

Cost-Effective and Easily Configurable High Voltage Motor Controllers for Automotive Use

Jonah Frosch, Marek Jablonski, Bryce Rega, Gavin Patel, and Long Yu

Abstract

The rise in electric vehicles has grown the market for automotive parts not commonly used prior. High voltage motor controllers use high voltage from an electric vehicle's battery pack and can be digitally controlled to feed the electric motors the correct power. There are many configurations and special features that come with equipment like these. A single high voltage motor controller can be thousands of dollars and difficult to use.

University solar car teams have been a decades-long testing bed for electric vehicles and the technology that has eventually made it to mainstream production vehicles. Iowa State has been a long-time participant in this and therefore making Iowa State's solar vehicles and their motors excellent testing beds for improved high voltage motor controllers. Custom, easily configurable motor controllers will be developed that can be used by the same motors Iowa State's solar car team as well as other vehicles (such as electric bikes) while being more affordable than current comparable motor controllers.

Expected Deliverables

The result of this project will be a fully functioning custom high voltage motor controller that can interface with the solar car team's motors and run them nominally. This includes being able to start and stop the motor, run the motors up to their maximum rated power, change motor directions, and smoothly adjust the power to the motor by the standard automotive messages that the solar car uses.

A successful project would result in the total cost of the motor controller being cheaper than that of the production motor controllers the solar car team purchases, and an interface that users can easily configure all special parameters and messages with.

Expected Timeline

Description	Date
Development Board Selected and Ordered	September 2024
Software Development Environment Setup	September 2024
Example Test Code Running & Motor Reacting	October 2024
Hardware Schematic Rev 1 Complete	November 2024
Hardware Layout Rev 1 Complete	November 2024
Hardware Revision 1 Ordered	December 2024
Hardware Rev 1 Tested	January 2025
Hardware Schematic Rev 2 Complete	February 2025
Hardware Layout Rev 2 Complete	February 2025
Hardware Revision 2 Ordered	March 2025
Hardware Rev 2 Tested	April 2025
Custom 6 Step Control Working	December 2024
Custom Multistep Control Working	January 2025
Custom Continuous (FOC/Sinusoidal) Control Working	April 2025

Stretch Goals

Our first stretch goal is to have a GUI for interfacing with and configuring the motor controller.

Another stretch goal that we intend to accomplish during our mission is to have a more advanced cooling setup utilized through an active thermal monitoring device feeding into controls to a variably controlled atmospheric displacement device (fan).

An additional stretch goal is to have a more advanced housing component for our motor controller than a bare PCB and components, or additive manufactured Polyacetic Acid (PLA) box. Specific goals could be towards a sheet aluminum box, or an additive manufactured nylon polyethylene terephthalate glycol (Nylon PETG) container custom designed to our specifications.

A follow up stretch goal is to fully test this controller across multiple vehicles (A operational solar car and an ebike) to test various loads speeds and voltages across varying motor models.

A stretch goal on the control theory side is to implement regenerative braking to slow down the motor by converting the mechanical energy to electrical energy.

Specialized Resources

The development of a high-voltage motor controller requires specific test equipment. This includes a high voltage power supply, high power load, and a relevant motor. These items are able to be borrowed from the PRISUM Solar Car Club for the purpose of this project.

Financial Resources

Generic costs will be split across all team members. Some team members have expressed interest and plan on purchasing specific pieces that are relevant to their other work. Jonah can fund both motor controller revisions and any test motors. Marek can fund the development board. Bryce will fund the programmer/debugger and accessories.