Overview of the Electrical Team

University of Calgary Solar Car Team
Electrical Technical Documentation Team

1 Introduction

The electrical team deals with all of the electrical work for the University of Calgary Solar Car project. The electrical work can be broken down into roughly four basic areas of work; the four areas roughly are PCB design, the electrical systems, the battery system, and the solar arrays.

2 PCB Design

The PCB work for the car is done by our PCB design team. All of our PCBs are designed in Altium PCB designer. A list of the PCBs designed for the solar car is given below

- The AUX BMS
- The DC-DC Converter
- The CCS
- The Lights Board
- The Driver Control Board
- The CAN Spliter
- The Fan Board
- The Audio Board
- The Strobe Board
- The Relay Board

Some of the more complex boards will be discussed bellow

2.1 The Central Control System

The Central Control System or CCS is a board designed to control the CAN network of the car. The primary use of the CCS in the car is sending data from the CAN network to the Raspberry Pis. A picture of the CCS hardware is given in figure 1

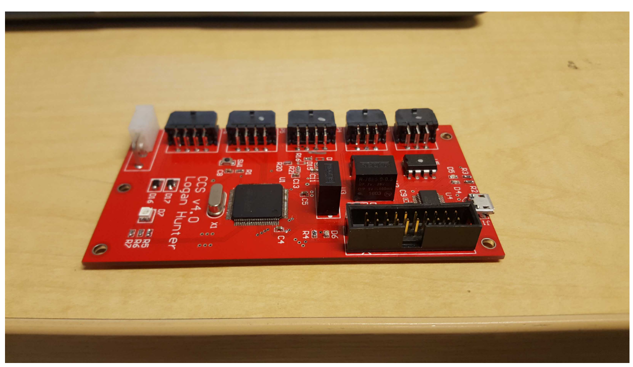

Figure 1: The CCS board Hardware

2.2 The Driver Control Board

The driver control board manages all driver inputs from the car and distributes the inputs over the CAN network. The inputs include but are not limited to acceleration and regen brake pedals, buttons for lights, drive control. A picture of the driver control hardware is given in figure 2

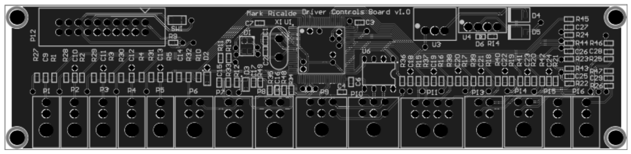

Figure 2: The Driver Control Hardware Schematic, as designed in Altium

2.3 The Lights Board

The purpose of the lights board is to control all of the lights on the car, such as the headlights. The basic operation of the lights board the CAN network will tell the lights board which lights to turn on and then the board will send power to the necessary lights. Future upgrades that the team would want to make to the light board include integration of the emergency strobe board into the lights board and a sufficient power system to run the cars horn on. A picture of the lights board is given in figure 3.

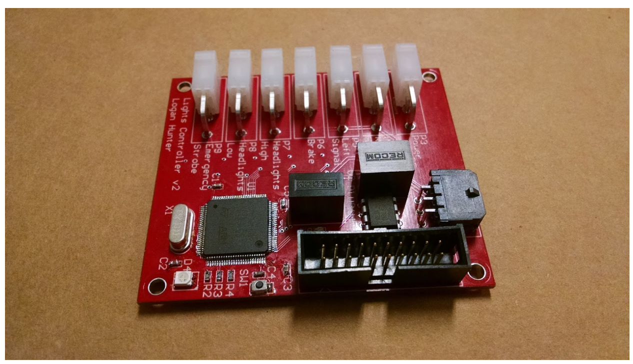

Figure 3: The Lights Board Hardware

2.4 The Audio Board

The audio board will be used to add a media player into the solar car. It is designed to take aux input from a phone or other audio source and send it to two speakers which will be integrated into the car. The audio board is currently under active development. A picture of the audio board hardware is given in figure 4

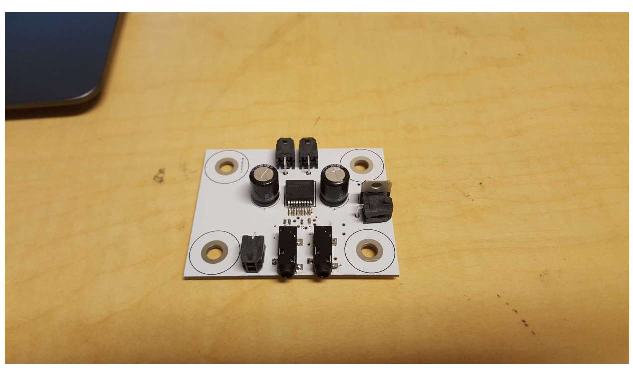

Figure 4: The Audio Board Hardware

The AUX BMS and DC-DC converter will be talked about with the battery as they are directly inside the battery.

3 Electrical Systems

The electrical systems consist of the connection of all of the electrical components we make, such as the PCBs and battery, and the ones we purchase pre-made. All of our electrical devices in the car communicate over the CANbus network. One of the largest systems in the solar car is the high voltage system. A brief diagram of the cars electrical systems is shown in figure 5

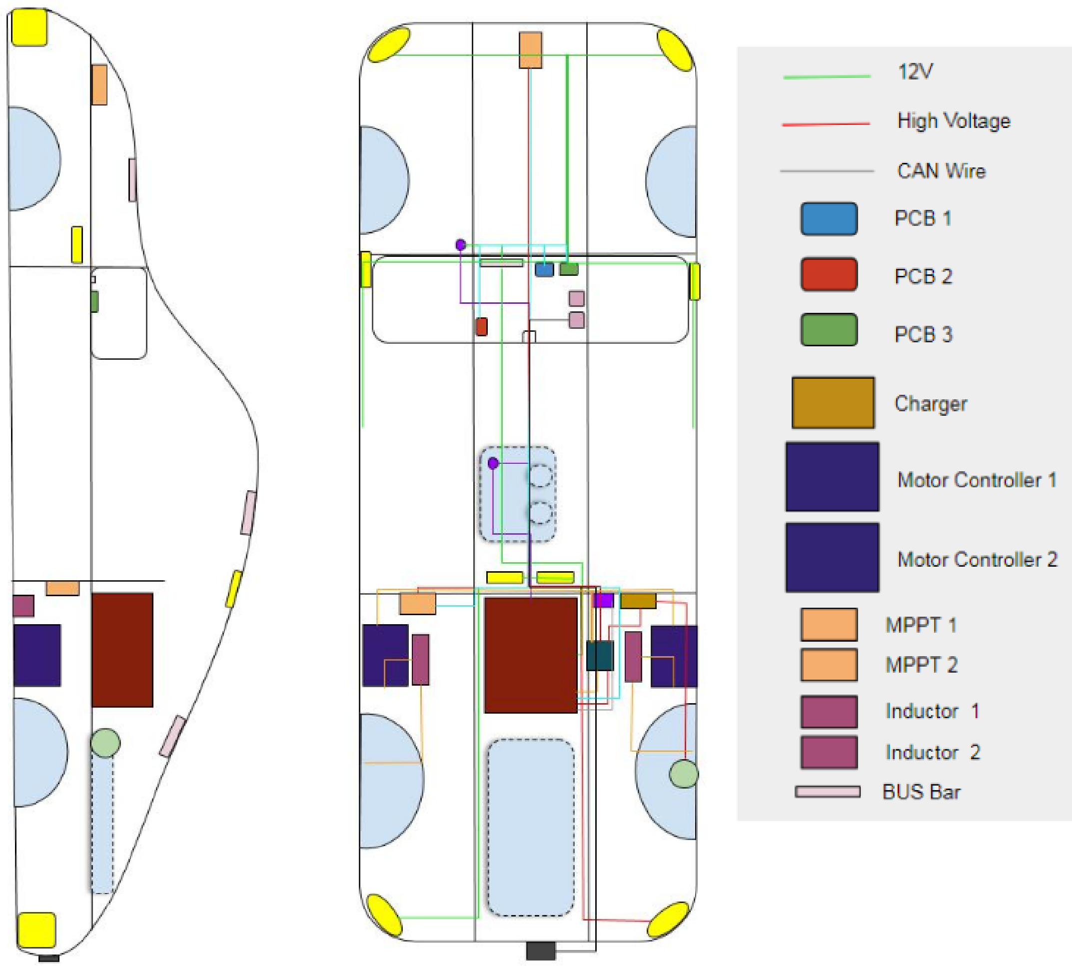

Figure 5: A rough schematic of the electrical systems in the car

The high voltage system consists of our motors, the motor controllers, and the charge system. Multiple of the high voltage components are shown in figure 6

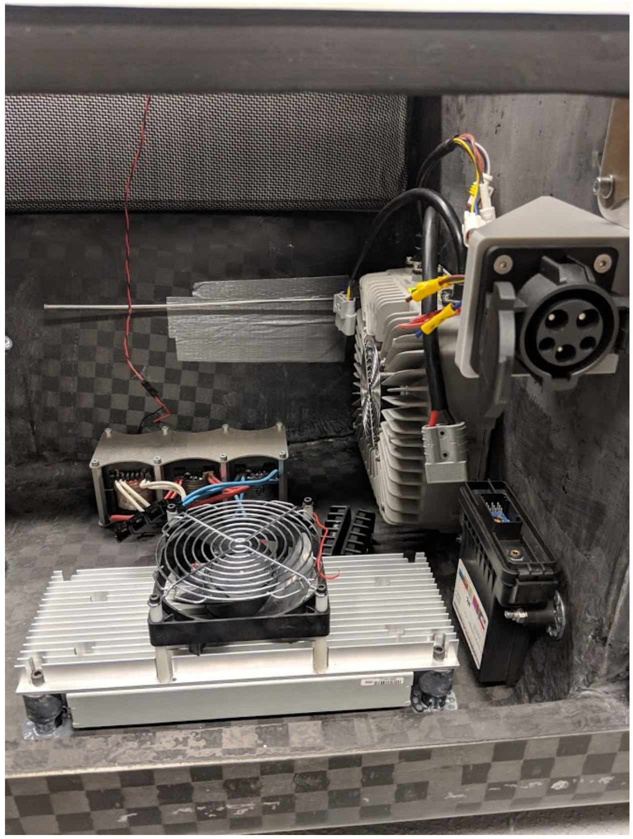

Figure 6: Some of the high voltage components of the car. Shown in the top right is the J1772 charging port, the bottom is one of the Tritium Wavesculpter 22 Motor Controllers, behind the motor controller is the motor inductors, and on the right is the charger and charge controller.

The motor controllers used in the car are Tritium Wavesculpter 22s. There is two motor controllers, one for each of the two motors. The internals of the motor controller are shown in figure 7. Each of the motor controllers costs about \$4 500 [1]. With our next generation vehicle we are planning to replace the current motor controllers.

[1] All prices are given in USD unless otherwise stated

Figure 7: The internals of one of our Tritium Wavesculpter 22 Motor Controllers

The motors used in the car are Marand Arial Flux Surface Mount Motors. The motors are 98.7% efficient. They are 3 phase brushless DC motors that sit in the wheel hub. The motors can drive the car at up to 95 km/h. A picture of our motors are shown in figure 8.

Figure 8: The motors built into the back wheel

In the next generation car we are looking to replace our motors with an estimated cost of $40 000 per motor.

Another of the major systems in the car is the lights system. The lights are all turned on or off through the lights control board. The lights on the car are head lights, left signals, right signals, rear lights, break lights, and the emergency strobe light. There is plans to add interior lights to the car for at demo events. A picture of the car with the lights on is shown in figure 9

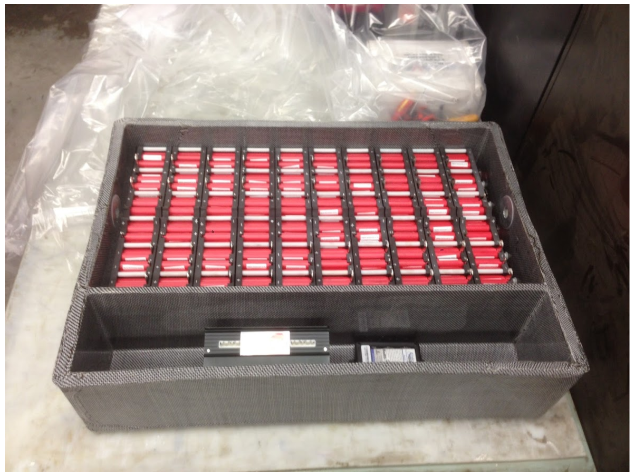

Figure 10: The 18650 battery cells in the battery casing

Figure 9: A picture of the solar car with all of its lights on from Beakerhead 2019

4 Battery Systems

The battery provides the electrical power for the car. The battery consists of a 10000 mAh nickle metal hydride auxiliary battery, and 1440 18650s lithium ion battery cells. Each lithium cell costs around \$4 leading to a total cost of around \$5760. The total capacity of the batter is 18 kWh which is around the total daily energy usage of a typical Albertan household per day. The battery can output 126 V at up to 230 A. All 1440 lithium cells are shown in figure 10. On top of the batteries in the battery box there is also safety equipment to ensure the safe operation of the battery. The major components in the battery protection system are the Orion battery management system (BMS), the Aux Battery management system PCB (AUX BMS), the DC to DC converter PCB and the aux battery itself. The internal electrics of the battery can be seen in figure 11. The Orion Battery management systems main job is to monitor the temperature, voltage, and current output of the battery. Should any of the expected values ever become unsafe it will send a message to the AUX BMS board. The Orion BMS costs around \$3 000.

The AUX BMS has three major jobs. The first of its jobs is monitoring the AUX battery output. The second and more important is monitoring the output of the main BMS. In the event that the BMS detects a

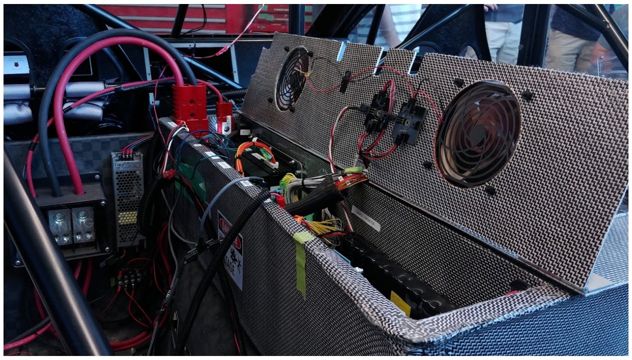

Figure 11: The insides of the battery

battery system fault the AUX BMS will open the 3 contactors connecting the battery to the rest of the car. This isolates the battery from the rest of the car, preventing damage or electric discharge through the body of the car. The final job of the AUX BMS is to check if the main battery is safe to start when turn the car on. During this time it is powered from the aux battery. The aux bms was designed by the team in altium as shown in figure 12

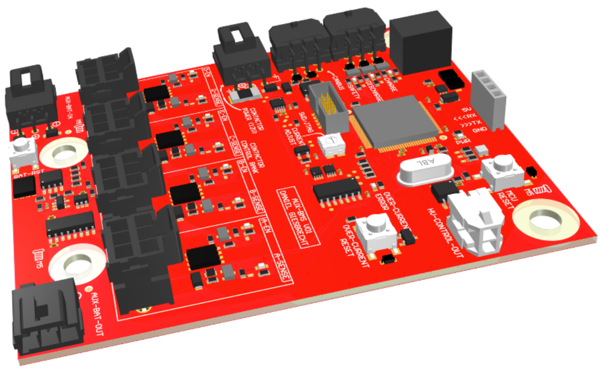

Figure 12: The aux BMS being displayed in Altium Designer

After the design in altium our final PCB is shown in figure 13

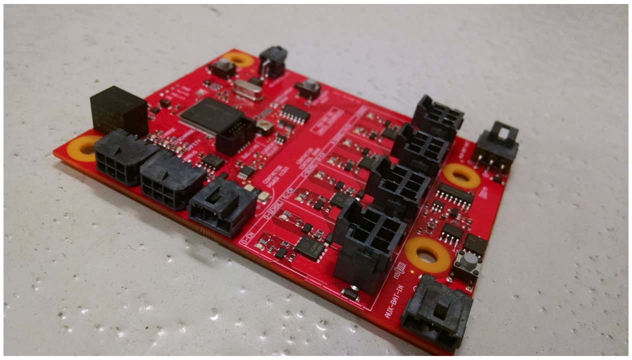

Figure 13: Aux BMS hardware

The DC to DC boards primary job is to convert the 120 V DC from the battery pack to 12 V DC for the PCBs and CAN bus in the car to be powered from. It also converts the approximate 12 V output of the

Aux Battery into exactly 12 V to power the aux BMS in the startup of the car and during an emergency shutdown. The DC-DC board was designed by the solar car team in Altium Designer. The board is shown in figure 14

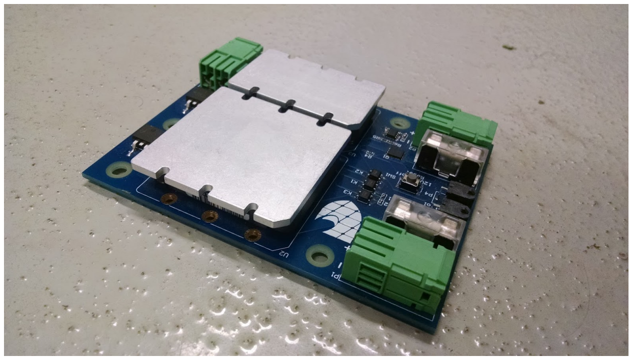

Figure 14: The DC to DC board

As all the electronics in the battery box can get hot, there is 8 cooling fans to help cool the battery. 6 of the fans pull air out of the main compartment where all 1440 lithium ion cells are; As per the solar car race regulations, we can not push air into the area with the lithium cells with fans for fear of a fire. Instead air is pushed in to the battery compartment through side vents on the car as we drive in race. 2 additional fans are used cool the safety electronics with one pushing air in and one pulling air out. The fans can be seen in figure 15

Figure 15: The 8 battery cooling fans

5 Solar Arrays

The solar panels are what convert our car from an electric car, to a solar car. The car has approximately 5 m^2 of solar panels covering its upper surfaces. All the solar panels on our car are encapsulated to increase the efficiency of the panels; Encapsulation is the process by which our panels are coated with tiny prisms to refract the light more perpendicularly into the panels. The solar arrays on the car cost around \$100 000. Figure **??** shows the schematic of how our arrays are wired into the car.

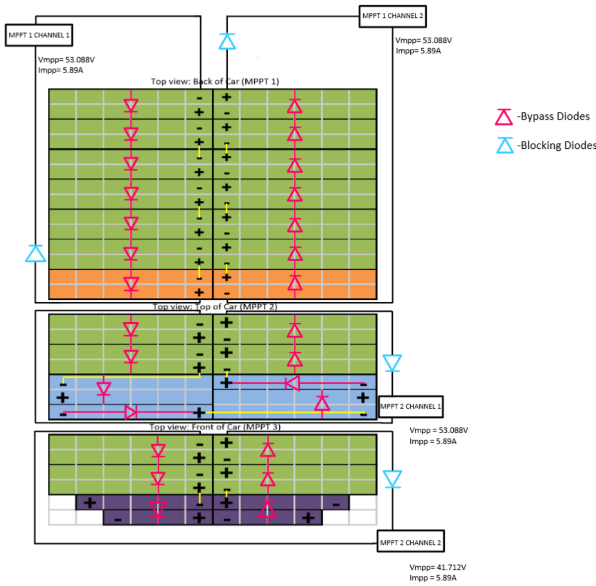

Figure 16: The schematic of the solar arrays in the car

The array on the car is shown in figure **??**

Figure 17: The Arrays on the back of Schulich Elysia