Cooling User Manual

ECE 492 - Spring 2020

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Abstract

This document is intended to detail the aspects of the cooling system that is used to cool the Motor Controller and Motor in the 2020 EV Sparky.

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Executive Summary

Introduction

The cooling system provides cooling for the motor controller and motor. There are three major parts: a 24 V to 12 V DC-to-DC converter, a 3-pin pump, and a radiator which includes two 3-pin fans. The top level diagram and the connections are shown in Figure 1 below. Black lines represent electrical wires and blue lines represent water tubes. The temperature and flow sensors are connected inside the system but are not shown on this diagram. This can be found in the TSI schematic. Whenever the motor controller is on, the cooling system will also be turned on and the pump and fans should run at full speed. The system complies with rule T.8.1 by only using water to cool the system.

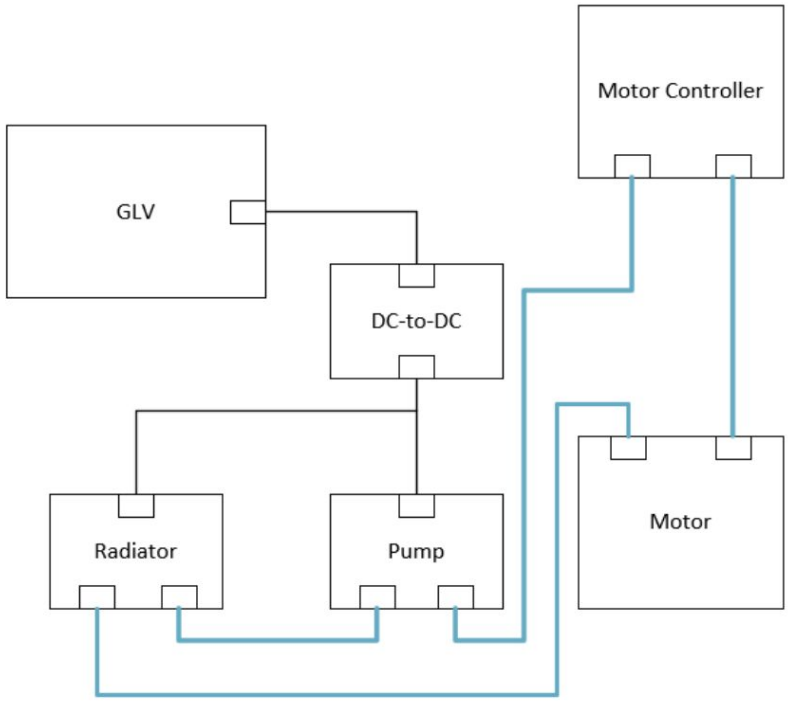

Figure 1 - Block Diagram

How to Install

First connect the motor controller and the motor using tubing in the dyno room and on the car that tube should never need to be changed, ideally it could move from dyno to car if long enough. The tube from the motor to the radiator and the tube from the MC to the pump each should have a quick disconnect to mount to the enclosure. This allows them to be connected to each other when the enclosure is removed for maintenance. There are two slots in the back of the cooling enclosure on top that can easily be mounted somewhere in the dyno room using 80-20 or on the back of the car directly behind the seat on the bar

below the roll hoop. There are also two more slots on the bottom of the back panel, these can be used for stability, but are not essential for mounting, in the dyno.

Emptying and Filling

Filling the system is relatively easy with the quick disconnects provided. You can consider filling it in two halves, the mc with the motor, and the cooling enclosure. You can fill the enclosure by sitting it on its fans and filling from the quick disconnects. They are air tight so you will need somewhere for the air in the enclosure to go. This is similar to the other half, using the same connections you used to fill the enclosure. Just fill until there is no air left in the tubes, and then connect to the enclosure via the quick disconnects. If there is air left it will go to the bottom of the system so repeat the enclosure process again.

Emptying the system is a little more difficult than filling, but also is done in two halves. Ensure the enclosure is at a high point and empty from the quick disconnects just like filling. The bottom half will likely need to be moved upwards to fully empty but dismounting the motor and pouring out the contents will work.

The connector panel on the side as shown below allows the enclosure to be removed without dealing with cables.

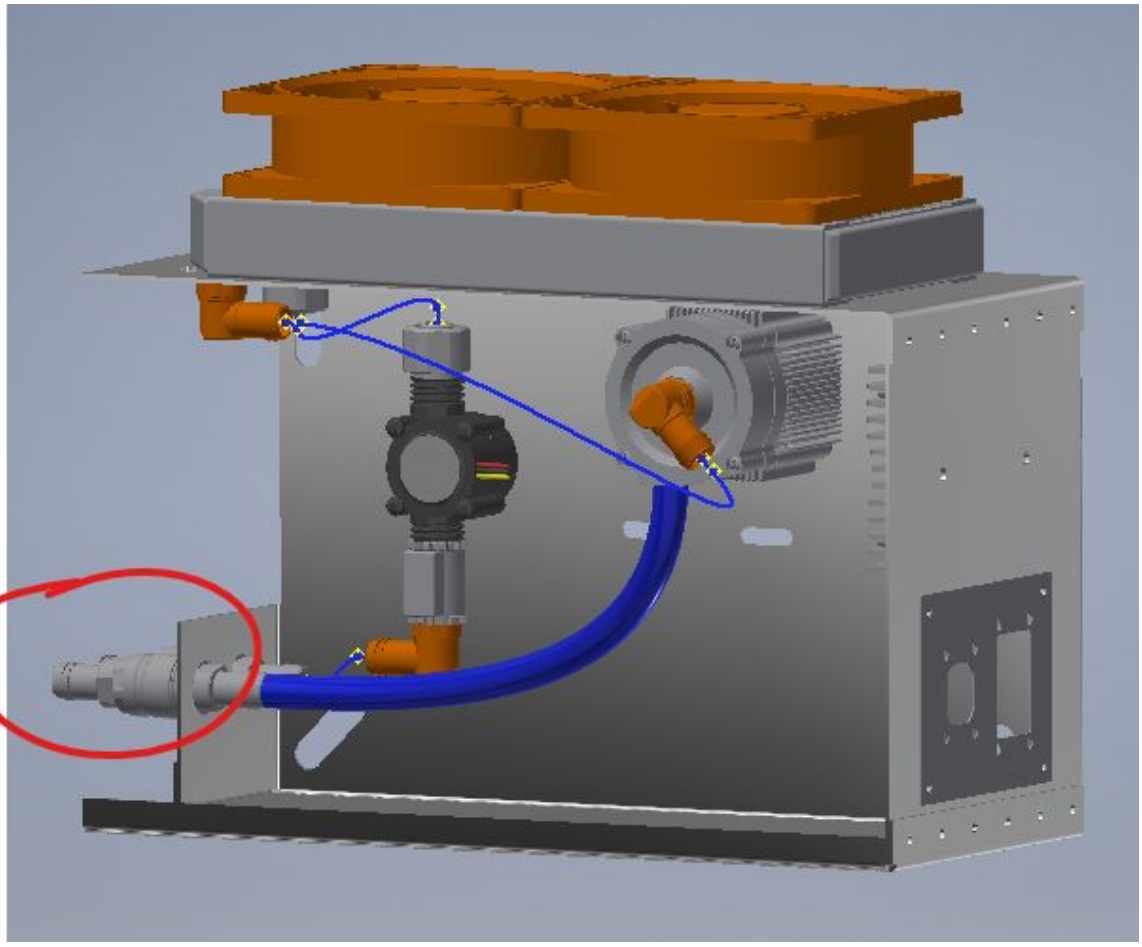

Figure 2 - Intended Future Cooling Enclosure with quick disconnects circled

Algorithms

Heat Loss in a Pipe

$$Q = \frac{2\pi * kL(T_1 - T_2)}{ln(r_2/r_1)}$$

K = heat transfer coefficient of PVC tubing
T1 = Water Temperature
T2 = Ambient Temperature
L = Length Unit
R1 = Inner Pipe Radius (Where water flows)
R2 = Outer Pipe Radius (Insulation)

Energy Lost Due to Heat During Endurance

$$H = \frac{4E_s(1 - eff)}{\frac{3600L}{Speed_{avg}}}$$

Es = Energy per segment (Joules)
Eff = efficiency of system (%)
L = Length of Event (km)
Speedavg = Average speed during event (km/hr)

Notes

The cooling enclosure that exists currently in the dyno room, assuming it hasn't leaked, was a temporary prototype made to be tested, not a permanent design

Analysis of the cooling system was not completed due to the cutting short of the on-campus portion of the semester.