Low-cost platform for electric drives experimentation

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Low price drive

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Abstract

Our client Dr.Yaramasu currently teaches the electric drives and advanced electric drives course at Northern Arizona university. The labs for these course are based on the dSPACE DDS1104 hardware, software and MATLAB/Simulink. The dSPACE hardware and software are very costly to buy and upgrade. Costing roughly $300 for each unit to update the software and $4000 for the hardware.
The purpose of the project is to replace the dSPACE hardware and software with a cheaper alternative, which is the Arduino. To make the electric drives labs more accessible to students and to help other universities that can't afford to buy the dSPACE hardware and software. Therefore, we will use the Arduino hardware and MATLAB/Simulink as the software to create the circuit for each lab and the show the results for the motor functions.

Requirements

- The design must support MATLAB/Simulink workflow based on Arduino
- The design must make the same kinds of measurements and control as dSPACE
- The design must support the same learning outcomes for students as dSPACE
- The design should support similar lab design and setup as dSPACE
- The design must be robust and low-cost
- The design should be small
- Ideally is easy to replicate

Technologies

ARDUINO OPEN-SOURCE COMMUNITY

MATLAB SIMULINK®

Figure 1: Hardware and software we used

Design process

The hardware technologies used in this project are inverter board, DC motor, and Arduino MEGA 2560. The Arduino will be the controller instead of the dSPACE hardware. Two connectors will connect the devices with the Arduino:

- The DB-15 pin connector will be connecting the motor encoder to the Arduino giving the feedback from the motor to show the motor's speed.
- The DB-37 pin connector will be connecting the Arduino to the inverter board so that the Arduino able to send signals to the board such as PWM signals and digital signals.

Moreover, A BNC cable connected from the board to the Arduino to send current feedback from the inverter board. All the feedback from the inverter board and the motor encoder will display on the MATLAB/Simulink scope. Because the diagram circuit of a lab will be designed in the Simulink and run to generate the code for the Arduino via the Simulink.

Connections

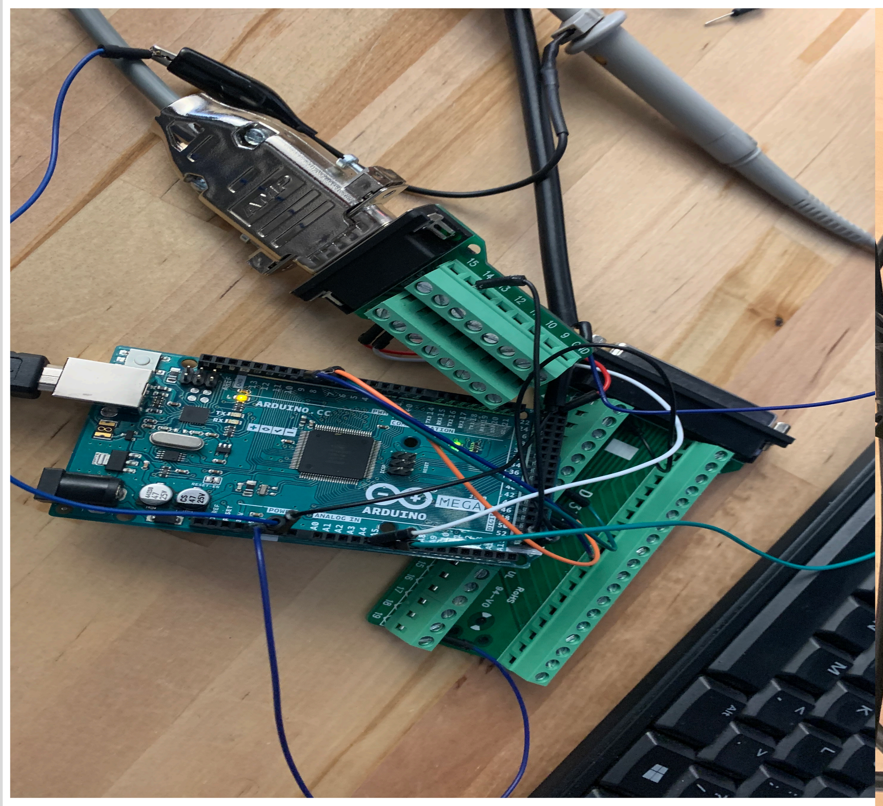

Figure 2: Arduino connections

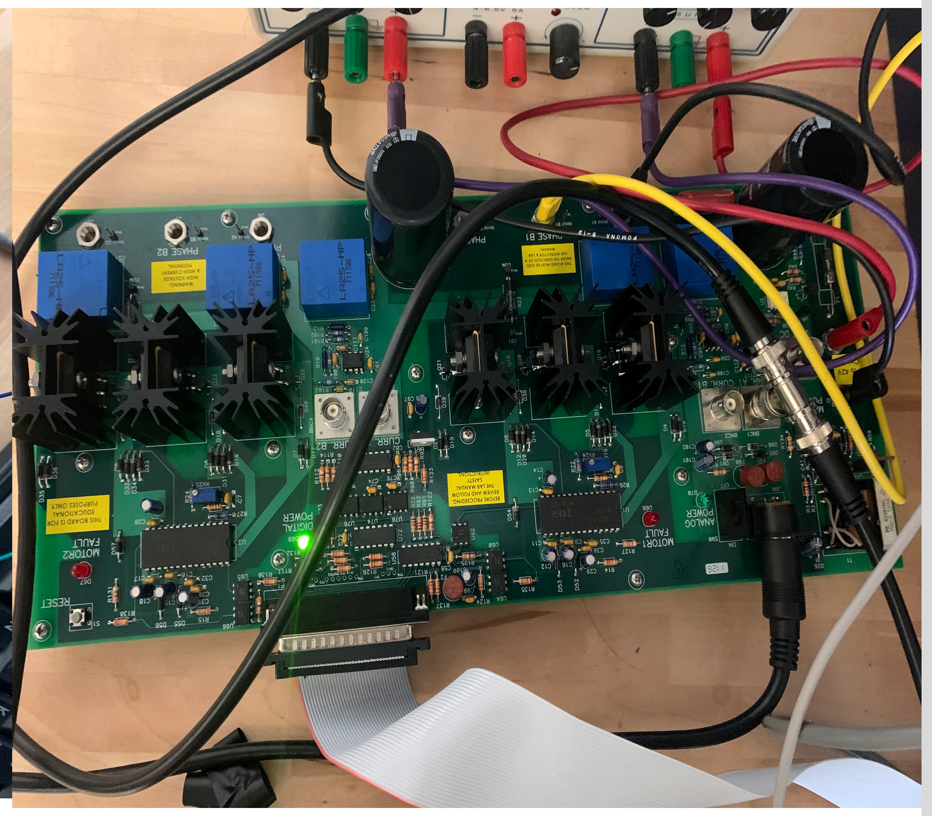

Figure 3: Inverter board

Results

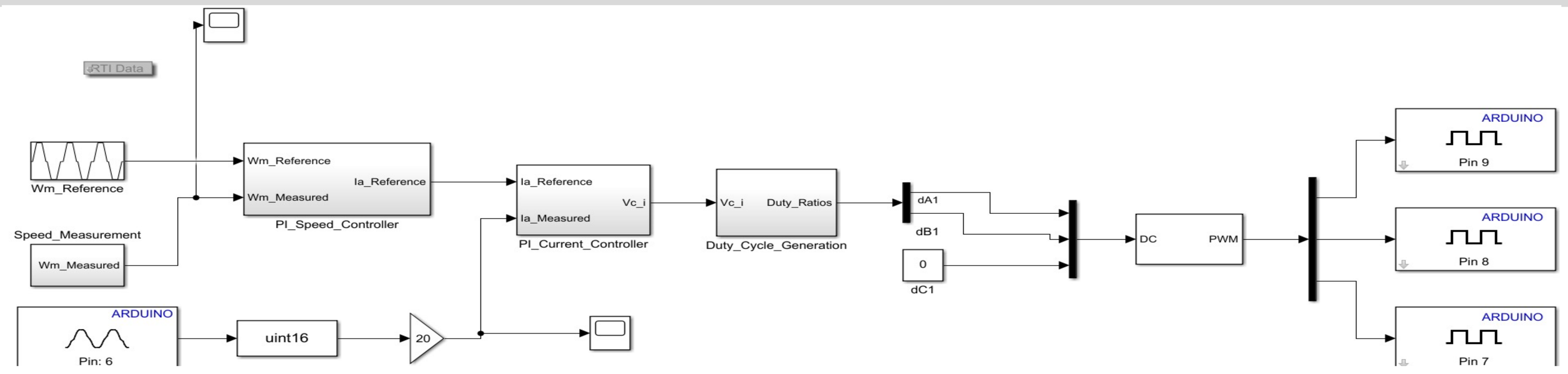

Figure 4: A functioning redesign of the lab 1 dSPACE circuit.

Test	Input (in Voltage)	Expected Result (in Voltage)	Results		
			Pass	Fail	N/A
1	PWM: 0.25, 0.75,0	phasA:0.25, phaseB:0.75, phaseC:0	Pass		
2	PWM: 0.25,0.5,0	phasA:0.25, phaseB:0.5, phaseC:0	Pass		
3	PWM: 0.5, 0.6,0	phasA:0.5, phaseB:0.6, phaseC:0	Pass		
4	PWM: 0.25, 0.8,0	phasA:0.25, phaseB:0.8 ,phaseC:0	Pass		
5	PWM: 0.25,1,0	phasA:0.25, phaseB:Constant 1 ,phaseC:0	Pass		
6	PWM: 1,1,0	phasA:Constant 1, phaseB:Constant 1 ,phaseC:0	Pass		

Figure 5: Table results of the PWM between the Arduino and DC motor

In figure 4 is the redesigned circuit of lab 1 dSPACE circuit into a circuit that the Arduino can read the code that generated by Simulink. we changed the dSPACE block to the Arduino blocks with a specific pins that will be connected to the Arduino.
In figure 5 is the results of one of tests between the Arduino connection and the circuit in Simulink. We tested the PWM with changing the input of each constant and kept an eye on the Oscilloscope to check the changes of the PWM waveforms.

Final Design

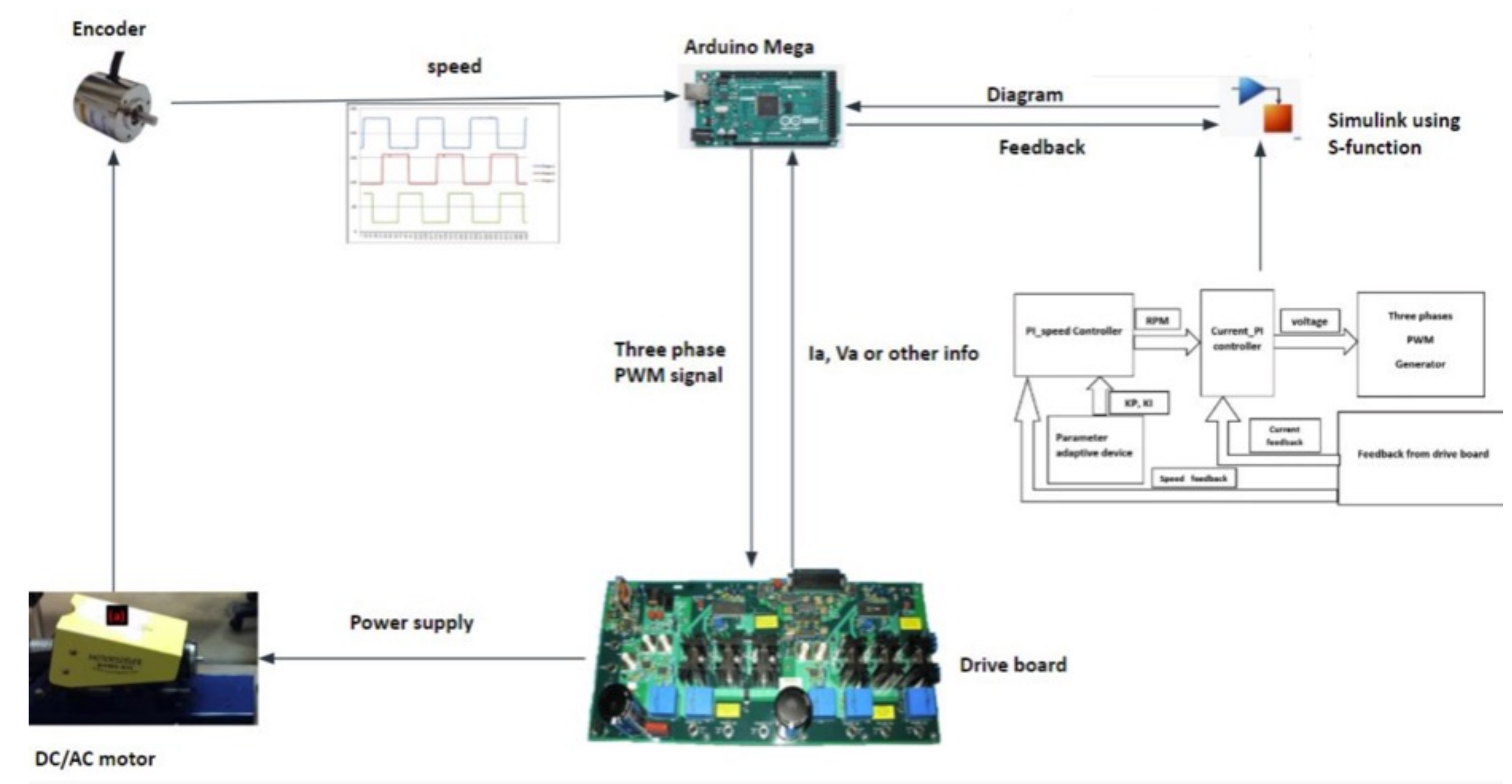

Figure 6: Final design of the project

Conclusion

There was a total of 8 labs that we had to work on and redesign. The Arduino is effective enough to replace the dSPACE in all those labs. It can act as the controller for the DC motor and receive feedback from its encoder to display on the computer screen. Because of the lack of time, we did not have the chance to fix some of the errors we had while testing lab 1 after redesigning the circuit of lab. By the time we figured all the blocks of the Arduino and the connections between the connectors and the Arduino we tried to test lab 1 but we faced some errors needed to be fixed. However, the electric drives labs now is more accessible for students and universities.

Future Plans

Further improvements can be made to this project. One improvement that can be made is redesigning the inverter board. With new technology the board can be smaller. It is possible to reduce the size of the board to a quarter of what it is right now. Also, continuing the testing of all the remaining labs.

References

1. Department of Electrical and Computer Engineering, DSP Based Electric Drives Laboratory User Manual, 2012, University of Minnesota
2. P. Purushothaman, "Electrical drives and control Assignment," Research Gate, 2012

Acknowledgements

We would like to thank our client Dr.Yaramasu for giving us the opportunity to work on his project.
We would like to thank Dr.Severinghaus for giving us guidelines.
We would like to thank our GTA Han Peng for helping us throughout the project process.