

# Interface Control Document

ECE 492 - Spring 2015

## Abstract

This document dictates the interfaces between each aspect of the LFEV design project for the 2015 spring semester. Refer to this document for the block diagram showing the connections between the subsystems.

Revision 3.0.0  
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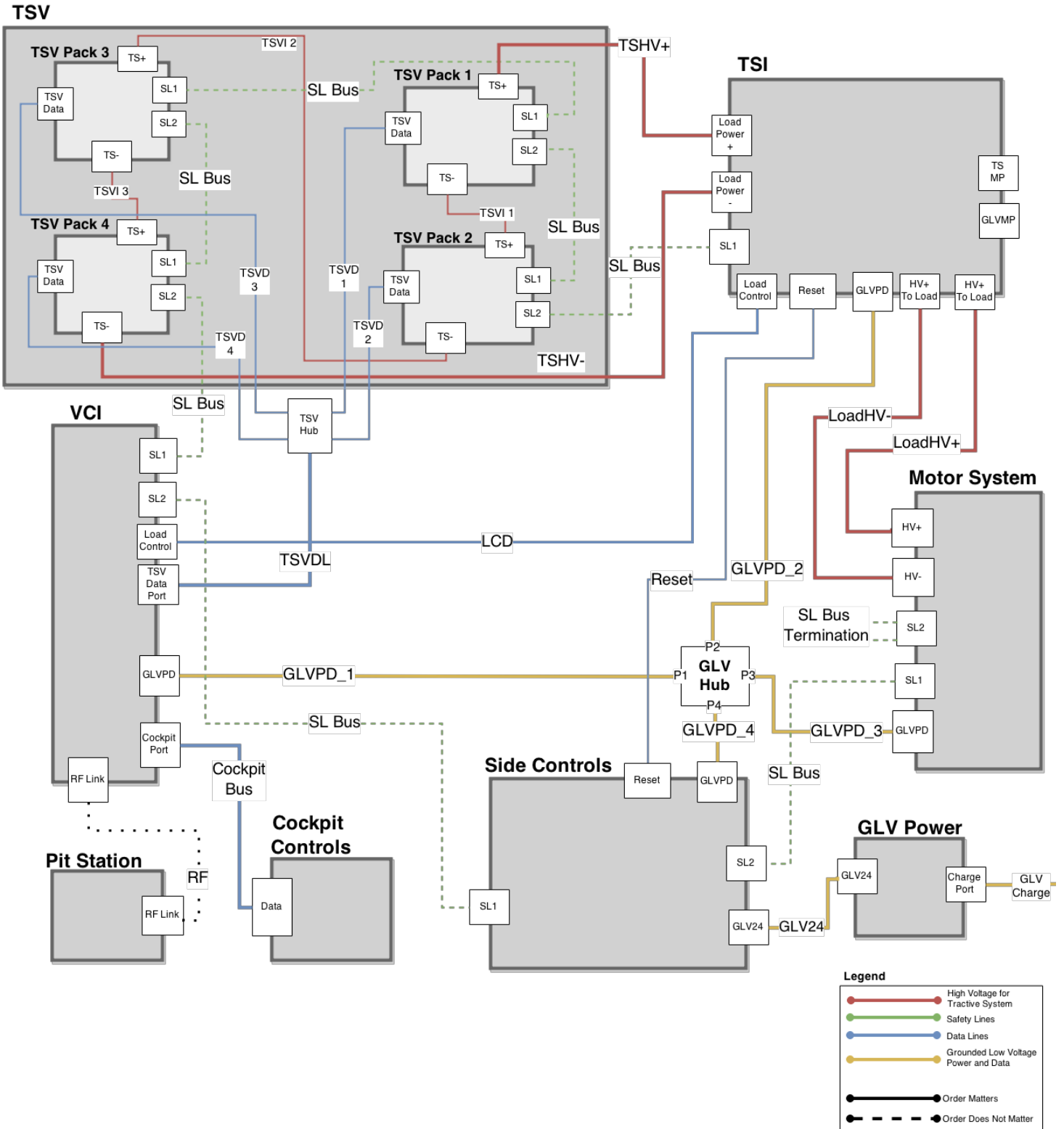
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# Introduction

This Interface Control Document (ICD) describes the connections between each of the major systems in the 2015 Lafayette Formula Electric Vehicle system. This document should dictate and govern all physical interfaces and software interfaces between systems of the electric vehicle.

# System Interconnection



# Interface List

## Main System Components

Component	Description
<a href="#">TSV</a>	Tractive system voltage supply
<a href="#">TSI</a>	Tractive system to motor controller interface
<a href="#">Motor System</a>	Houses motor controller and motor
<a href="#">GLV Power</a>	Supplies grounded low voltage to system
<a href="#">Side Controls</a>	User interfaces that must be located on the side of the car chassis
<a href="#">Cockpit Controls</a>	User interfaces that must be located in the cockpit of the car chassis
<a href="#">Pit Station</a>	Non-vehicle computer
<a href="#">VCI</a>	Vehicle to computer interface
<a href="#">TSV Hub</a>	Connects the TSV Pack data to the VSCADA computer
<a href="#">GLV Hub</a>	Connects system GLV data and power

## Physical Interfaces

Interface	Signal	Connection A	Connection B
<a href="#">SL Bus</a>	Safety Loop Bus	N/A (see SL Bus)	N/A (see SL Bus)
<a href="#">GLVPD 1</a>	GLV Data/Power	VCI : GLVPD	GLV Hub : P1
<a href="#">GLVPD 2</a>	GLV Data/Power	TSI : GLVPD	GLV Hub : P2
<a href="#">GLVPD 3</a>	GLV Data/Power	Motor System : GLVPD	GLV Hub : P3
<a href="#">GLVPD 4</a>	GLV Data/Power	Side Controls : GLVPD	GLV Hub : P4
<a href="#">GLV24</a>	GLV Data/ 24V Raw	GLV Power : GLV24	Side Controls : GLV24
<a href="#">TSVD 1</a>	TSV Data Ethernet Connection	TSV Pack 1 : TSV Data	TSV Data Switch : P1
<a href="#">TSVD 2</a>	TSV Data Ethernet Connection	TSV Pack 2 : TSV Data	TSV Data Switch : P2
<a href="#">TSVD 3</a>	TSV Data Ethernet Connection	TSV Pack 3 : TSV Data	TSV Data Switch : P3
<a href="#">TSVD 4</a>	TSV Data Ethernet Connection	TSV Pack 4 : TSV Data	TSV Data Switch : P4
<a href="#">TSVDL</a>	TSV Data Ethernet Connection	VCI : TSV Data Port	TSV Data Switch : P5
<a href="#">Cockpit Bus</a>	Cockpit Communication Bus	VCI : Cockpit Port	Cockpit Controls : Data
<a href="#">LCD</a>	Load Control Data Line	VCI : Load Control	TSI : Load Control
<a href="#">Reset</a>	Safety Loop Reset Line	TSI : Reset	Side Controls : Reset
<a href="#">TSVI 1</a>	Tractive System HV Interconnect	TSV Pack 1 : TS-	TSV Pack 2 : TS+
<a href="#">TSVI 2</a>	Tractive System HV Interconnect	TSV Pack 2 : TS-	TSV Pack 3 : TS+
<a href="#">TSVI 3</a>	Tractive System HV Interconnect	TSV Pack 3 : TS-	TSV Pack 4 : TS+
<a href="#">TSHV+</a>	Tractive System Positive	TSV Pack 1 : TS+	TSI : Load Power +
<a href="#">TSHV-</a>	Tractive System Negative	TSV Pack 4 : TS-	TSI : Load Power -
<a href="#">LoadHV+</a>	Positive High Voltage Load Supply	TSI : HV+ To Load	Motor System : HV+
<a href="#">LoadHV-</a>	Negative High Voltage Load Supply	TSI : HV- To Load	Motor System : HV-

## Software Interfaces

Interface	Protocole	Description	Location
GLV Data	<a href="#">CAN</a>	Communicates between VSCADA and sensors located around the electric vehicle system	GLVPD Buses
TSV Data	UNKNOWN	Communicates data between the VSCADA computer and the PACMAN computers	TSVD and TSVDL ethernet lines.
RF	UNKNOWN	Interfaces between the onboard VSCADA computer and the Pit Station computer	VCI and Pitstation

# SL Bus

## Description

The safety loop must start at the TSI box and connect (in so specific order) :

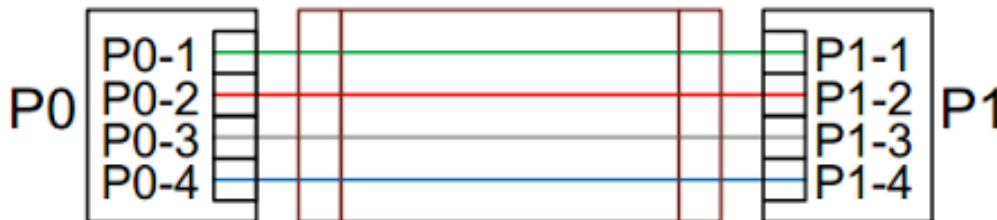
- TSV Pack 1
- TSV Pack 2
- TSV Pack 3
- TSV Pack 4
- VCI
- Side Control Panel
- Motor System

The termination of the safety loop must use a SL Bus Termination Cap.

## Safety Loop Cable

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
SL Bus			4-Wire Cable	Brown
P0			TE 4 Pin Connector (M)	White
P1			TE 4 Pin Connector (M)	White



### Cable Connections

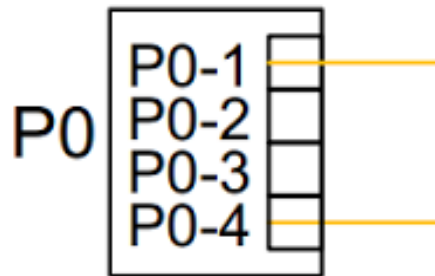
Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	Loop Out	20 AWG	Green
P0-2	P1-2	SL24+	20 AWG	Red
P0-3	P1-3	SL_GND	20 AWG	White
P0-4	P1-4	Loop In	20 AWG	Blue



## Safety Loop Termination Cap

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
SL Bus			1-Wire Cable	Blue
P0			TE 4 Pin Connector (M)	White



### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P0-4	Loop Out	20 AWG	Orange

# Physical Interfaces

## GLVPD

### Description

The Grounded Low Voltage Power and Data interface (GLVPD) powers all non-tractive systems within the electric vehicle. It also dictates the data exchange protocol of the Motor System, GLV Power, VCI, and TSI systems. At the center of these connections is the [GLV Hub](#) which simply combines all the lines of the GLVPD vehicle.

See the [CAN Protocol](#) section for software protocol information.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
GLVPD_1 GLVPD_2 GLVPD_3 GLVPD_4			4-Wire Cable	Brown
P0			TE 6 Pin Connector (M)	White
P1			TE 6 Pin Connector (M)	White

### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	GLV 24V+	20 AWG	Red
P0-2	P1-2	Data+	20 AWG	White
P0-3	P1-3	Data-	20 AWG	Blue
P0-4	P1-4	GLV Ground	20 AWG	White
P0-3	P1-3	NC	NC	NC
P0-4	P1-4	NC	NC	NC

## GLV24

### Description

The GLV24 interface is the same as the GLVPD connections, except it is mandatory that the [GLV Power](#) box is directly connected to the [Side Controls Panel](#). This is to integrate the GLV Master Switch and Emergency Shutdown Big Red Buttons (BRBs) in the proper sequence for the shutdown circuit. See the [CAN Protocol](#) section for software protocol information.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
GLV24			4-Wire Cable	Brown
P0			TE 6 Pin Connector (M)	White
P1			TE 6 Pin Connector (M)	White

### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	GLV 24V+	20 AWG	Red
P0-2	P1-2	Data+	20 AWG	White
P0-3	P1-3	Data-	20 AWG	Blue
P0-4	P1-4	GLV Ground	20 AWG	White
P0-3	P1-3	NC	NC	NC
P0-4	P1-4	NC	NC	NC

## TSVD

### Description

Tractive System Voltage Data Line, communicated through an ethernet cable. All TSVD connect to the TSV Hub which routes TSV pack data to the VCI System.

See the [Ethernet Interface](#) for protocol information.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
TSVD_1 TSVD_2 TSVD_3 TSVD_4			Ethernet Cable	Brown
P0			Ethernet Connector (M)	Clear
P1			Ethernet Connector (M)	Clear

### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1			
P0-2	P1-2			
P0-3	P1-1			
P0-4	P1-2			
P0-5	P1-1			
P0-6	P1-2			
P0-7	P1-3			
P0-8	P1-4			

## TSVDL

### Description

Tractive System Voltage Data Line, communicated through an ethernet cable. All TSVD connect to the TSV Hub which routes TSV pack data to the VCI System.

See the [Ethernet Interface](#) for protocol information.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
TSVDL			Ethernet Cable	Brown
P0			Ethernet Connector (M)	Clear
P1			Ethernet Connector (M)	Clear

### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1			
P0-2	P1-2			
P0-3	P1-1			
P0-4	P1-2			
P0-5	P1-1			
P0-6	P1-2			
P0-7	P1-3			
P0-8	P1-4			

## Cockpit Bus

### Description

The Cockpit Bus is a communication line between the VCI and Cockpit Controls. The data over this line controls the dashboard, dashboard controls, and the cockpit BRB.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
Cockpit Bus			UNKNOWN	

### Cable Connections

Connection A	Connection B	Description	Gauge	Color
UNKNOWN				

## LCD

### Description

The Load Controller Data line directly controls the isolation relays within the TSI from the VCI. These isolation relays work as a load controller between the TSV system and the Motor Load. The signal is simply high when active, and low when not active, because the isolation relays are normally open.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
LCD			2-Wire Cable	Black
P0			3-Pin Molex (M)	White
P1			3-Pin Molex (M)	White

### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	LC+	20 AWG	White
P0-2	P1-2	NC	NC	NC
P0-3	P1-3	LC-	20 AWG	Blue

## Reset

### Description

The Reset line directly connects the safety circuit inside the TSI to the Side Control's reset button.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
Reset			2-Wire Cable	Black
P0			2-Pin Molex (M)	White
P1			2-Pin Molex (M)	White

### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	Reset Out	20 AWG	White
P0-2	P1-2	Reset In	20 AWG	Blue



# TSVI

## Description

The the Tractive System Voltage Interconnects (TSVI) are high voltage lines used to interconnect each of the 4 TSV Packs in series.

## Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
TSVI_1 TSVI_2 TSVI_3			1-Wire Cable	UNKNOWN
P0			Poler Lock Connector (Drain)	N/A
P1			Poler Lock Connector (Source)	N/A



## Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	High Voltage Interconnect	2/0 AWG	UNKOWN

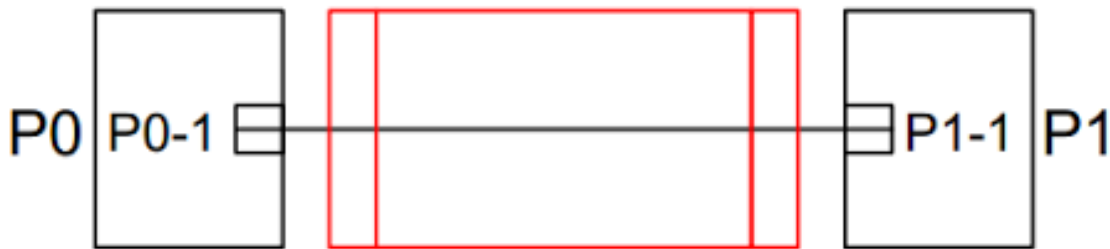
## TSHV+

### Description

The Tractive System High Voltage Positive line interconnects the TSV Packs highest voltage pack to the Load Controller.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
TSHV+			1-Wire Cable	Red
P0			Polar Lock Connector (Source)	N/A
P1			Ring Terminal	N/A



### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	TS High Voltage Positive	2/0 AWG	UNKNOWN

## TSHV-

### Description

The Tractive System High Voltage Positive line interconnects the TSV Packs lowest pack to the Load Controller.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
TSHV-			1-Wire Cable	Black
P0			Poler Lock Connector (Source)	N/A
P1			Ring Terminal	N/A



### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	TS High Voltage Negative	2/0 AWG	UNKNOWN

## LoadHV+

### Description

The High Voltage Positive to Load line interconnects the TSI's load controlled high voltage to the Motor System.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
TSHV+			1-Wire Cable	Red
P0			Polar Lock Connector (Source)	N/A
P1			Ring Terminal	N/A



### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	TS High Voltage Positive	2/0 AWG	UNKNOWN

## LoadHV-

### Description

The High Voltage Negative to Load line interconnects the TSI's load controlled high voltage to the Motor System.

### Physical Parts

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Type	Color
TSHV-			1-Wire Cable	Black
P0			Polar Lock Connector (Source)	N/A
P1			Ring Terminal	N/A



### Cable Connections

Connection A	Connection B	Description	Gauge	Color
P0-1	P1-1	TS High Voltage Negative	2/0 AWG	UNKNOWN

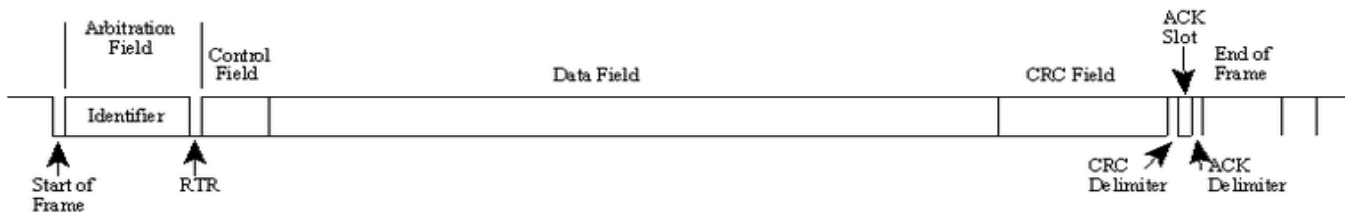
# Software Interfaces

The VSCADA team has decided on protocol's to communicate with the rest of the team. VSCADA communication to the DYNO team's motor controller and to the sensors from the GLV team will be communicated through the CAN bus protocol. The VSCADA team will communicate with the TSV teams packman systems via ethernet.

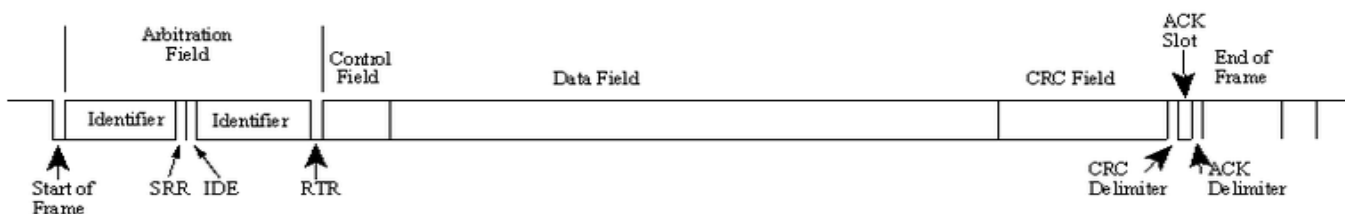
## CAN Protocol

### Introduction

The SCADA team will use the CAN bus protocol to communicate with the Motor Controller and the GLV Interface. The CAN bus protocol is defined by the 11898-1 standard. It is a physical layer transmitted by a differential on a twisted pair of wire. The messages are at most eight data bytes and implement a checksum. The address of the message only define it's priority on the bus. The protocol also implements an elaborate error handling scheme that results in retransmissions, and there are ways to isolate faults. The CAN bus is a broadcast bus, all nodes can hear transmission.



*A CAN 2.0A ("standard CAN") Data Frame.*



*A CAN 2.0B ("extended CAN") Data Frame.*

## Types of CAN bus messages

1. Data Frame
  - a. Contents
    - i. Arbitration field - determines the priority of the message when two or more nodes are contending for the bus
    - ii. Data field - Contains zero to eight bytes of data
    - iii. CRC field - 15 bit checksum
    - iv. ACK Slot - if a CAN controller has been able to receiver the message sends an ACK at the end of the message back to the transmitter. Transmitter check for the ACK and retransmission if no ACK was detected.
2. Remote Frame
  - a. Like Data BUT RTR in Arbitration Field is recessive, and NO data
  - b. Summary: "Hello everyone, can somebody please produce the data labeled X?"
  - c. Resquest-response traffic management
  - d. \*Not used alot in practice
3. Error Frame
  - a. Violated framming rules of a CAN message.
  - b. Is transmitted when a node detects a fault then will try to retransmit
4. Overload Frame
  - a. Not use very often

## Message Priority

The CAN protocol implements a system called arbitration which is define as an agreement on what sensor's packet should occupy the bus. When the bus is idle a sensor can start transmitting. When two or more sensors begin to send packets at the same time, the sensor with the higher priority will transmit and the lower priority sensor's packet will be stopped until the bus is idle again.

## Higher Layer

The VSCADA team will implement a higher layer as a way to manage CAN communication by establishing flow control and transportation of data larger than can fit in the 8 byte message.

## Ethernet Interfaces

### Introduction

The VSCADA team plans to use an ethernet to communicate with the PACMAN system. VSCADA will open an Secure Shell (ssh) connection with the PACMAN and read data from the PACMAN. SSH is a network protocol for securing data communication, the VSCADA computer will act as the client and the PACMAN will act as the server containing all of the data from the accumulators.



## RF Interfaces

### Introduction

The on board embedded computer will communicate with the pit station computer via a Wifi connection. Wifi is a local area wireless system and the transceiver will be commercially available and will interface with the on board computer.

# System Components

## Cockpit Control Panel

### Interface Description

The Cockpit Control Panel allows the driver of the vehicle interact with the electric vehicle and view important system information. The 'brains' of the Cockpit Control Panel is the VSCADA computer located within the VCI.

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
Data			Cockpit Bus	

## GLV Hub

### Interface Description

The GLV Hubs connects all GLVPD lines together so that they all share the same data ether and power.

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
P1			GLVPD_1	TE 6 Pin Connector (F)
P2			GLVPD_2	TE 6 Pin Connector (F)
P3			GLVPD_3	TE 6 Pin Connector (F)
P4			GLVPD_4	TE 6 Pin Connector (F)

## GLV Power

### Interface Description

The GLV Power system supplies power to the reset of the system. It primarily consists of a batter, which must be charged via the Charge Power. Several sensors within the system must also be integrated into the GLV data line, GLVPD.

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
Charge Port			GLV Charge	UNKNOW
GLV24			GLV24	TE 6 Pin Connector (F)

## Motor System

### Interface Description

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
HV+			High Voltage Positive	Nut and Bolt
HV-			High Voltage Negative	Nut and Bolt
SL1			Safety Loop In	TE 4 Pin Connector (F)
SL2			Safety Loop Out	TE 4 Pin Connector (F)
GLVPD			GLV Power and Data	TE 6 Pin Connector (F)

## Pit Station

### Interface Description

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
RF			Pit Station Communications	UNKNOW

## Side Control Panel

### Interface Description

The Side Control Panel houses physical interfaces to the safety loop and shutdown circuit.

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
SL1			Safety Loop In	TE 4 Pin Connector (F)
SL2			Safety Loop Out	TE 4 Pin Connector (F)
GLVPD			GLV Power and Data	TE 6 Pin Connector (F)
Reset			Reset Line	TE 3 Pin Connector (F)
GLV24			Raw GLV24	TE 6 Pin Connector (F)

## TSI

### Interface Description

The Tractive System Interface houses the safety circuit, load controller, TSAL, and voltage measuring point

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
HV+ To Load			High Voltage Positive	Panel Mount Powerlock (Drain)
HV- To Load			High Voltage Negative	Panel Mount Powerlock (Source)
SL1			Safety Loop Out	TE 4 Pin Connector (F)
GLVPD			GLV Power and Data	TE 6 Pin Connector (F)
Reset			Reset Line	TE 3 Pin Connector (F)
Load Control			LCD	TE 2 Pin Connector (F)
Load Power +			TSV+	Nut and Bolt
Load Power -			TSV-	Nut and Bolt
TSMP			TSV	Red/Black Banana Jack (F)
GLVMP			GLV	Red Banana Jack (F)



## TSV Packs

### Interface Description

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
TSV Data			TSV Pack Data	Ethernet Port (F)
TS+			TS Pack Voltage +	Panel Mount Powerlock (Drain)
TS-			TS Pack Voltage -	Panel Mount Powerlock (Source)
SL1			Safety Loop In	4 Pin Connector (F)
SL2			Safety Loop Out	4 Pin Connector (F)
Charge Port			Charge Port	Anderson Config. A (F)

## TSV Hub

### Interface Description

Interface	Distributor/ Part No.	Manufacturer/ Part No.	Signal	Interface Type
P1			TSV Pack 1 Data	Ethernet Port (F)
P2			TSV Pack 2 Data	Ethernet Port (F)
P3			TSV Pack 3 Data	Ethernet Port (F)
P4			TSV Pack 4 Data	Ethernet Port (F)
P5			TSV Data Line	Ethernet Port (F)

**VCI****Interface Description**

<b>Interface</b>	<b>Distributor/ Part No.</b>	<b>Manufacturer/ Part No.</b>	<b>Signal</b>	<b>Interface Type</b>
SL1			Safety Loop In	TE 4 Pin Connector (F)
SL2			Safety Loop Out	TE 4 Pin Connector (F)
GLVPD			GLV Power and Data	TE 6 Pin Connector (F)
TSV Data Port			TSVDL	Panel Mount Ethernet (F)
Load Control			LCD	TE 2 Pin Connector (F)
RF Link			RF Link	UNKNOWN
Cockpit Port			Cockpit Bus	UNKNOWN