Three Phase Motor Controller

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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 will allow 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. In the end we would like to have a motor controller that drives a larger range of currents, redesign the controller's board in order to maximize the use of space, and a more robust implementation of the position control.

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 current design does 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 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.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

Reaching the project's best outcome would mean the product is very close to market readiness. When this product is released into the market it would mean a higher level of precision and safety for current motor controllers found in the medical industry. The product can be applied to an even wider range of technologies that need a reliable motor controller that may or may not even take advantage of our position control algorithm, like a human operated electric vehicle or appliance. With our best outcomes met we would be bringing a robust motor controller to a wide variety of markets.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved; many goals we completed; board layout and some firmware tasks were not completed.

KEY ACCOMPLISHMENTS:

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. Modifications will have to be done to work with degrees rotated as opposed to distance traveled in the Matlab script since we won't know the exact conversion factors on a range of different applications and their gear ratios. The calculations are all done the same way, some constants may have to be redefined for this conversion

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. Modifications will have to be done to work with degrees rotated as opposed to distance traveled in the Matlab script since we won't know the exact conversion factors on a range of different applications and their gear ratios.

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.

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. Added a simpler 5V power supply. The previous design used a switching mode power supply that dropped the unregulated supply down to 5V. We removed this because it was no longer necessary. A simple linear regulator that drops 11V to 5V is what we need.

Updated 3.3V power supply. The improvements made to the controller will require a 12-60V input voltage that the current 3.3V regulator is not equipped to handle. 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.

Added a quad 2-1 multiplexer for the current sensing circuit. The necessary updates to the current sensing requires there to be 8 outputs that must be monitored by the DSP rather than 4. We needed to add this multiplexer so the DSP has the capability to monitor all 8 signals. 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.

Finalized all new schematics and began work on the new board layout.

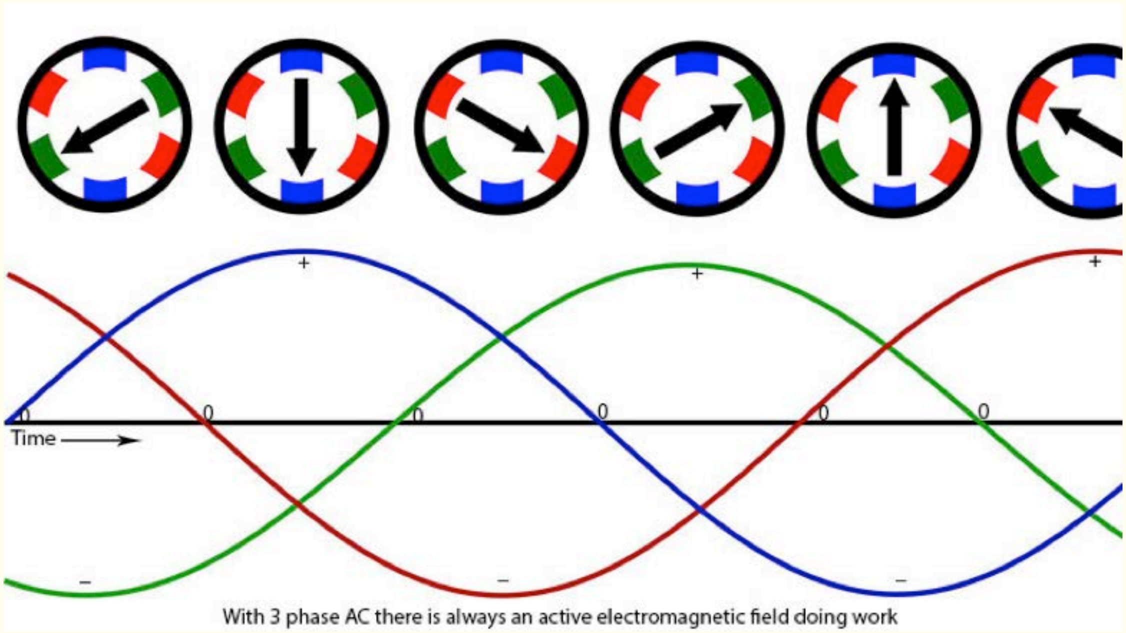

Fig 1: Representation of three phase induction.

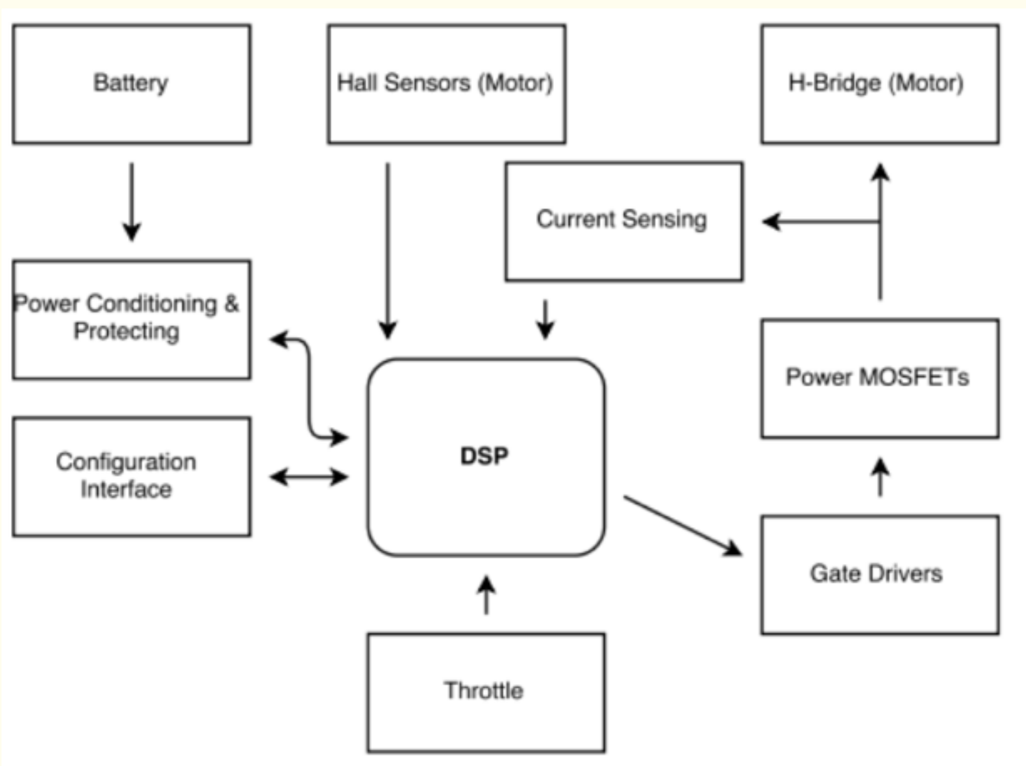

Fig 2: Block Diagram of the components in our Three Phase Motor Controller, describing which components communicate with each other

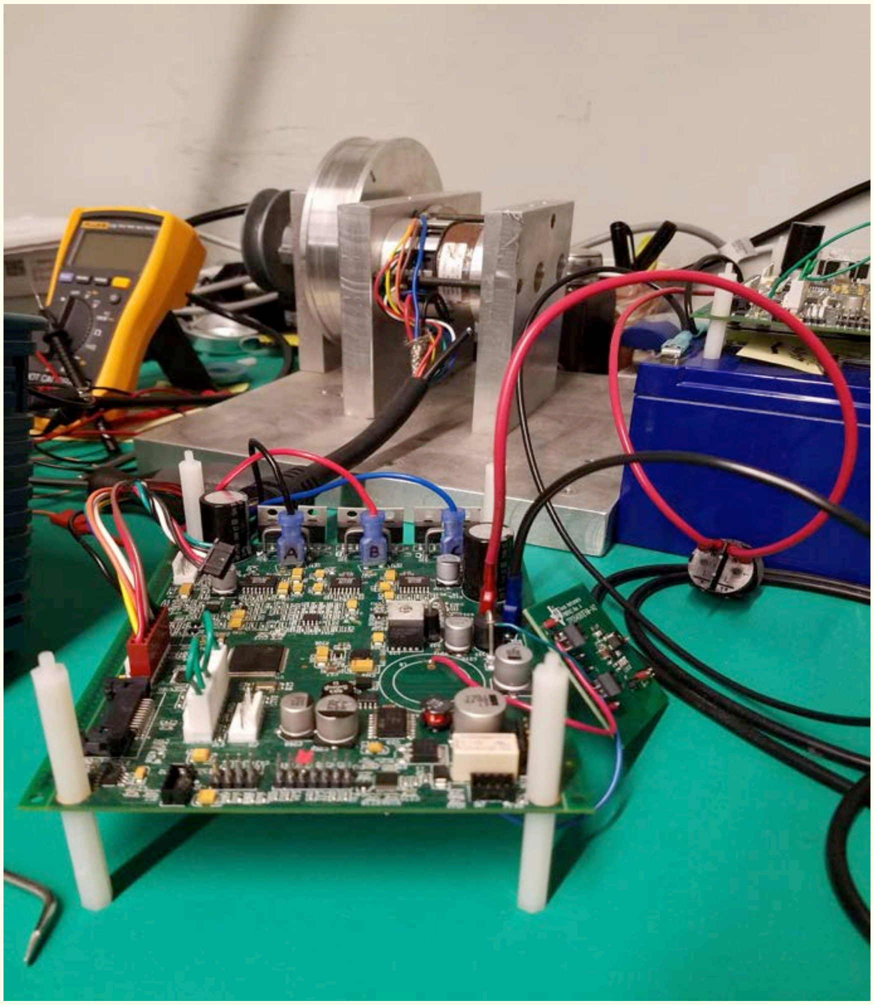

Fig 3: Our testing area, including a motor and our motor controller

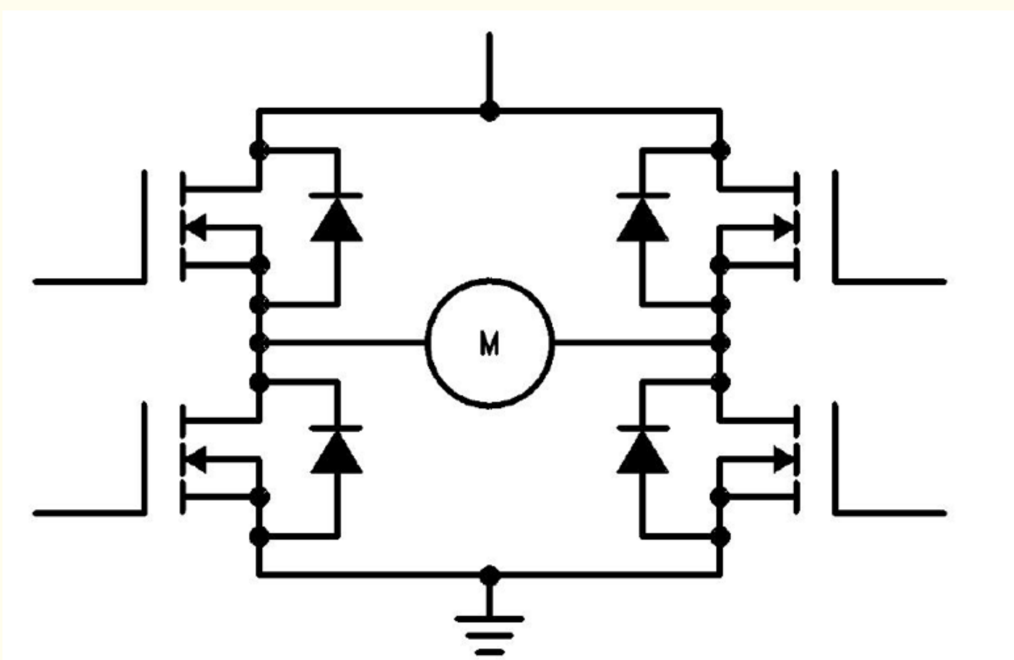

Fig 4: H-bridge MOSFET design that is used to drive the motor