TACHOMETER SENIOR PROJECT

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INTRODUCTION

REQUESTED BY

This project was requested by Dr. Glenn Wrate for the use inside of his lab at NMU.

WHY

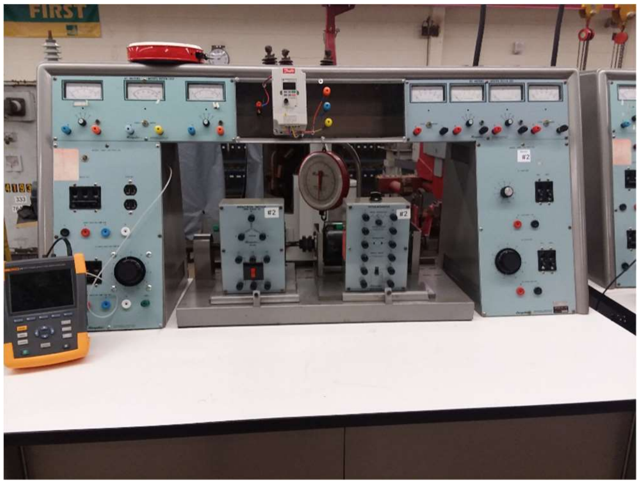

Figure 1: Lab Bench

Inside of Dr. Wrate's lab there are separate benches as seen in Figure 1. At these benches there are two separate motors that are coupled together as shown in Figure 2 and Figure 3.

Since these motors are coupled together, they both spin at the same rate while in use, with one of them acting as a generator. These motors are meant to be set up in different configurations to simulate different industrial motor scenarios.

By doing this, the students can see how different configurations can affect the actual outputs of the motors, and also how the motors react underneath different loading conditions. In the tests they preform, an important parameter to know is the RPM of the motors. In order to take these measurements, the students need to use a device called a tachometer.

Figure 3: Front view of the motors

Figure 2: Rear view of the motors

WHAT IS A TACHOMETER

Figure 4: Tachometer currently used in the lab

A tachometer is by definition a device that measures revolutions per minute (RPM).

One of the tachometers currently available to the students is shown in Figure 4. This particular one is non-contact, meaning an infrared light is emitted from the tachometer which reflects off a piece of reflective tape adhered directly to the shaft of the motor. Each reflection generates a pulse, which is recorded by the tachometer. This is how it measures RPM.

An issue with this particular set up is that accurate readings can sometimes be difficult to obtain. The reflective tape does peel off after sometime, as well as there being limited space causing issues as far as clear line of site.

The main issue though is that since these tachometers are hand held, they have a tendency be misplaced. There are only so many that are available to the students, and they are also needed from time to time to be used in other classes. They are also battery operated, meaning that once the batteries die it takes time to track down replacements, if any are available.

SOLUTION

The solution to these problems was to create a tachometer that could be permanently adhered to a bench with a permanent power supply, that way it could always be available to the students. Not only would this new device be able to give a more accurate reading of RPM, but it would also be able to tell the students the direction the motor is spinning all via an LCD display.

DESIGN

ENCODER

The first design choice was what sort of interfacing device would be used to measure raw data that could be used to calculate an accurate RPM reading as well as the direction that the motor was spinning. It was decided that the best choice would be an optical rotary encoder, as show in Figure 5.

The shaft of the encoder would be coupled to the shaft of one of the motors, so that as the motors would spin, the shaft of the encoder would spin at the same rate. This would generate a digital square wave output which could be used to calculate the desired outputs.

Figure 5 Encoder Model: HN3806-AB -400N

The main issue with using this particular encoder was that its shaft size was smaller by a substantial amount to that of the motors. A coupling device needed to be designed that could be used to connect the two different sized shafts, since nothing currently on the open market would be able to accomplish this task in an efficient matter.

3D DESIGN

Fortunately there already is a pre-existing “J” style coupling on the shaft of the motor, as shown in Figure 6. It was decided that it was best to use this existing coupling and do a 3D design of an insert that could directly be used with this coupler. On the back of the insert would be a smaller hole which the shaft of the encoder could compression fit into.

This design not only would allow for the shaft of the encoder to rotate at the exact rate of the shaft of the motor, but also allow for ease of use as this would all be done via compression fit. That way if the insert/encoder ever had to be removed, it could be done quickly and easily.

Figure 6 Example of J style coupling

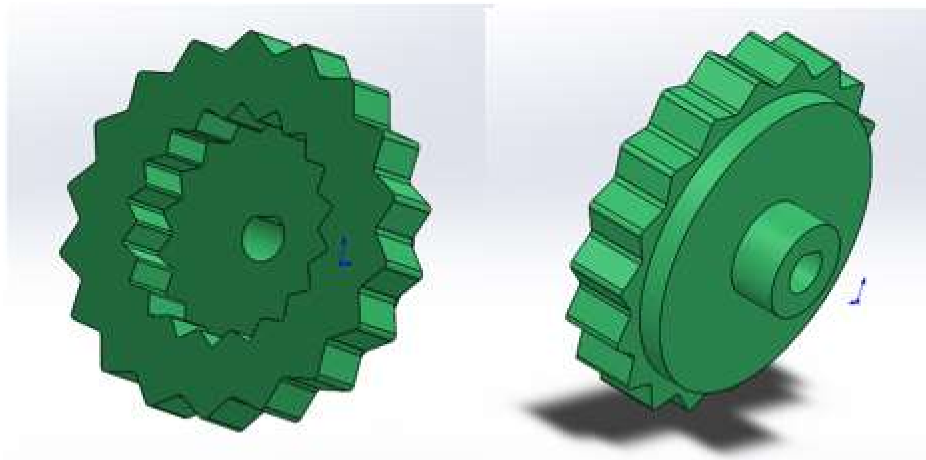

Figure 7 3D design of coupling insert

With the coupling portion of the 3D design finished, the next step was to make a support structure that could hold the encoder in place so it was not free hanging. Although the main point of this design was to allow the shaft of the encoder to spin freely, it was important to also make sure that the rest of the encoder did not move or become dislodged from the coupling system. The design which finally was decided upon is shown in Figure 8 with the encoder and coupling insert attached.

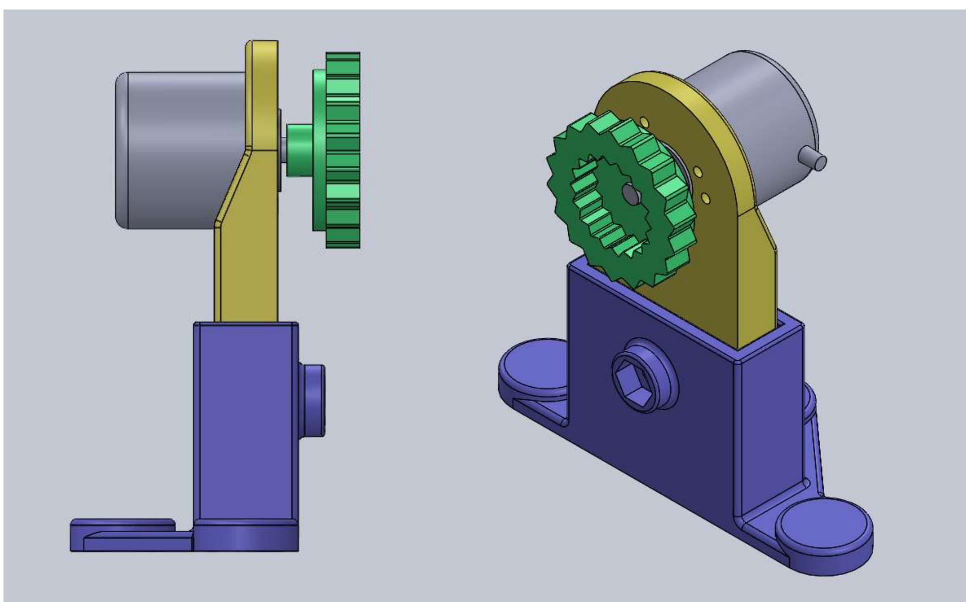

Figure 8 3D design of encoder support assembly

The base is comprised of two pieces. The yellow portion was designed to be adjustable to allow for different shaft height variations. It also was where the body of the encoder was face mounted directly to. It should be noted that there actually is slot that runs down the center of the yellow insert that allows for a threaded bolt to go straight through.

The purple portion is the actual base of the assembly. There are three cavities on the bottom in which magnets would be placed into. This would allow the assembly to adhere directly to the metallic plate that the motors rest upon. This was done so that the whole assembly could be removed/adjusted easily at any moment. There is also a hole where a threaded bolt is fed thru with a wingnut on the other side that when tightened causes compression which would hold the yellow insert in place.

MICROCONTROLLER

Figure 9: PIC16F1823 microcontroller

With the encoder properly coupled and secured to the motor, the next portion was to choose what sort of microcontroller would be used to read the data being generated and do the calculations necessary.

A PIC16F1823 was chosen due to that it fit all the requirements needed for the project as well as there being plenty on hand which could be used.

These particular microcontrollers are programed via a program called MPLAB using C code programing language. The microcontroller would read the digital square wave signals being generated by the encoder via two separate wire connections. After the RPM and the direction of the motor are found, the information is sent to the LCD display.

LCD DISPLAY


Figure 10: LCD display

A basic 16x2 LCD display is what was used, with the top line displaying the RPM readings and the bottom line displaying the direction that the motor was spinning.

CIRCUITBOARD

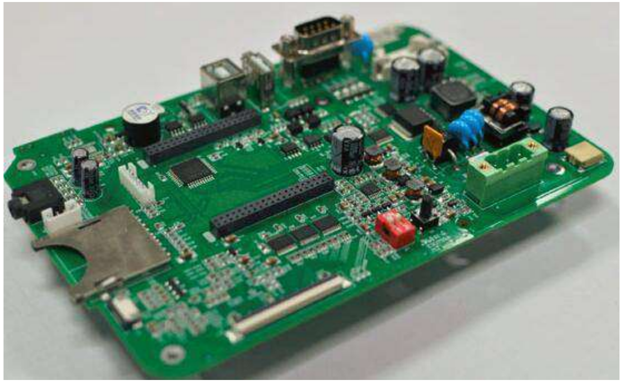

Figure 11: Example of a PCB

The design for the circuit board on this project initially called for a printed circuit board (PCB) to be used. After the final circuit board configuration was completed, it would be ordered from a company called ExpressPCB. They would then produce the circuit board in which the components could be soldered onto.

OVERALL BENCH CONFIGURATION

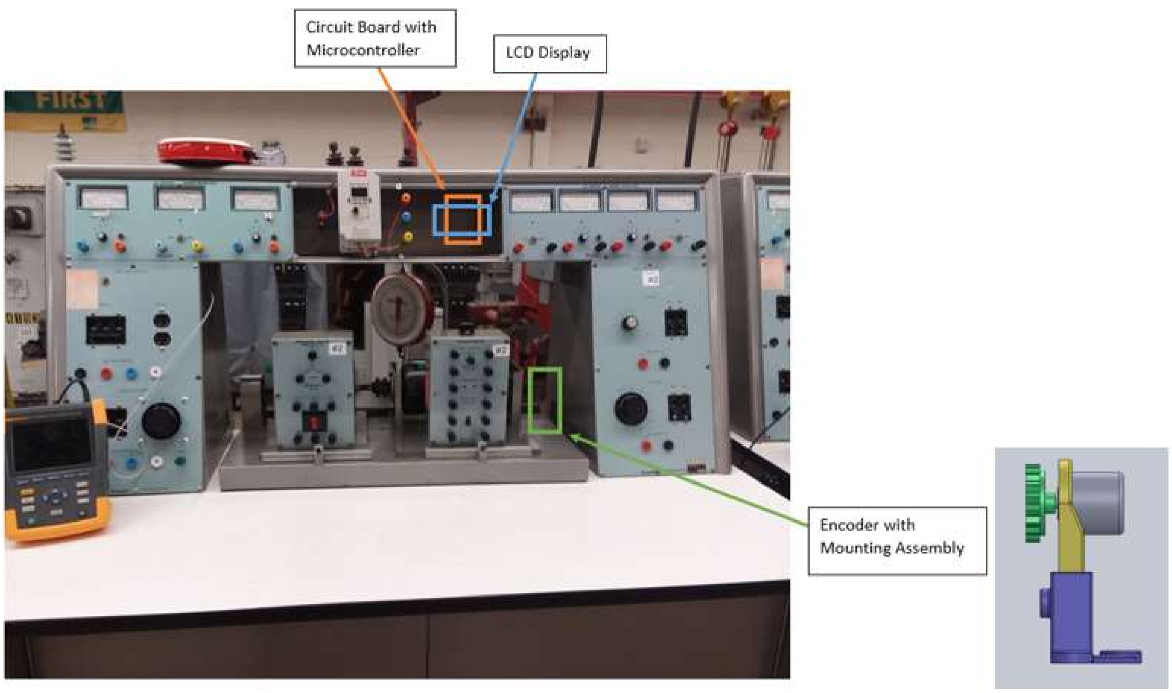

Figure 12: Layout of bench configuration with tachometer

FABRICATION

3D PRINTING

Figure 13: 3D printed coupling insert

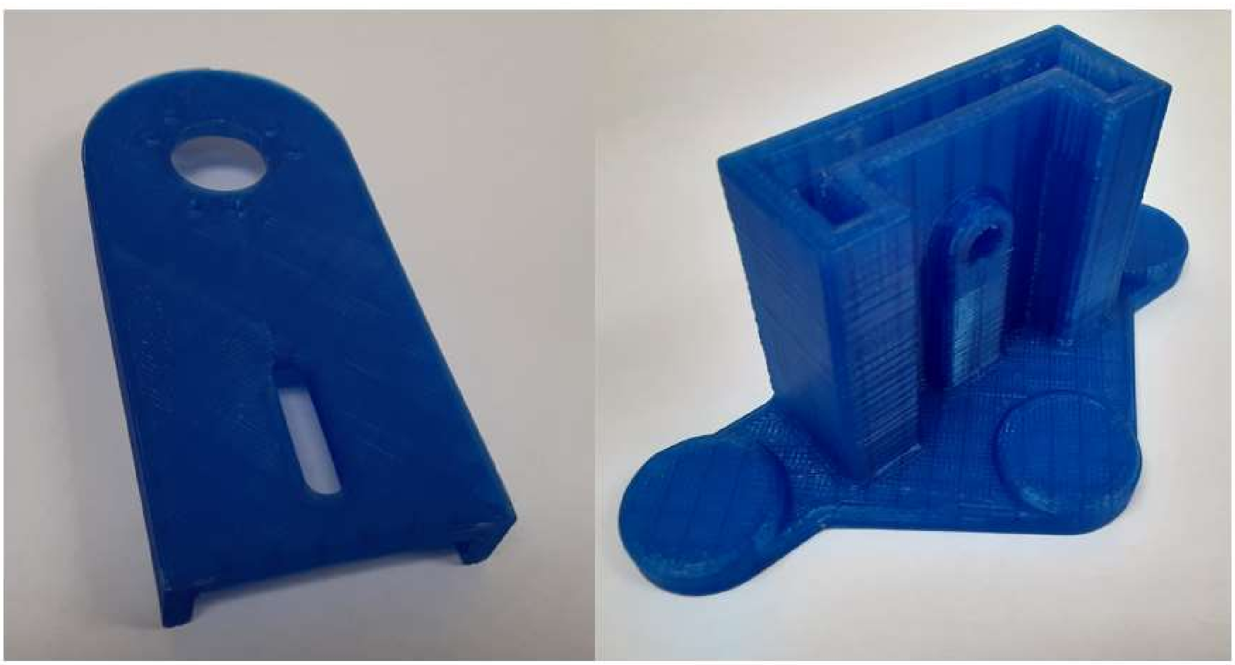

Figure 14: 3D printed encoder support assembly

PROTOTYPE CIRCUITBOARD

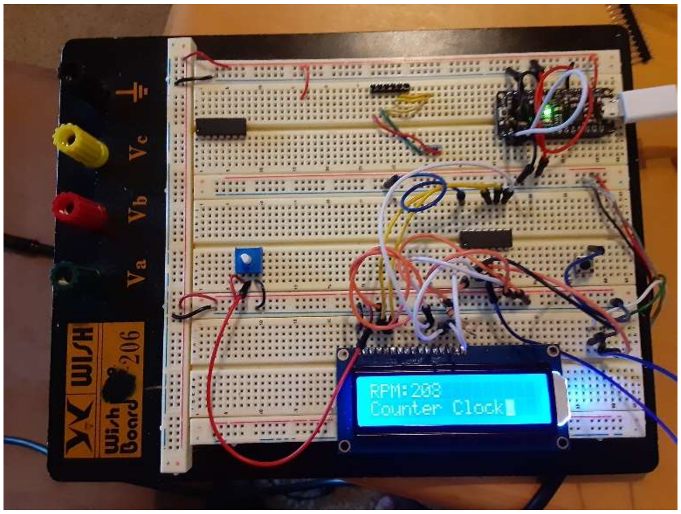

Figure 15: Breadboard used for tachometer project

Due to the coronavirus events, the PCB board was not able to ordered/produced. The only circuit board that was used for this project was a breadboard.

POWER SUPPLY

Figure 16: Power supply

All of the electrical components in this project operated off of 5 VDC. It was decided that the pre-existing 120 VAC on the bench would be tapped into and a separate outlet would be installed inside of the bench.

A step down power converter would be plugged into this outlet, which then would be connected to the circuit board providing power for all of the components.

TESTING

IDEAL TESTING PARAMETERS

Testing RPM (using a separate tachometer and calculations to confirm readings)

- Run the motor at low, medium, and high speeds
- Allow the motor to run for a prolonged period of time
- Continually switch motor speeds

Testing Direction

- Run motor in clockwise direction
- Run motor in counter clockwise direction
- Alternate between directions while allowing the program to continue running

ACTUAL TESTING PARAMETERS

Testing RPM

- Move the shaft of the encoder by hand and attempt to reach 60 RPM

Testing Direction

- Run motor in clockwise direction
- Run motor in counter clockwise direction
- Alternate between directions while allowing the program to continue running

RESULTS

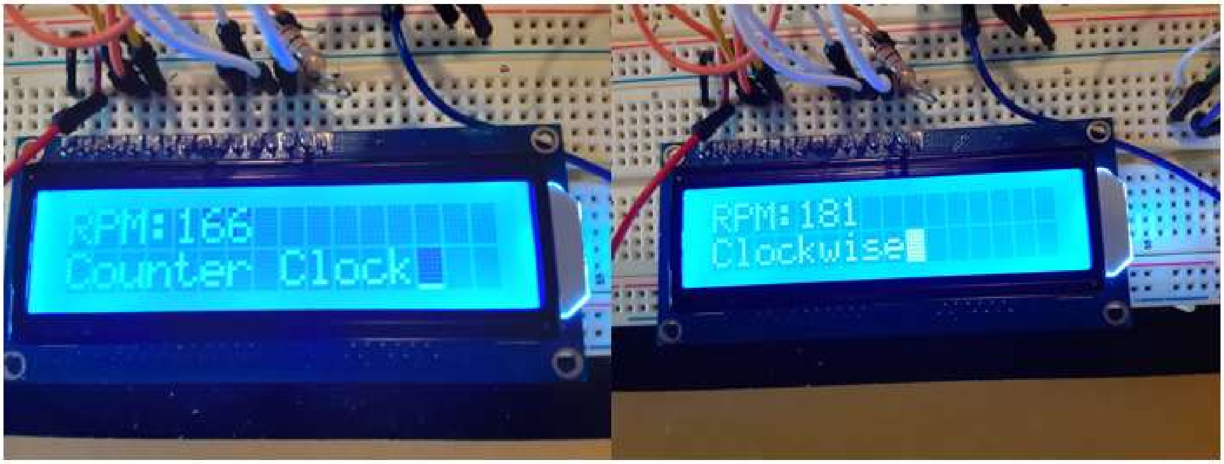

Figure 17: LCD display showing test results

As shown in Figure 17, an RPM reading was obtained as well as the direction the "motor" was spinning.

Without a proper way to actually confirm the RPM, it is almost impossible to know if a reliable output was being generated. The shaft of the encoder was spun by hand at an attempted one spin per second, which consistently resulted in around 60 RPM. Although that is promising, there is no way to tell if the program would stay accurate at higher speeds, or prolonged periods.

Testing for direction was successful. The program was mostly accurate as far as consistency with direction and with change of direction. There did seem to be an issue that sometimes the display would show the wrong direction for a short period of time before reverting back to the proper direction. It's hard to know if this would be fixed at higher RPMs, or if that would only make the results more inconsistent.

BUDGET/SCHEDULE

BUILD SCHEDULE		
January 20th - February 8th	Mounting Encoder	3D printing the mounting assembly and ensuring that everything aligns properly
February 9th - Februray 29th	Programing Microcontroller	Program the microcontroller, test with encoder to ensure proper RPM output is being measured
March 8th - March 21st	Prepping Bench / Ordering PCB	Prep the bench for installation and order PCB
March 22nd - March 28th	Circuit Board Assembly	Getting the bench ready for installation
March 29th - April 4th	Final Assembly	Adhere permanently to the workbench

Figure 18: Build schedule for the project

Estimated cost

Encoder	$17.16
Microcontroller	$4.94
PICkit 3 Programmer	$80.12
LCD Display	$9.95
DC Power Supply	$13.99
3D Printed Material	$15.00
Printed Circuit Board	$12.50
Miscellaneous	$25.00
TOTAL COST	**$178.66**

Actual cost

Encoder	$0.00
Microcontroller	$0.00
PICkit 3 Programmer	$0.00
LCD Display	$0.00
DC Power Supply	$0.00
3D Printed Material	$0.00
Printed Circuit Board	$0.00
Miscellaneous	$0.00
TOTAL COST	**$0.00**

Figure 19: Budget and spending

Due to all the required components being available at the school, everything could be made at no cost. The only portion that would have needed to be ordered was the printed circuit board, which could not due to the coronavirus events.

ISSUES

3D PRINTING

The main issue with the project was the 3D printing of the encoder mounting assembly. The first couple weeks of the semester revolved around some slight alterations to the initial design, but after that was done the focus was put into the actual printing.

Initially the material being used to print was getting too hot to the point where successful prints couldn't be achieved. Eventually a proper printing temperature was found, and a couple parts were able to be printed. The coupling insert was successful after some slight design alterations, but the insert for the base was not inserting correctly, as it kept getting stuck. This alone seemed to be adding weeks to the project, which was turning into an issue.

It was around this point that the 3D printer actually broke and wasn't able to be used for over three weeks. By the time the printer was fixed and ready to be used again, the coronavirus epidemic was taking its toll. One final print was able to take place, which resulted in a print that still had some tolerance issues. It was at this point that the school was shut down and students were no longer allowed on campus.

TESTING

Without the mounting assembly printed there wasn't an efficient/accurate way to test the microcontroller programing. Although the encoder could be spun by hand, the maximum RPM that could be achieved in that fashion was around 300 RPM, which was not nearly fast enough to get reliable results.

SUMMARY

CONCEPT

The concept of this project was to create a readily available and reliable tachometer that would be permanently be adhered to one of Dr. Wrate's lab benches.

DESIGN

The design mainly focused around the 3D design of a coupling and mounting assembly for the encoder. There was also coding involved in the project, in which a microcontroller was used.

FABRICATION

The fabrication of this project was mainly based around the 3D printing of the previously mentioned coupling and mounting assembly for the encoder. A PCB was intended to be produced, but in the end was not able to be made.

ADVANTAGES

The advantages of this project was that it was going to provide readily available and reliable tachometer for the students that could improve the accuracy of their lab reports.

DISADVANTAGES

The only somewhat disadvantage of this project was that the tachometer assembly would always be adhered to the bench, meaning that it couldn't be removed without great hassle. Although this wouldn't be much of a problem, there could be instances where it could become a nusicance.