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:	May 15, 2017	**Team Number:**	24
Organization:	Midnight Sun Solar Rayce Car Team	**Team Battery Contact:**	Taiping Li
mail:	taiping.li@uwmidsun.com	**Phone:**	226 – 606 - 9948

MANUFACTURER INFORMATION

Manufacturer:	LG Chem	**Type (lead acid, LION, etc):**	LI-ION
Battery Name:	LG MJ1	**Model Number:**	INR18650 MJ1
Battery Capacity (Ah):	3.5	**Rate (C/3, C/20, etc):**	0.2C Standard Discharge
Battery Mass (kg):	Max 0.049kg	**Battery Voltage:**	Nominal: 3.635 V Max: 4.2V
Battery Cost (US$):	$3.88 USD	**Max Current per Cell:**	10A

VEHICLE BATTERY PACK SPECIFICATIONS

Number of batteries in the vehicle battery pack : 1296 Cells

Pack Mass (kg):	63.504 kg in cells alone	**Pack Voltage:**	Nominal: 130.86V Max: 151.2V
Pack Configuration:	36 cells in parallel for a module, and 36 modules in series with each other		

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:	http://www.lgchem.com/global/main	**Contact:**	Jon Caserta, Liion Wholesale Batteries (Supplier)
Email:	support@liionwholesale.com	**Phone:**	888-972-2883
Battery Name:	LG INR18650MJ1	**Supplier Model #:**	LG INR18650MJ1

Note: For this form, the term "battery" refers to the smallest single unit produced by the manufacturer. A lithium ion battery usually contains one cell. A typical 12v lead acid battery contains six cells. Teams or suppliers may group batteries together to form "modules". The term "battery pack" refers to the full vehicle battery system made up of multiple batteries.

Team Coordinator

ascteams@americansolarchallenge.org
www.americansolarchallenge.org

ASC/FSGP Solar Cell Info

Email completed form to ascteams@americansolarchallenge.org
The manufacturer's specification sheet also needs to be submitted

Team Information	**Date Submitted:**	October 14, 2017
	Team Number:	24
	Organization/School:	Midnight Sun Solar Rayce Car Team/University of Waterloo
Team Array Contact	**Name:**	Minghao Ji
	Phone:	519-500-1296
	Email:	minghao.ji@uwmidsun.com
Manufacturer's Specifications	**Manufacturer:**	Sunpower Corporation
	Manufacturer Contact POC, Phone, & Email:	Zach Campeau, N/A, Zach.Campeau@sunpower.com
	Type:	Monocrystalline Silicon
	Cell Name:	Maxeon Gen 3 E
	Cell Model Number:	Bin Le1
	Area of Single Cell (Square Centimeters):	153.33
Complete at Least Three of the Following Spaces Based on Manufacturer's Specifications	**Vmp (Volts):**	0.632
	Imp (Amperes):	5.9
	Pmp (Watt):	3.63
	Efficiency (Percent):	23.7%
Vehicle Array Specs	**ell Area After Trimming For Placement on Car (cm^2):**	153.33
	Number of Cells in Array:	326
	Total Array Photovoltaic Area (Square Meters):	4.999
	Additional Comments:	
Supplier Information	**Supplier:**	Sunpower Corporation
	Contact Person:	Zach Campeau
	Phone:	N/A
	Email:	Zach.Campeau@sunpower.com
	Supplier Cell Name:	Maxeon Gen 3 E
	Supplier Cell Model Number:	Bin Le1
	Pre-Encapsulated Price Per Cell (US Dollars):	$6.38
	Pre-Encapsulated Cost Per Watt (US Dollars):	$1.76

Notes:

Midnight Sun Solar Car Team
University of Waterloo

MSXII

Preliminary Vehicle Design Report

Electrical

Prepared by:
Minghao Ji
minghao.ji@uwmidsun.com
October 15, 2017

www.uwmidsun.com
(519) 888-4567 x32978

Contents

List of Figures

1 History

Midnight Sun was founded in 1988 at the University of Waterloo. The team has produced 11 solar-powered vehicles since its inception, numbered MSI through MSXI. MSX and its predecessors have been traditional Challenger class cars. MSXI was the team's first attempt at a Cruiser class vehicle, which ultimately suffered from design issues relating to its monocoque design. With MSXII, the team has regrouped and designed a new Cruiser vehicle from the gound up, focussing strongly on reliability, safety, and manufacturability.

2 Contacts

Questions regarding the electrical design and implementation of MSXII should be directed to one of the following contacts:

Name	Title	Phone	Email
Tak Alguire	Project Manager	519-574-4610	tak.alguire@uwmidsun.com
Minghao Ji	Engineering Manager	519-500-1292	minghao.ji@uwmidsun.com
Titus Chow	Electrical Lead	226-978-7104	titus.chow@uwmidsun.com

3 Overview

Midnight Sun XII's electrical system consists of high- and low-voltage domains that are electrically isolated for safety. The high-voltage system includes the Sunpower E-series solar cells, Nomura maximum power point trackers, Tritium motor controllers and NGM SCM-150 motors. These are externally-sourced components purchased by the team and interface with the vehicle's custom embedded systems.

The low-voltage system is comprised of custom circuit-boards serving several functions for monitoring and controlling the vehicle, primarily: driver controls, power distribution, battery management, and external lights. Several smaller PCBs are located throughout the vehicle to support various sensor interfacing and data collection functions. Most boards communicate over a unified CAN bus, with some nodes supporting smaller subsystems over I2C or SPI. The low-voltage power rail is normally provided by the main battery pack via DC-DC converters, but can also be switched to an auxiliary 12 V Ni-MH battery during startup or fault modes.

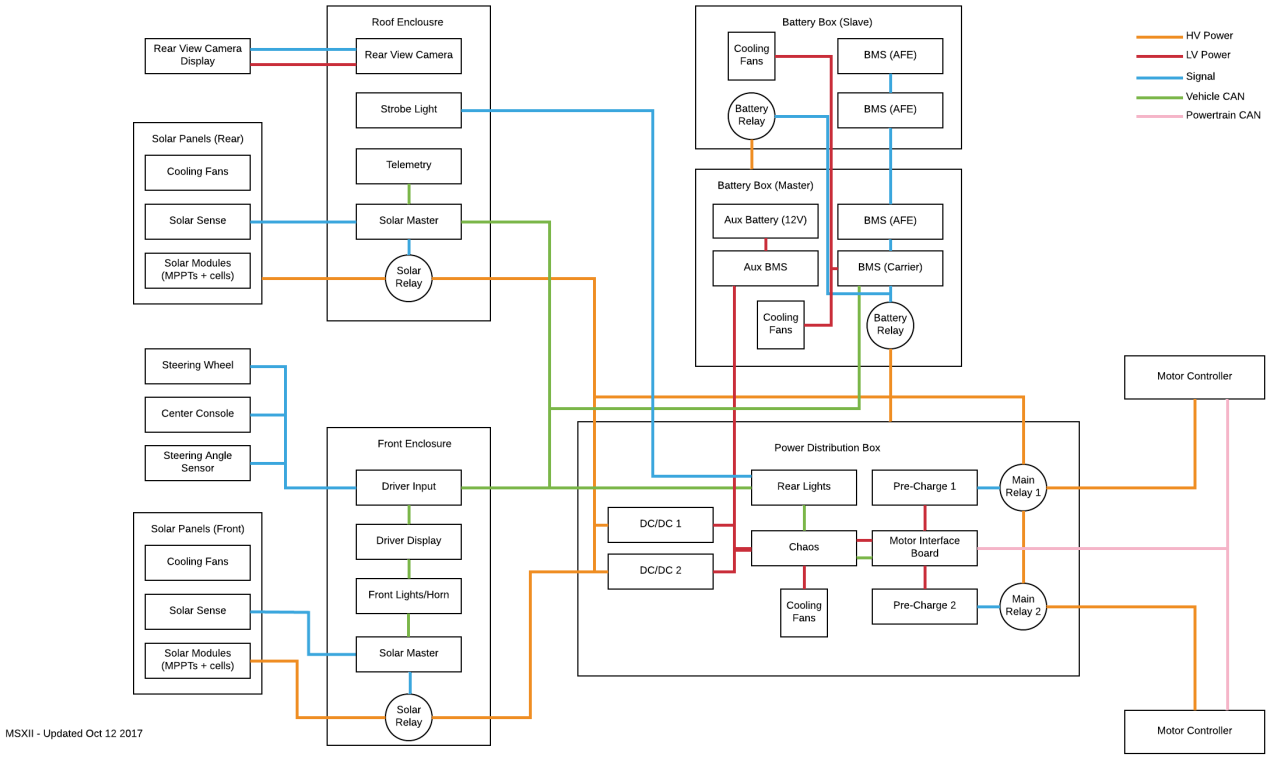

Figure 1: Block diagram of all electrical systems

Due to the different CAN specifications of the Tritium WaveSculptor motor controllers, they are allocated a separate powertrain CAN network which interfaces with the primary CAN bus via dedicated transceiver boards. A block diagram of all electrical systems is shown in Figure 1. A block diagram of only the vehicle's high-voltage systems is shown in Figure 2.

4 Battery

For MSXII the team chose to use MJ1 18650 cells produced by LG Chem Ltd. 36 MJ1 cells are put in parallel to form a module, and 36 modules are put in series to provide a 130.86 V nominal, 16.5 kW h capacity battery pack. Within each module, cells will be spot welded to nickel tabs, which are themselves soldered to copper bus bars forming a high-ampacity interconnect. Bus bars of adjacent modules are mechanically connected together to create series connections through the pack.

The cells were sourced from Liion Wholesale in early 2017.

5 Testing Methodology

Battery testing is expected to be completed in 4 main phases, outlined below.

5.1 Phase One

The first phase requires verification of the battery management system (BMS). This will test the system's ability to measure and monitor voltage, current, and temperature measurements from each of the modules. The system must be able to correctly respond to under-voltage, over-voltage, over-current, and over-temperature conditions to demonstrate that the BMS can actively protect the battery. Phase one is currently underway and is expected to be complete by November 2017.

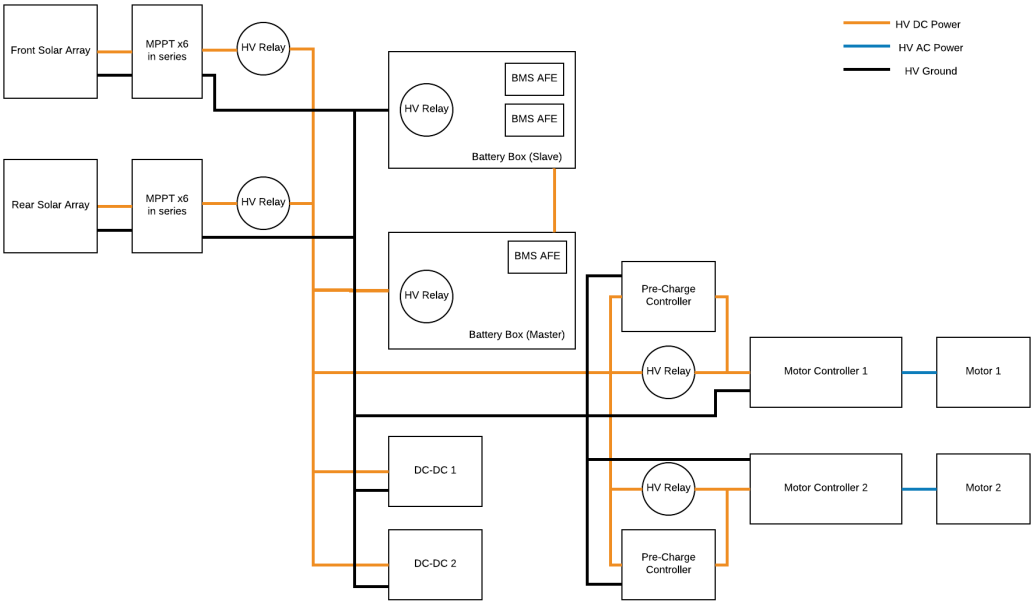

Figure 2: Block diagram of all high-voltage electrical systems

5.2 Phase Two

The second phase requires testing module performance and reliability. A prototype module containing 36 cells in parallel will be built and tested. This module will undergo charge cycle tests using a benchtop power supply and an electronic load. The BMS will be connected to log data and ensure safety. The team will then build 3 battery modules to test the series connections between modules. Phase two is expected to be complete by December 2017.

5.3 Phase Three

The third phase involves the full manufacturing and testing of the battery pack. The team will be able to assess the overall performance of the battery and make necessary modifications to the cooling system prior to installing the battery in the car. The pack will be discharged at 1C, which is approximately 120 A of current. This will be accomplished by either powering the vehicle motors mounted to a dynamometer, or by using a salt water load with a resistance designed for the target current draw. Phase three is expected to be completed by the end of January 2018.

5.4 Phase Four

The final phase of battery testing will involve building a mechanical enclosure and integrating the pack into the vehicle. With a drivable vehicle, the team will be able to test the pack under real world conditions, and make any changes necessary prior to the race. Reliability of the modules and connections under harsh environmental conditions can be evaluated during road tests. Since this requires the vehicle to be in a drivable state, it is expected to begin in April or May 2018 and finish before July.