

## **IMD Test Board**

### **Relevant definitions and concepts:**

High Voltage – Any voltage above 60 volts is considered high voltage. The car's high voltage system must be kept Isolated from the Low voltage system.

Tractive System – Every part of the car that is connected to the motor or accumulator. UT24's accumulator will operate at 414V nominal.

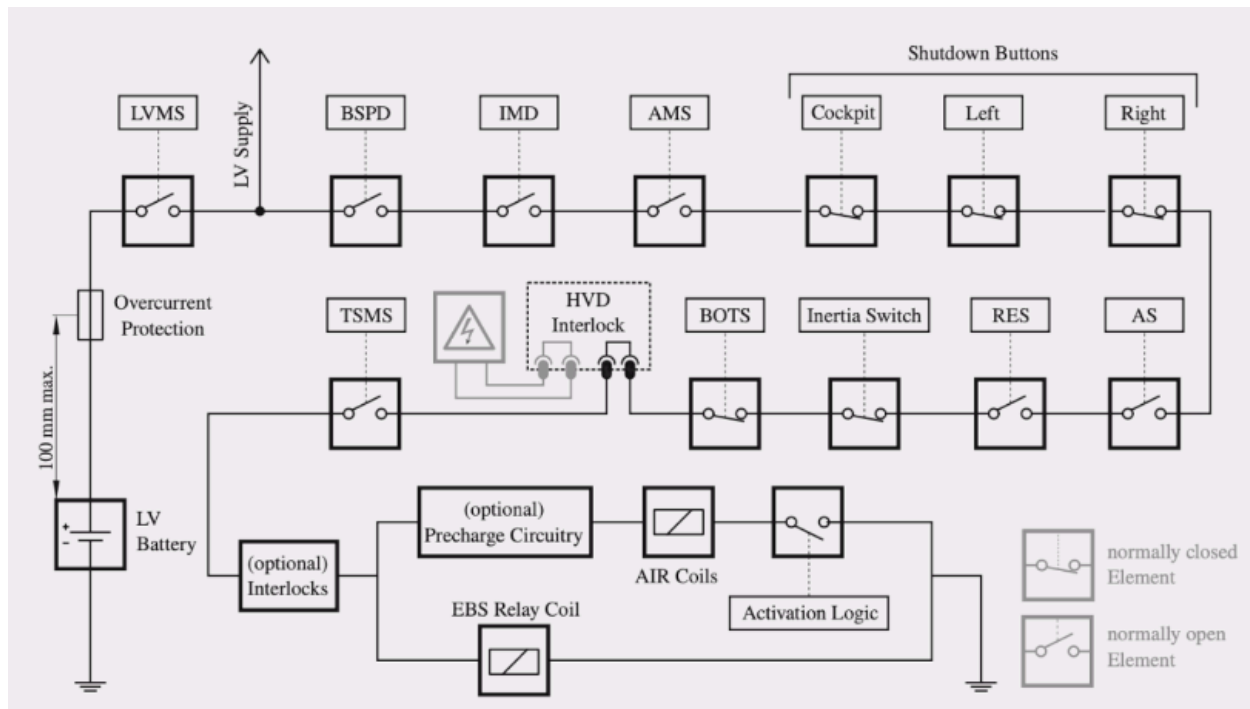
Relay – A switch with a coil next to it. When current passes through the coil, the magnetic field it generates pulls the switch, or contacts, closed. When current stops passing through the coil, the magnetic field disappears, and the switch opens. A relay can either be "Normally Closed", where the contacts conduct when the coil is not energized, or "Normally Open", where the contacts do not conduct when the coil is not energized.

PWM – Pulse Width Modulation: A voltage waveform that switches between high and low voltage levels at some frequency. By changing the ratio of the amount of time the signal spends high vs. low, information can be conveyed.

Isolation – Two elements are isolated if there is no conductive path between them. The high voltage and low voltage systems on the car must be isolated.

### **1. Shutdown Circuit**

The Shutdown Circuit (SDC) is a continuous circuit that runs through the entire car, essentially consisting of multiple switches wired in series. When one of those switches is opened, current stops conducting, causing the car to turn off. The IMD controls one of those switches.



## 2. IMD

Bender IMD:

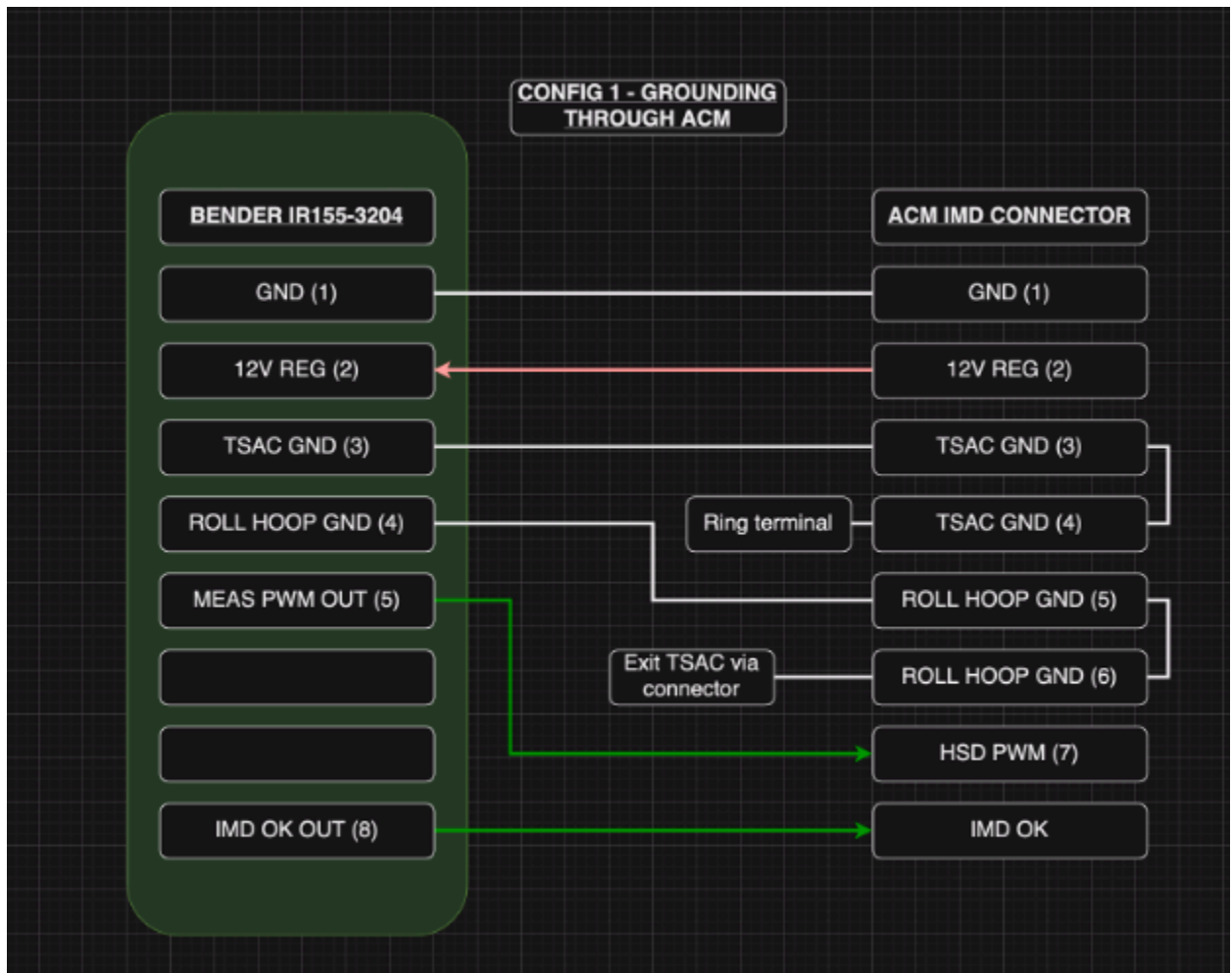
<https://www.benderinc.com/products/ground-fault-monitoring-ungrounded/isometer-ir155-03-04-series/>

Datasheet:

[https://www.benderinc.com/fileadmin/content/Products/d/e/IR155-32xx-V004\\_D00115\\_D\\_XXEN.pdf](https://www.benderinc.com/fileadmin/content/Products/d/e/IR155-32xx-V004_D00115_D_XXEN.pdf)



The Insulation Monitoring Device, or IMD, monitors the resistance between the High Voltage (HV) system and the Low Voltage (LV) system to ensure that it is high enough to comply with Formula SAE and Formula Student's isolation requirements. If the resistance between HV and LV drops below a pre-determined threshold, the IMD throws a fault, opening the Shutdown Circuit.



IMD connection to the Accumulator Control Module

We had some issues with the IMD last year where it would throw faults at unexpected moments. We also have a new IMD which will serve as a backup. Testing the IMD will be important to understanding it and verifying that it works as expected.

### 3. Testing the IMD

The IMD requires 12V of power to operate properly. We have power supplies capable of providing 12V. Pin 8 on the IMD is the IMD OK pin – when this pin is “high”, meaning near 5V, the IMD has not detected a fault. When this pin is pulled “low”, a fault has been detected. This pin can be measured using an oscilloscope or a multimeter. The high voltage side of the IMD connects to the HV+ and HV- nodes between the accumulator and the inverter.

The goal of this project will be to design a breakout board, likely by soldering components onto a protoboard:



The response value of the IMD must be set to  $\geq 500 \Omega/V$ , related to the maximum TS voltage.

The IMD must be connected on the vehicle side of the AIRs.

One IMD chassis ground measurement line must be connected to the grounded TSAC or the respective grounded enclosure of the IMD. The other chassis ground measurement line must be connected to the main hoop. Each connection must use a separate conductor, rated for at least maximum TS voltage. An open circuit in any of these ground measurement connections must result in an opened SDC.

In case of an insulation failure or an IMD failure, the IMD must open the SDC. This must be done without the influence of any programmable logic. See also EV 6.1.6 regarding the re-activation of the TS after an insulation fault.

A red indicator light in the cockpit that is easily visible from inside and outside the cockpit even in bright sunlight and clearly marked with the lettering “IMD” must light up if and only if the IMD opens the SDC. It must stay illuminated until the error state has been manually reset, see EV 6.1.6. Signals controlling this indicator are SCS, see T 11.9.

## Formula SAE

### EV.7.6 Insulation Monitoring Device - IMD

The vehicle must have an Insulation Monitoring Device (IMD) installed in the Tractive System

The IMD must be a Bender ISOMETER® IR155-3203 or IR155-3204 ([website](#)) or an approved alternate equivalent IMD

Refer to the Rules FAQ on the FSAE Online website for approved equivalent IMD

The response value of the IMD must be set to 500 Ohm / Volt or higher, related to the maximum Tractive System operation voltage.

The IMD must monitor the Tractive System for:

- a. An isolation failure
  - b. A failure in the IMD operation
- This must be done without the influence of any programmable logic.

If the IMD detects one or more of the conditions of **EV.7.6.4 above** the IMD must:

1. Open the Shutdown Circuit **EV.7.2.2**

2. Turn on the IMD Indicator Light. The light must stay on until the IMD is reset **EV.7.2.3**

The IMD Indicator Light must be:

1. Color: Red
2. Clearly visible to the seated driver in bright sunlight
3. Clearly marked with the lettering “IMD”

## **Formula H+E**

### EV 7.9 Insulation Monitoring Device (IMD)

Every car must have an insulation monitoring device installed in the tractive system.

The IMD must be a Bender<sup>28</sup> A-ISOMETER ® iso-F1 IR155-3203 or IR155-3204 or equivalent IMD approved for automotive use.

Equivalency may be approved by the rules committee based on the following criteria: robustness to vibration, operating temperature range, availability of a direct output, a self-test facility and must not be powered by the system which is monitored. The IMD must be a stand- alone unit. IMD functionality integrated in an AMS is not acceptable.

The response value of the IMD needs to be set to no less than 500 ohm/volt, related to the maximum tractive system operation voltage.

In case of an insulation failure or an IMD failure, the IMD must shut down all the electrical systems, open the AIRs and shut down the I.C. drive system.

The tractive system must remain disabled until manually reset by a person other than the driver. It must not be possible for the driver to re-activate the tractive system from within the car in case of an IMD-related fault.

Latching circuitry added by teams to comply with **EV7.9.5** must be implemented using electro-mechanical relays. (See **Appendix G** – Example Relay Latch Circuits.)

The status of the IMD must be displayed to the driver by a red indicator light in the cockpit. (See **EV9.4**). The indicator must show the latched fault and not the instantaneous status of the IMD.

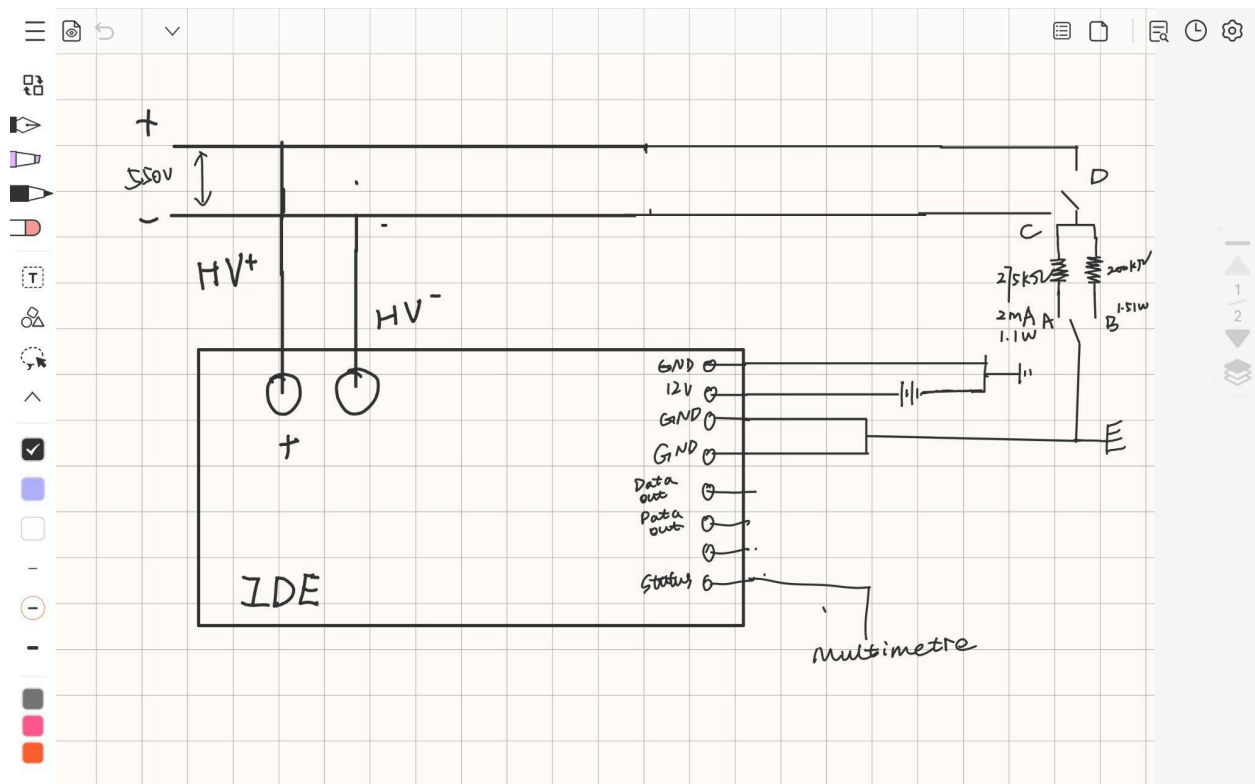
**Note:** The electrical inspectors will test the IMD by applying a test resistor between tractive system (positive or negative) and GLV system ground. This must deactivate the system.

Disconnecting the test resistor may not re-activate the system. i.e. the tractive system must remain inactive until it is manually reset.

The IMD high voltage sense connections may be unfused if wiring is less than 30 cm in length, is less than or equal to #16 wire gauge, has an insulation voltage rating of at least 600V, and is “double insulated” (e.g. has additional sleeving on both conductors). If any of these conditions is not met, the IMD HV sense connections must be fused in accordance with [EV3.2.3](#)

## Meeting Notes December 31st

ToDo:



- Don't connect 550V,
- Short HV+ and HV-

Fix schematic for IMDok

- New schematic for IMD PWM - probably need to use an arduino uno