ELECOMP CAPSTONE SUMMIT
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO

Three Phase Motor Controller

Bay Computer Associates

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Project Motivation

Originally, this project started as a motor controller for an electric wheelchair. This controller was later augmented for the operation of an electric bicycle, and is currently being redesigned for medical technologies that would require our motor controller. Many new design decisions have been made with the transition into the newest implementation, most notably, the control system in place for the position control algorithm; which left us with a lot of room for improvement. Second is the implementation of a parallel transistor setup that has allowed us to achieve higher current output while keeping the parasitic capacitance of the transistor configuration low. The goal of this project is to continue overcoming the obstacles that have yet to be solved and to further our designs. For our end result, we would like to have a motor controller that drives a larger range of currents, a completely new board layout that uses space efficiently, and a more robust implementation of the position control.

Key Accomplishments

Algorithm Development in Matlab: Development of the position control algorithm, this was done in Matlab as a proof of concept. We can give the motor a distance to travel in either forward or reverse and it will travel that distance within the desired accuracy.

C Program development: Research and development of firmware functions to implement our position control algorithm in C; figuring out where we will be grabbing data from and the structure of other files that interact with the task scheduler to make sure we deal with race conditions properly and for code cleanliness and consistency.

Implementation of algorithm in C Sim: Implementation of the position control algorithm in C using floating point notation and a proof of concept and starting point for the fixed point representation. We can give the motor a distance to travel in either forward or backward directions and it will travel that distance.

MOSFET Driver: The current design of the motor controller uses the H-Bridge design to output about 20 Amperes to the motor. To increase current output, we designed an H-Bridge with parallel MOSFETs. This parallel MOSFET configuration will be able to output up to 200 Amperes to the motor.

Power Supplies: Redesigned 11V, 5V, and 3.3V power supplies. The 11V and 3.3V are switching regulators that can handle an unregulated input voltage of 12-60V. The 5V supply is no longer a switching regulator, now it is a simple linear regulator that drops the 11V to 5V.

Schematics: Combed through the schematics and removed features that are no longer necessary. One of the goals of this project was to make the motor controller more generic. This meant removing some miscellaneous circuitry such as the buzzer and the 5.5V drop down regulator for the CAN interface.

Current Sensing: Finalized the new current sensing amplifier design. This design features two op-amps and two sensing resistors for each phase and for the total bus current. This will give us a higher resolution in being able to monitor currents that are less than 20 Amperes. A new op-amp was chosen for this design, as the previous op-amp was not fast enough.

Layout: Finalized all new schematics and began work on the new board layout. They layout of the board is not fully complete, but we were able to layout all of our new circuits we designed. This includes the power supplies, current sensing circuits and MOSFET stage. Many circuits can be copied over from the previous design, such as the gate drivers and the 1.9V power supply.

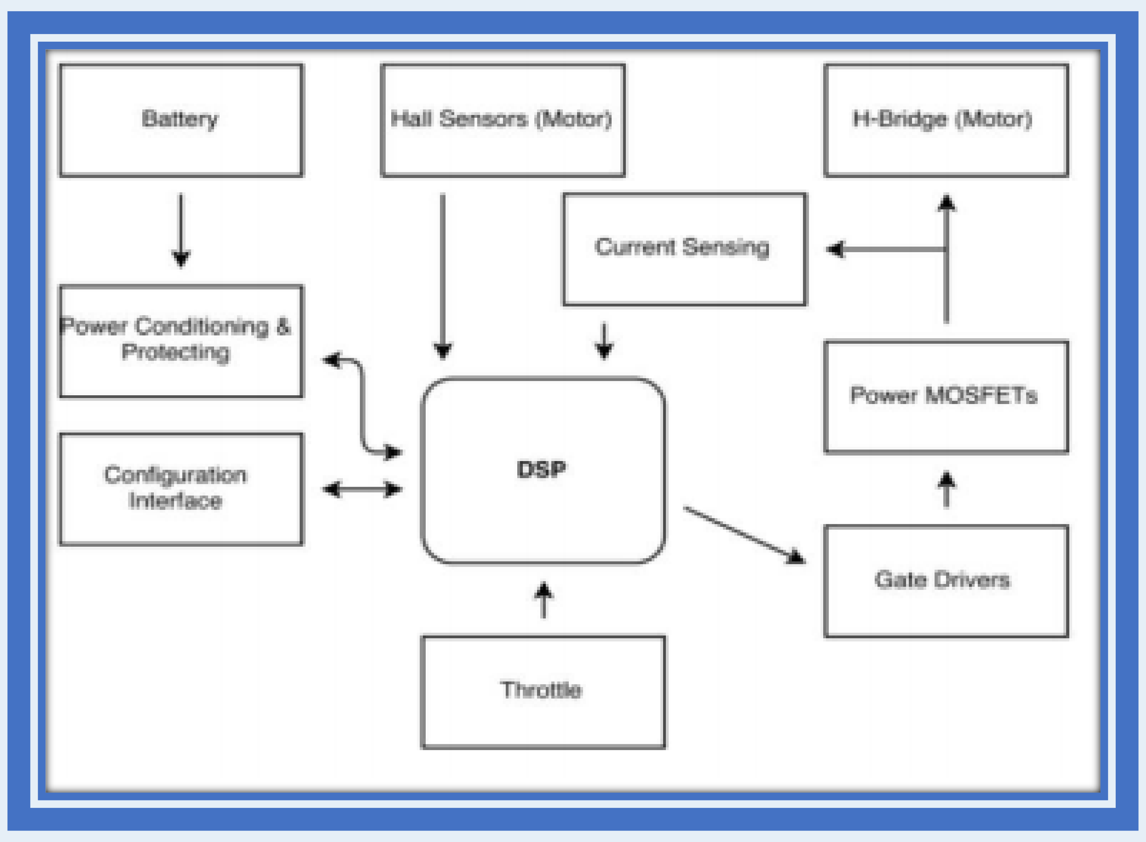

Fig 1. Block Diagram of the components in our Three Phase motor controller, describing which components communicate between each other

Block Diagram Breakdown:
- The throttle takes user input and sends a signal to the DSP chip. Controlling the correct amperage to output the to each leg of the motor.
- sensing amplifiers will be in place to protect the user as well as the circuit board.
- The circuit board can be powered over a range of voltages from 12-60 volts, so there are numerous voltage regulators on the board to step down this voltage to useable values for specific components.
- Hall Effect sensors will sense the position of the motor legs.
- A computer interface is used for tuning our motor controller to desired specifications.
- The DSP is the heart of the circuit board, as it controls many major processes on the board and allows us to implement a position control algorithm.

Anticipated Best Outcome

The best outcome of the project would be to have a completed market ready product with all updated and redesigned features that the previous design did not have. These features include a redesigned MOSFET layout that can produce higher output currents, updated power supplies that can handle an increased range of input voltages, reliable current sensing, and the development of a robust position control algorithm. The final outcome of this project will yield a product that is capable of controlling higher powered motors than the ones seen in previous designs, and can control the motor of a large scale medical device.

Project Outcome

The Anticipated Best Outcome was not achieved. We achieved many of our goals, however the board layout and some firmware tasks were not completed.

Figures

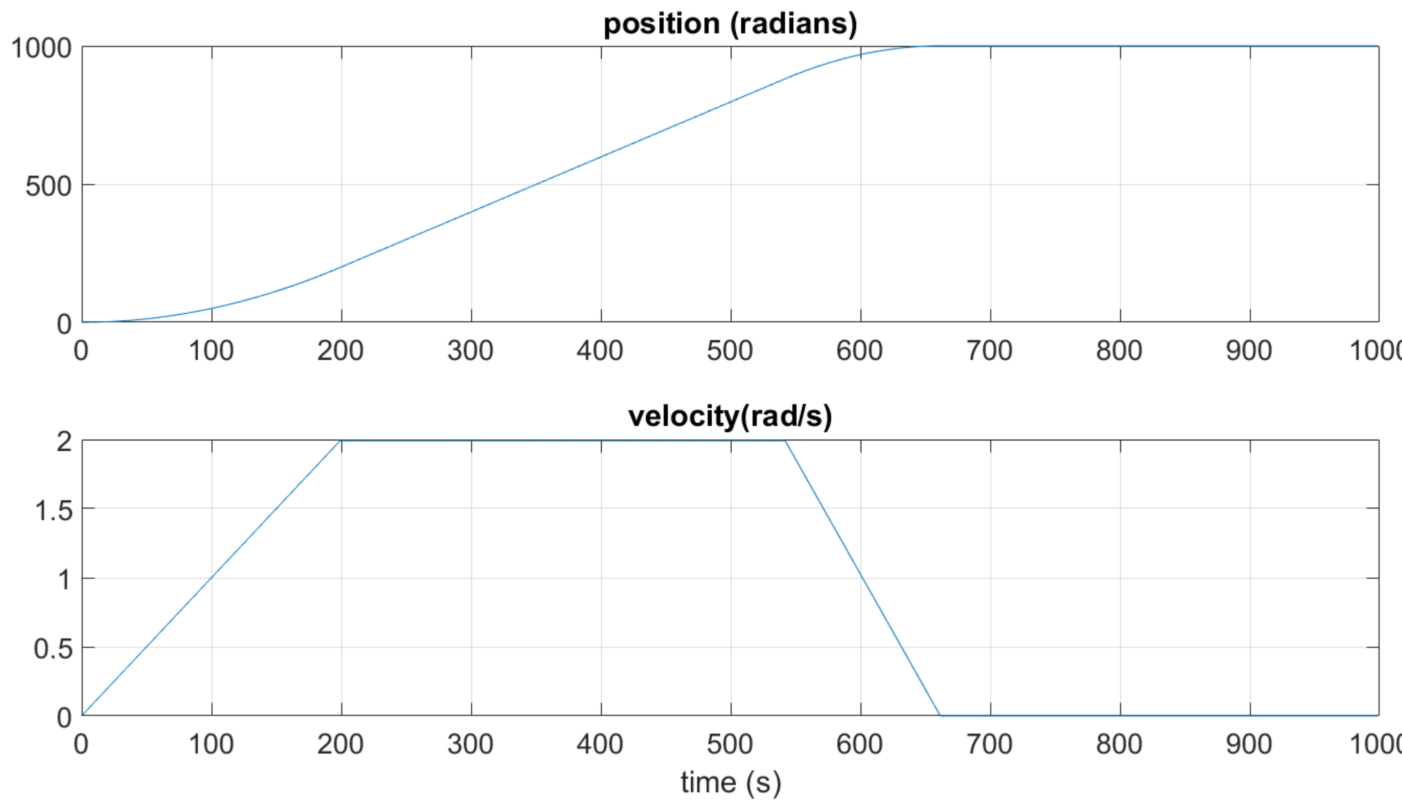

Fig2. Matlab script graph as proof of concept for position control algorithm

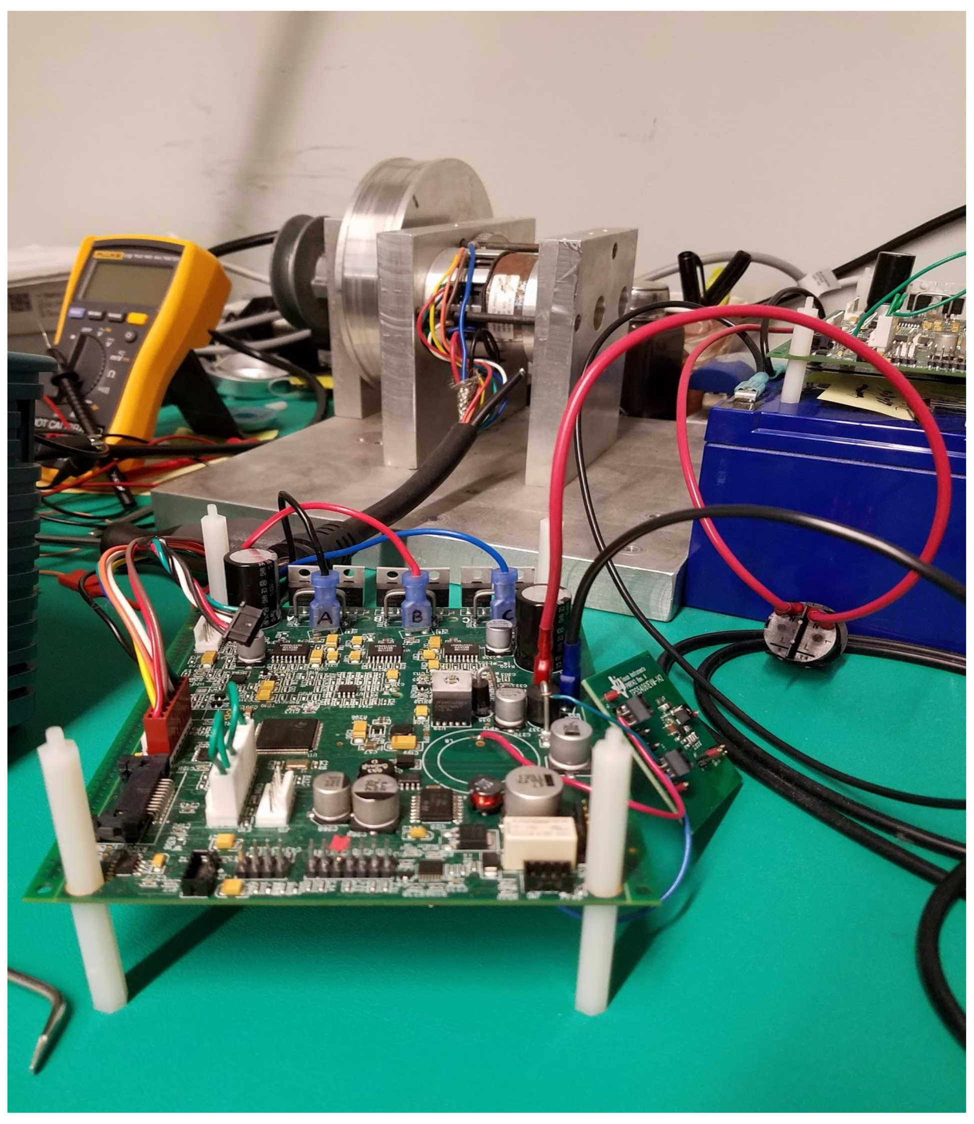

Fig 3. Our testing area, including a motor and our motor controller