Lafayette College | Electrical and Computer Engineering

TSI User Manual

ECE 492 Spring 2018

Prepared by Thomas Clagett, Peter Phelan, Austin Mam

Introduction

This document details the operation and specifications for the Tractive System Interface (TSI) subsystem within the LFEV 2018 project. Here we will discuss the proper usage of the system and common issues you may encounter. The TSI servers several key functions:

- Safely deliver power from the TSV system to the motor controller. Power is delivered through the bus bars and precharge relay.
- Provide throttle plausibility checks to prevent a single point of failure from compromising throttle signal (Rule IC1.6.4)
- Provide isolation between signals (throttle to motor controller, TS voltage and current measurements) that pass between the low and high voltage domains
- Manage drive states and do necessary checks to enter and leave drive mode. This also includes motor overcurrent protection.
- Provide safety checks with the IMD and brake overtravel switch. Both of these must be ok for AIRs to be closed.
- Energize TSAL lights with TS voltage.
- Provide feedback through indicator lights (brake light, IMD status, drive mode light).
- Provide feedback to SCADA over CAN network. This includes the CAN isolator so data can be read directly from the motor controller.

A simplified wiring diagram for the TSI can be seen on the next page.

Hardware

The git repository for the TSI board containing circuit layout files, budget, interconnect board layout files, and PCB wiring diagram is accessible from the following link:
https://github.com/phelanp/TSI-2018

IMD

A pinout for the IMD can be found on the datasheet here under IR155-3204:
http://www.bender-es.com/fileadmin/products/doc/IR155-32xx-V004_D00115_D_XXEN.pdf

The main connections that need to be connected are the power and three grounds to the GLV signals, the OK_{HS} used in a 24V relay to control the safety loop, and the PWM output of measured resistance to the PCB. The high voltage side needs to be connected to the proper high voltage bar.

CAN Isolator

The CAN Isolator used in the TSI box connects to the can signal coming from the motor controller. This is used to ensure the high voltage signal is isolated from the low voltage. This is mounted on din rail and should span the high and low voltage sides of the box.

TSI WIRING DIAGRAM

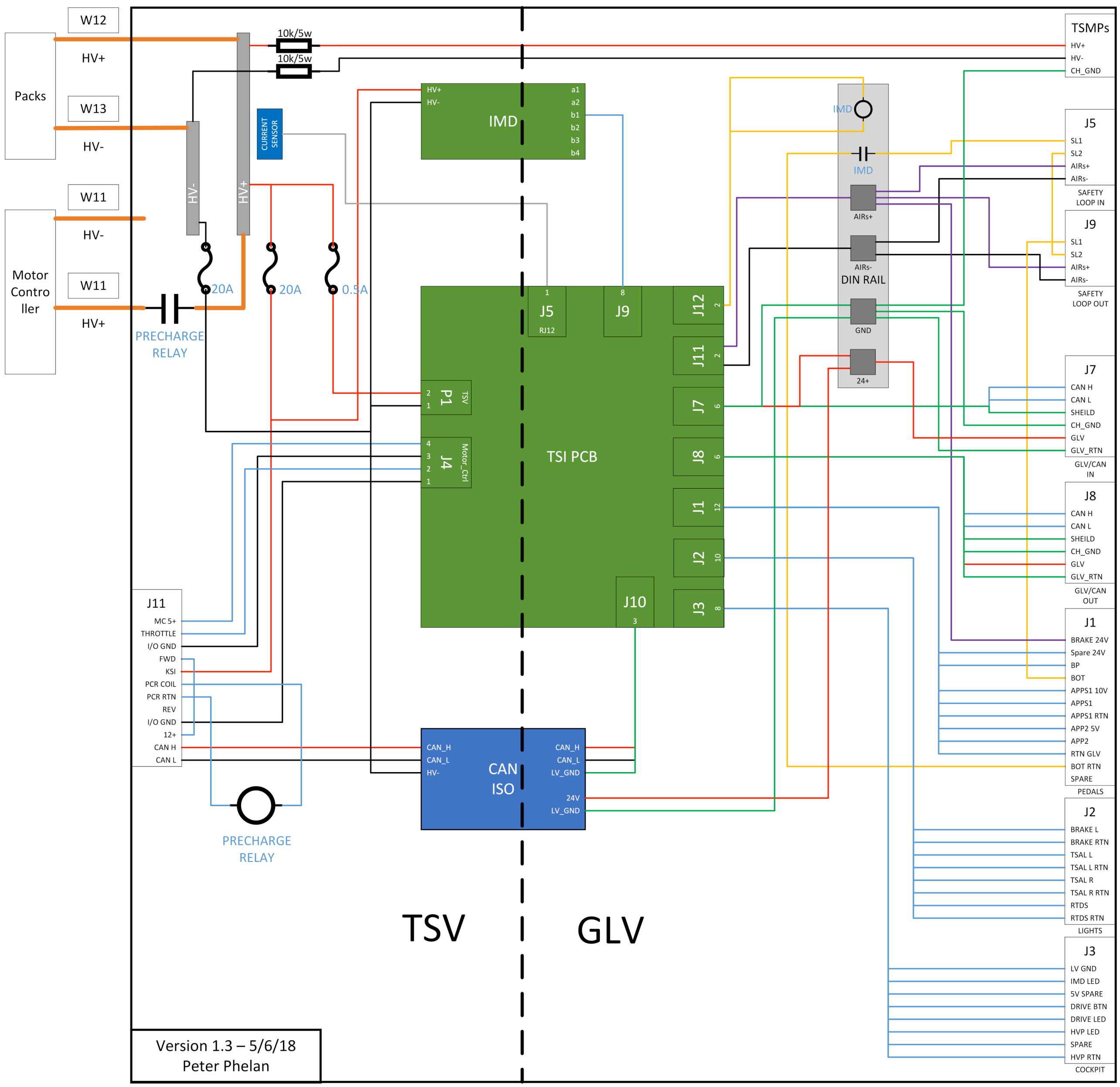


Figure 1: Wiring Diagram

Current Sensor

The data sheet for the Bus Bar current sensor can be found here:
http://www.gmw.com/magnetic_sensors/ametes/documents/BBM-01Spec%20v3.pdf

The current sensor is responsible for measuring the current through the TSI.

TSI Board

The TSI Board was designed by Peter Phelan based off the board designed Adam Ness and Jack Plumb of the LFEV 2017 team. This is the brains of the TSI system and interfaces with most of the I/O that comes into the box. Each external connector on the low voltage side has a corresponding internal Molex connector. For the high voltage side, the power connectors need to be connected to the proper high voltage aluminum bar in the high voltage side of the box. A 4 pin connector is also used to connect the isolated throttle signal to the motor controller. A picture of the board can be found below.

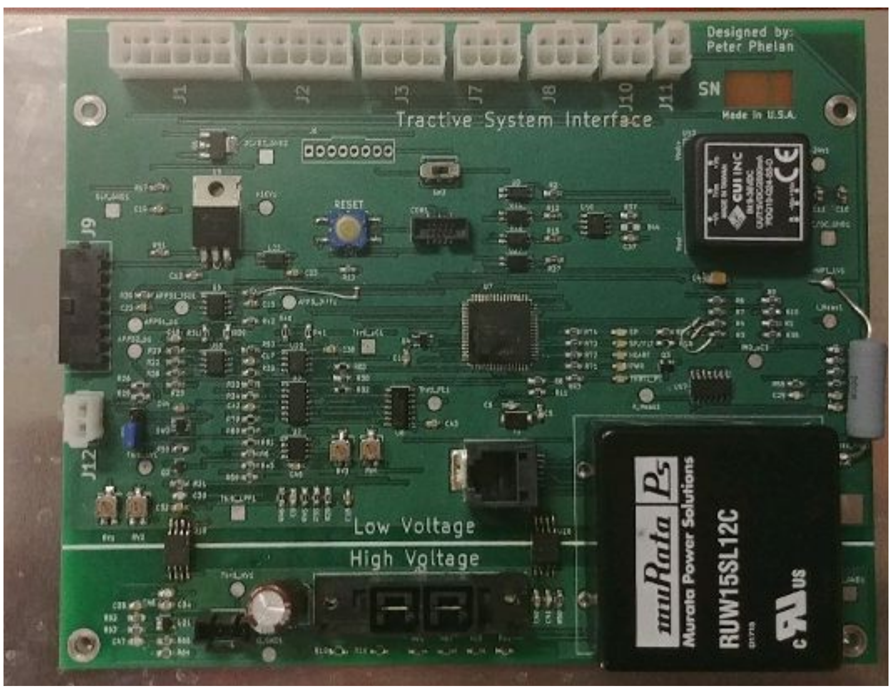


Figure 2: TSI PCB

TSI Enclosure

The picture below shows the TSI enclosure that is on the car. The TSI board, CAN isolator, and IMD are mounted on grounded backplate. The GLV and TSV are isolated by a board made out of Garolite. All wires connected to TSV are protected by resistors (TSMPs) or fuses. Current measurements made with electromagnetic current sensor on HV+.

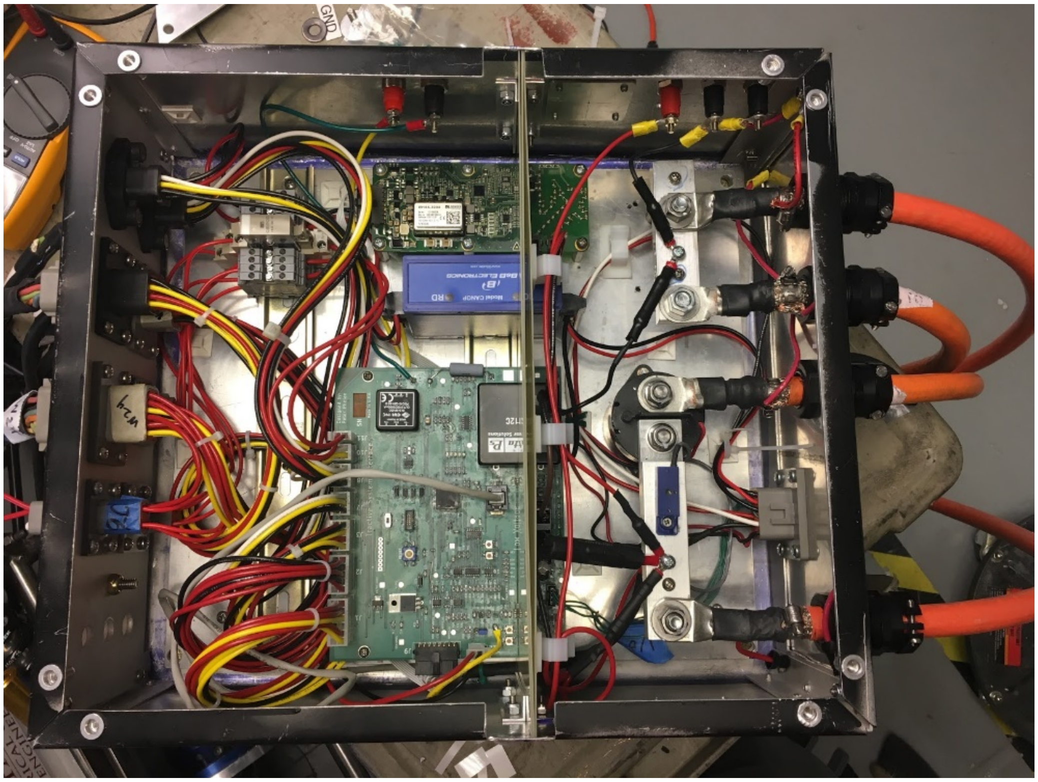


Figure 3: TSI Enclosure

Cockpit Panel

The cockpit panel elements controlled by the TSI are the IMD fault light, HV light, drive light, and drive button. The IMD fault light is active when the IMD detects a short between TSV and GLV. The HV light is active when high voltage is present (the AIRs are closed and TSV is connected to the motor controller). The drive button is used in conjunction with the brake pedal to put the car into drive mode. When the car is in the drive mode the drive light is steadily on. If the drive light is blinking the car is in the overcurrent state.

Brakes

The left foot pedal is the brake pedal. The brake light will only illuminate when the AIRs are closed. The brake pressure switch is short when brake pressed but only 15k ohms when not pressed. A 5k pulldown resistor was added across the brake light to drive the optical isolator low so the microcontroller correctly reads the brake input. A Zener diode was added before the brake light to drop the GLV down to the 12V necessary to run the light. The brake overtravel switch opens the safety loop if depressed. To reset the brake overtravel switch, pull up the round tab on the top of the switch.

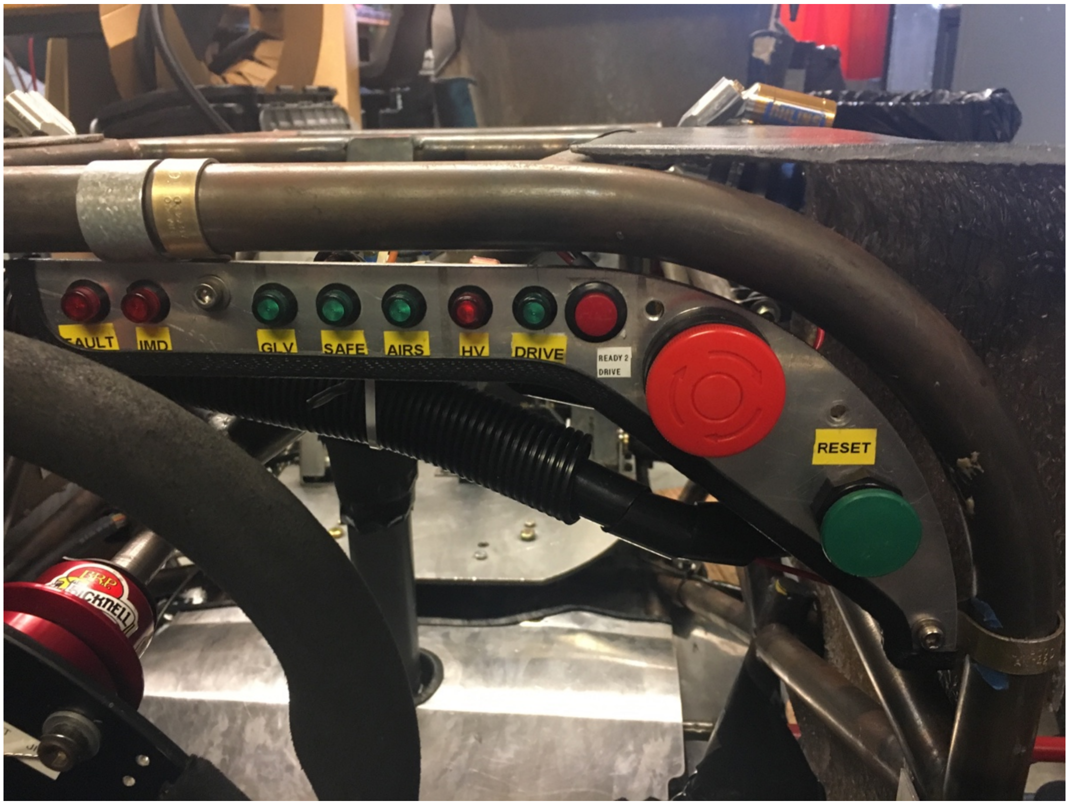


Figure 4: Cockpit Panel

Throttle

The right pedal is the throttle. The throttle is composed of two mechanically linked 5k piston potentiometers. The first (APPS1) is biased from 5-10V, the second (APPS2) is biased from 0-5V. APPS1 is then then stepped down into the 0-5V range (APPS1_ISO). APPS2 voltage is sent to the microcontroller and sent to the motor controller. For the throttle to be plausible APPS1_ISO and APPS2 need to be between 0.25-4.75V. In addition, the difference between APPS1 and APPS2 needs to be between 0.5 and -0.5V. An implausibility should only occur if a mechanical failure occurs or one of the throttle wires become disconnected. The mechanical throttle stops cause the resting throttle to sit around 0.45V and the fully extended throttle should rest at 4.2V. The wiring for the throttle pot power and return is reversed as noted on the pots as we are operating them in the opposite of the intended direction.

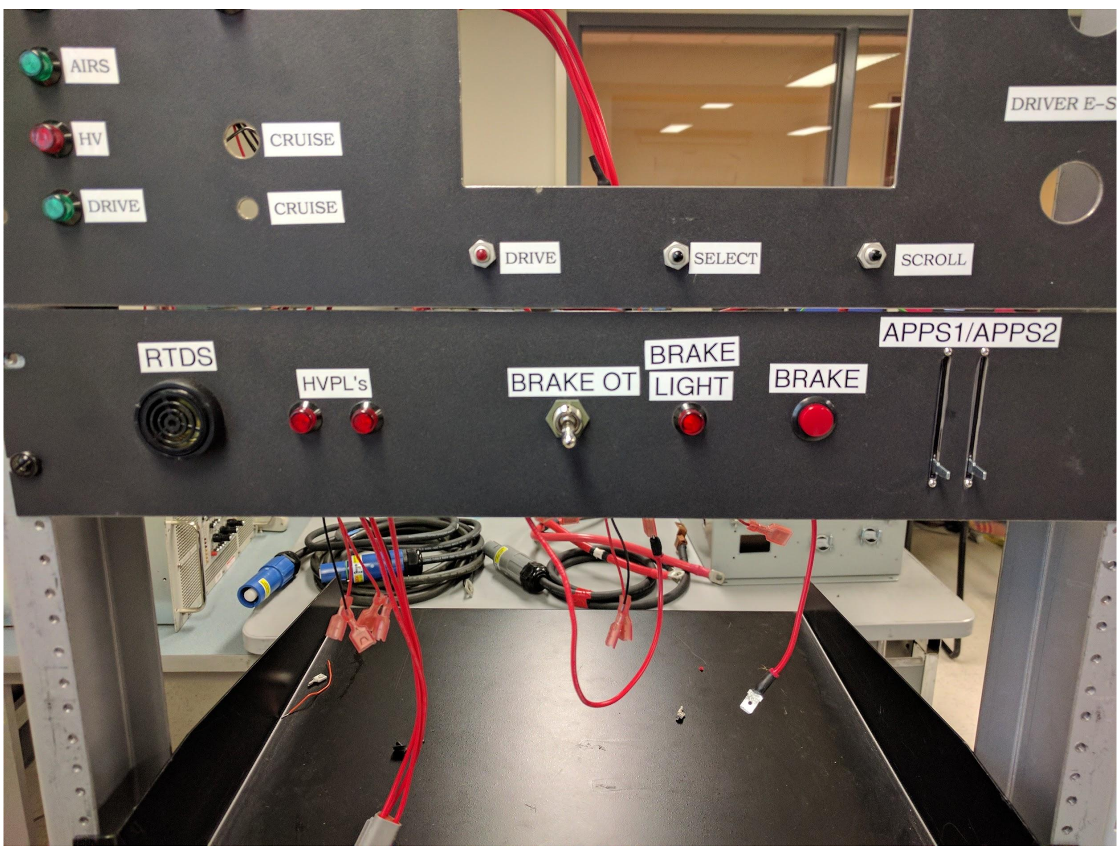
Plausibility Biasing

In order for the plausibility checks to work the throttles need to be properly biased. The throttles are biased with the correct range when there is 5V across the power and return terminals. To bias APPS1 place a voltmeter across the blue and brown wires of the APPS1 pot and adjust VR2 until the meter reads exactly 5V. To bias APPS2 repeat this process with the APPS2 pot and

VR1. Once the pot ranges are biased the throttle pots need to have their difference biased. To do this, place a voltmeter across the signal (black) and ground (brown) lead of each pot. Adjust the difference by adjusting the threaded rod attached to the end of each pot. This adjusts the length of compression to make sure the pots compress equally over the range of motion.

TSI Test Panel

The picture below shows the TSI test panel designed by Jack Plumb of the LFEV 2017 team. It is used to simulate the driver interactions in the dyno room. The two slide potentiometers labeled APPS1/APPS2 are used to control the throttle and give the user the ability to cause an implausibility in the system. The brake button generates a binary signal similar to what the pressure sensor does in the car. The brake overtravel switch will simulate what happens if there is a mechanical brake failure in the car and how the TSI would respond. This switch can also be used to test if the safety loop is closed. The RTDS is simply a speaker that sounds when the TSI is in drive mode. The HVPL are both of the high voltage lights that indicate when power is flowing through the system.



Software

The git repository for the TSI can be found here: https://github.com/austinmam/TSI

Programming Instructions

The microcontroller used in the TSI board is the AT90CAN128 and is the same as the microcontrollers in the PacMAN. The programming instructions can be found at the following link: https://sites.lafayette.edu/ece492-sp18/files/2018/05/Programming-Manual.pdf

Drive States

Getting Started

The TSI system is fairly easy to setup. The connectors on the outside of the box are used to interface with the other subsystems on the car, mainly GLV, TSV, and the motor controller. The larger of the two panels is used for the low voltage connections while the sides and back connect with high voltage systems. There are several connections on the inside of the box that will interface with the IMD, PCB, Precharge Relay, and high voltage bars. The positive bar is the one that connects to the Precharge Relay and the negative bar is on the other side of the box. The IMD connectors on the high voltage side have the positive connection closer to the edge of the board. The PCB setup was talked about in the TSI Board section above.

FAQ

Q: Why can I not enter drive mode?
A: There are various signals that need to be asserted before the user can put the car into drive mode. These include the AIRS being closed, the safety loop being closed, GLV power provided, no throttle implausibilities, the throttle below 0.5V, and no drop-out-of-drive signal from SCADA. If these are all okay, make sure the brake is pressed before hitting the drive button.

Q: How do I use the test panel?
A: The test panel can be used to simulate the important components of the car to the TSI system in the Dyno room. The two slide potentiometers are the two throttle inputs that the pedals connect to. These need to be set near each other to not cause implausibility. The brake button acts as a binary signal of whether or not the brake has been pressed. The switch for brake

overtravel will be held as long as you need it to as the user will need to reset this manually in the car as well.

Q: Why am I seeing throttle implausibility?
A: The slide potentiometers may be set too far apart from one another. Use a multimeter to measure the voltages you are seeing across them and verify they are within the acceptable range. If this is not the case, there may be an issue in the implausibility circuit on the PCB. Make sure the resistors are setting the correct gain and no shorts have occurred.

Q: Why is nothing working right?
A: If you didn't accidently short the board and burn the whole thing out, board is most likely dirty. The dirt creates stray resistances which causes circuits to not work correctly. The board should be cleaned first using flux cleaner and a soft toothbrush. Hold the board upright and rinse the board with the flux cleaner. Once the stray material has been cleaned off rinse the board with isopropyl alcohol. Finally rinse the board with DI water. Evaporate the water on the board with a heat gun in an enclosed box.