NU solar

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ELECTRICAL REPORT – ASC 2020

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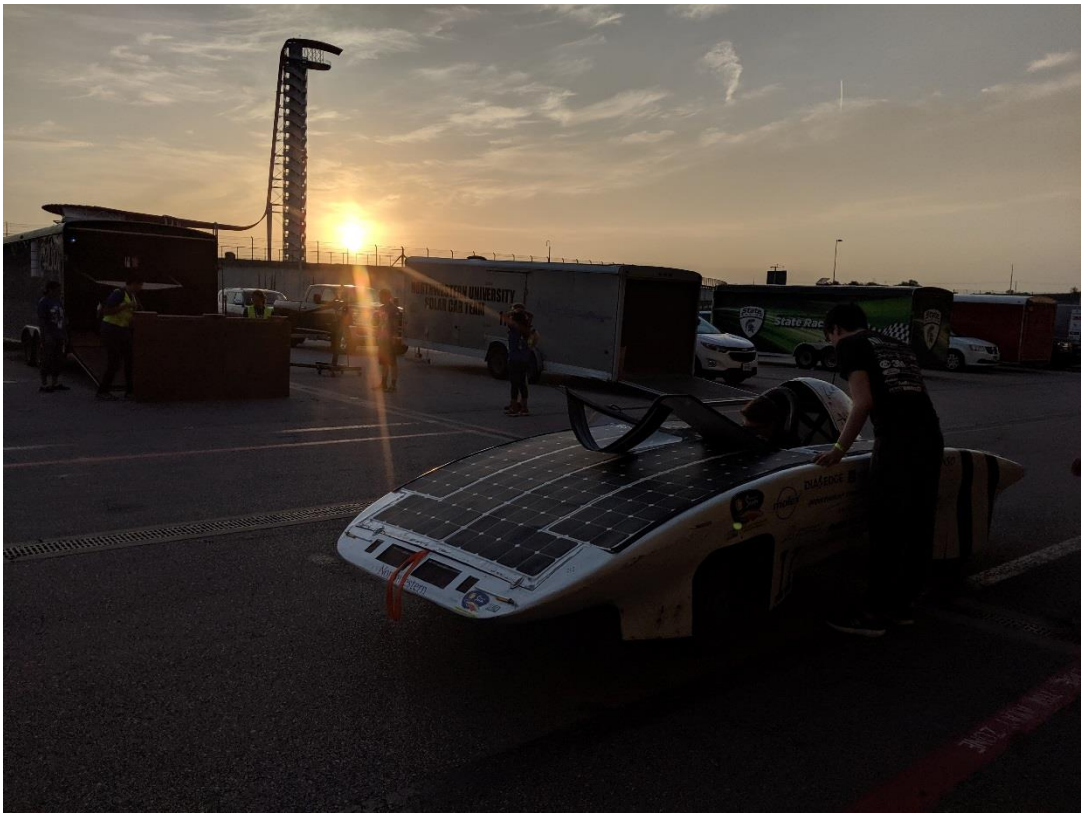

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HIGH VOLTAGE SYSTEM OVERVIEW

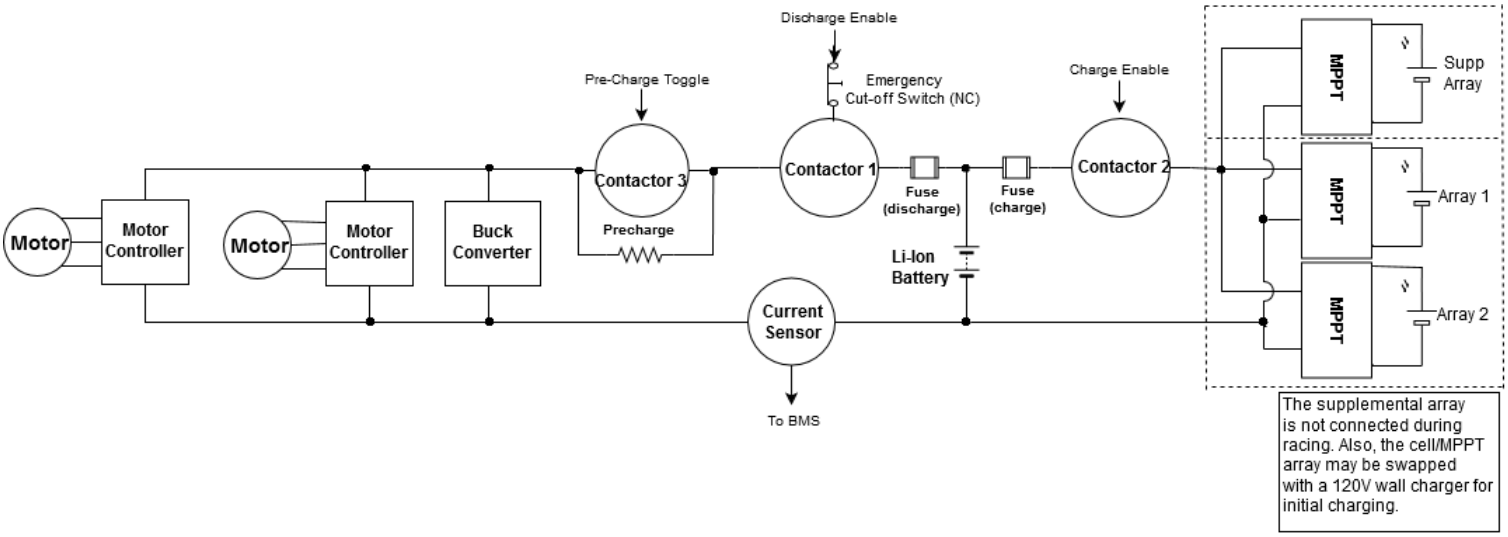

Figure 1: High-voltage system diagram

All wire segments shown carry 70-110 VDC. Each motor is a Mitsuba M2096-3 three-phase brushless DC (BLDC) type, and contactors are EV200 series Kilovac units rated for 500A load, and 12V drive coils.

The high voltage system 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 transition between states is described in “Power-Up Sequence”.

LOGIC OVERVIEW

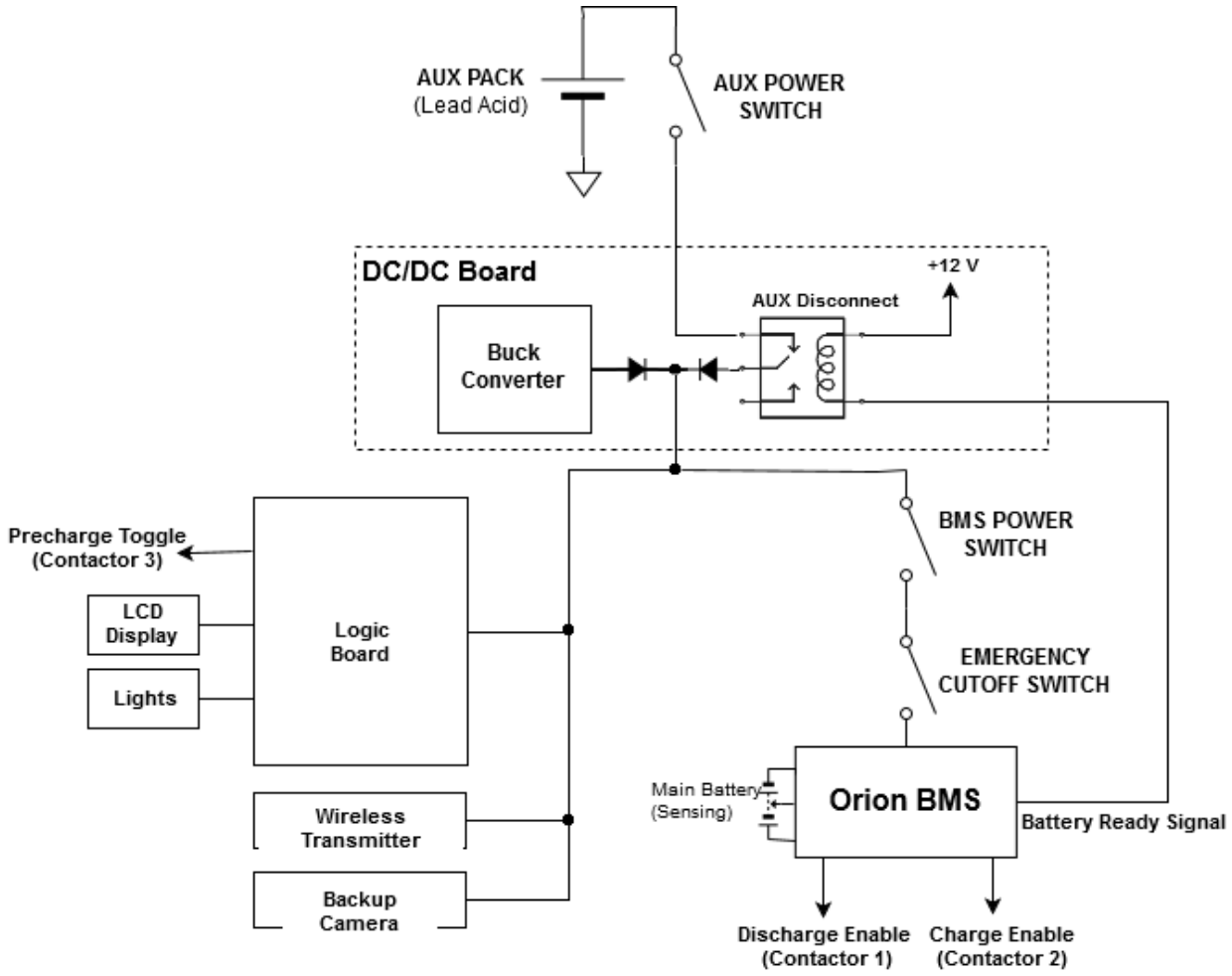

Figure 2: 12V system logic

All wire segments shown carry 12VDC. The “Aux Pack” is a 12V lead-acid battery used only for the initial startup sequence. The input and all outputs of the buck converter are appropriately fused (not shown).

POWER-UP SEQUENCE

1. Driver flips on “Aux Power Switch”
    - Motor controller internal capacitors gradually charge through precharge resistor
    - Logic board powers on, and after three seconds, “Precharge Toggle” closes Contactor 3 (Fig. 1)
2. Driver flips on “BMS Power Switch”
    - BMS powers on and checks all battery cells
        - If all tests pass, the BMS closes Contactors 1 & 2 (Fig. 1) and issues “Battery Ready Signal” to disconnect the Aux Pack from the 12V power bus
3. Car is ready to be driven

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).

ELECTRICAL RATINGS

HV DISCHARGE WIRING

4 AWG copper wire (TEMCo Industrial Welding Cable) is used for all HV wiring on discharge side (Fig. 1):

SPECIFICATIONS

Color: Red, Black, or 50% Black / 50% Red
Conductor Size: 4 AWG
Length (ft): 5 to 1000 ft
Feet Per Pound: 6.8
Stranding (qty. x dia): 364 / 0.01"
Nominal O.D. (in.): 0.348"
Conductor Material: Copper
Insulation Material: High Grade EPDM
Max. Amps: 150
Max. Voltage: 500
Min. Temperature Rating: -50°C
Max. Temperature Rating: 105°C

As shown, these cables support a max amperage of 150A. The batteries support a maximum discharge current of 160A (10A per cell; 16 cells in parallel). **These ratings support the choice of a 150A fuse on the discharge path**.

HV CHARGING WIRING

The Li-Ion battery pack can support a maximum charge current of 23.6A (1.475A per cell; 16 cells in parallel). Thus, 10 AWG copper wire (rated for at least 30A at all temps) was chosen to connect the MPPT outputs in parallel to the battery pack. **These ratings support the choice of a 25A fuse on the charge path**.

The fuse model is shown on the following page. The 150A and 25A versions were chosen.

POWR-GARD® Fuse Datasheet

Littelfuse
Expertise Applied | Answers Delivered

CLASS T – JLLN / JLLS SERIES FUSES

300/600 VAC • Fast-Acting • 1-1200 A

Description

JLLN/JLLS fuses are less than ⅓ the size of comparable Class R fuses and are typically used for short circuit protection of drives and surge sensitive components. When rated in accordance with the NEC®, JLLN/JLLS fuses provide fast-acting overload and short circuit protection for non-inductive circuits and equipment.

Applications

- Variable speed drive protection
- Compact mains switches

Features/Benefits

- Extremely current-limiting
- Compact design
- 200 kA Interrupting Rating

Specifications

Voltage Ratings
AC: 300 V (JLLN)
600 V (JLLS)
DC: 160 V (JLLN 1 – 60 A)
125 V (JLLN 70 – 1200 A)
300 V (JLLS)

Interrupting Ratings
AC: 200 kA rms symmetrical
DC: 20 kA (JLLN & JLLS)

Ampere Range
1 – 1200 A

Approvals
AC: Standard 248-15, Class T
UL Listed (File: E81895):
JLLN (1 – 1200 A)
JLLS (1 – 800 A)
UL Recognized (File: E71611)
JLLN PCB Mount (35 – 60 A)
JLLS (900 – 1200 A)
CSA Certified (File: LR29862)
JLLN/JLLS (1 – 600 A)
DC: UL Listed (File: E81895):
JLLN (35 – 1200 A)
Littelfuse self-certified
JLLN (1 – 30 A)
JLLS (1 – 1200 A)

Environmental
RoHS Compliant

Ordering Information

AMPERE RATINGS				
1	30	90	250	800
2	35	100	300	900*
3	40	110	350	1000
6	45	125	400	1100
10	50	150	450	1200
15	60	175	500	
20	70	200	600	
25	80	225	700	

*JLLS only
Note: Contact the factory for RoHS compliant Class T fuses.

SERIES	VOLTAGE	AMP	MOUNTING SUFFIX	CATALOG NUMBER	ORDERING NUMBER
JLLS	600	6	–	JLLS006	JLLS006T
JLLN	300	35	V	JLLN035V	JLLN035TXV

Part Numbering System

JLLN xxx T XL

Series
Amperage
Package Quantity
T = 10 (1-60 A)
V = 5 (70-100 A)
X = 1 (110-1200 A)
Mounting Options
JLLN 35-60 A Only
Blank = Cartridge Type
XL = Leaded
XV = Vertical Mount
XLS = Solder Lead

Web Resources

TC Curves, downloadable CAD drawings and other technical information: **Littelfuse.com/jlln**
Littelfuse.com/jlls

Recommended Fuse Holders

LFT30 Series
LFT60 Series
LSCR Series for 700-800 A

Dimensions

Please refer to the Class T dimensions on page 3

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**
Organization:	**Northwestern University**	**Team Battery Contact:**	**Charlie Costakis**
mail:	**solar@u.northwestern.edu**	**Phone:**	**(847)-644-6202**

MANUFACTURER INFORMATION

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

VEHICLE BATTERY PACK SPECIFICATIONS

Number of batteries in the vehicle battery pack : **416**

Pack Mass (kg): **19.97** **Pack Voltage:** **93.6V nominal**

Pack Configuration: **26 modules in series. Each module contains 16 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.

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