BUILD SPECIFICATION

PORSCHE 996 — EV CONVERSION

PACK CONFIG	NOMINAL VOLTAGE	DRIVE + CONTROLLER	BMS
96S2P	**~355** V	**Tesla RDU** + T-2C	**Caanan** 192-cell

DRIVETRAIN

MOTOR & DRIVE	
Traction drive unit	**Tesla Model S small RDU**
Drive unit year	**2019**
Peak power	**220 kW (300 hp)**
Controller / inverter	**EV Controls T-2C**

HV SAFETY & PROTECTION	
HV contactors	**4 — T-2C controlled**
Pyro fuse	**controlled (T-2C)**
Dead-short protection	**built-in**
Rollover cutoff	**yes**

Tesla rear drive unit on a custom-built subframe that integrates the motor mount and rear battery box into a single unit.

ENERGY STORAGE

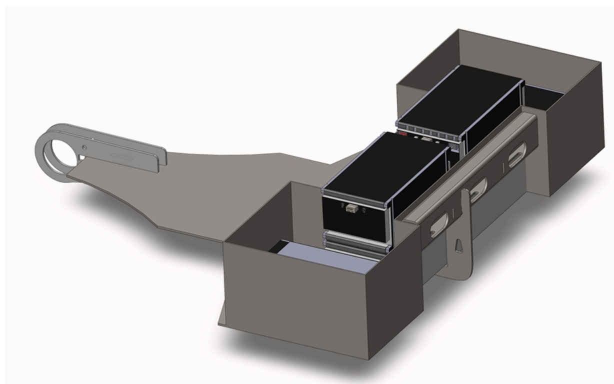
The subframe houses one of the two 48S2P battery packs (6 modules).

TRACTION BATTERY	
Cell chemistry	**Li-NMC (LG Chem)**
Source modules	**Pacifica PHEV × 12**
Module config	**16S**
Total cell config	**96S2P**
Pack split	**48S2P front + 48S2P rear**
Nominal pack V	**~355** V
Full-charge V	**~403** V
Pack capacity	**90 Ah · ~32 kWh**

BATTERY MANAGEMENT	
BMS	**Caanan Electric**
Active balancing	**1** A
Monitoring	**192-cell · V + temp**
Interface	**CAN**
Regen interface	**BMS CCL → T-2C regen limit**
Pack health	**balanced · verified**

Mechanical — Packaging

The core mechanical problem was packaging the new system into the small chassis of the 996. Battery and drive unit selection were carefully chosen to fit the limited spaces available. I fabricated a custom rear subframe that combines the Tesla drive-unit and the rear battery box into a single structural assembly all while tying into the factory chassis mounting points, as shown below. The original motor and transmission assembly is rigid for all intensive purposes and the subframe design takes that into account. The subframe is composed of CNC cut ¼”, and ⅛” steel plates. The front battery box required expanding the “frunk” of the car and adding additional mounts.



Electrical — Power, Monitoring & Control

Once the drive unit was selected, cell modules were chosen that could be built into an arrangement that satisfied the requirements of the drive unit as well as physically fit in the spaces available. The Chrysler Pacifica LG Chem modules, whose 16S1P form factor and air cooled design were ideal for building a 96S2P pack broken into two 48S2P banks across the front and rear boxes.

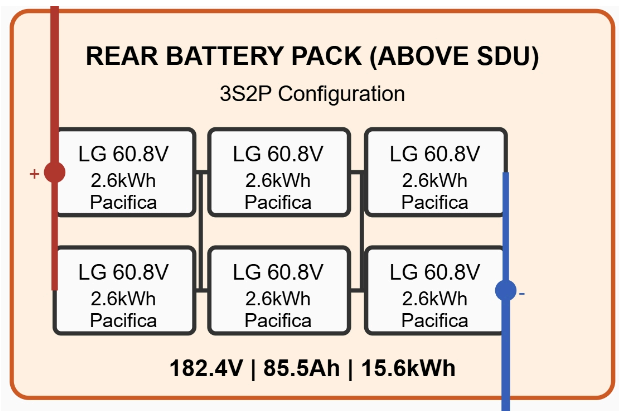
Battery Pack Design: The front and rear battery box are 48S2P (6 module) packs connected in series. One question when building a 48S2P battery bank out of 6 (16S1P) cell modules is where the modules are paralleled. Is it two strings of 3 in series modules paralleled at the ends? or each module parallel to another before being put in series?

Two Methods:

(two series strings, paralleled at the terminals): Two complete 3 module strings independently and tie them together only at the + and − terminals of the string. Electrically, the only nodes the two strings share are the endpoints.

(Three 2P groups, then series): Parallel modules creating three 2P modules then series-connect them. Every parallel node is a common bus shared by both modules at that position.

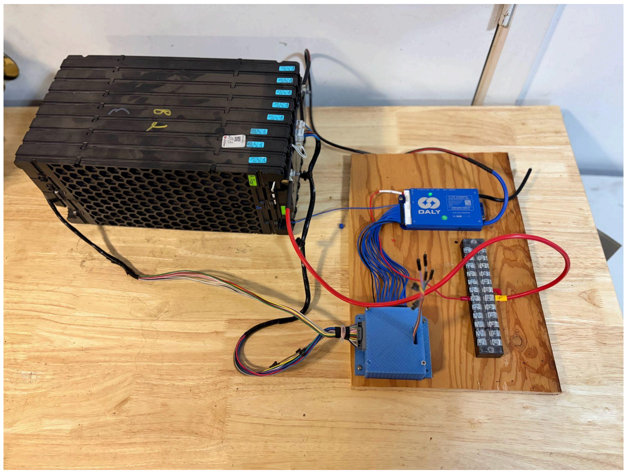
The core issue is where equalization happens. Modules in direct parallel sit on a common node and continuously equalize so the 2P group behaves as one larger module. In (two series strings, paralleled at the terminals) the only place the two strings can equalize is the terminals, and equal string voltage does not imply equal per module state of charge. In (two series strings, paralleled at the terminals) one string could be providing all the current while the other does little. These modules are from two separate Chrysler Pacifica vehicles, therefore these modules do not share the same history or have the same internal resistance. A mismatch in series-summed internal resistance between the two strings could lead to a difference in state of charge between the strings. Due to these reasons the front and rear battery bank design includes paralleling each of the 6 modules as shown.



BMS: The project required a BMS system capable of cell monitoring, state of charge calculations, and provide max discharge and charge rates over CAN. The BMS would also have to be split into satellites that could sit local to the battery banks rather than routing dozens of cell tap wires through the car, a potential short circuit hazard. Nothing commercially met the need, for this reason the BMS is being built by Canaan Electric with 192 cell monitoring divided between the front and rear battery bank. Dividing the pack across two boxes also created additional isolation requirements, so positive and negative contactors were installed in each box allowing total isolation for any HV wires outside of the battery boxes.

The EV Controls T-2C commands the system: Tesla drive unit control, contactor and pre-charge resistor circuit timing, pyrotechnic disconnect, communication with the BMS over CAN. Regenerative braking and max drive unit current parameters are controlled by the T2C which in conjunction with the BMS's state of charge calculation will ensure that the drive unit can never over-charge or draw too much current from the battery bank. The T-2C monitors for multiple failures which could lead to the T-2C limiting drive unit power, commanding the contactors open, or triggering the pyro fuse depending on the fault. Amongst these include airbag deployment, rollover(set by the SRS system), E-stop, and a short circuit condition which would be set by the BMS.

Battery Assembly Considerations:
When assembling the battery boxes and paralleling the modules the voltage difference between the modules being paralleled must be minimal so that an arc isn't created and discharge/charge rates are not exceeded as the two modules equalize. To do so I built a 16-cell charger using an off the shelf BMS(shown below). This charger allows me to ensure cell health before assembly as well as charge each module to the same level. Before connecting the paralleling bus bars, the two modules are connected using a small resistor to allow the module's voltage difference to reach as close to zero as possible.



Single module Balance/Charger: diagram on right