High Level EECS Overview

Powered off to Driving

Note this is not exhaustive!
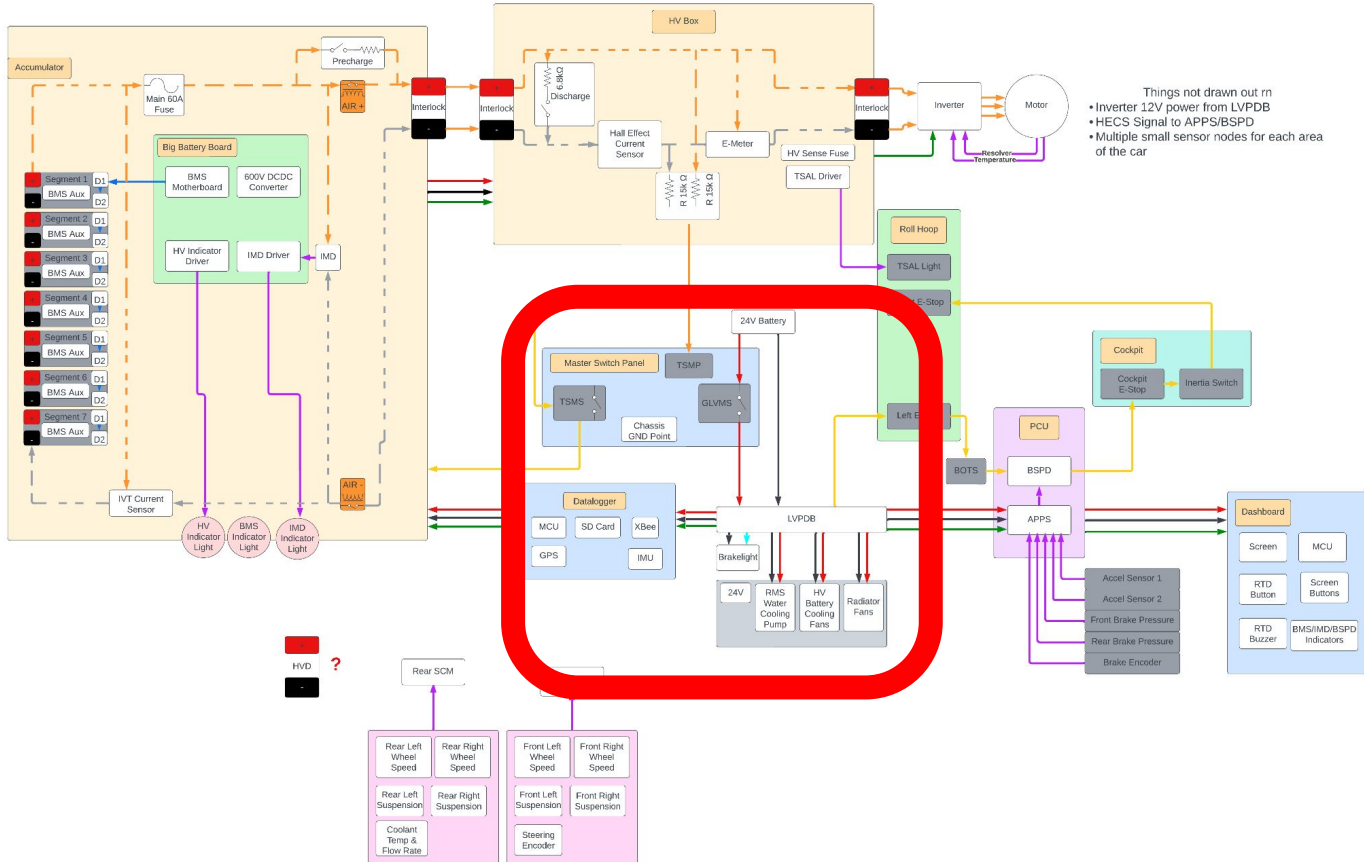
The SN3 EECS Diagram

Formula Electric at Berkeley
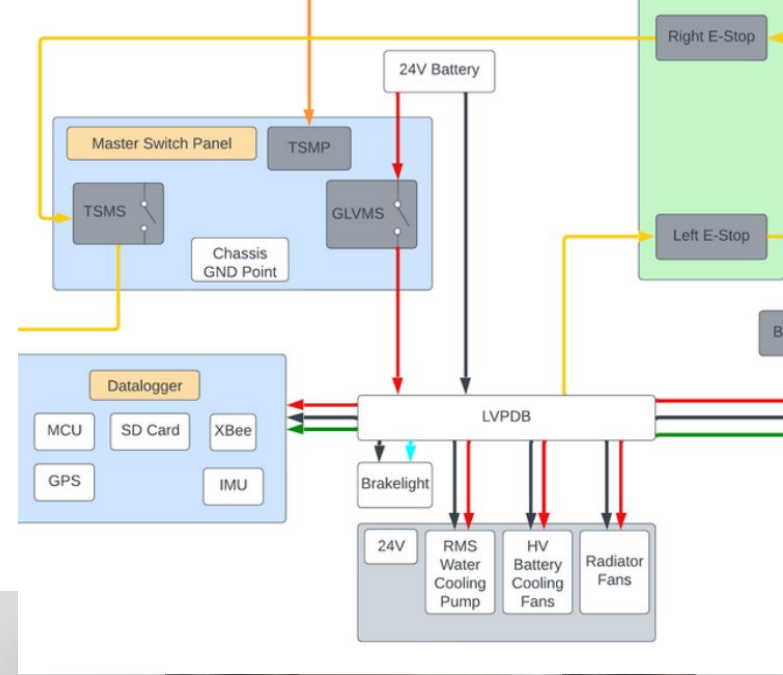SN3 Electrical System Diagram
Rev 1.1
Last Updated 10/08/23
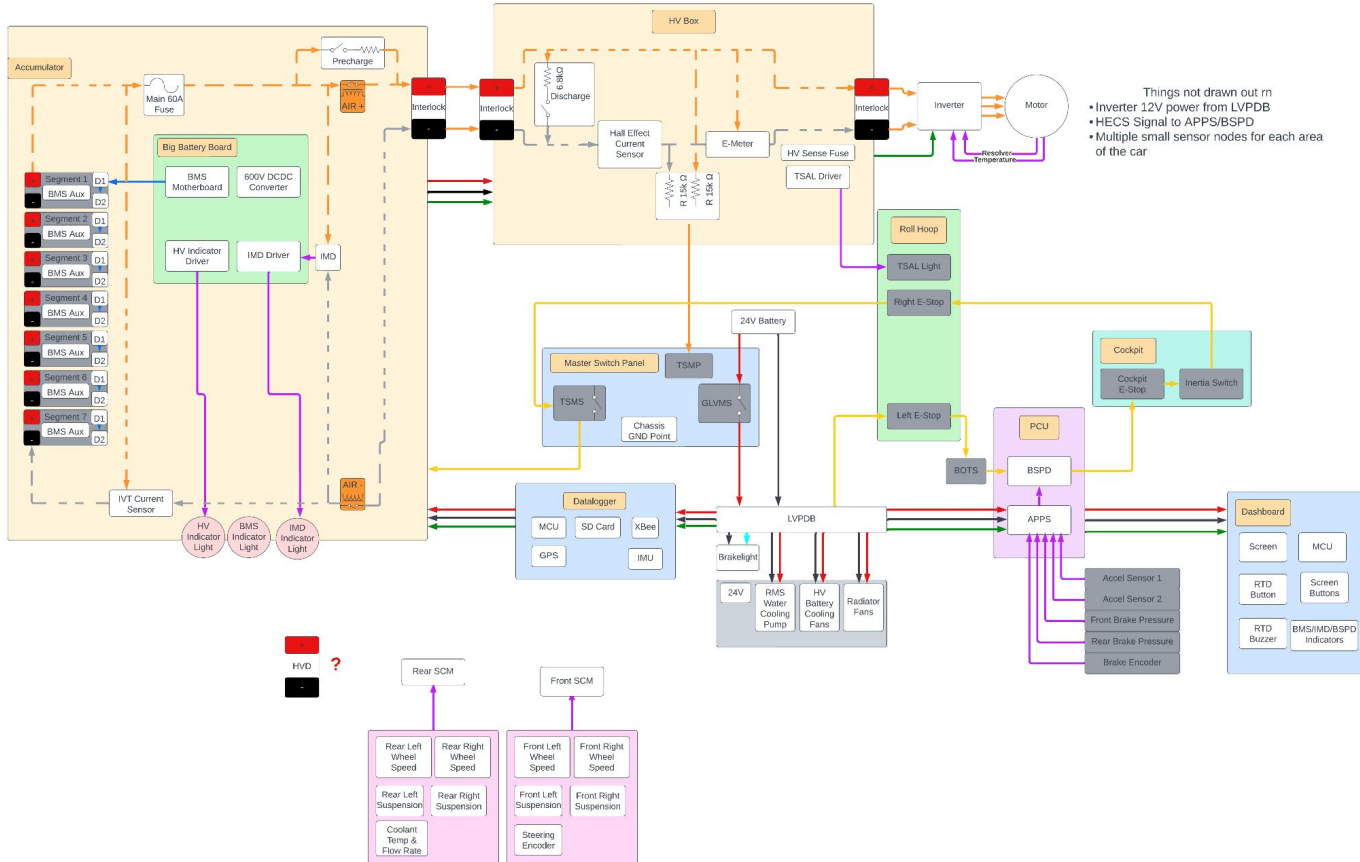
The First Key (GLVMS)

GLVMS and LVPDB

Grounded Low Voltage Master Switch

- Key that turns on all Low Voltage Systems on the car (i.e. most PCB's)
- This connects the 24V drill batteries to the LVPDB (Low Voltage Power Distribution Board)
- Turns TSAL (Tractive System Activation Light) from OFF to SOLID GREEN

GLVMS and LVPDB

Low Voltage Power Distribution Board

- Steps down the 24V battery supply to 12V, which is then sent to most PCB's for power
- LVPDB also powers the powertrain cooling pump, motor controller, and the powertrain cooling fans

Black Box further down
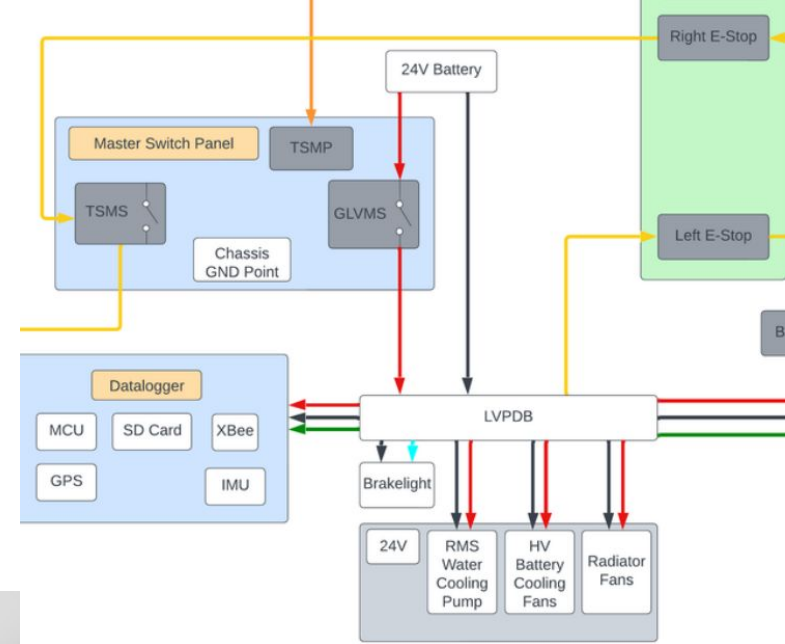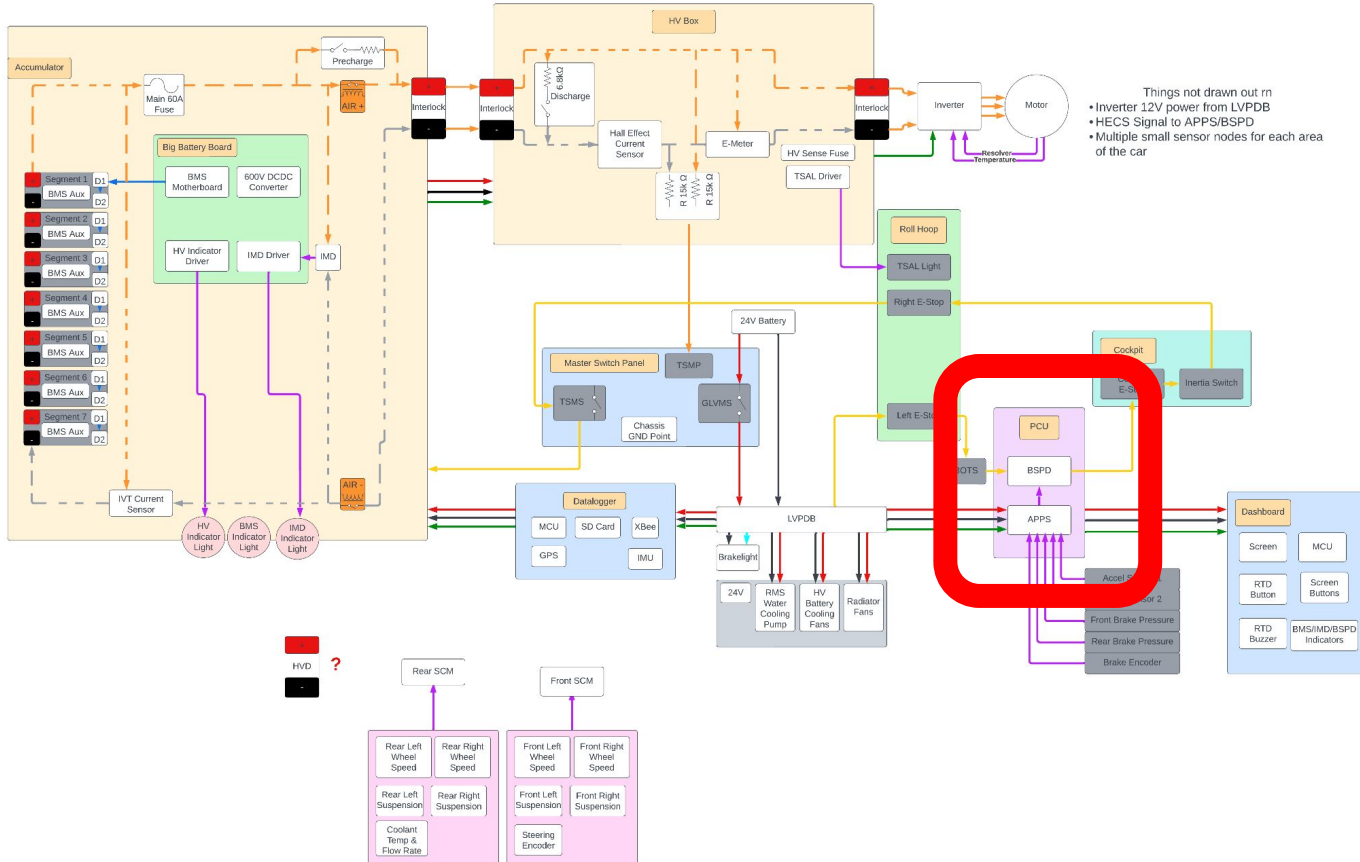
APPS

Accelerator Pedal Position Sensor

- Measures pedal sensor input and converts it into a torque command:
  - Pedal not pressed = 0 torque
  - Pedal all the way down = Max torque
- Forwards the torque command onto the CAN bus (to be read by the motor controller)

Inside box around here

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SN3 Electrical System Diagram
Rev 1.1
Last Updated 10/08/23

HV + | 24 Volts (LV) | Shutdown | isoSPI
HV - | GLV | CAN | Analog

Accumulator

Main 60A Fuse
Precharge

Big Battery Board
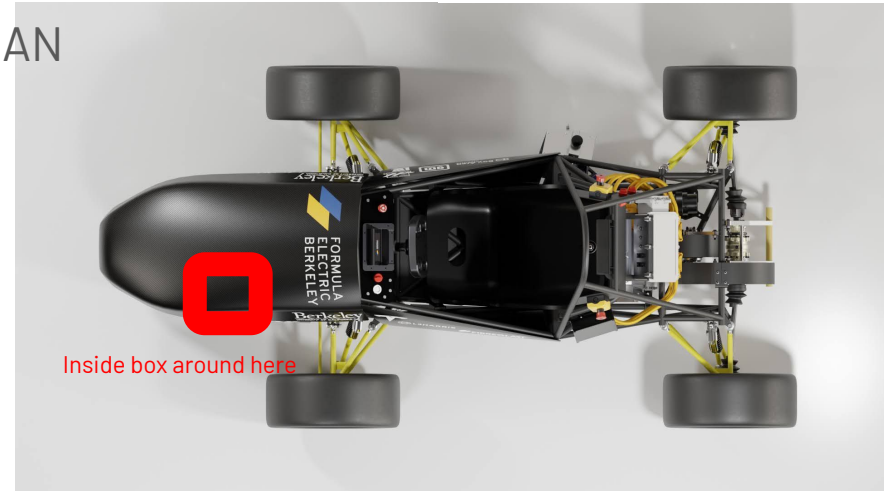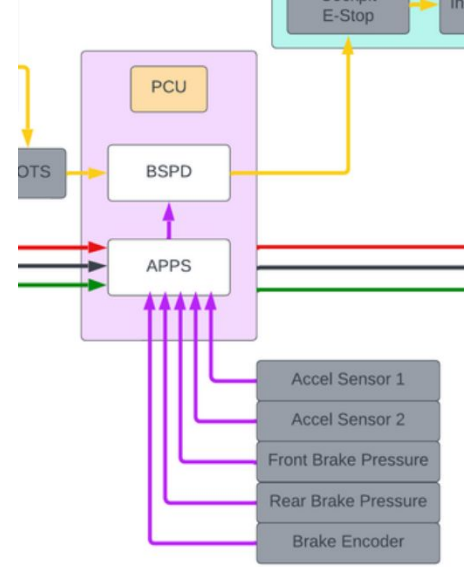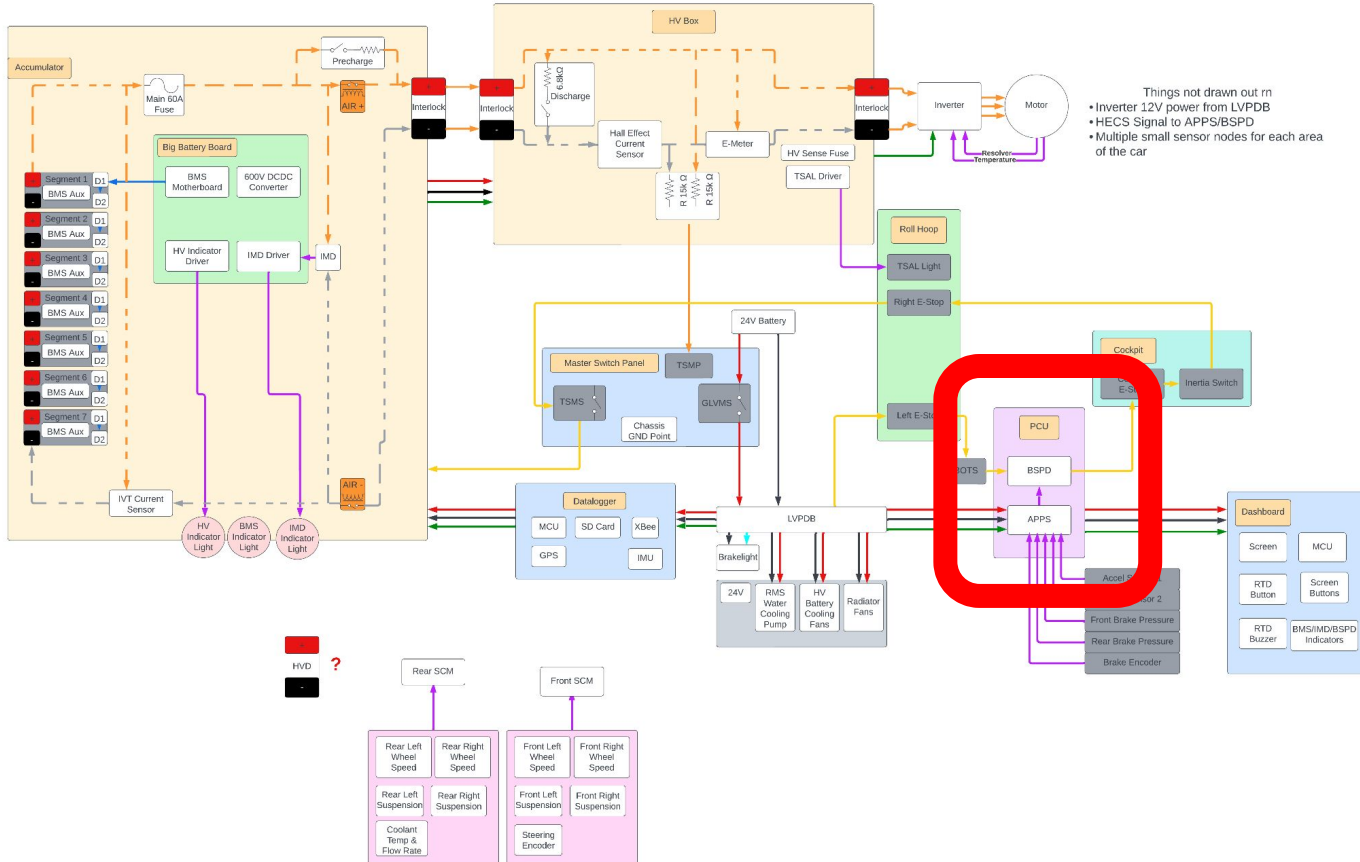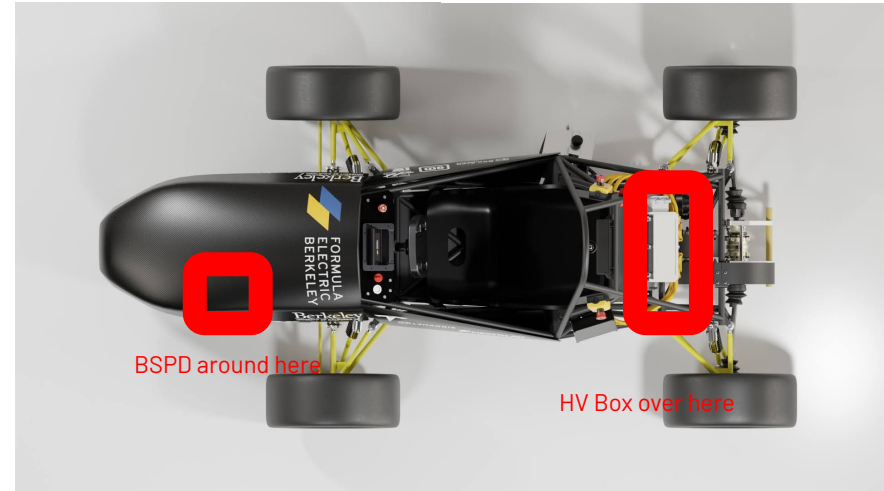
Segment 1 D1
BMS Aux D2
Segment 2 D1
BMS Aux D2
Segment 3 D1
BMS Aux D2
Segment 4 D1
BMS Aux D2
Segment 5 D1
BMS Aux D2
Segment 6 D1
BMS Aux D2
Segment 7 D1
BMS Aux D2

BMS Motherboard
600V DCDC Converter
HV Indicator Driver
IMD Driver
IMD
AIR +
AIR -

IVT Current Sensor

HV Indicator Light
BMS Indicator Light
IMD Indicator Light

Interlock
Interlock

HV Box

Discharge 6.8kΩ
Hall Effect Current Sensor
E-Meter
HV Sense Fuse
TSAL Driver
R 15k Ω
R 15k Ω

Interlock
Inverter
Motor
Resolver Temperature

Things not drawn out rn
• Inverter 12V power from LVPDB
• HECS Signal to APPS/BSPD
• Multiple small sensor nodes for each area of the car

Roll Hoop
TSAL Light
Right E-Stop
Left E-Stop

24V Battery

Master Switch Panel
TSMP
TSMS
Chassis GND Point
GLVMS

Cockpit
E-Stop
Inertia Switch

PCU
BSPD
MOTS
APPS

Datalogger
MCU SD Card XBee
GPS IMU
Brakelight

LVPDB

24V RMS Water Cooling Pump HV Battery Cooling Fans Radiator Fans

Accel Sensor 2
Front Brake Pressure
Rear Brake Pressure
Brake Encoder

Dashboard
Screen MCU
RTD Button Screen Buttons
RTD Buzzer BMS/IMD/BSPD Indicators

HVD ?

Rear SCM
Front SCM

Rear Left Wheel Speed Rear Right Wheel Speed
Rear Left Suspension Rear Right Suspension
Coolant Temp & Flow Rate

Front Left Wheel Speed Front Right Wheel Speed
Front Left Suspension Front Right Suspension
Steering Encoder
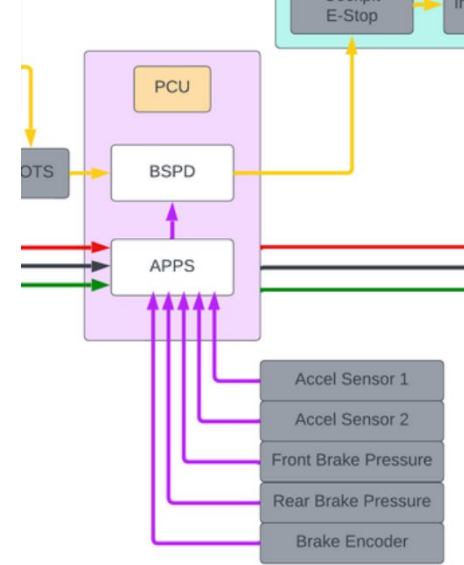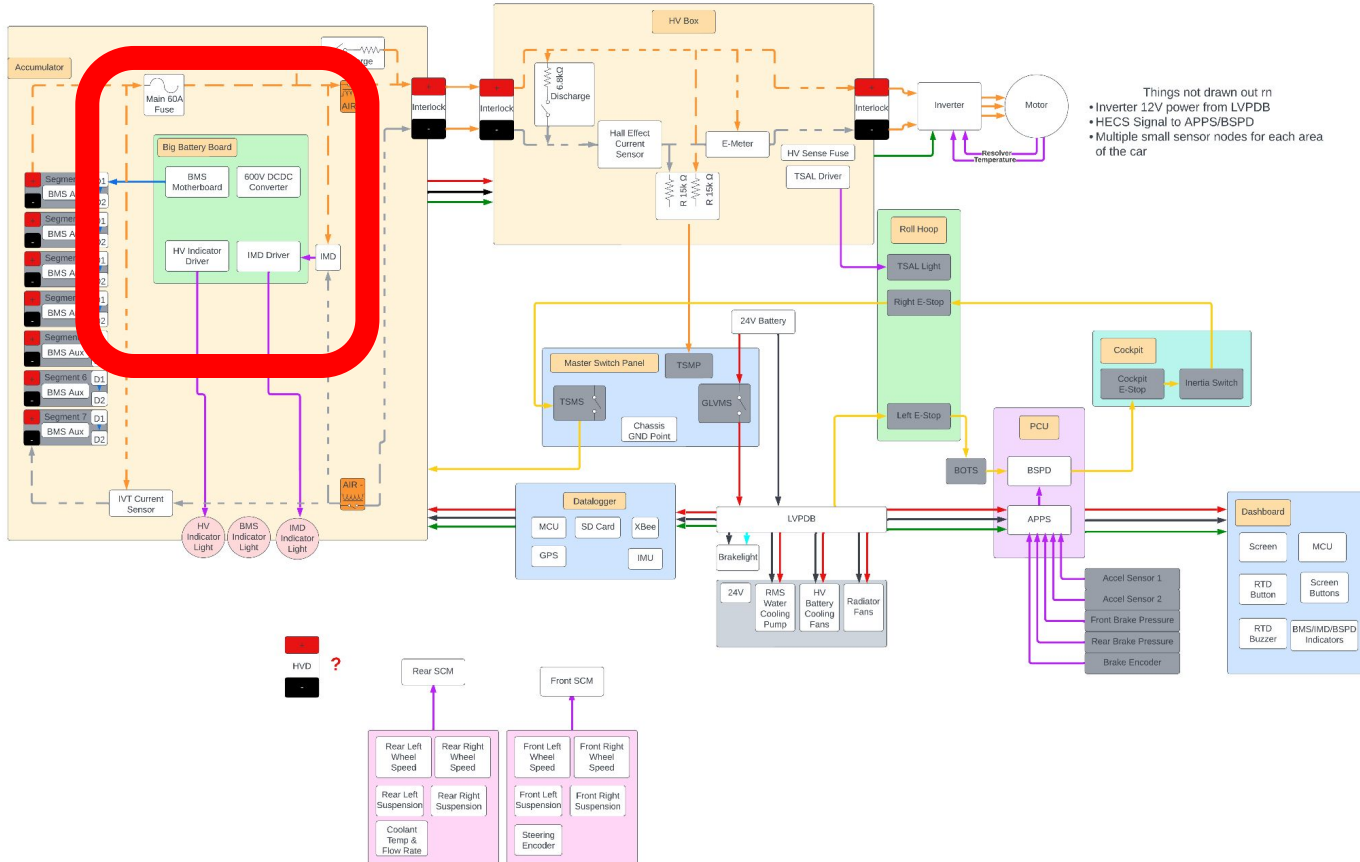
BSPD

Brake System Plausibility Device

- Ensures driver safety! (and rule compliance)
- Causes shutdown if current is flowing out of accumulator while brakes are engaged
- Has a position sensor on the brakes
- Connects to the HECS (hall effect current sensor) in the HV Box

BSPD around here

HV Box over here

LV System 3/3: BBB

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SN3 Electrical System Diagram
Rev 1.1
Last Updated 10/08/23

Legend:
- HV +
- 24 Volts (LV)
- Shutdown
- isoSPI
- HV -
- GLV
- CAN
- Analog

Things not drawn out rn
- Inverter 12V power from LVPDB
- HECS Signal to APPS/BSPD
- Multiple small sensor nodes for each area of the car

Accumulator
- Main 60A Fuse
- Big Battery Board
  - BMS Motherboard
  - 600V DCDC Converter
  - HV Indicator Driver
  - IMD Driver
  - IMD
- Segment 1 / Segment 2 / Segment 3 / Segment 4 / Segment 5 / Segment 6 / Segment 7
  - BMS Aux D1 D2
- IVT Current Sensor
- AIR
- HV Indicator Light
- BMS Indicator Light
- IMD Indicator Light

HV Box
- Interlock
- Discharge 6.8kΩ
- Hall Effect Current Sensor
- E-Meter
- R 15k Ω / R 15k Ω
- HV Sense Fuse
- TSAL Driver
- Inverter
- Motor
- Resolver/Temperature

Roll Hoop
- TSAL Light
- Right E-Stop
- Left E-Stop

24V Battery

Master Switch Panel
- TSMP
- TSMS
- GLVMS
- Chassis GND Point

Cockpit
- Cockpit E-Stop
- Inertia Switch

PCU
- BSPD
- BOTS
- APPS

Datalogger
- MCU
- SD Card
- XBee
- GPS
- IMU
- Brakelight

LVPDB

24V / RMS Water Cooling Pump / HV Battery Cooling Fans / Radiator Fans

Dashboard
- Screen
- MCU
- RTD Button
- Screen Buttons
- RTD Buzzer
- BMS/IMD/BSPD Indicators

Accel Sensor 1
Accel Sensor 2
Front Brake Pressure
Rear Brake Pressure
Brake Encoder

HVD ?

Rear SCM
- Rear Left Wheel Speed
- Rear Right Wheel Speed
- Rear Left Suspension
- Rear Right Suspension
- Coolant Temp & Flow Rate

Front SCM
- Front Left Wheel Speed
- Front Right Wheel Speed
- Front Left Suspension
- Front Right Suspension
- Steering Encoder

BBB - Function 1/2*: BMS

<u>Big Battery Board as Battery Management System Motherboard</u>

- Talks to all BMS Aux Boards (1 per segment)
  - Each BMS Aux Board uses 2 daughter boards to measure the VOLTAGE and TEMPERATURE of 17 battery modules
- Cause shutdown if temperatures or voltages are unsafe
- Cause shutdown if current out of accumulator is unsafe
- Facilitate charging and cell balancing
- *Note BBB has way more than 2 functions

Accumulator Attic
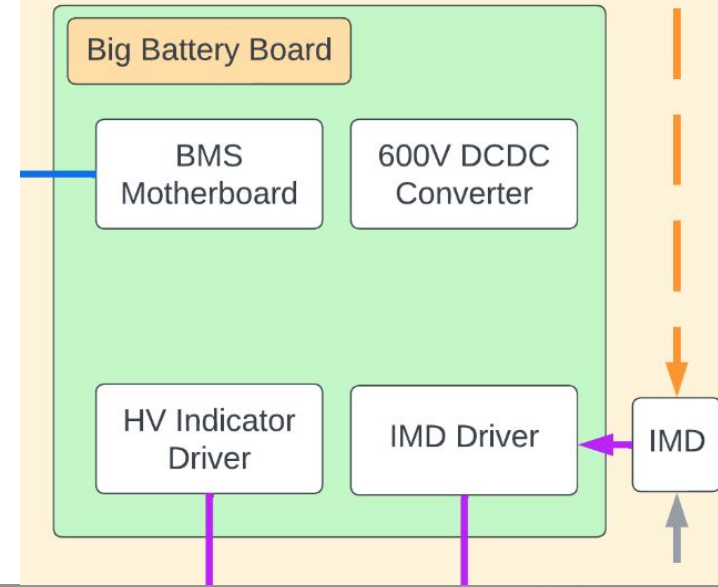
BBB - Function 2/2*: IMD Driver

Big Battery Board as Insulation Monitoring Device Driver

- IMD is a device we have to buy to be rules compliant
- It senses if there is a short circuit between high voltage and low voltage, which would likely result in death and the battery exploding
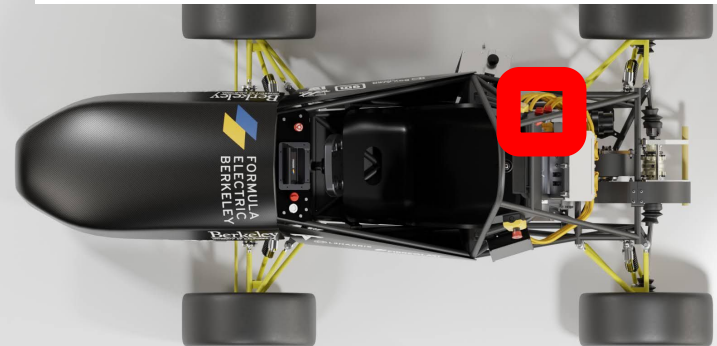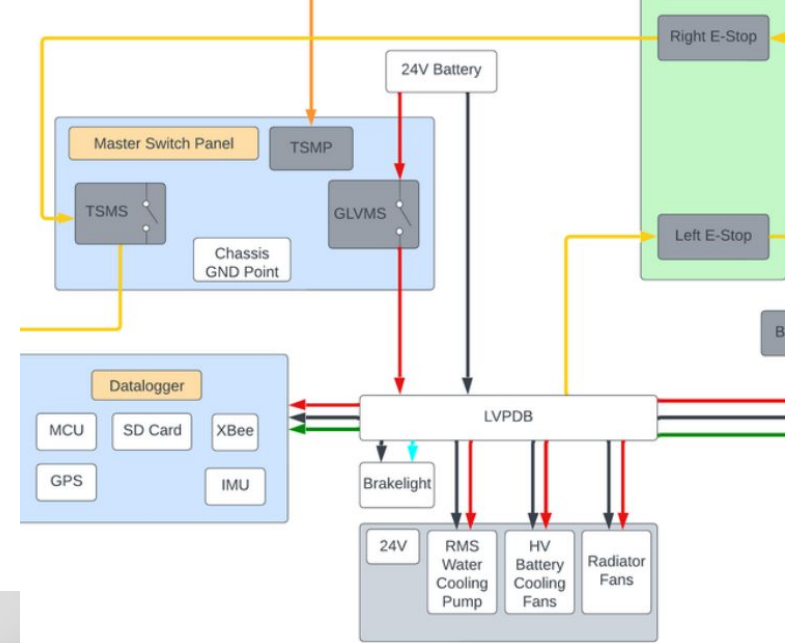- BBB talks to this board and causes shutdown if it detects a short circuit
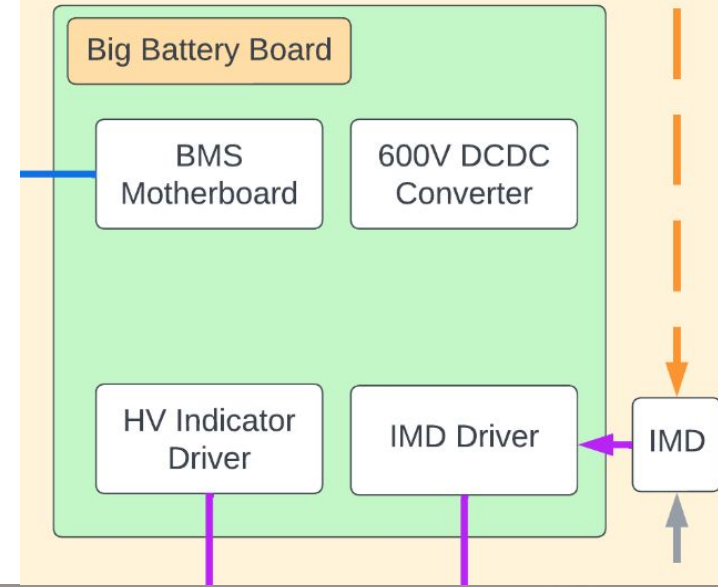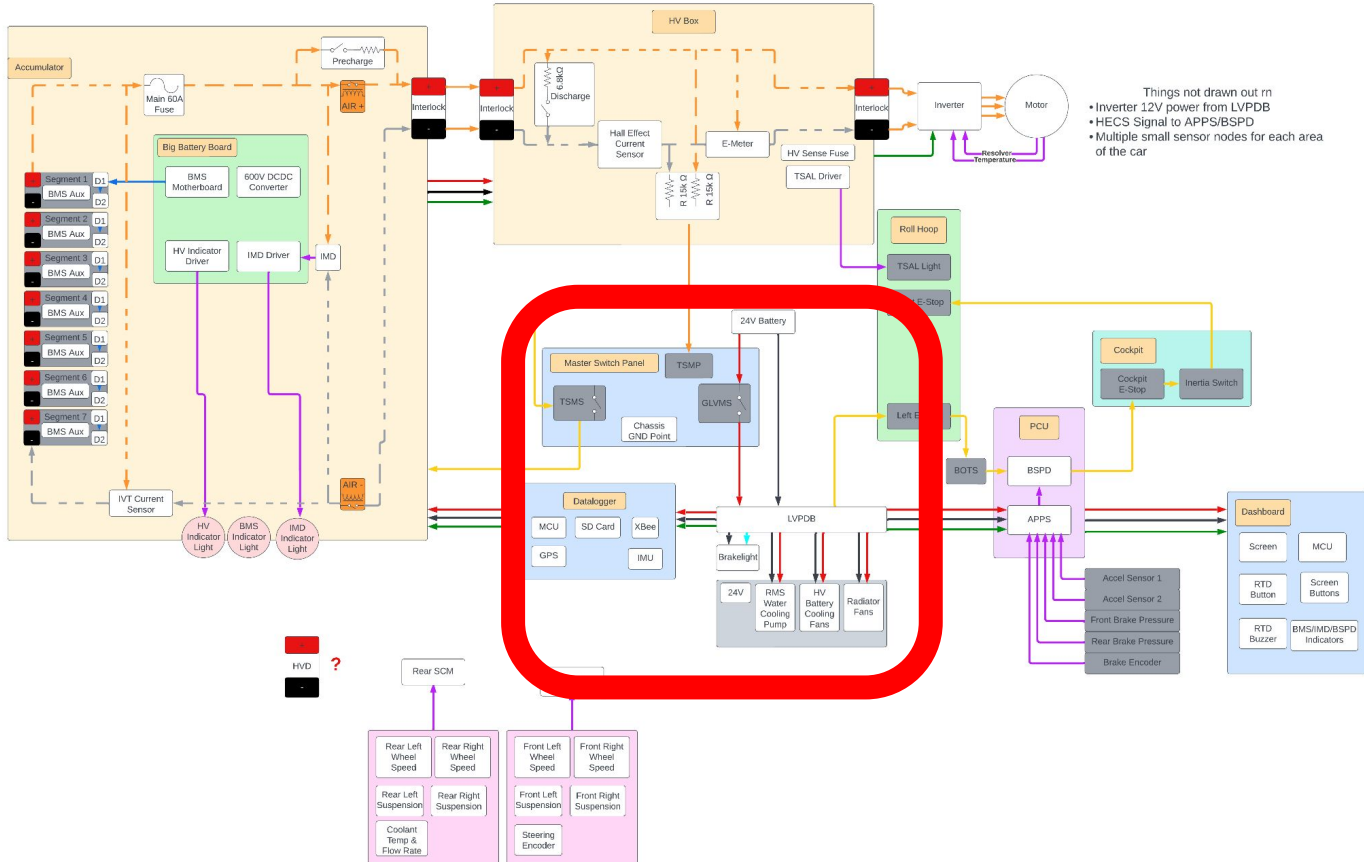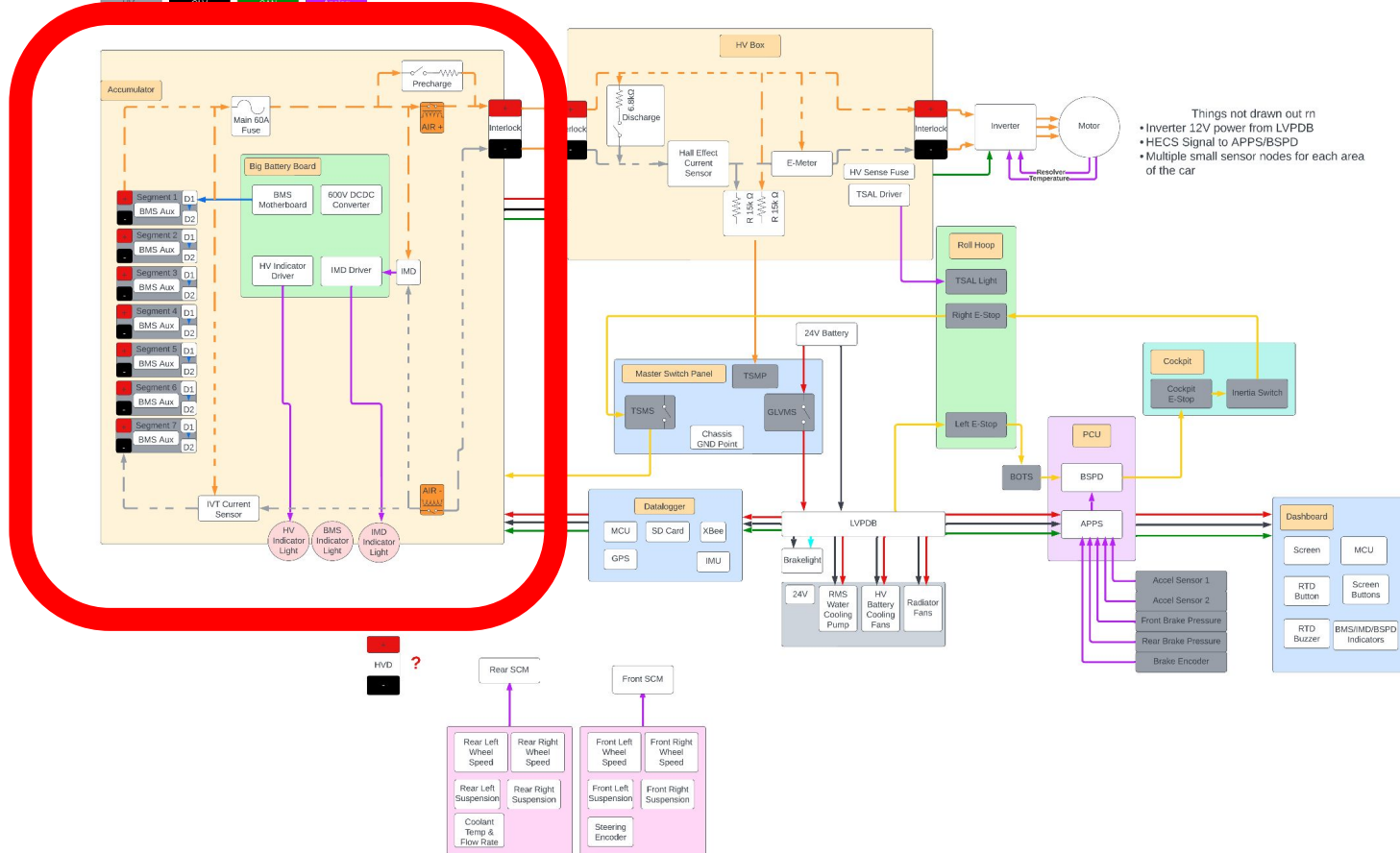

Accumulator Attic

TSMS

Tractive System Master Switch

- Key that turns on High Voltage Systems on the car (i.e. connects the accumulator to the rest of the car)
- Only does so if the rest of the shutdown circuit determines the car is safe to operate
- Turns TSAL (Tractive System Activation Light) from SOLID GREEN to FLASHING RED

Formula Electric at Berkeley
SN3 Electrical System Diagram
Rev 1.1
Last Updated 10/08/23

HV +   24 Volts (LV)   Shutdown   isoSPI

Accumulator

Big Battery Board

BMS Motherboard   600V DCDC Converter

HV Indicator Driver   IMD Driver   IMD

Main 60A Fuse
Precharge
AIR +
Interlock

Segment 1   D1 / BMS Aux / D2
Segment 2   D1 / BMS Aux / D2
Segment 3   D1 / BMS Aux / D2
Segment 4   D1 / BMS Aux / D2
Segment 5   D1 / BMS Aux / D2
Segment 6   D1 / BMS Aux / D2
Segment 7   D1 / BMS Aux / D2

IVT Current Sensor
AIR -

HV Indicator Light   BMS Indicator Light   IMD Indicator Light

HV Box

6.8kΩ Discharge
Hall Effect Current Sensor
E-Meter
HV Sense Fuse
TSAL Driver
R 15k Ω   R 15k Ω

Interlock

Inverter   Motor
Resolver Temperature

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Cockpit E-Stop   Inertia Switch

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GLVMS
Chassis GND Point

Left E-Stop

PCU
BOTS   BSPD
APPS

Datalogger
MCU   SD Card   XBee
GPS   IMU

LVPDB
Brakelight

24V   RMS Water Cooling Pump   HV Battery Cooling Fans   Radiator Fans

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Accel Sensor 2
Front Brake Pressure
Rear Brake Pressure
Brake Encoder

Dashboard
Screen   MCU
RTD Button   Screen Buttons
RTD Buzzer   BMS/IMD/BSPD Indicators

HVD   ?

Rear SCM
Front SCM

Rear Left Wheel Speed   Rear Right Wheel Speed
Rear Left Suspension   Rear Right Suspension
Coolant Temp & Flow Rate

Front Left Wheel Speed   Front Right Wheel Speed
Front Left Suspension   Front Right Suspension
Steering Encoder

Accumulator

Misc. Accumulator Stuff

- AIRs - Accumulator Isolation Relays
  - These are switches that physically open to shutdown the car
- Segments
  - Think of these like 7 triple A batteries that we have to connect for the car to be powered
- Interlocks
  - Big orange connectors that connect different HV components together
- [Notion Page](#) on Accumulator Subteam
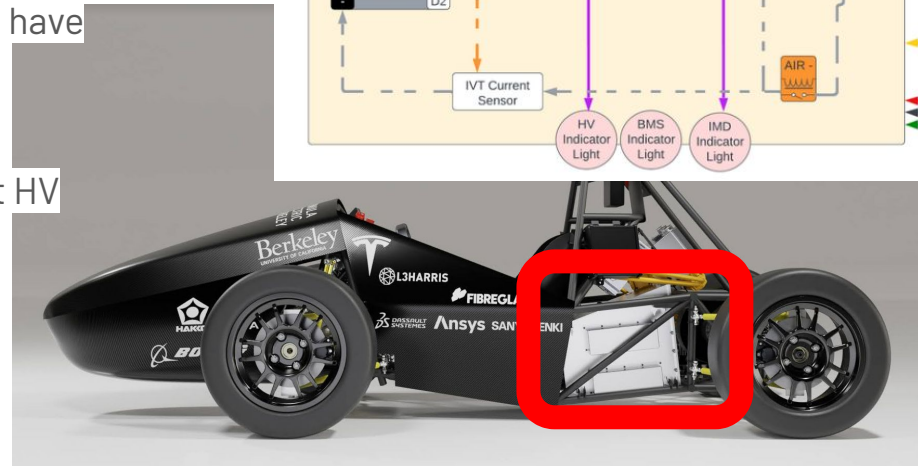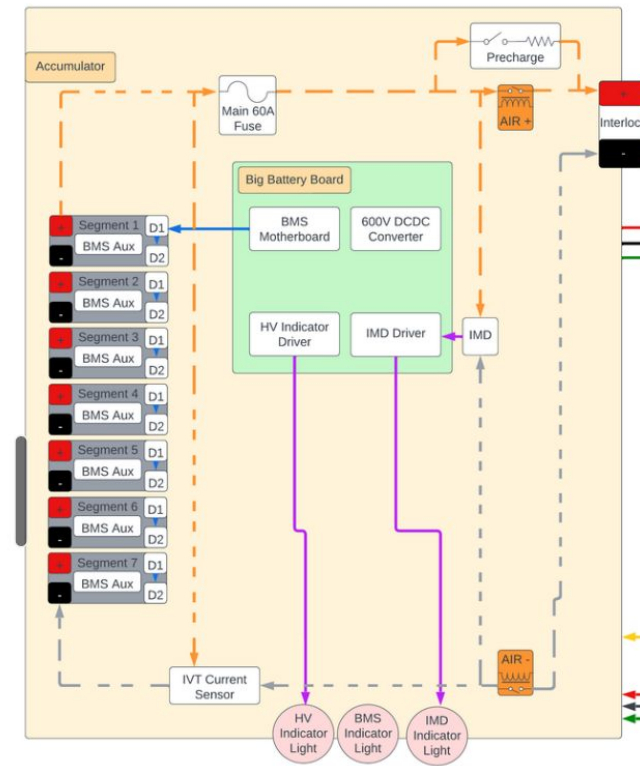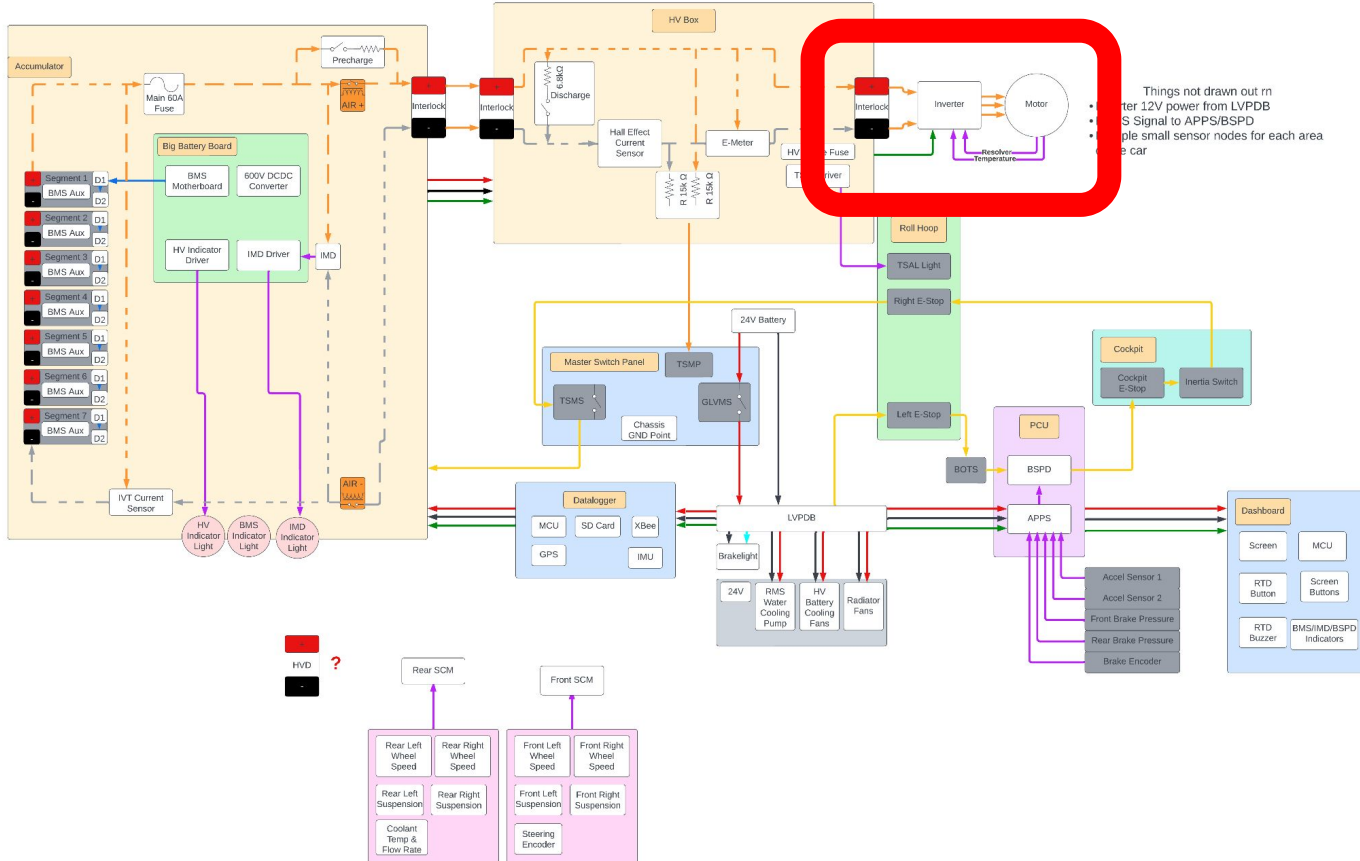
E-Powertrain 1/2: Inverter



Inverter (AKA Motor Controller)

- Controls the motor
- Receives torque commands from the CAN Bus (sent by APPS)
- Converts the DC power from the accumulator into 3-phase AC power to the motor
- Performs the mathematical operations to figure out specifically how to convert the power to get the desired torque output
- Shuts down if motor is too hot
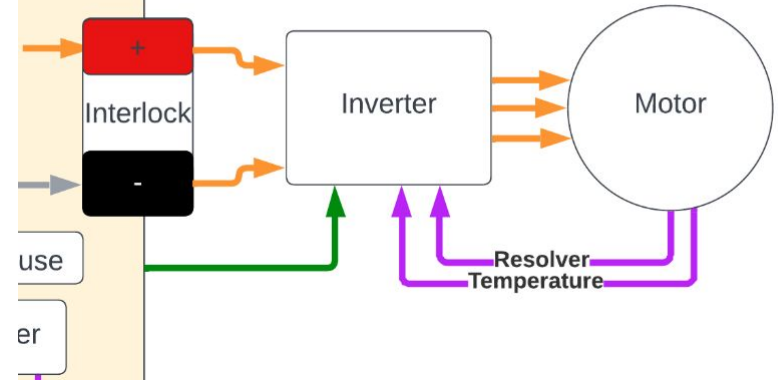
E-Powertrain 2/2: Motor

Motor

- Applies the torque to the wheels
- Physically uses the 3 phase currents from the inverter to spin
- Has a resolver attached to it that measures its speed – sends this signal back to the inverter so it can adjust its commands
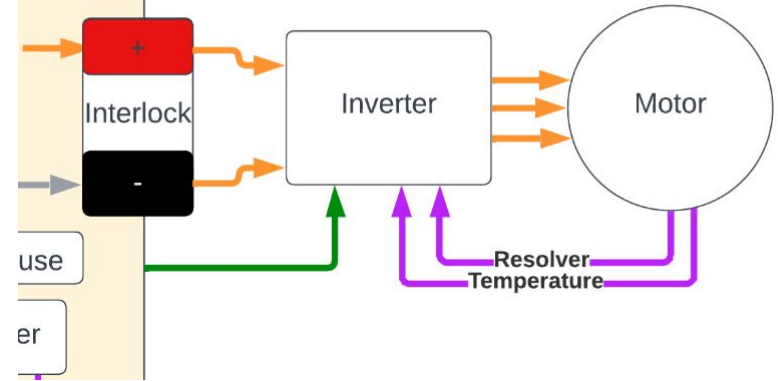
Miscellaneous

DCU

Data Control Unit

- Logs all the messages sent over the CAN bus and saves them to an SD card to be read later
- Extremely critical for analyzing the performance of our car
- Examples of data:
  - Battery voltage/current, motor speed, commanded/measured motor torque, coolant temperature, etc.
- Not present on SN2