



BATTERY PROTECTION REPORT NORTHWESTERN UNIVERSITY (11)

Charlie Costakis – Electrical Lead

Email: solar@u.northwestern.edu



SYSTEM DIAGRAM

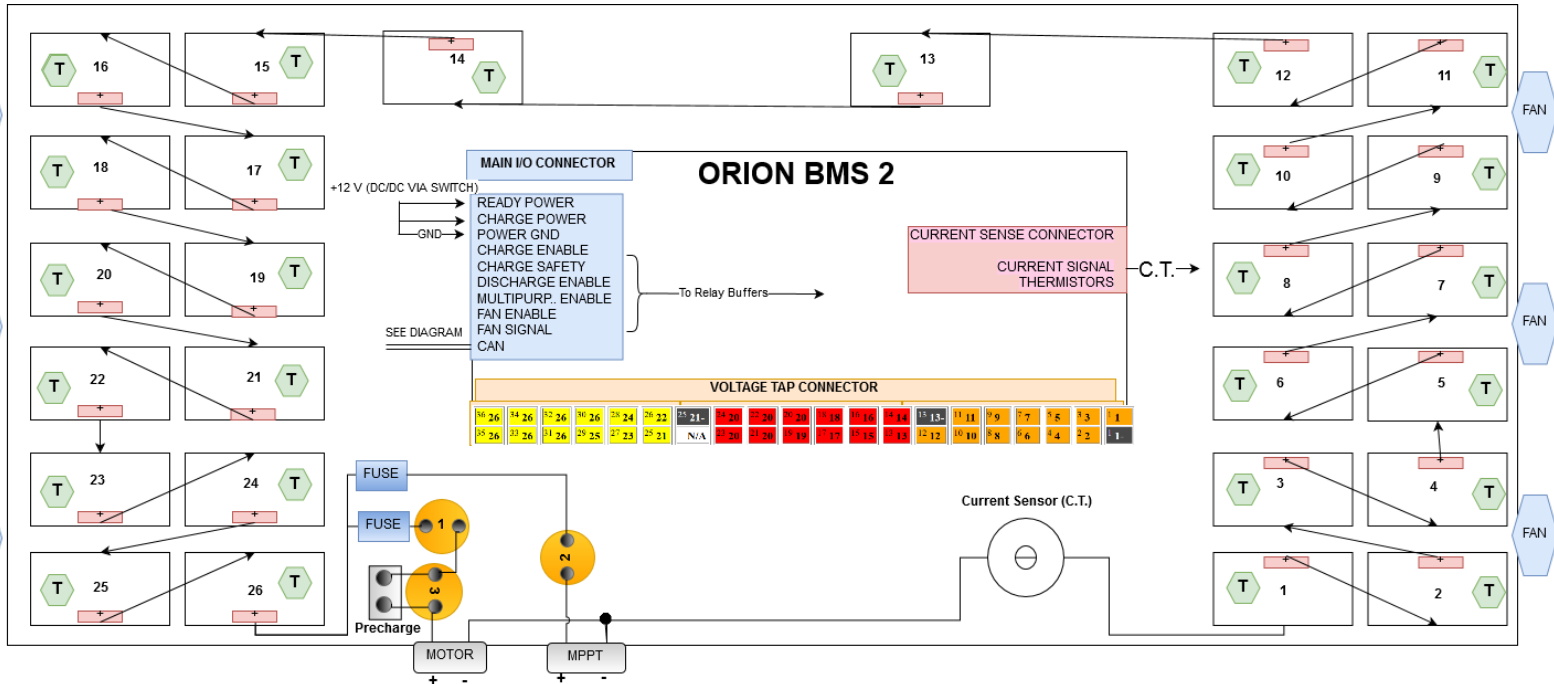


Figure 1: Battery Box Physical Layout

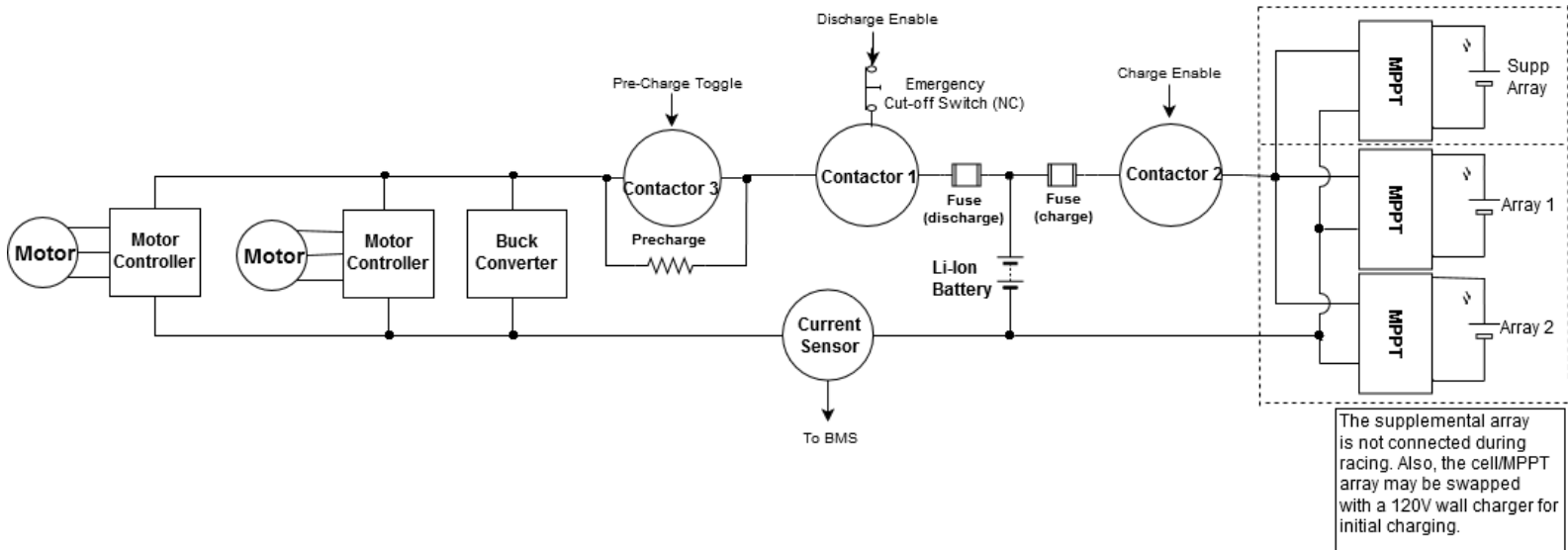


Figure 2: High Voltage system schematic

- As shown above, our battery consists of a string of 26 modules (Fig 1)
- Each module contains sixteen Panasonic 18650GA cells in parallel
- The total cell count is thus 416
- Over temperature is:
 - (Charging): 45° C
 - (Discharging): 60° C
- Under-voltage set-point = 2.7V
- Over-voltage set-point = 4.19 (cell maximum charging voltage = 4.20V)
- “T” blocks are Orion temperature sensors
- See Electrical Report diagram for External Cutoff Switch (normally-closed switch cuts power to BMS, and thus, contactors)

The high voltage system (Fig 2) may be in one of four states:

1. **Fully off** – All contactors open
2. **Precharge** – Contactors 1 and 2 closed, but Contactor 3 open
3. **Fully On** – All contactors closed
4. **Discharge Only** – Contactors 1 and 3 opened, but Contactor 2 open

The Li-Ion cells may be discharged when their temperature is below 60C. However, the charging temperature cannot exceed 45C. For this reason, if the temperature is between 45C and 60C, then the car operates in **Discharge Only** mode (Contactor 1 and 3 closed, but not 2).

BPS OPERATION

1. Once the user switches on power, the BMS checks for the following conditions
 - a. Every cell falls between under- and over-voltage limits
 - b. Total pack current falls under current limit (separate limits for charging and discharging)
 - c. Every cell falls between set temperature limits (separate limits for charging and discharging)
2. If all conditions are satisfied, the BMS engages Contactors 1 and 2
 - a. Else, the BMS sends a CAN packet to our Arduino microcontroller, which enables the strobe light
3. After 3 seconds, Contactor 3 (pre-charge) closes from an Arduino timer signal (via relay)
4. BMS continually monitors conditions 1(a) thru 1(c) and disengages all contactors if any condition becomes unmet. Ten seconds must elapse before repeating step (1).

The Orion BMS can be programmed with a custom password set by the race officials for sealing after scrutineering.



ASC/FSGP Battery Approval Form

Submit to ascteams@americansolarchallenge.org

NOTE: The manufacturer's specification sheet, the battery's MSDS sheet with accident protocol, and a description of the protection circuitry (protection circuitry schematic, high level description, list of items protected) must also be submitted to ASC prior to approval. Battery approval is subject to verification at Scrutineering. If the manufacturer changes the battery's specifications, the new specifications must be submitted for re-approval. Teams should bring AT LEAST 3 unmodified cells for weight verification.

CONTACT INFORMATION

Date: 12/24/2019 Team Number: 11
Team Battery
Organization: Northwestern University Contact: Charlie Costakis
mail: solar@u.northwestern.edu Phone: (847)-644-6202

MANUFACTURER INFORMATION

Manufacturer:	<u>Panasonic</u>	Type (lead acid, LION, etc):	<u>Li-Ion</u>
Battery Name:	<u>NCR18650GA</u>	Model Number:	<u>NCR18650GA</u>
Battery Capacity (Ah):	<u>3.45</u>	Rate (C/3, C/20, etc):	<u>0.42C charge, 2.89C discharge</u>
Battery Mass (kg):	<u>48g per cell</u>	Battery Voltage:	<u>3.6V nom</u>
Battery Cost (US\$):	<u>\$4.04/cell</u>	Max Current per Cell:	<u>10A discharge, 1.475A charge</u>

VEHICLE BATTERY PACK SPECIFICATIONS

Number of batteries in the vehicle battery pack : 416
Pack Mass (kg): 19.97 Pack Voltage: 93.6V nominal
26 modules in series. Each module contains 16
Pack Configuration: parallel

SUPPLIER INFORMATION

The manufacturer is the Manufacturer of the battery cell This must be the **original manufacturer** not a reseller. If the supplier uses a different model name or number than the manufacturer, please provide that information, also.

No Panasonic website
Manu. URL: available, [here is reseller link](http://pages.na.industrial.panasonic.com/Batteries-Contact-Page.html) Contact: Li-Ion Wholesale (reseller)
<http://pages.na.industrial.panasonic.com/Batteries-Contact-Page.html>
Email: [Page.html](http://pages.na.industrial.panasonic.com/Batteries-Contact-Page.html) Phone: (888)-972-2883 (reseller)
Battery Name: NCR18650GA Flat Top 10A Supplier Model #: ncr18650ga

