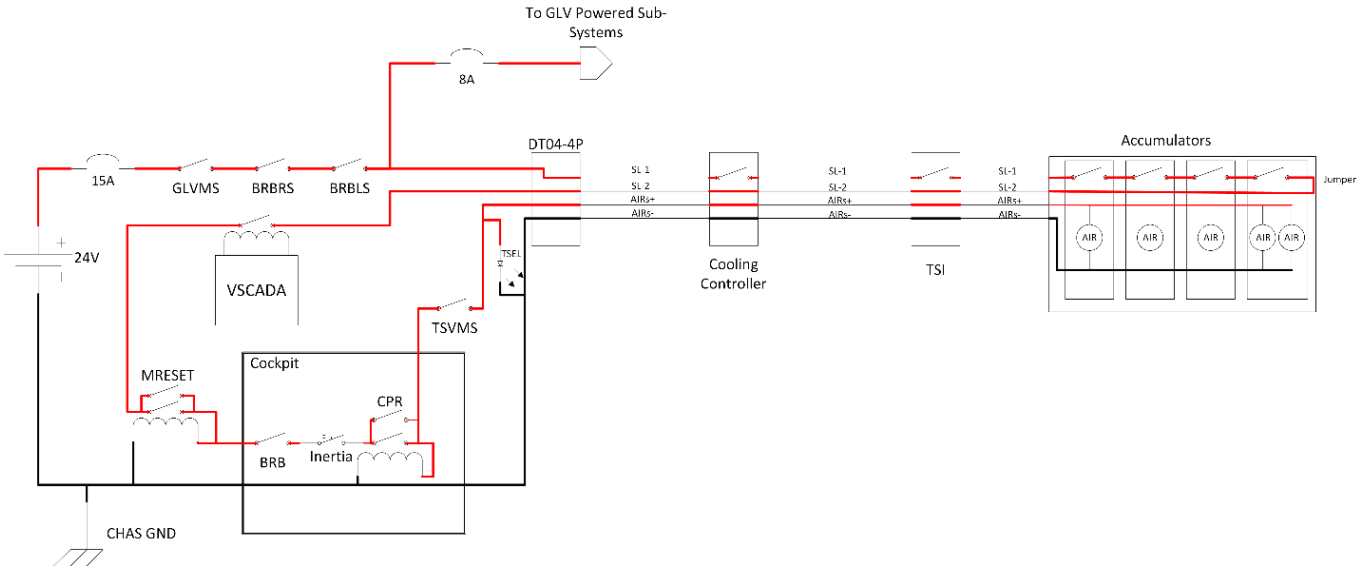


GLV BoB Block Diagram

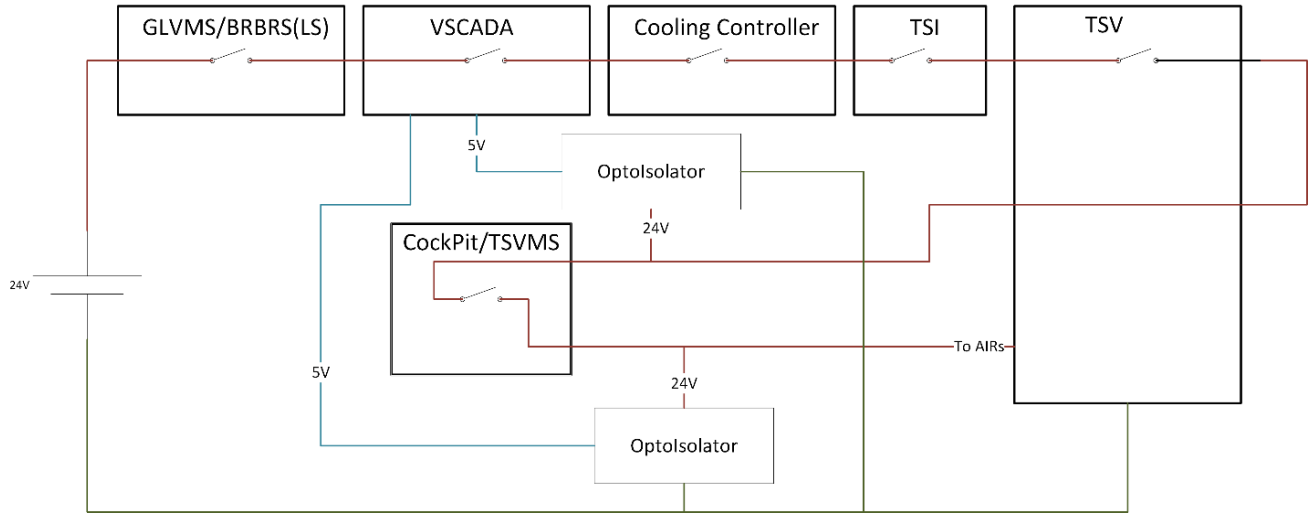


Conceptual Diagrams

Safety Loop Schematic

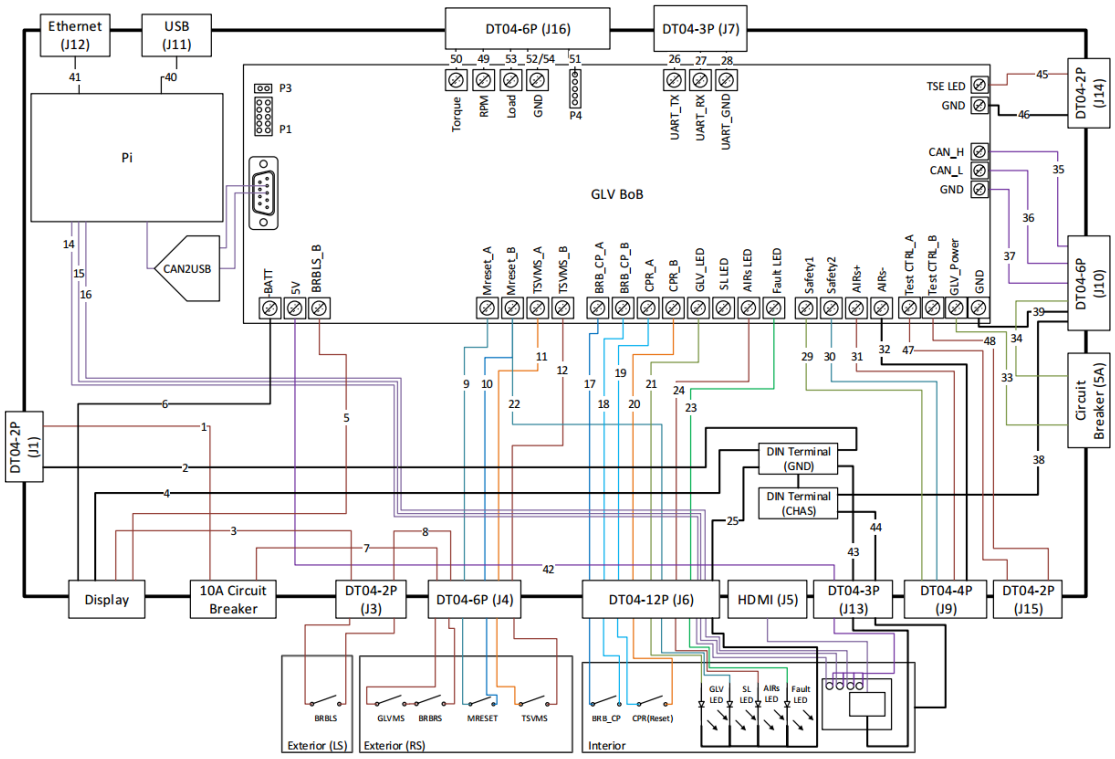


Safety Loop Monitoring Diagram



Wiring Diagram

GLV Wiring Diagram



GLV Wire List

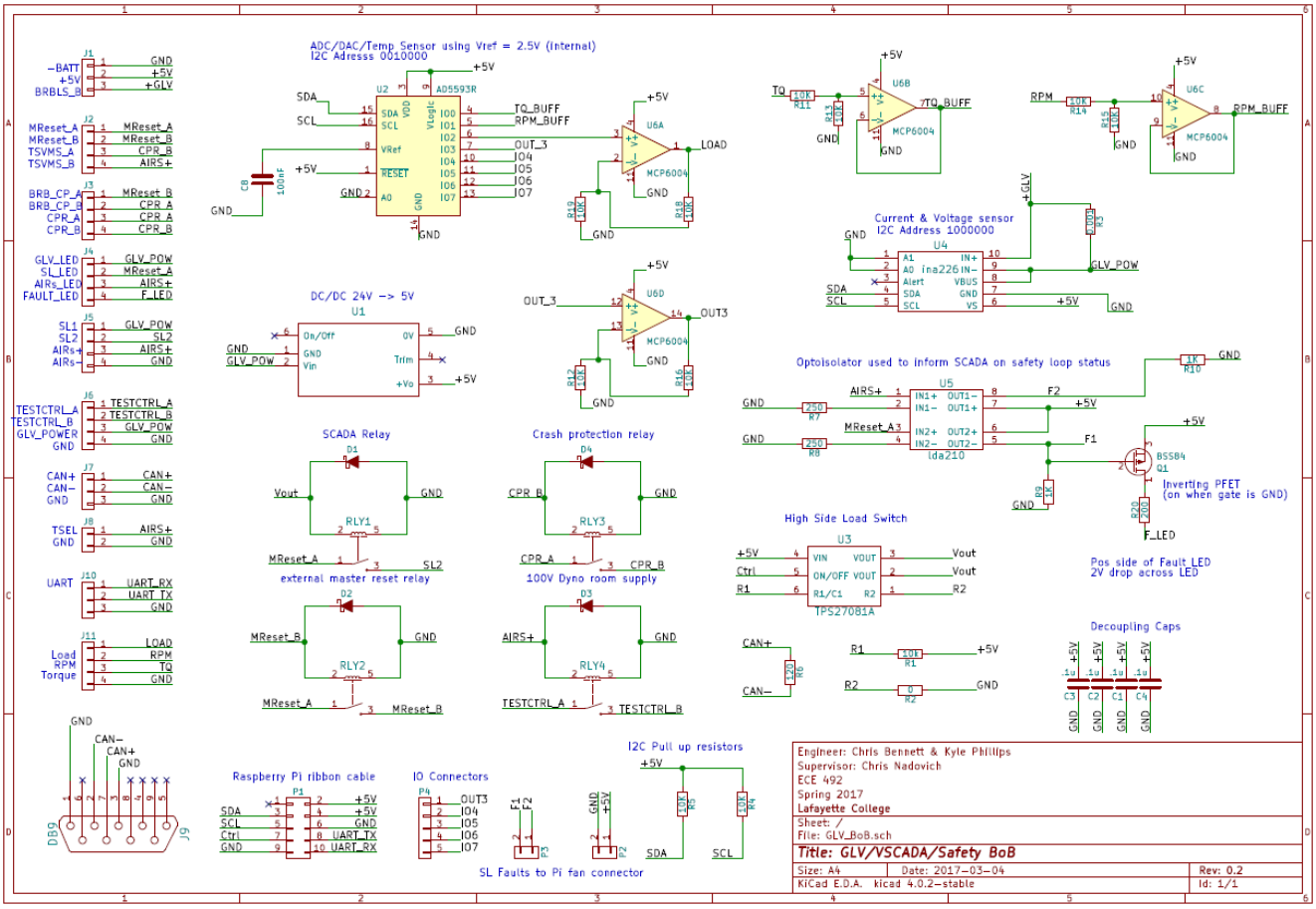
Wire Number	Conn A	Conn B
1	Battery +	High Amp Circuit Breaker In
2	Battery -	DIN Terminal (GND)
3	High Amp Circuit Breaker	BoB (+24VBatt)
4	CHAS GND	DIN Terminal (CHAS)
5	BoB (-BATT)	DIN Terminal (GND)
6	DIN Terminal (GND)	DIN Terminal (CHAS)
7	BoB (GND)	GLV Power Out (GND)
8	DIN Terminal (CHAS)	GLV Power Out (CHAS)
9	DIN Terminal (GND)	Int Panel Power (GND)
10	DIN Terminal (CHAS)	Int Panel Power (CHAS)
11	BoB (GLVMS_A)	Ext Panel RS (GLVMS)
12	Ext Panel RS (BRBRS)	BoB (BRBRS_B)
13	BoB (BRBLS_A)	Ext Panel LS
14	Ext Panel LS	BoB (BRBLS_B)
15	BoB (Safety1)	SL OUT (SL1)
16	SL OUT (SL2)	BoB (Safety2)
17	BoB (Mreset_A)	Ext Panel RS (Mreset)

18	Ext Panel RS (Mreset)	BoB (Mreset_B)
19	BoB (BRB_CP_A)	Int Panel (BRB_CP)
20	Int Panel (BRB_CP)	BoB (BRB_CP_B)
21	BoB (CPR_A)	Int Panel (CPR)
22	Int Panel (CPR)	BoB (CPR_B)
23	BoB (TSVMS_A)	Ext Panel RS (TSVMS)
24	Ext Panel RS (TSVMS)	BoB (TSVMS_B)
25	BoB (AIRs+)	SL OUT (AIRs+)
26	BoB (AIRs-)	SL OUT (AIRs-)
27	BoB (Test_CTRL_A)	100V Supply Disconnect A
28	100V Supply Disconnect A	BoB (Test_CTRL_B)
29	BoB (GLV_Power)	Low Amp Circuit Breaker In
30	Low Amp Circuit Breaker Out	GLV Power (24V)
31	BoB (GLV_LED)	Int Panel (GLV_LED)
32	BoB (SL_LED)	Int Panel (SL_LED)
33	BoB (AIRs LED)	Int Panel (AIRs LED)
34	BoB (Fault LED)	Int Panel (Fault LED)
35	BoB (TSE LED)	TSE Light (+)
36	BoB (GND)	TSE Light (-)
37	BoB (CAN_H)	CAN (H)
38	BoB (CAN_L)	CAN (L)
39	BoB (GND)	CAN (GND)
40	From HUFF (Torque)	BoB (Torque)
41	From HUFF (RPM)	BoB (RPM)
42	From HUFF (Load)	BoB (Load)
43	BoB (UART_TX)	UART (TX)
44	BoB (UART_RX)	UART (RX)
45	BoB (GND)	UART (GND)
46	Ethernet	Pi (Ethernet)
47	USB	Pi (USB)
48	BoB (+5V)	Int Panel Power (5V)
49	Pi (I/O)	Int Panel (Buttons)
50	Pi (I/O)	Int Panel (Buttons)
51	Pi (I/O)	Int Panel (Buttons)
52	Pi (I/O)	Int Panel (Buttons)
53	Pi (HDMI)	Int Panel (HDMI
54	BoB (10 Pin Header)	Pi pins
55	BoB (2 Pin Header)	Pi pins
56	BoB (GND)	Huff Box (GND)

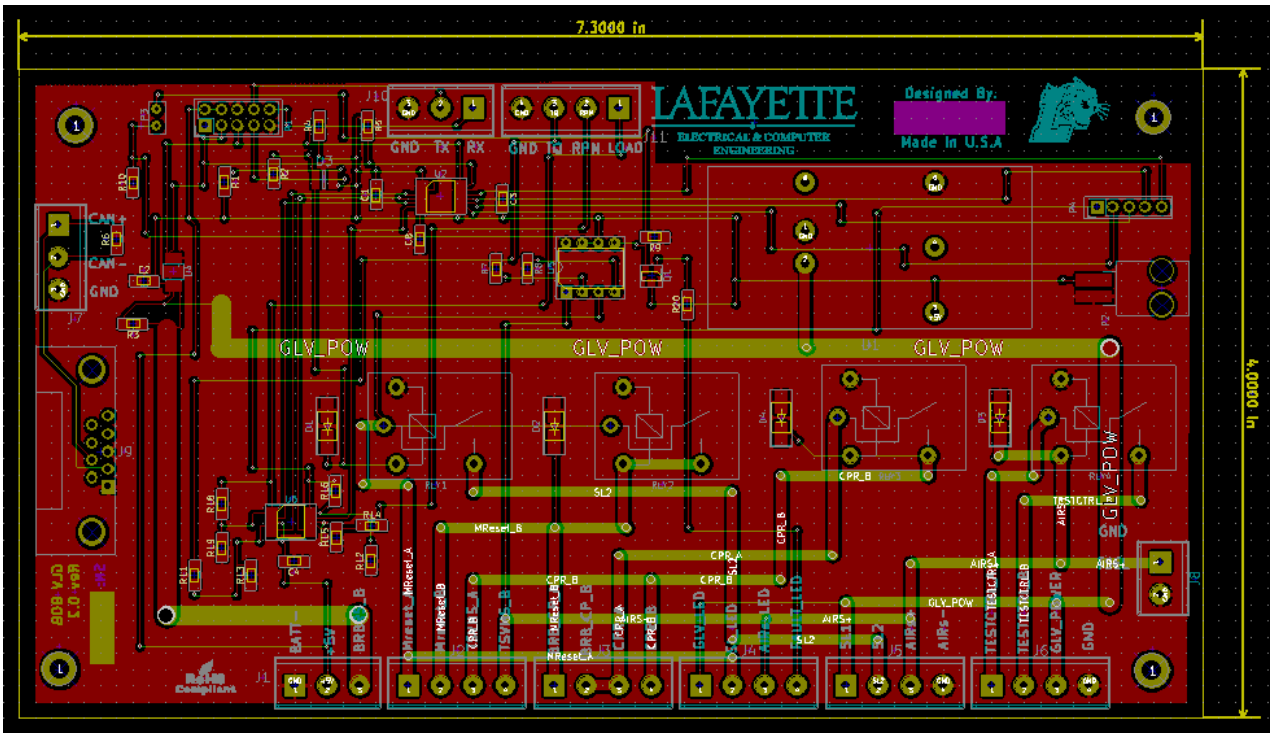
PCB Schematic (L17_GLV_07)

GLV PCB Gerber Files are attached.

GLV PCB Schematic



GLV PCB Layout



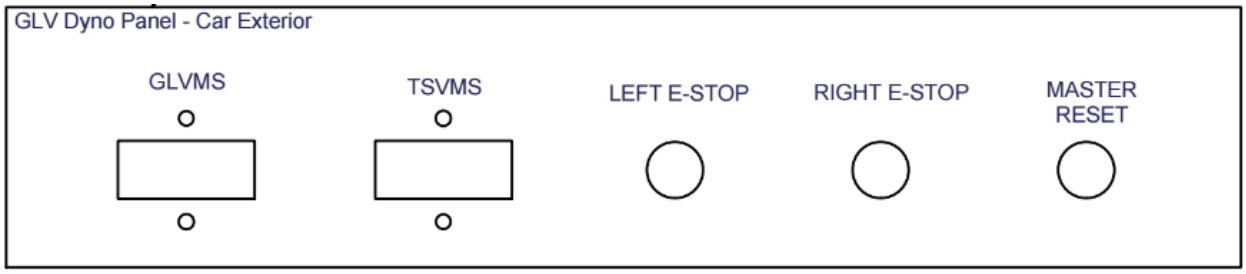
PCB BOM

Referance	Description	Manufacturer	Part Number	Supplier
U1	24V-5V DC/DC	CUI inc	PYB20-Q24-S5	Digikey
U2	ADC/DAC & Temp I2C	Analog Devices inc	AD5593RBRUZ	Digikey
U3	IC Switch	TI	TPS27081ADDCR	Digikey
U4	Current Monitor	TI	INA226AIDGSR	Digikey
U5	Opto-Isolator	IXYS	LDA210	Digikey
U6	Quad Op-Amp	Microchip Tech	MCP6004-I/P	Digikey
Q1	PFet	Fairchild	BSS84	Digikey
RLY1	Relay	Omron	G5LE-1A4	Digikey
RLY2	Relay	Omron	G5LE-1A5	Digikey
RLY3	Relay	Omron	G5LE-1A6	Digikey
RLY4	Relay	Omron	G5LE-1A7	Digikey
C1	.1u	AVX Corp	08055C104KAT2A	Digikey
C2	.1u	AVX Corp	08055C104KAT2A	Digikey
C3	.1u	AVX Corp	08055C104KAT2A	Digikey
C4	.1u	AVX Corp	08055C104KAT2A	Digikey
C5	100n	AVX Corp	08055C104MAT2A	Digikey
D1	Diode Schottky	Micro Commercial	SK310A-LTP	Digikey
D2	Diode Schottky	Micro Commercial	SK310A-LTP	Digikey
D3	Diode Schottky	Micro Commercial	SK310A-LTP	Digikey
D4	Diode Schottky	Micro Commercial	SK310A-LTP	Digikey
R1	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R3	0.001	Stackpole Electronics inc	CSNL1206FT1L00	Digikey
R4	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R5	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R6	120	Stackpole Electronics inc	RMCF0805JT120R	Digikey
R7	250	Stackpole Electronics inc	RNCF0805TKY250R	Digikey
R8	250	Stackpole Electronics inc	RNCF0805TKY250R	Digikey
R9	1k	Yageo	RC0805JR-071KL	Digikey
R10	1k	Yageo	RC0805JR-071KL	Digikey
R11	10k	Panasonic Electronic Componants		Digikey
R12	10k	Panasonic Electronic Componants		Digikey
R13	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R14	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R15	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R16	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R17	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R18	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R19	10k	Panasonic Electronic Componants	ERJ-6ENF1002V	Digikey
R20	200	Stackpole Electronics inc	RMCF0805FT200R	Digikey

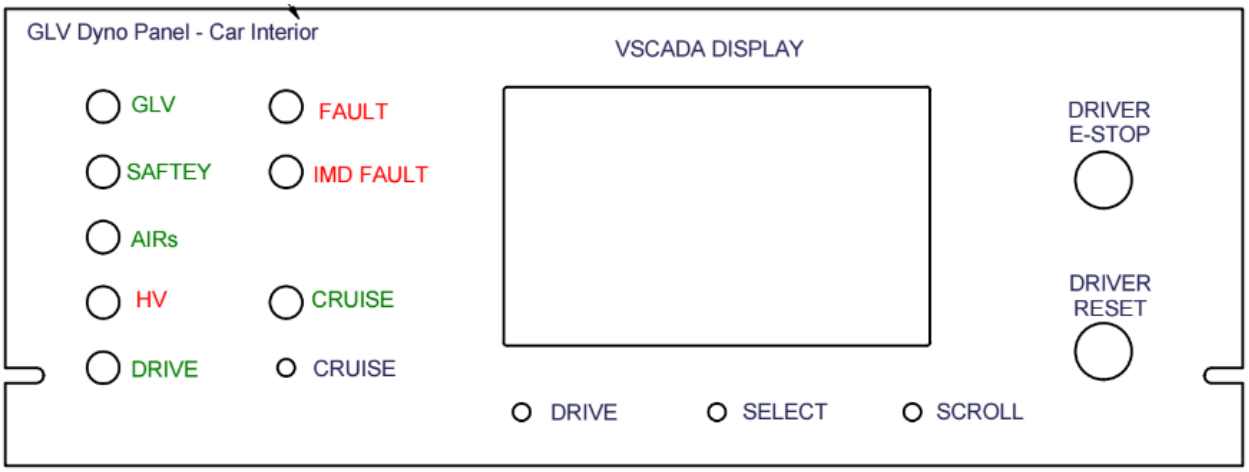
Mechanical Drawings

Below shows informational drawings including labels or basic dimensions for each of the GLV mechanical parts. Inventor files with all dimensions and screw hole taps attached.

GLV Dyno Panel – Car Exterior (GLV_L17_02)

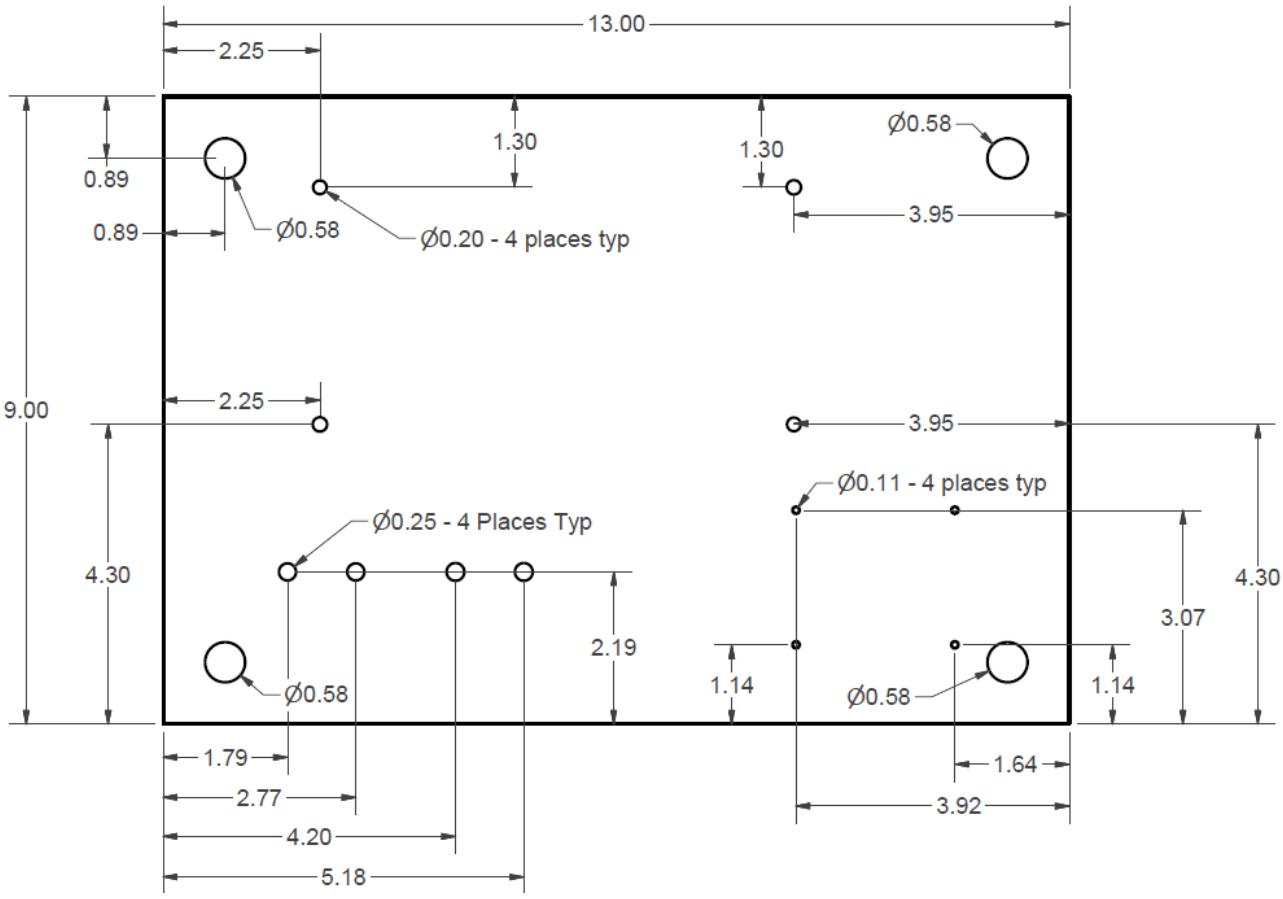


GLV Dyno Panel – Car Interior (GLV_L17_03)

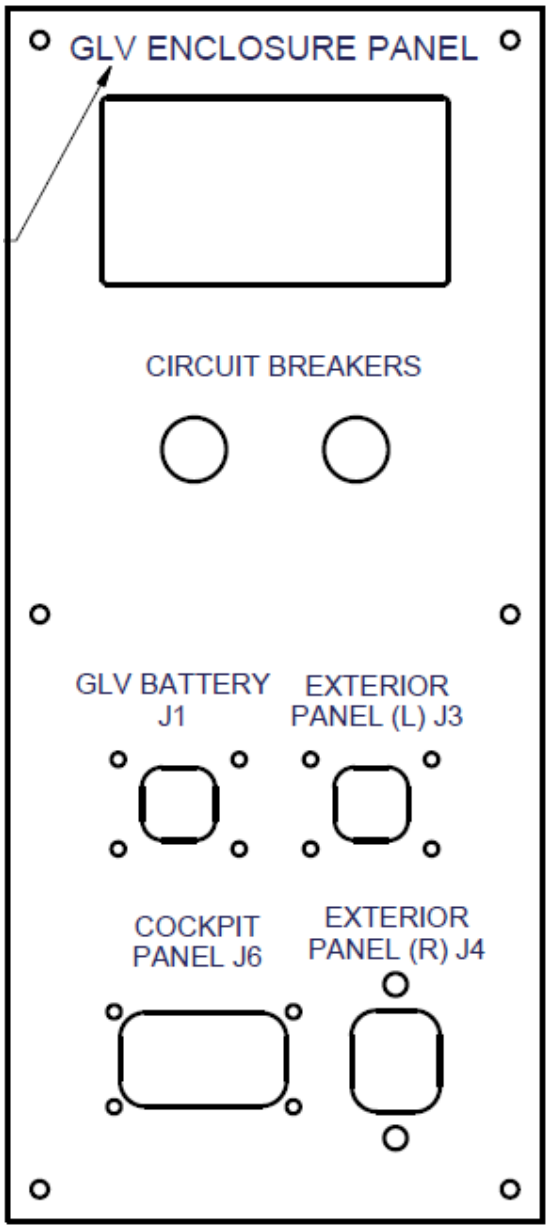


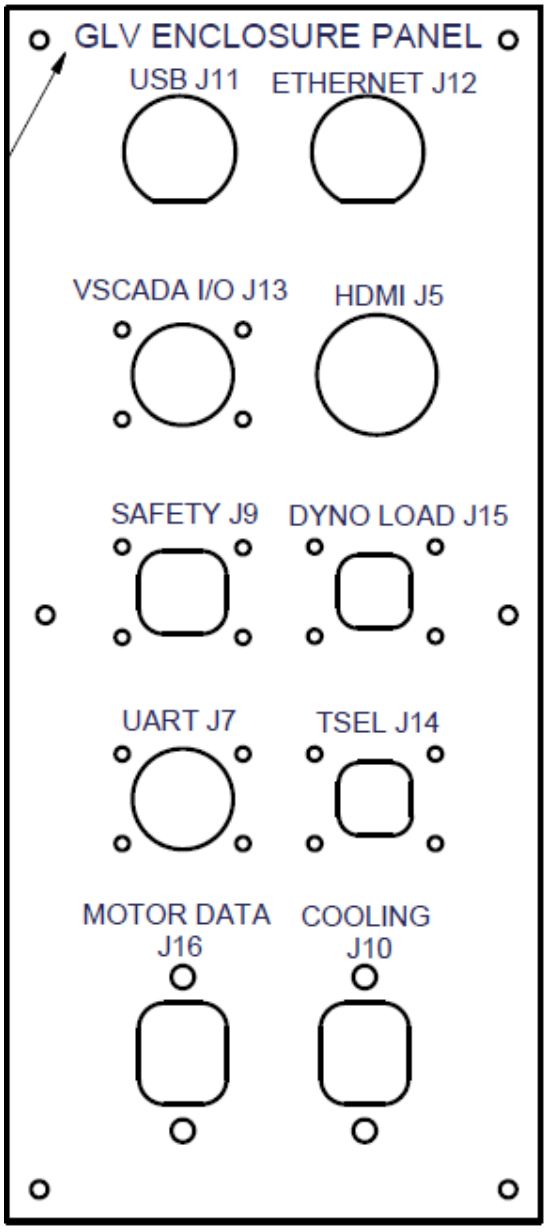
GLV Enclosure Base Plate (GLV_L17_04)

This is the mounting place for GLV components inside the GLV enclosure.



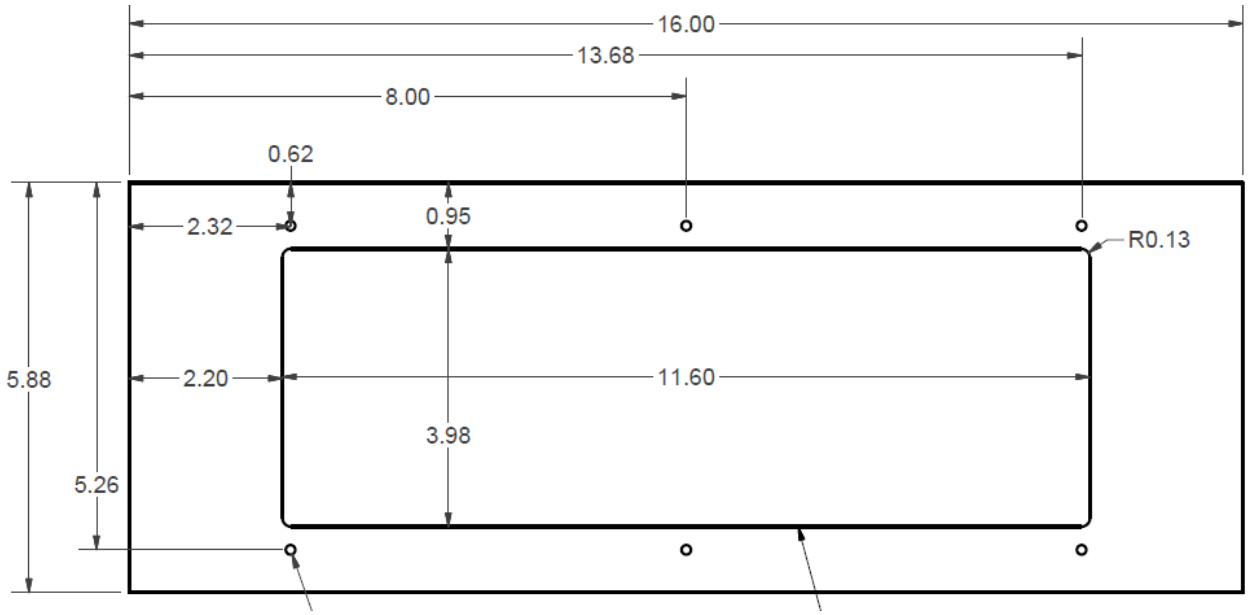
GLV Enclosure Panels (GLV_L17_05/06)





GLV Enclosure (GLV_L17_08)

Both 16” x 6” sides of the GLV enclosure which was purchased from McMaster-Carr were cut to mount the GLV Enclosure Panels.



Mechanical BOM

GLV Mechanical Bill of Materials							
Reference Designator	**Value**	**Description**	**Manufacturer**	**Manufacturer P/N**	**Supplier**	**Supplier P/N**	**Unit Cost**
Battery	24V, 10AH	Lithium Iron Phosphate Rechargeable Lithium Battery	PowerStream	LFP256099	PowerStream	LFP256099	$295.00
Battery Charger	24V	Battery charger UL approved	PowerStream	PST-G100-24F8	PowerStream	PST-G100-24F8	$50.00
Battery Enclosure		Battery Box	PowerStream	69995K81	PowerStream	69995K81	$13.13
BRBRS (Left side E-stop)		22MMHW SeriesEmergency Stop Switches	IDEC	HW1E-LV402Q4R			
BRBLS (Right side E-stop)		22MMHW SeriesEmergency Stop Switches	IDEC	HW1E-LV402Q4R			
BRB (Driver Accessible)		22MMHW SeriesEmergency Stop Switches	IDEC	HW1E-LV402Q4R			
Master Reset		Momentary Push Button (Non-Illuminated)	NEMA	22PB-NO-X-PM-GN			
CPR		Momentary Push Button (Non-Illuminated)	NEMA	22PB-NO-X-PM-GN			
GLVMS		Car Rotating Battery/Electrical Master Switch					
TSVMS		Car Rotating Battery/Electrical Master Switch					
Interia Switch	24V	First Technology Inertia Switch	First Tech		EVWEST		52.8
Cruise Control Switch (SCADA I/O 1)	5V	SWITCH PUSH SPST-NO 0.15A 5V	Greyhill	30-601 RED	Digikey	GH1368-ND	3.04
Scroll Menu Button (SCADA I/O 2)	5V	SWITCH PUSH SPST-NO 0.15A 5V	Greyhill	30-601 BLK	Digikey	GH1367-ND	3.04
Select Menu Item Buttom (SCADA I/O 3)	5V	SWITCH PUSH SPST-NO 0.15A 5V	Greyhill	30-601 BLK	Digikey	GH1367-ND	3.04
Drive Button	5V	SWITCH PUSH SPST-NO 0.15A 5V	Greyhill	30-601 RED	Digikey	GH1368-ND	3.04
GLV LED	24V	Panel Mount Indicator (Green)	Dialight	6823235142F	Digi-Key	350-4053-ND	$8.94
Safety LED	24V	Panel Mount Indicator (Green)	Dialight	6823235142F	Digi-Key	350-4053-ND	$8.94
AIRs LED	24V	Panel Mount Indicator (Green)	Dialight	6823235142F	Digi-Key	350-4053-ND	$8.94
HV LED	24V	Panel Mount Indicator (Red)	Dialight	682-3132-141F	Digi-Key	350-4050-ND	$6.97
Drive LED	24V	Panel Mount Indicator (Green)	Dialight	6823235142F	Digi-Key	350-4053-ND	$8.94
Fault LED	24V	Panel Mount Indicator (Red)	Dialight	682-3132-141F	Digi-Key	350-4050-ND	$6.97
IMD Fault LED	24V	Panel Mount Indicator (Red)	Dialight	682-3132-141F	Digi-Key	350-4050-ND	$6.97
Cruise LED	24V	Panel Mount Indicator (Green)	Dialight	6823235142F	Digi-Key	350-4053-ND	$8.94
TSEL	24V	Tractive System Energized Light	Encell	STB-A35	Amazon	STB-A35	$30
GLV Battery Connector (J1)		DT04-2P	Deutsch	DT04-2P			

Left Exterior Panel Connector (J3)		DT04-2P	Deutsch	DT04-2P			
TSEL Connector (J14)		DT04-2P	Deutsch	DT04-2P			
Dyno Load Connector (J15)		DT04-2P	Deutsch	DT04-2P			
UART Connector (J7)		DT04-3P	Deutsch	DT04-3P			
VSCADA I/O Connector (J13)		DT04-3P	Deutsch	DT04-3P			
Safety Loop Connector (J9)		DT04-4P	Deutsch	DT04-4P			
Right Exterior Panel Connector (J4)		DT04-6P	Deutsch	DT04-6P			
Cooling Connector (J10)		DT04-6P	Deutsch	DT04-6P			
Motor Data (J16)		DT04-6P	Deutsch	DT04-6P			
Cockpit Panel Connector (J6)		DT04-12P	Deutsch	DT04-12P			
USB Connector (J11)		USB Panel Mount Connector					
Ethernet Connector (J12)		Ethernet Panel Mount Connector					
HDMI Connector (J5)		HDMI Panel Mount Connector					
Pi		Rasberry Pi					
CB1		Circuit breaker 15A	TE Connectivity	W28-XQ1A-15	Digikey	PB192-ND	
CB2		Circuit breaker 8A	TE Connectivity	W28-XQ1A-8	Digikey	PB189-ND	
L17_GLV_01_1		Basic Safety Loop Panel					
L17_GLV_02_1		External Panel (Dyno room only)	Hammond Manufacturing	PBPS19014BK2	Mouser	546-PBPS19014BK2	
L17_GLV_03_1		Internal Panel (Dyno room only)	Hammond Manufacturing	PBPS19014BK2	Mouser	546-PBPS19014BK2	
L17_GLV_04_1		Enclosure Plate					
L17_GLV_05_1		Left Side Enclosure Side Panel					
L17_GLV_06_1		Right Side Enclosure Side Panel					
L17_GLV_07_1		GLV PCB					
L17_GLV_08_1 (GLV/SCADA Enclosure)		Weather-Resistant Enclosure 16" x 12" x 6"	McMaster-Carr	7649K13	McMaster-Carr	7649K13	$120.37
VSCADA Display		Raspberry Pi Display	Adafruit	2718	Adafruit	2718	$79.95
GLV Enclosure Multimeter Display		Digital Display Multimeter	Bayite	PZEN-31	Amazon		$14.99
Terminal Blocks	600V, 20A	4 x Feed-Through Terminal Blocks	Amphenol PCD	ATB2			
Din Rail		35 mm DIN Mounting Rail	Square D	9080MH379			
Rack Mount Plate for GLV Enclosure		14U Steel Rack Panel	Hammond Manufacturing	546-PBPS19014BK2	Mouser	546-PBPS19014BK2	
Screws for mounting GLV Enclsoure		4 x Alloy Steel Socket Head Screws (10-24)					

Screws for mounting L17_GLV_01/02/03 to Rack		10 x Rack mount screws (10-32)					
Screws for din rail on L17_GLV_04_1		2 x Press Fit Nuts for sheet metal (10-32)	McMaster-Carr	95185A185	McMaster-Carr	95185A185	$6.26
Screws for GLV board and Pi on L17_GLV_04_1		8 x Press Fit Nuts for sheet metal (2-56)	McMaster-Carr	95185A105	McMaster-Carr	95185A105	$9.40
Spacers for board and pi screws on L17_GLV_04_1		2 x Nylon unthreaded spacers	McMaster-Carr	94639A703	McMaster-Carr	94639A703	$7.51
Spacers for din rail screws on L17_GLV_04_1		8 x Nylon unthreaded spacers	McMaster-Carr	94639A351	McMaster-Carr	94639A351	$7.68
Screws for board and pi screws on L17_GLV_04_1		Steel Phillips Screws 10-32	McMaster-Carr	90272A827	McMaster-Carr	90272A827	$3.95
Screws for din rail screws on L17_GLV_04_1		Steel Phillips Screws 2-56	McMaster-Carr	90272A079	McMaster-Carr	90272A079	$3.28
Screws for DT04-06 on L17_GLV_05/06_1		6 x M5 by 0.8mm Hex Head Screws	McMaster-Carr	91280A223	McMaster-Carr	91280A223	$9.39
L17_GLV_05/06_1 Screws (minus DT04-06 screws)		44 x 8-32 Steel Phillips Rounded Head Screws	McMaster-Carr	90272A197	McMaster-Carr	90272A197	$4.10

QA Testing

Safety Loop Q/A Testing

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

GLV PCB Q/A Testing – Continuity Tests

Continuity (tests to be done with no external connections or power supplied to board)			
Ground Nets			
1	Connection between -BATT and AIRs-		
		Expected:	0 Ohms
		Observed:	0 Ohms
2	Connection between -BATT and TESTCTRL_GND		
		Expected:	0 Ohms
		Observed:	0 Ohms
3	Connection between -BATT and CAN_GND		
		Expected:	0 Ohms
		Observed:	0 Ohms
4	Connection between -BATT and TSEL_GND		
		Expected:	0 Ohms
		Observed:	0 Ohms
5	Connection between -BATT and UART_GND		
		Expected:	0 Ohms
		Observed:	0 Ohms
6	Connection between -BATT and ADC/DAC_GND		
		Expected:	0 Ohms
		Observed:	0 Ohms
Safety Loop			
1	Connection between BRBLS_B and SL1		
		Expected:	0 Ohms
		Observed:	0 Ohms
2	Connection between BRBLS_B and GLV_LED		
		Expected:	0 Ohms
		Observed:	0 Ohms
3	Connection between BRBLS_B and GLV_POWER		
		Expected:	0 Ohms
		Observed:	0 Ohms
4	Connection between BRBLS_B and SL2		
		Expected:	MegaOhms/Open
		Observed:	MegaOhms/Open
5	Connection between BRBLS_B and AIRs+		
		Expected:	MegaOhms/Open

		Observed:	MegaOhms/Open	
6	Connection between SL2 and Mreset_A			
		Expected:	MegaOhms/Open	
		Observed:	MegaOhms/Open	
7	Connection between Mreset_A and Mreset_B			
		Expected:	MegaOhms/Open	
		Observed:	MegaOhms/Open	
8	Connection between Mreset_B and BRB_CP_A			
		Expected:	0 Ohms	
		Observed:	0 Ohms	
9	Connection between BRB_CP_A and BRB_CP_B			
		Expected:	MegaOhms/Open	
		Observed:	MegaOhms/Open	
10	Connection between BRB_CP_B and CPR_A			
		Expected:	0 Ohms	
		Observed:	0 Ohms	
11	Connection between CPR_A and CPR_B			
		Expected:	MegaOhms/Open	
		Observed:	MegaOhms/Open	
12	Connection between CPR_B and TSVMS_A			
		Expected:	0 Ohms	
		Observed:	0 Ohms	
13	Connection between TSVMS_A and TSVMS_B			
		Expected:	MegaOhms/Open	
		Observed:	MegaOhms/Open	
14	Connection between TSVMS_B and AIRs+			
		Expected:	0 Ohms	
		Observed:	0 Ohms	
15	Connection between AIRs+ and AIRs_LED			
		Expected:	0 Ohms	
		Observed:	0 Ohms	
16	Connection between AIRs+ and TSEL			
		Expected:	0 Ohms	
		Observed:	0 Ohms	
17	Connection between TESTCTRL_A and TESTCTRL_B			
		Expected:	0 Ohms	
		Observed:	0 Ohms	

VCI		
1	Connection between CAN+ and Pin7 of 9-USB	
	Expected:	0 Ohms
	Observed:	0 Ohms
2	Connection between CAN- and Pin2 of 9-USB	
	Expected:	0 Ohms
	Observed:	0 Ohms
3	Connection between CAN- and Pin7 of 9-USB	
	Expected:	MegaOhms/Open
	Observed:	MegaOhms/Open
4	Connection between BATT- and Pin1 of 9-USB	
	Expected:	0 Ohms
	Observed:	0 Ohms
5	Connection between BATT- and Pin3 of 9-USB	
	Expected:	0 Ohms
	Observed:	0 Ohms
6	Connection between BATT- and Pin7 of 9-USB	
	Expected:	MegaOhms/Open
	Observed:	MegaOhms/Open
7	Connection between UART_RX and Pin10 of 10-pin header	
	Expected:	0 Ohms
	Observed:	0 Ohms
8	Connection between UART_TX and Pin8 of 10-pin header	
	Expected:	0 Ohms
	Observed:	0 Ohms
9	Connection between UART_TX and Pin10 of 10-pin header	
	Expected:	MegaOhms/Open
	Observed:	MegaOhms/Open
10	Connection between BATT- and Pin9 of 10-pin header	
	Expected:	0 Ohms
	Observed:	0 Ohms
11	Connection between BATT- and Pin6 of 10-pin header	
	Expected:	0 Ohms
	Observed:	0 Ohms
12	Connection between BATT- and Pin8 of 10-pin header	
	Expected:	MegaOhms/Open
	Observed:	MegaOhms/Open

GLV PCB Q/A Testing – Power on Tests

Below is a list of test for 24V supplied with no external connections.		
1	GLV_LED terminal voltage	
	Expected:	24V
	Observed:	24V
2	GLV_POWER terminal voltage	
	Expected:	24V
	Observed:	24V
3	SL1 terminal voltage	
	Expected:	24V
	Observed:	24V
4	+5V terminal voltage	
	Expected:	5V
	Observed:	5V
5	Pin 2 on 10 pin header voltage	
	Expected:	5V
	Observed:	5V
6	Pin 4 on 10 pin header voltage	
	Expected:	5V
	Observed:	5V

GLV PCB Q/A Testing – Relay Tests

5V VSCADA Relay			
1	Connect Pin 7 to Pin 6 on 10 Pin Header		
		Connection between SL2 and MresetA	
		Expected	Mega Ohms (Open)
		Observed	Mega Ohms (Open)
2	Connect Pin 7 to Pin 2 on 10 Pin Header		
		Connection between SL2 and MresetA	
		Expected	0 Ohms
		Observed	0 Ohms
Mreset Relay			
1	Normal MresetA and Mreset B (pre shorting)		
	Expected	Mega Ohms (Open)	
	Observed	Mega Ohms (Open)	
2	Short MresetA and Mreset B (check for latch)		
	Expected	0 Ohms	
	Observed	0 Ohms	
CPR Relay			
1	Normal CPRA and CPR B (pre shorting)		
	Expected	Mega Ohms (Open)	
	Observed	Mega Ohms (Open)	
1	Short CPRA and CPR B terminals and then check for latch		
	Expected	0 Ohms	
	Observed	0 Ohms	
TestCTRL Relay			
1	Make sure AIRs does not have 24V		
	Expected	0 Ohms	
	Observed	0 Ohms	
2	Complete Safety Loop to power AIRs (make sure AIRs terminal reads 24Vs)		
	Expected	Mega Ohms (Open)	
	Observed	Mega Ohms (Open)	

GLV PCB Q/A Testing – LED and Optoisolator Test

Turn GLV Power ON and open SL1 and SL2, connect header Pin 7 to header Pin 6		
1	Check Voltage on SL LED	
	Expected:	0V
	Observed	0V
2	Check Voltage on Fault LED	
	Expected:	5V
	Observed	5V
Turn GLV Power ON and short SL1 and SL2, connect header Pin 7 to header Pin 6		
1	Check Voltage on SL LED	
	Expected:	0V
	Observed	0V
2	Check Voltage on Fault LED	
	Expected:	5V
	Observed	5V
3	Check Voltage on F1	
	Expected:	0V
	Observed	0V
4	Check Voltage on F2	
	Expected:	0V
	Observed	0V
Turn GLV Power ON and short SL1 and SL2, connect header Pin 7 to header Pin 2		
1	Check Voltage on SL LED	
	Expected:	24V
	Observed	24V
2	Check Voltage on Fault LED	
	Expected:	0V
	Observed	0V
3	Check Voltage on AIRs LED	
	Expected:	0V
	Observed:	0V
4	Check Voltage on F1	
	Expected:	5V

	Observed:	5V
5	Check Voltage on F2	
	Expected:	0V
	Observed:	0V
Turn on AIRs Power by connecting relays		
1	Check Voltage on AIRs LED	
	Expected:	24V
	Observed	24V
2	Check Voltage on F2	
	Expected:	5V
	Observed:	5V