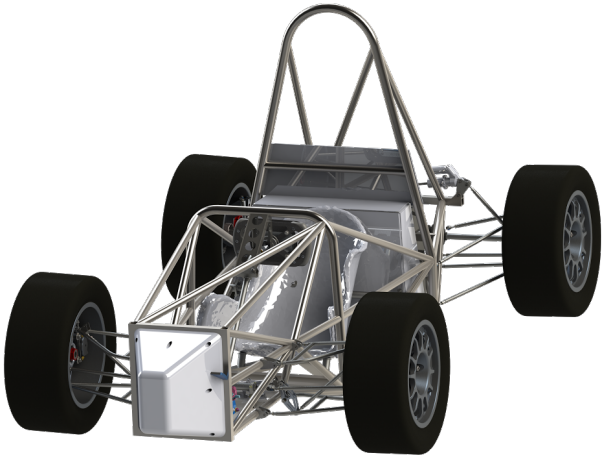
REVO Electric Racing

ESF Part 1



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1 Vehicle Overview

Vehicle is:

- ☑ New (built on an entirely new frame)
- ☐ New, but built on a pre-existing frame (FSAE, FS, FH electric-only, etc.)
- ☐ Updated from a previous year vehicle

Architecture:

- ☐ Hybrid
- ☐ Hybrid in rogress (HIP)
- ☑ Electric Only

Drive:

- ☐ Front Wheel
- ☑ Rear Wheel
- ☐ All-wheel

Regenerative Braking:

- ☐ Front Wheels
- ☑ Rear Wheels
- ☐ All-wheels
- ☐ None

Note: Our use of regenerative braking is undecided, however, if we use it we will utilize our tractive system motors on the rear wheels.

2 Frame and Body

2.1 Frame

Materials: 4130 drawn-over-mandrel (DOM) chromoly tubing, square and round sections, meeting minimum material requirement per rule T3.3
Joining Methods and Construction: TIG welded joints with CNC milled tube miter profiles (courtesy of Cartesian Tube Profiling). Use of optical breadboard and custom aluminum jig fixtures to accurately locate parts prior to welding.

2.2 Body

Materials: Fiberglass bonded with epoxy (not designed yet), Dzus quarter-turn fasteners for attachment to frame
Construction: CNC routed foam molds with vacuum bag layup.

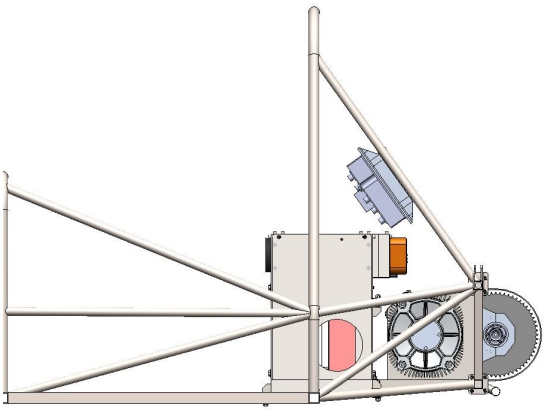

Figure 1: Frame and Body Construction

3 Engine

N/A: ELectric only vehicle

4 Electrical System Overview

4.1 Block Diagram

See following page

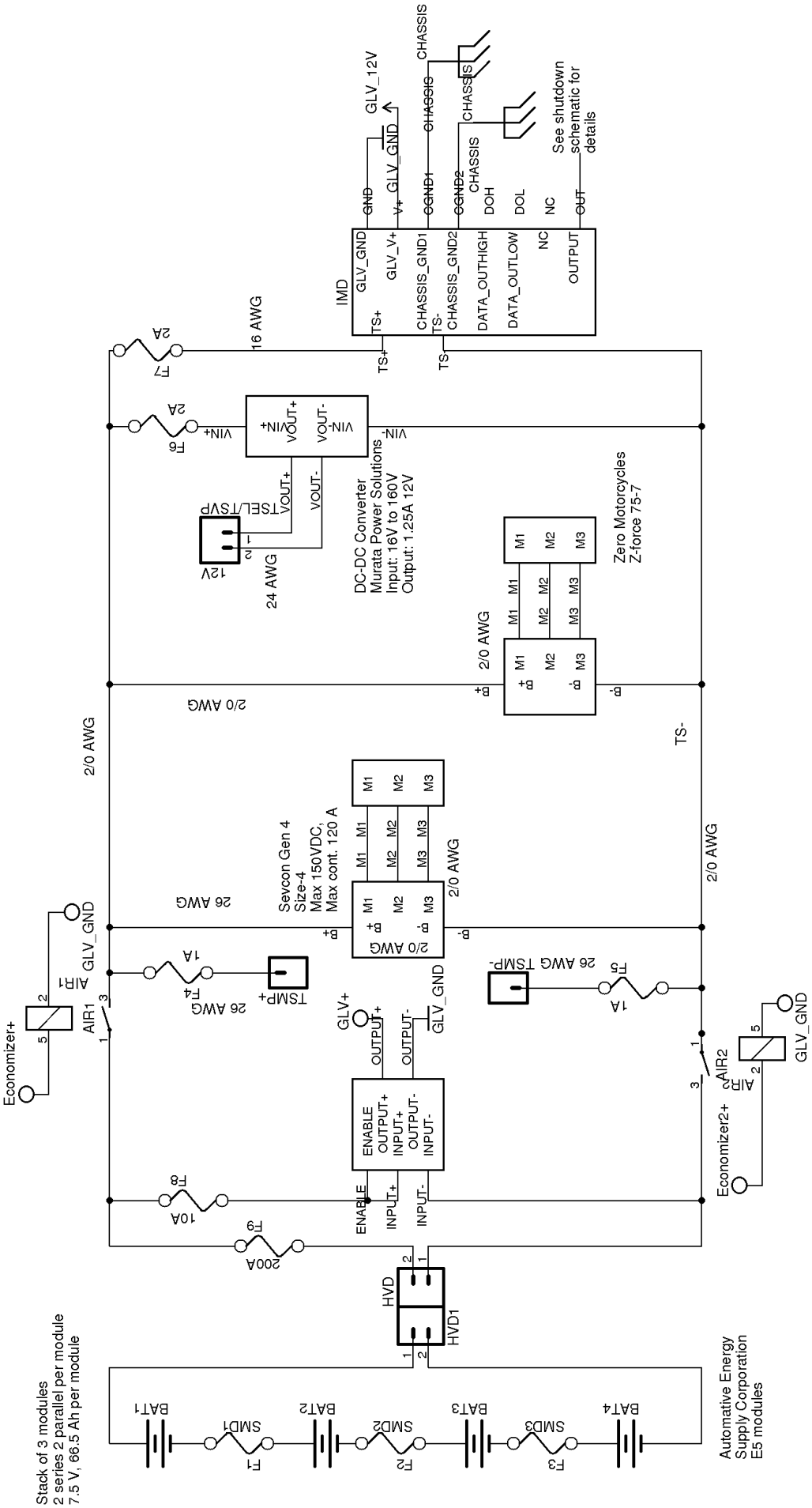

Figure 2: Electrical System Block Diagram

4.2 Vehicle Layout

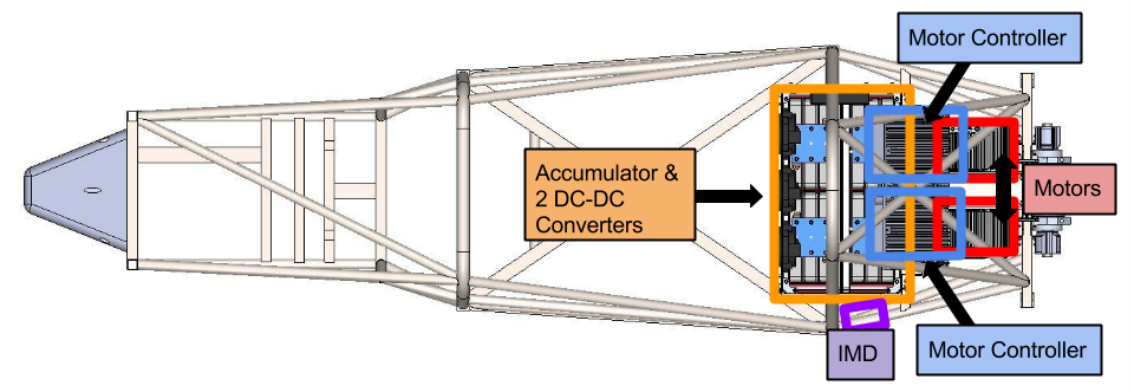

Figure 3: Vehicle Layout

4.3 Electrical System Parameters

Nominal Tractive System Voltage (TSV)	90 VDC
Max TSV (typically during charging)	100 VDC
Control System voltage (GLV)	12 VDC
Total Accumulator capacity	6.102 kWh
Accumulator type	Li-Ion
Number of electric motors total	2
Are wheel motors used?	No

Table 1: Electrical System Parameters

4.4 Firewall(s)

Description/Materials: The firewall is constructed of two layers. The layer facing the tractive system is 1.5 mm aluminum sheet metal. The second layer facing the cockpit is 1/8 in. Flame-Retardant Multipurpose Garolite (G-10/FR4). We have only 1 firewall that shields the driver from the accumulator since we do not have an engine or other components that pose a fire hazard.

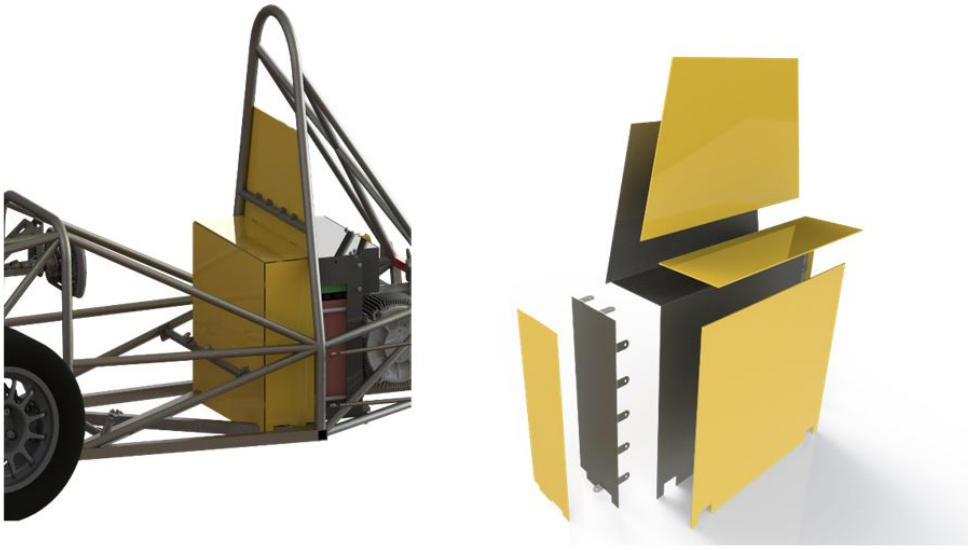

Figure 4: Firewall position in car

5 Tractive System

5.1 Motor(s)

Manufacturer	Zero Motorcycles
Model Number	30-0534
Motor Type	DC Brushless
Number of motors of this type used	2
Nominal motor voltage	104 V
Nominal/Peak motor current (A)	Nom: 250 Peak: 420
Nominal/Peak motor power	Nom: 26 kW Peak: 44 kW

Table 2: Motor Specifications

5.2 Motor Controller

NOTE: The motor controller's accelerator input CAN node will be galvanically isolated from the rest of the low voltage system. We are in the process of designing this isolation into our CAN system.

Manufacturer	Sevcon
Model Number	Gen4
Number of controllers of this type used:	2
Maximum Input Voltage:	150V
Nominal Input Current:	120 A
Output Voltage (Vac —-— or Vdc)	Same as input
Isolation voltage rating between GLV and TS connections	2000 V
Is motor controller accelerator input isolated from TSV?	YES

Table 3: Motor Controller Specifications

6 Accumulator System

6.1 Accumulator Pack

The accumulator system consists of 12 Nissan Leaf modules in series. The modules are arranged into 4 segments of 3 modules each. The electrical and mechanical architecture of the accumulator container is team designed. The complete pack is shown in the figures and tables below. No other accumulators, batteries, or capacitors are used.

Maximum Voltage (during charging)	101 VDC
Nominal Voltage	90 VDC
Total number of cells	48
Total number of modules	12
Cell arrangement	Series
Are packs commercially or team constructed?	Team constructed
Total Capacity	6.102 kWh
Maximum Segment Capacity	4.38 MJ

Table 4: Main Accumulator Parameters

6.2 Cell Description - Batteries

Cell Manufacturer	Automotive Energy Supply Corporation
Model Number	E5
Cell type	Pouch
Are these pouch cells	Yes
Cell nominal capacity	33.9 Ah
Discharge rate for nominal capacity	1C
Maximum Voltage	4.2 V
Nominal Voltage	3.75 V
Minimum Voltage	2.5V

Table 5: Main Cell Specification

6.3 Cell Description - Capacitors

We do not have any capacitors in our accumulator, nor do we plan to in the future.

6.4 Cell Configuration

There are 4 cells in each module in a 2S2P configuration. The schematic below shows the module's cell configuration. There is a shutdown separator between the cells in parallel. On the schematic it is attached to MIDPWR1 and MIDPWR2. Note that we are still obtaining specifications on these cells and will update the ESF as we get more data.

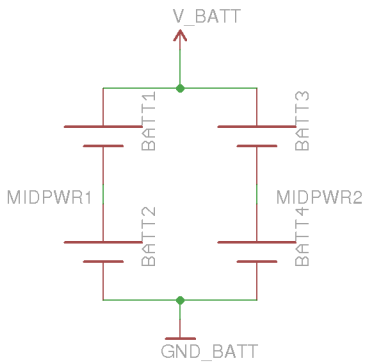

Figure 5: Nissan Leaf battery module schematic

Module Manufacturer	Automotive Energy Supply Corporation
Model Number	E5
Module Shape (prismatic, cylindrical, pouch, etc.)	Prismatic
Module normal capacity	67.8 Ah
Discharge rate for nominal capacity (e.g. 1C, 2C, etc.)	Unknown
Maximum Voltage	8.4 V
Nominal Voltage	7.5 V
Minimum Voltage	5 V
Maximum Module Temperature (charging)	Unknown
Maximum Module Temperature (discharging)	Unknown

Table 6: Module Specification

6.5 Lithium-Ion Pouch Cells

The vehicle accumulator ☐ DOES ☑ DOES NOT use individual pouch cells
A support ticket request (1084) has been opened on our Lithium-Ion Pouch Cells. Because we are using commercial modules, we do not need to follow rule EV3.9.

6.6 Accumulator Management System (AMS) Data

AMS Manufacturer	Team made
Model Number	N/A
Number of AMSs	4
Upper Cell Voltage Trip	4.0 V
Lower Cell Voltage Trip	2.7 V
Temperature Trip	65 °C

Table 7: Accumulator Management System

6.7 Charging

Charger Manufacturer	Delta Q Technologies
Model Number	QuiQ1000
Maximum Charging Power	945 W
GLV/TS isolation location: (ie.cell boards, main unit, etc.)	Unknown
UL Certification?	Yes
Maximum Charging Voltage	125 V

Table 8: Accumulator Charging Data

Note: We have been struggling to find 100V chargers that are UL listed, and would appreciate advice on alternatives. The charger above would most likely work, but may be beyond our budget.

6.8 Accumulator Container/Housing

The frame of the accumulator is comprised of " thick mild steel angle, TIG welded at joints, as shown in Figure 1. The frame is the load bearing structure and 3/16" milled c-channel mild steel brackets are welded directly to the frame and serve as mounting feet to the chassis. The frame will be powder coated to ensure corrosion is not a problem. Aluminum panels which only serve to prevent ingress of dust and liquid will be riveted to the frame on all sides of the box and gasketed along its perimeter. Additional steel sheet metal panels will be welded into the frame to provide mounting interfaces to connectors, SMD's, and wire pass-throughs.
We will be using 1/16" FR4-G10 garolite panels to provide electrical and fire resistance between segments, shown in red in Figure 2. Figure 2 also shows the internal construction of our accumulator. Two of these two-segment structures will be used to meet required rules. Each two-segment structure comprises six Nissan Leaf lithium manganese oxide modules, and $\frac{1}{2}$" polycarbonate machined brackets will be providing tensile and compressive support to the cells during high acceleration case loading. There is a step-out in the box to house our AIR's and other ancillary electronics critical to the accumulator including DC-DC converters and pre-charge discharge circuits.
We plan to use cold-air intakes on each side panel with fabric air filters to prevent dust and liquid ingress, with suction fans on the rear face of the step-out.
The accumulators will be located behind the driver's seat and firewall and before the motor. See the figure in Section 4.2 for a visual representation.
We will not be taking advantage of the virtual accumulator housing rule

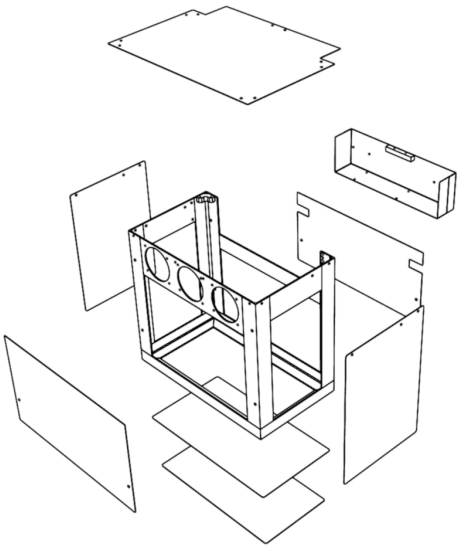

Figure 6: Exploded view of the accumulator housing

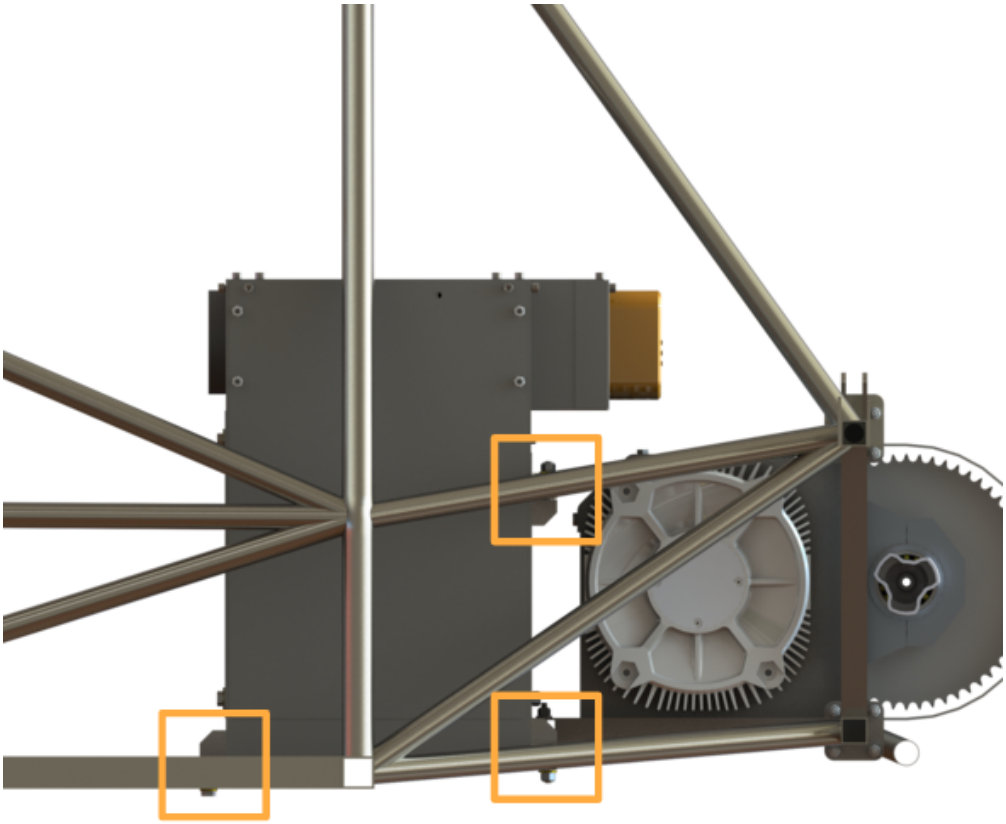

Figure 7: Accumulator Mounting

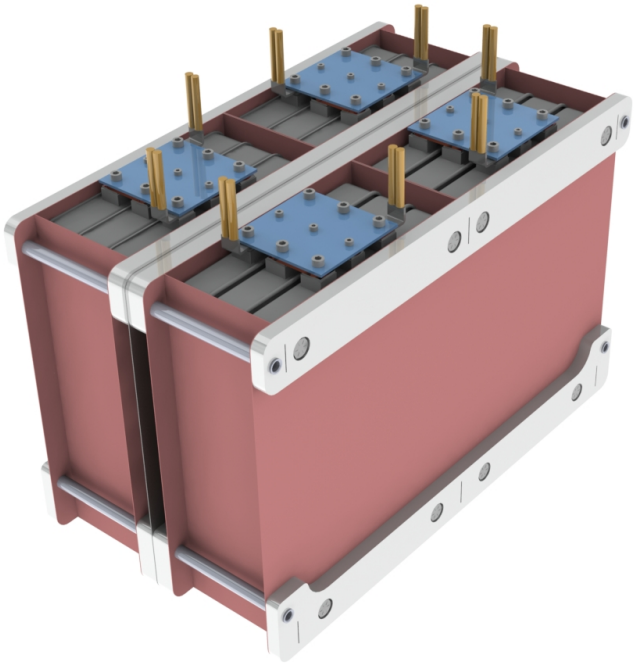

Figure 8: Module Stack

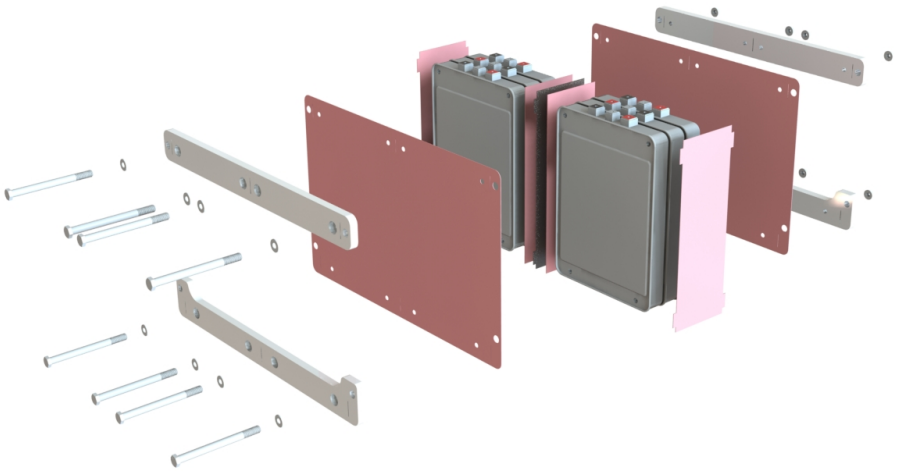

Figure 9: Module Stack Exploded

6.9 Shutdown Circuit

See following three pages for full schematics.

6.10 IMD

The IMD used in the vehicle is a Bender A-ISOMETER IR155-3203 set to a threshold voltage of 500 Ohms/volt. It will be run off the 12V supply. The IMD status light will be placed on the dash and controlled by the IMD status output such that it will light when the output is low (i.e. when a fault is detected.)

Manufacturer	Bender
Model Number	ISOMETER IR155-3203/IR155-3204
Set Response Value	50 kΩ

Table 9: Parameters of the IMD

7 GLV System

7.1 GLV System Data

The GLV system is powered off the tractive system by a galvanically isolated DC-DC converter off the main accumulator, with an output voltage of 12V. The GLV system is split up into 3 main parts: Shutdown circuit, CAN communication and sensors. The sensor and CAN systems branch off the shutdown circuit after the main GLV master switch and the three emergency-stop buttons, and fused again after the separation.
The CAN communication system nodes are the Watchdog, Control Panel, Emergency Buttons (Estops, Brake over travel switch, master switches), Insulation Modeling, AMS, Motor temperature and Motor Controller/Throttle nodes. While the CAN communication does look at aspects of the shutdown circuit, the shutdown circuit does not rely on it to shut down the car. All of the CAN communication's nodes on the shutdown circuit are purely for debugging purposes, and have no actual function for the driving of the car. Only the motor controller node, which connects the throttle to the motor controller, has a functional use for the car. The motor controller node relays the information from the throttle to the motor controller and controls the speed of the motor, and it will have galvanic isolation within the communication.
There will be a steering wheel sensor and two wheel speed sensors. These sensors will be used for driver training purposes.
The shutdown circuit, shown in the figure in section 6.8, which includes all of the minimum components, will be rated to 5A. An addition to the shutdown circuit, the torque plausibility check, will shut down power to the motors (via the motor controllers) if both the mechanical brakes and the torque pedal are more than 25% actuated simultaneously, and remains active until the torque pedal is less than 5% actuated. Potentiometers on both of the pedals will supply travel information to CAN. Both will be independently wired, and the check will come just before the motor controllers.
Overall, the GLV system will have 3 parallel paths, with the shutdown, sensors and CAN being on separate paths with appropriate fusing. Please note that the lights (TSAL/TSVP) are on their own (isolated) DC-DC converters, and not considered part of the GLV system.

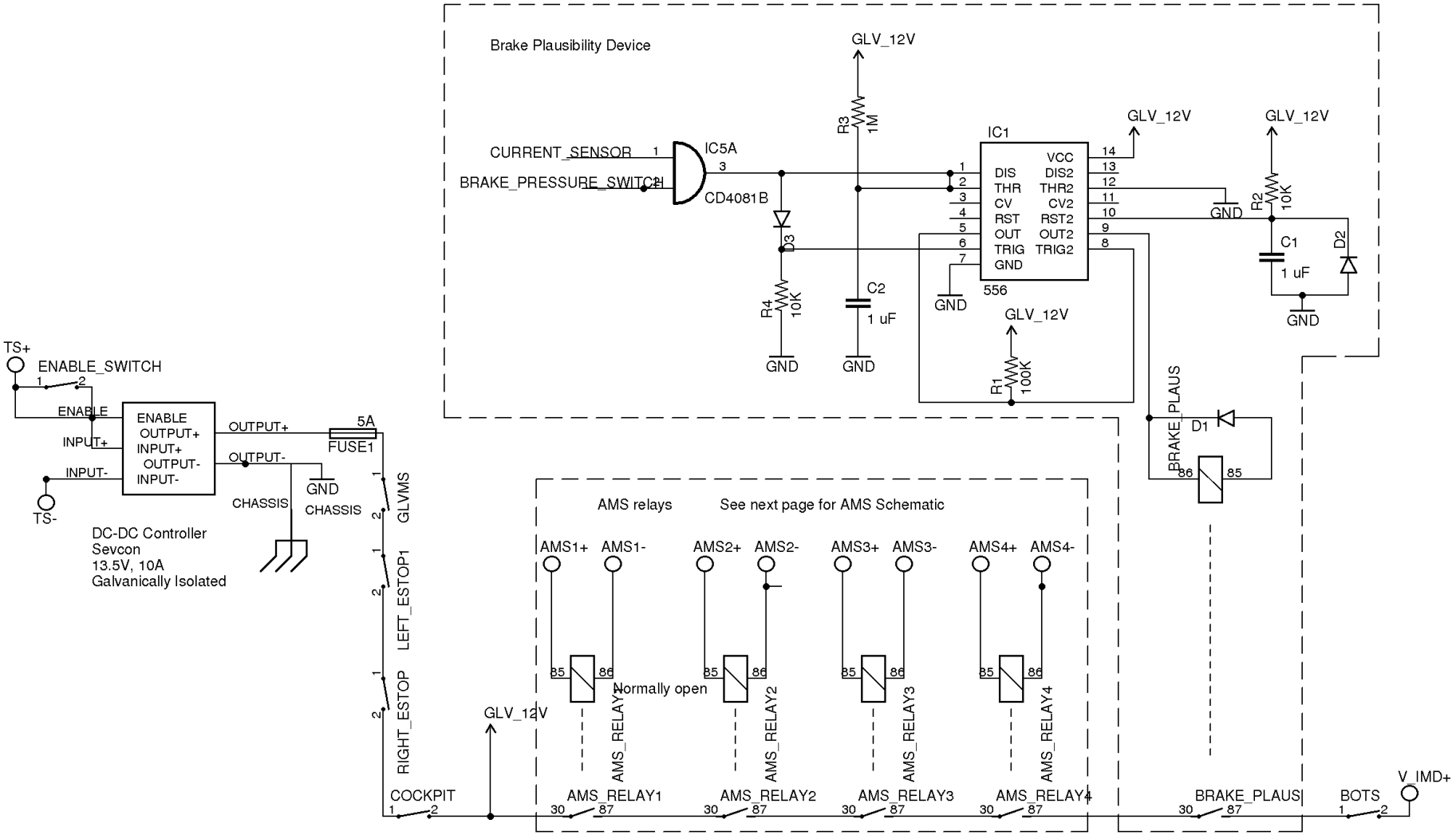

Figure 10: Shutdown circuit part one, including the AMS, Brake Plausibility device, Brake over travel switch and E-stops

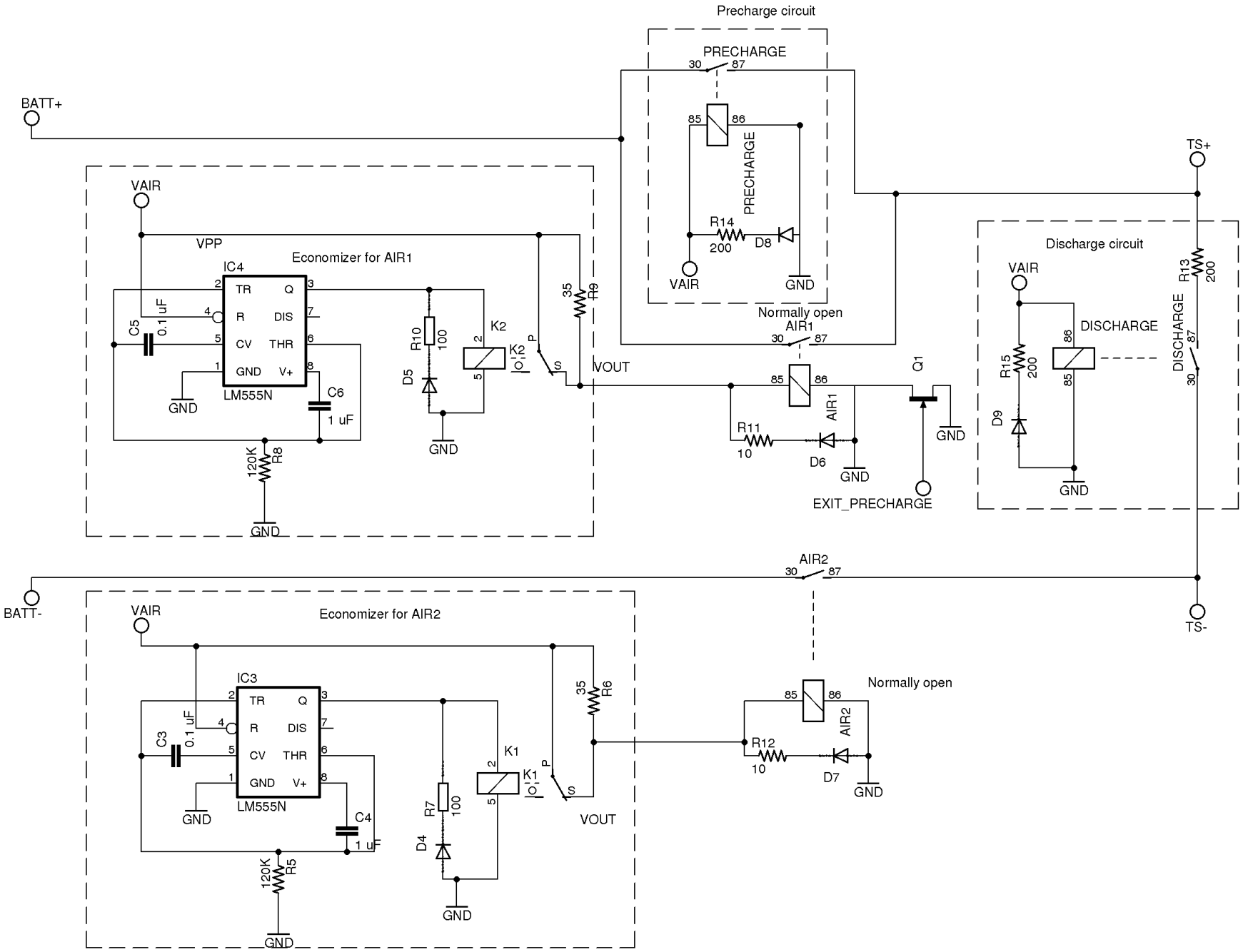

Figure 11: Shutdown circuit part two, including the AIRs, Precharge and Discharge circuits

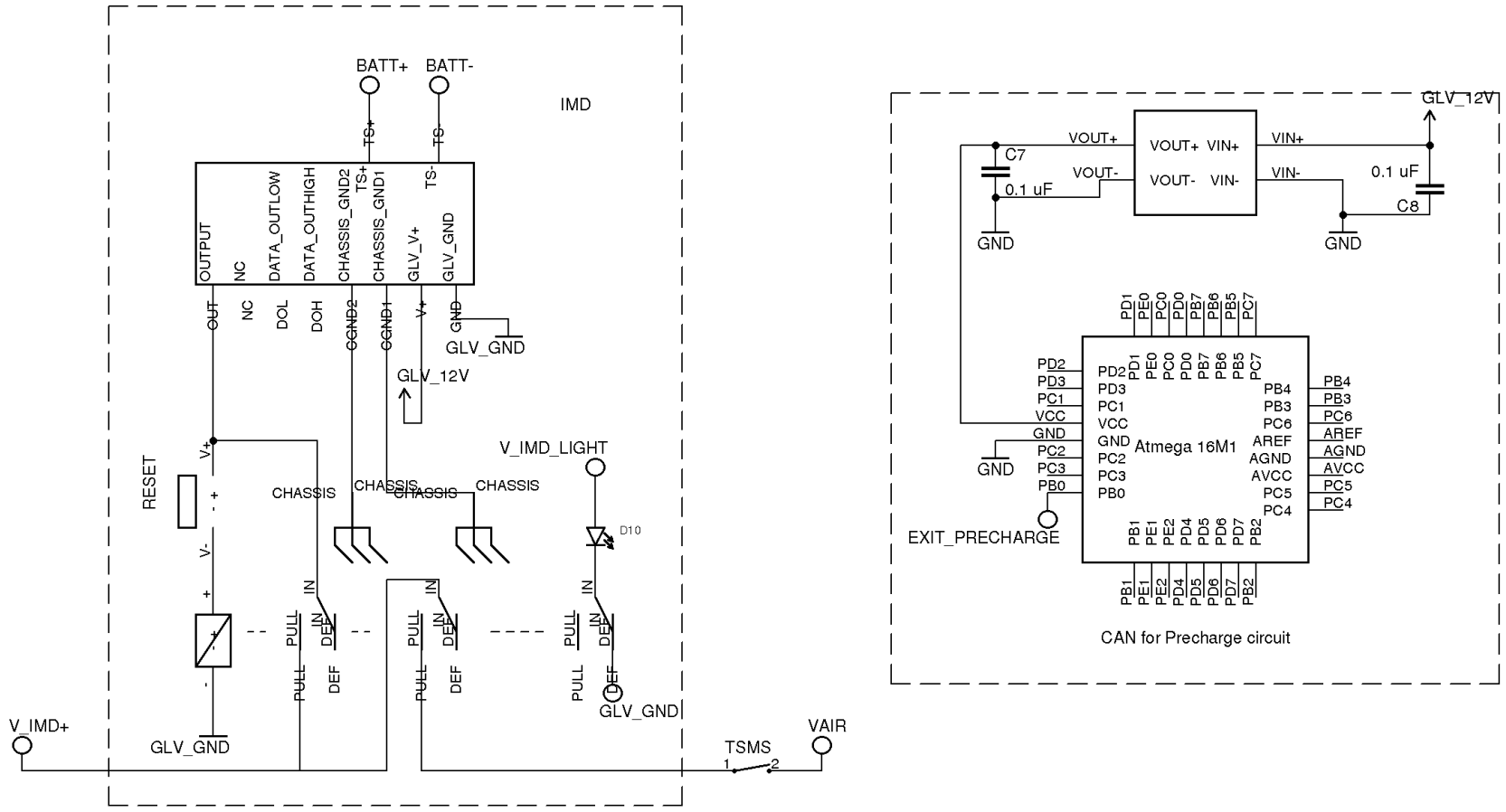

Figure 12: Shutdown circuit part three, including the IMD and its relay and the CAN node of the precharge system

GLV System Voltage	12V
GLV Main Fuse Rating	10A
GLV Accumulator type	DC-DC converter from TS Accumulator
How is the GLV storage recharged?	With the TS Accumulator charge

Table 10: GLV Data