Cooling Maintenance Manual

ECE 492 - Spring 2020

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Abstract

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

Table of Contents

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.

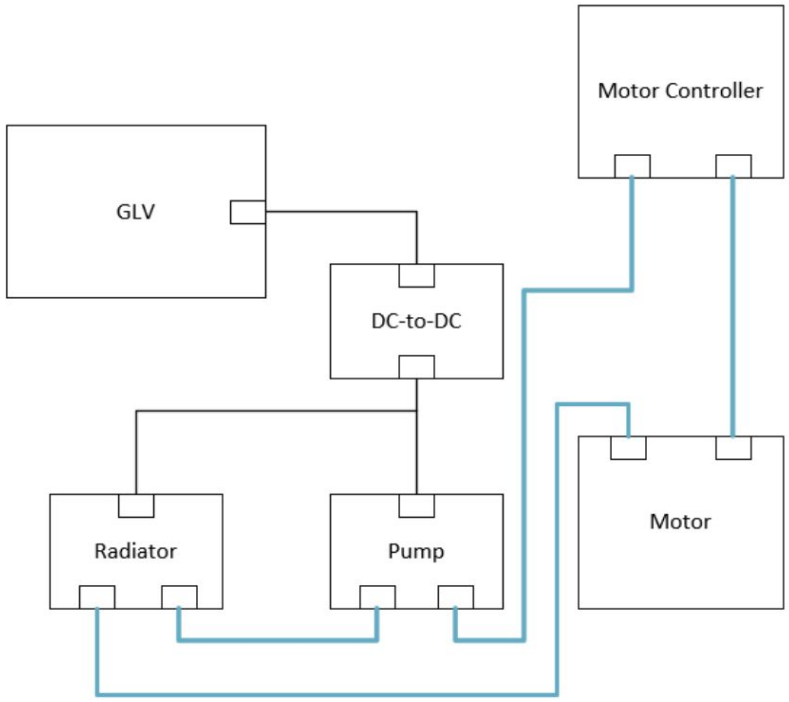

Figure 1 - Block Diagram

Tubing

The tubes are connected as shown in Figure 3 below. The arrows show the direction of the water and each of the lines is a section of ID ½" tubing. The water flows through the system and is cooled in a reservoir in the radiator before being pumped through the rest of the system. The water also passes through the sensors.

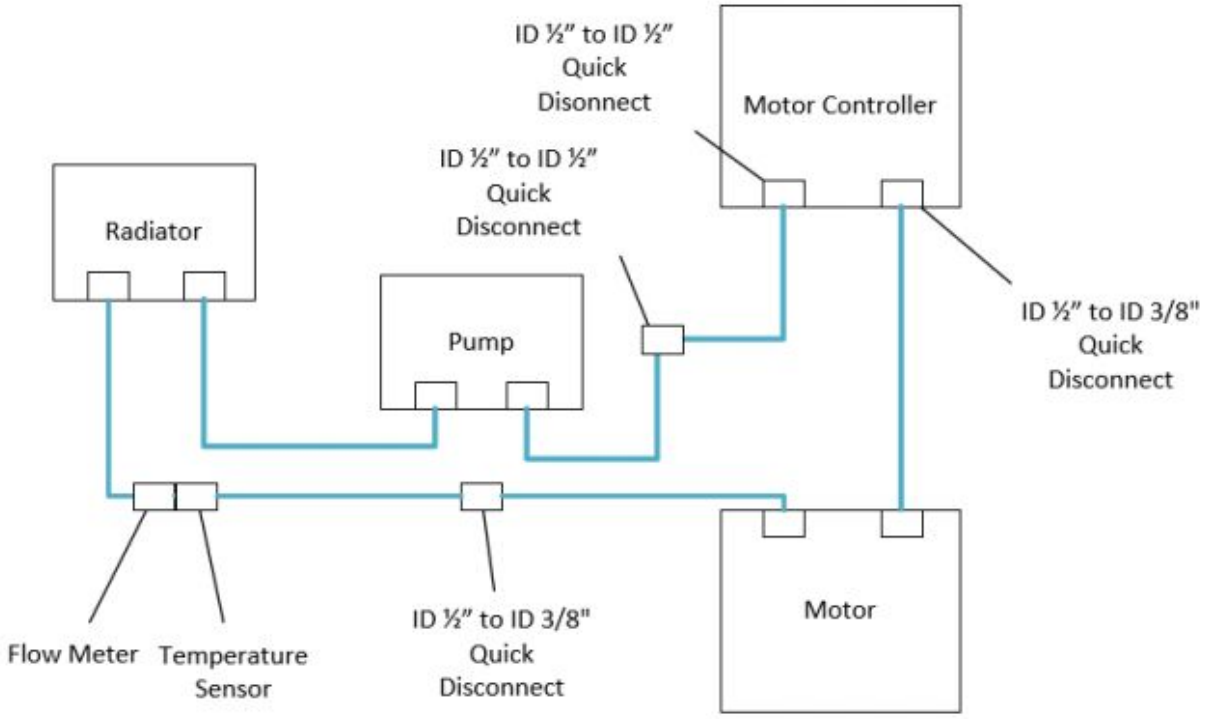

Figure 2 - Tubing Diagram

Principles of Operation

The cooling system is designed to be operational on its own. When provided with water, and the almost complete removal of air, the small radiator and fans provide a significant and powerful, yet small cooling system on the car. Endurance will be when most heat is dissipated over a long course of time, therefore doing the calculations provided in the user manual one can find how much heat the radiator needs to dissipate in order for the car to not overheat over a course of time. It is allowed for the cooling system to dissipate less heat than the car is outputting, but the cooling system must ensure that over the course of endurance, ~55 minutes, that the car doesn't overheat. Listed below are the main components used in the cooling system.

Components

Note: This cooling system is designed for the 2020 EV and the cooling system that exists as of April, 2020 should be temporary and not used on the car.

DC-to-DC Converter

The pump and fans run off of 12 VDC. The TSI is providing 24 VDC through the AIRs. Thus, the cooling system includes a DC-to-DC step down converter. The red and black (two leftmost wires) represent

positive and negative 24 VDC, respectively. The white and black (two rightmost wires) represent positive and negative 12 VDC, respectively, as shown in Figure 2.

Figure 2 - 24V DC-to-DC Converter

Pump

The Koolance PMP-500 is shown in Figure 3. The voltage range is from 6 to 12 VDC. In the current system, the pump receives 12 V. The red and black wires represent positive and negative 12 VDC and the yellow wire represents the control voltage. The default control voltage is 12 VDC so that the pump is running full speed whenever it is on. In the current cooling loop, it can achieve a flow rate of 6.7 L/min.

Figure 3 - Koolance PMP-500

Fans

The fans in the system now are 2600 RPM Koolance fans recommended to pair with the Koolance radiator. They run at 12V powered by the DC-DC and draw 0.75A each.

Figure 4 - Koolance fans mounted to radiator

Temperature Sensor

The system uses a Koolance TPL010K temperature sensor. The TPL010K is a thermistor whose resistance changes based on the surrounding temperature. This temperature is then sent to a circuit on the TSI board to read the resistances. The resistance measurements are sent to the VSCADA and converted back into a temperature reading. Refer to the datasheet for more information about temperature and resistance correlation.

Figure 5 - Koolance TPL010K

Flow Sensor

The YF-S201 is used as a flow sensor and is shown in Figure 4. The operating voltages range from 5 to 24 VDC. In the current cooling system, 5 VDC is used from the TSI board to power the sensor. The red and black wires carry positive 5VDC and GND respectively. The yellow wire represents the signal which is a pulse with a 40% to 60% duty cycle. The circuit on the TSI board measures its frequency and sends this information to VSCADA. The VSCADA then converts the frequency to flow rate.

Figure 6 - YF-S201 Flow Sensor

Calibration

Calibration for the system was never done for the 2020 car, but calibrating the sensor data can be found in the TSI documentation on the Lafayette Motorsports website here.

Testing

Testing was also never completed for the 2020 EV. One example of a written test is provided from this document in Figure 7. The most applicable way to test the cooling system would be to simulate the endurance test and autocross test. If the motor and motor controller can run at a simulated ~55 mph for an hour, the cooling system is operating sufficiently.

6.2 Cooling System Test

- Summary: Spin the motor torque up to 70 Nm for 30 seconds and verify the motor and motor controller remain below 60°C, in a different run spin the motor for up to ~3000RPM for 30 seconds and verify the motor and motor controller remain below 60°C
- Pass Criteria:
  A. After torque test motor is less than 60°C
  B. After torque test motor controller is less than 60°C
  C. After RPM test motor is less than 60°C
  D. After RPM test motor controller is less than 60°C
  E. No Cooling Leaks are observed
- Results:
  A. PASS / FAIL
  B. PASS / FAIL
  C. PASS / FAIL
  D. PASS / FAIL
  E. PASS / FAIL

Test Observed By:_____ **Date:**_____

Figure 7 - Cooling Test

Maintenance

Possibly the most important section, but fortunately one of the easiest for cooling. The designed system is manufactured to be easy to maintain and as long as there are no leaks nothing needs to be changed however if some parts need adjusting this is how you can maintain those.

Motor Controller

There should be two quick disconnects on the outside of the motor controller box similar to as shown in figure 1. These need to be opposite gendered so the cooling tubes do not need to hang off the motor controller for it to be removed.

Motor

The motor will be similar to the MC, but there are no quick disconnects so close to the motor. Removing the motor ideally would be easy, but with the current designed drivetrain enclosure it will not be. You will likely need to remove the entire drivetrain assembly, as well as the cooling tubes. Any motor maintenance will require disassembling the drivetrain to be completed.

Any cooling enclosure parts

Just remove the entire enclosure as listed in the user manual here.

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.