Brushless Motor Demonstration/Tachometer

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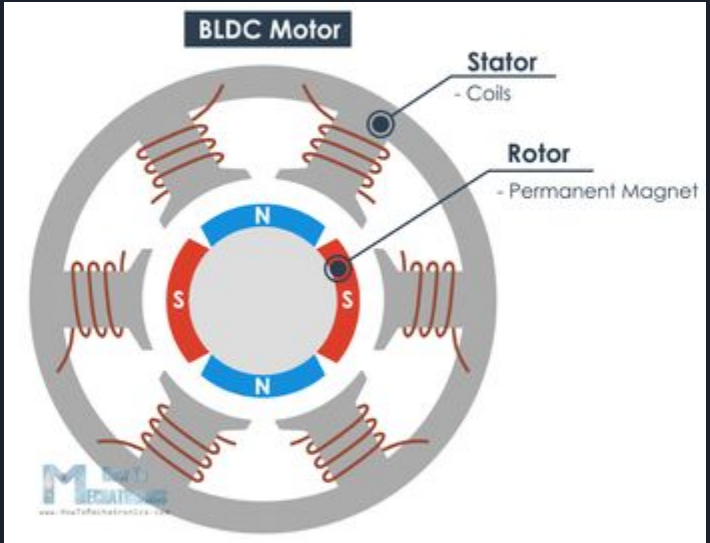
Project objective / Goals

The main objective of this project is to rebuild the brushless DC motor display in the lab as well as incorporate a method of speed control with the USB-6002 Data Acquisition Module

This motor display will help students visualize and understand the concept of brushless motors. The motor will serve as an interactive exhibit for both students and visitors.

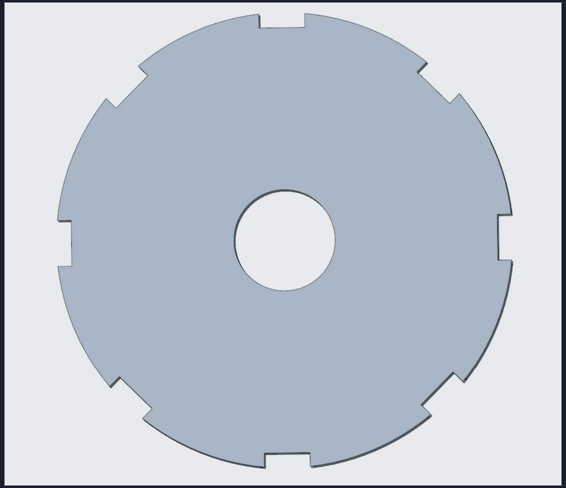
Brushless Motor Diagram

Brushless motors are composed of a stator and a rotor. The stator contains coils of wire that can be energized to generate a magnetic field. The rotor houses permanent magnets. By precisely timing the activation of the stator coils, the magnetic field interacts with the magnets in the rotor, causing the rotor assembly to rotate.



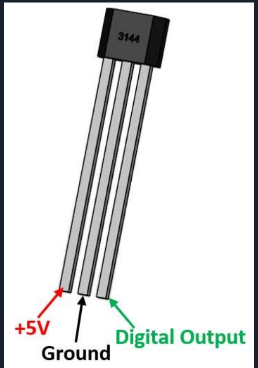
Description of System Design - Hardware

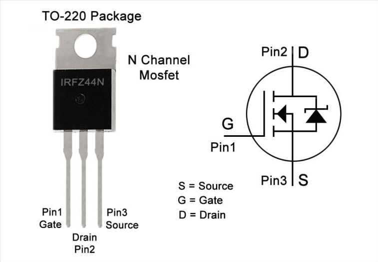
- 3D Printed Rotor
- Neodymium Magnets (12mm)
- 608ZZ / ABEC-7 - Bearing



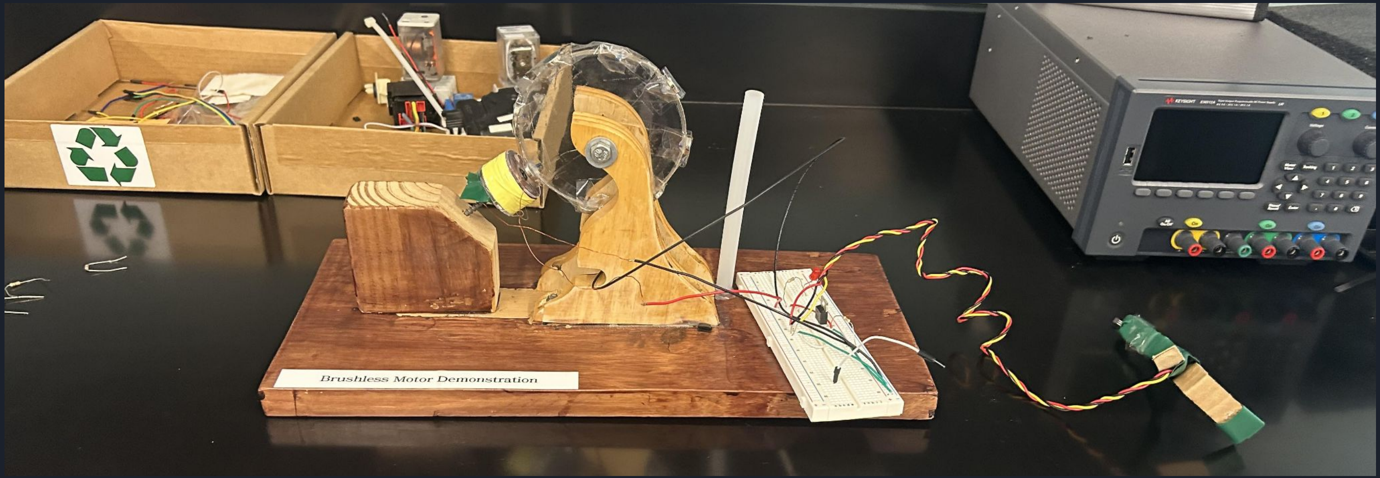
Description of System Design - Hardware

- A3144 - Hall Effect Sensor
- Copper Magnetic Coil - (800 - 1200 Turns)
- IRFZ44N - Mosfet
- NI USB-6002 - DAQ USB Device

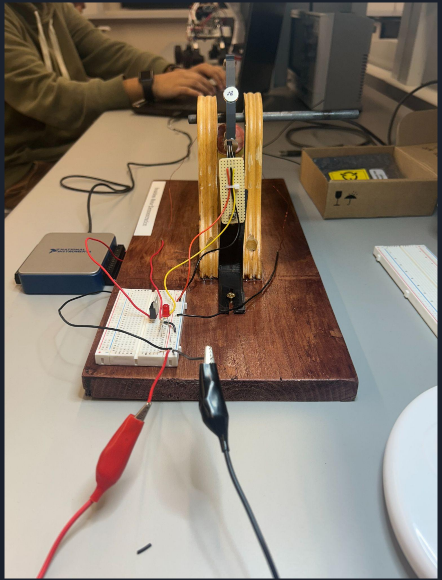




Previous Motor Display



Fully Assembled Motor

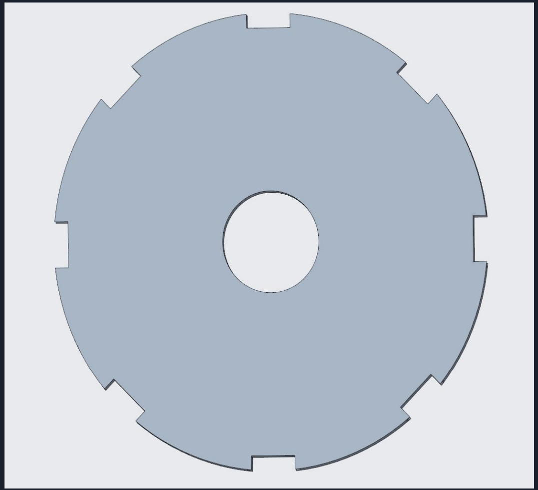


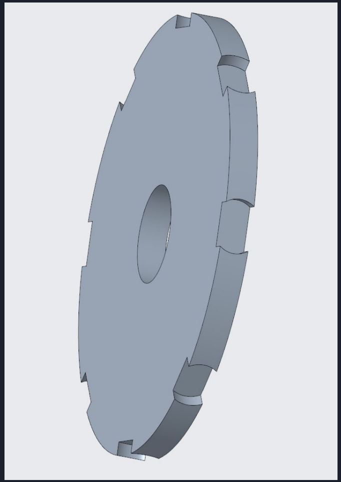
3D Printed Rotor

This is the rotor component of our brushless motor display. It is designed to house a bearing in the center and magnets around the outer rim of the rotor.

The rotor was created using the CAD program Creo.

- **Material:** ABS Plastic
- **Outer Diameter:** 100mm
- **Inner Diameter:** 22.2mm
- **Outer Slot Diameter:** 12.5mm
- **Slot Spacing:** 45 degrees apart





Neodymium Magnets

We are using neodymium magnets as the permanent magnets in the rotor due to their strong magnetic field and compact size.

Initially, we planned to use eight magnets however, due to complications, we resorted to use only six.

- **Outer Diameter:** 12mm
- **Thickness:** 3mm
- **Count:** 6

608ZZ - ABEC-7 bearing

We chose to include a bearing in this motor to reduce the rolling friction between the rotor and axle.

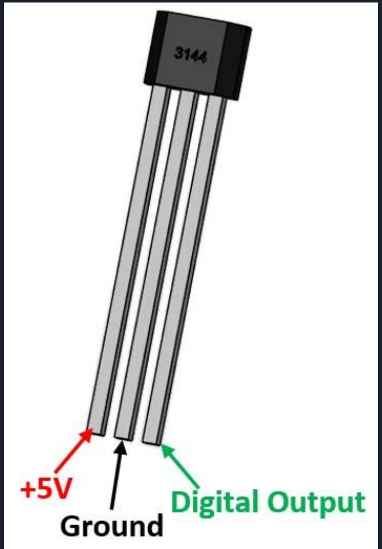
This greatly improved the efficiency of the motor.

- **Outer Diameter:** 22mm
- **Inner Diameter:** 8mm
- **Thickness:** 7mm

A3144 - Hall Effect Sensor

The A3144 Hall Effect sensor is used to detect the presence of the permanent magnets on the rotor.

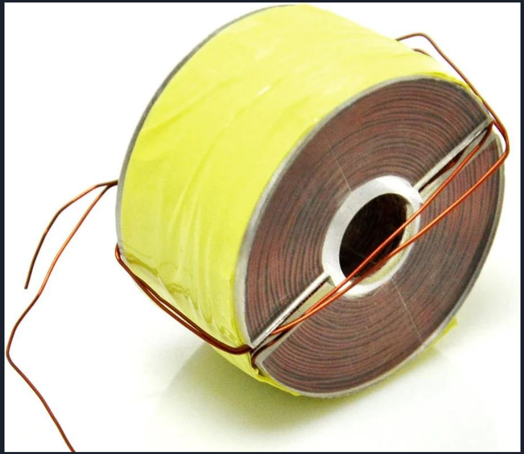
Normally, this sensor outputs a digital high signal. When it detects a magnetic field, it switches to a digital low output.



Copper Magnetic Coil

The copper coil acts as the stator, generating an electromagnetic field to repel the neodymium magnets on the rotor's outer rim.

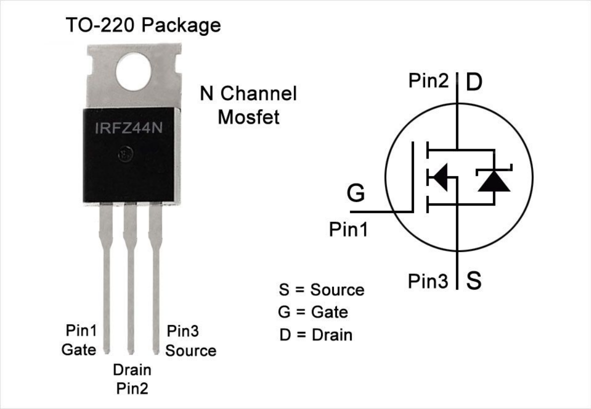
The coil will be integrated into a circuit that activates the magnetic field whenever a permanent magnet is detected.



IRFZ44N - Mosfet

We chose to use a MOSFET due to its fast switching speed and high efficiency.

The IRFZ44N MOSFET is used to switch the electromagnet on and off based on the signal from the Hall effect sensor.

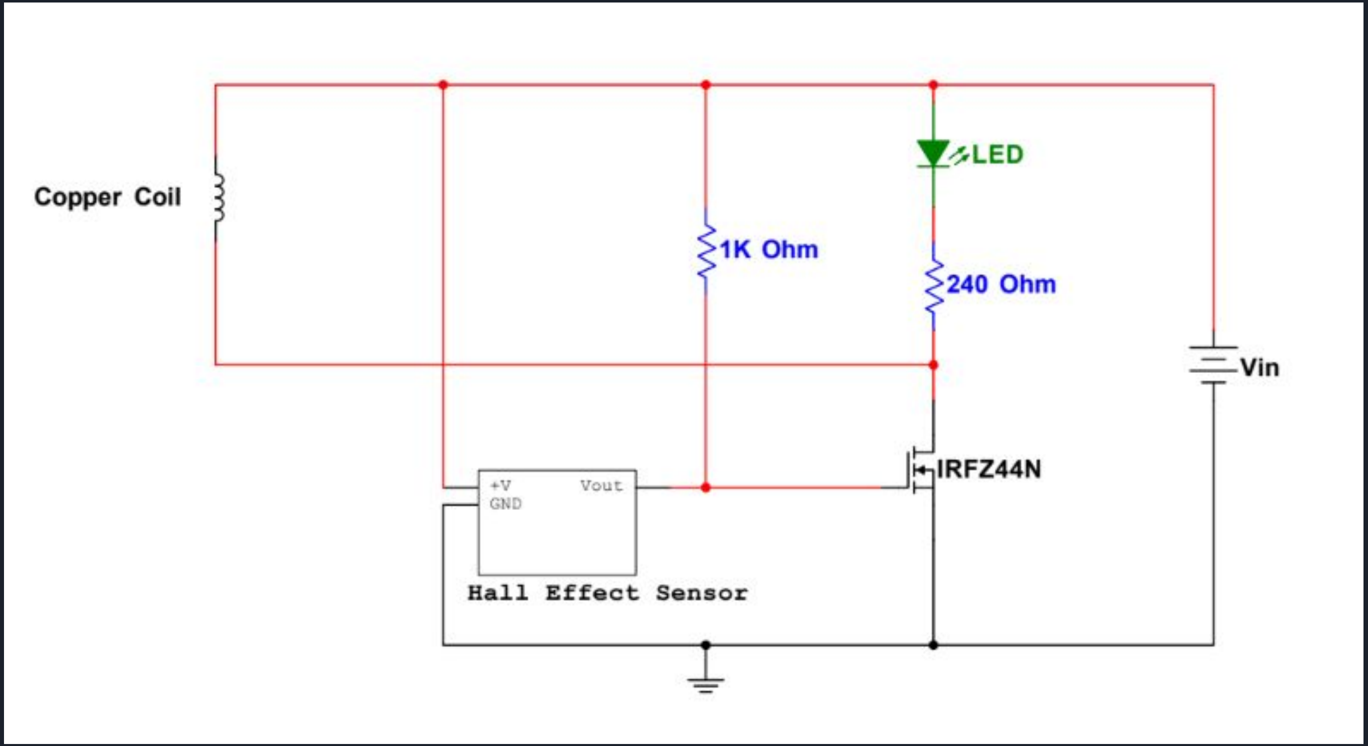


NI USB-6002 - DAQ USB Device

The NI USB-6002 DAQ is used to collect signal data from the Hall effect sensor in LabVIEW and to interface with the benchtop power supply.

By creating a VI in LabVIEW to read Hall sensor pulses, we can calculate the motor's RPM and control its speed by adjusting the voltage output of the power supply.

Brushless Motor Circuit

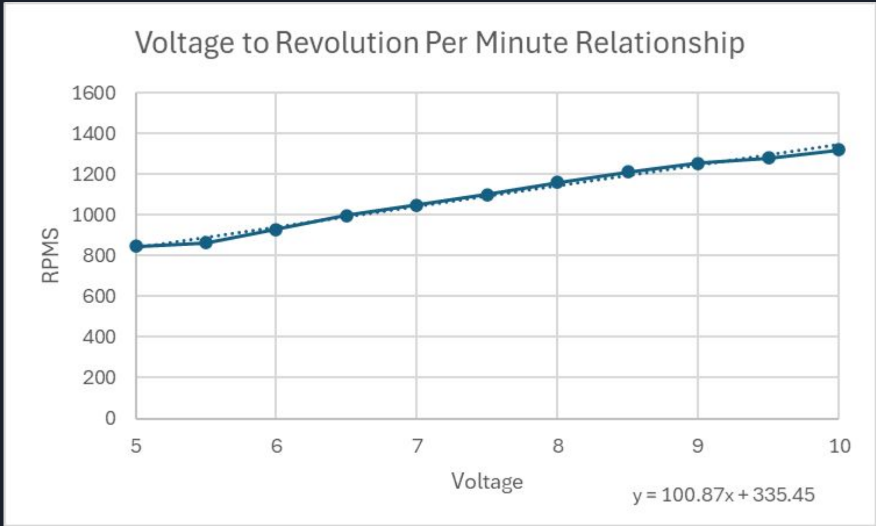


Software (Power Supply) Equation - LabVIEW

We were able to gather the equation for our operating region of 830 RPMS to 1320 RPMs by gathering 10 data points for each corresponding RPM value for each voltage value from 5V to 10V with a 0.5V stepping size.

$$RPMS = 100.84 \cdot V + 335.45$$

V = Voltage Calculated
RPMS = Input RPM wanted

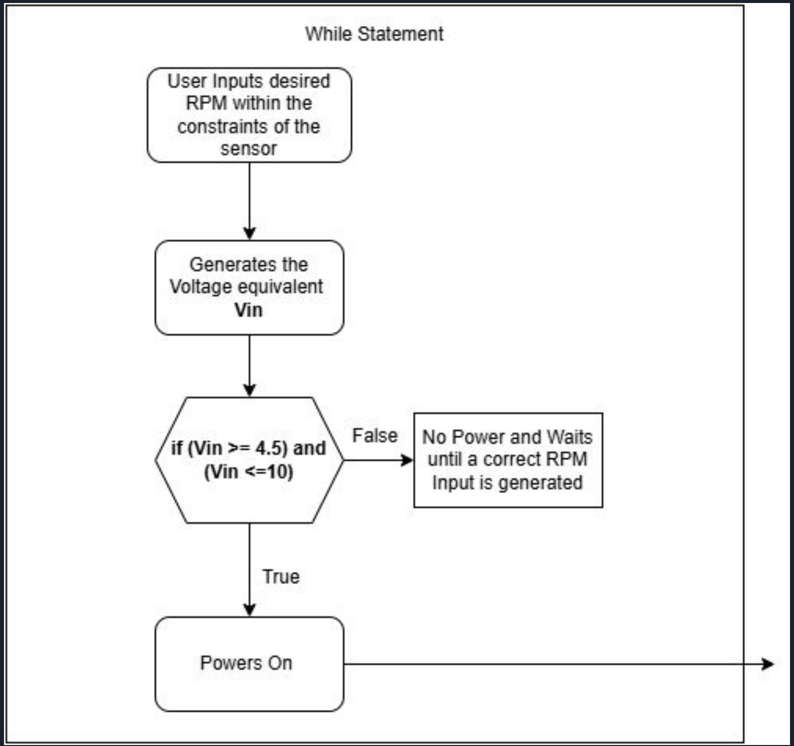


Software (Power Supply) - LabVIEW Schematic

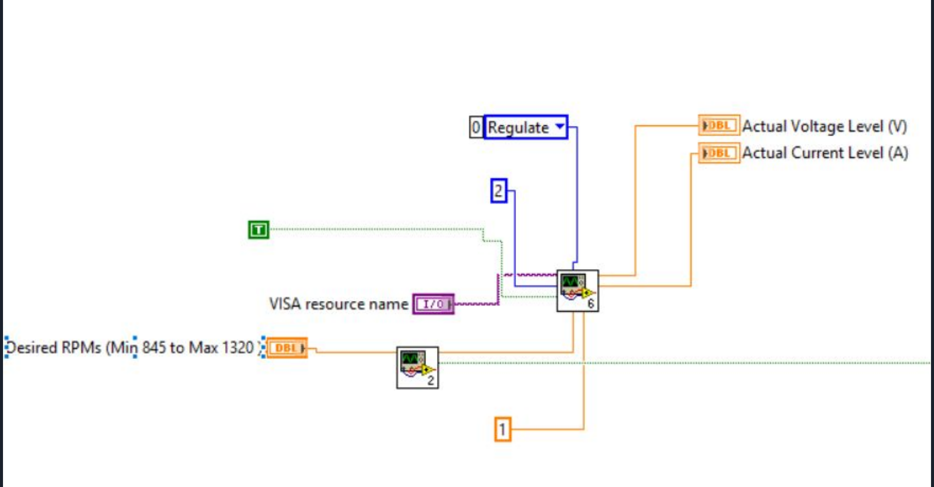
In this section of the code we will get an input from the user with their desired RMPs. We will then convert this RPM to the appropriate Voltage Level.

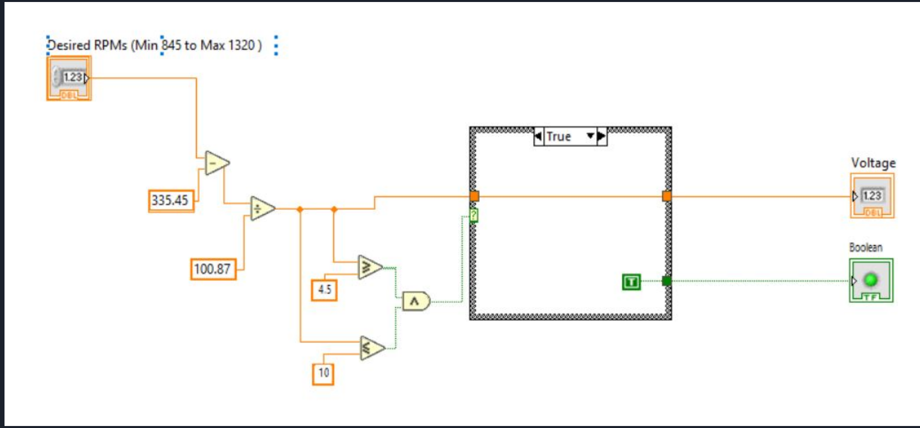
We will then check the conditions that the voltage is between our actual working voltage of Min 5.0 Volt and Max of 10.0V.

If it is true, then we just change the voltage to the power supply to the calculate voltage and a voltage of 0, effectively turning off our power supply if it is false.

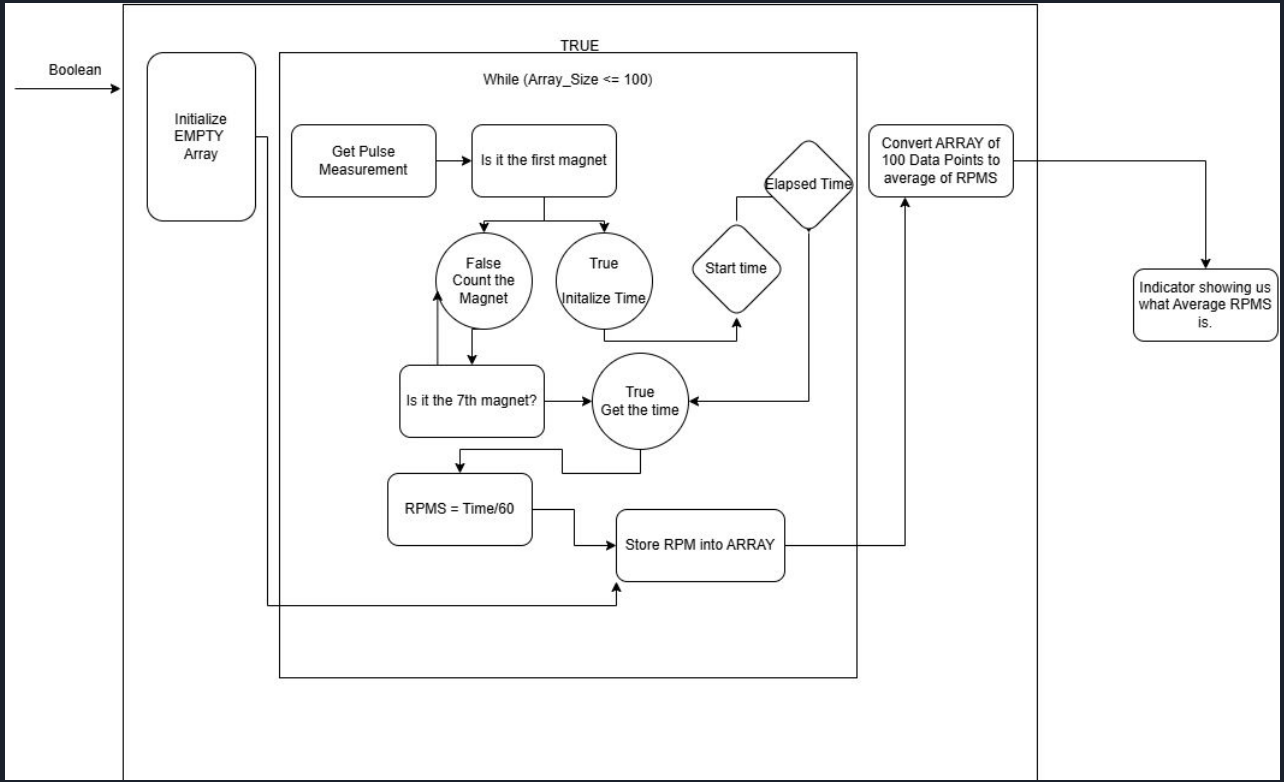


Software Portion (Power Supply)

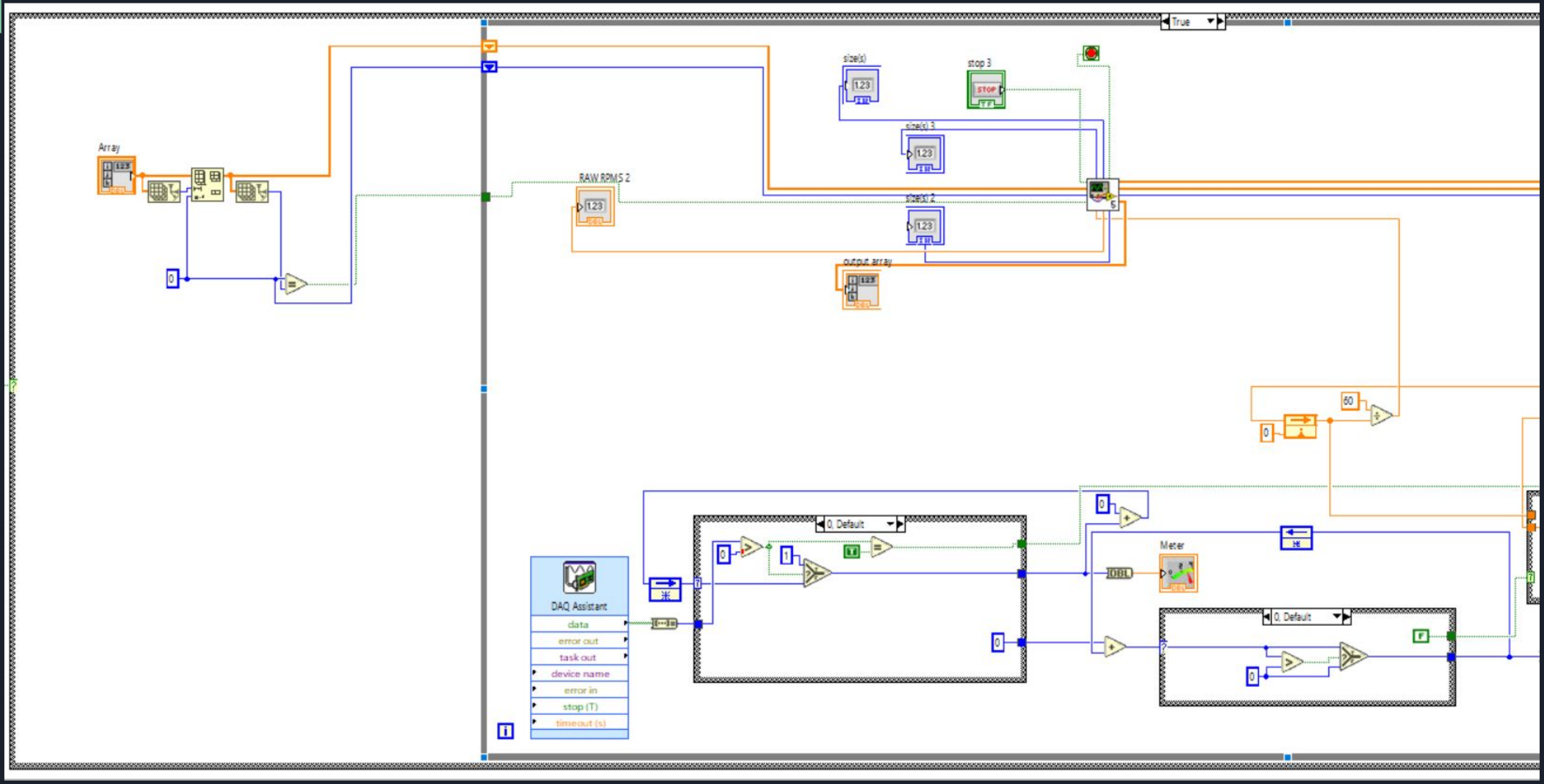




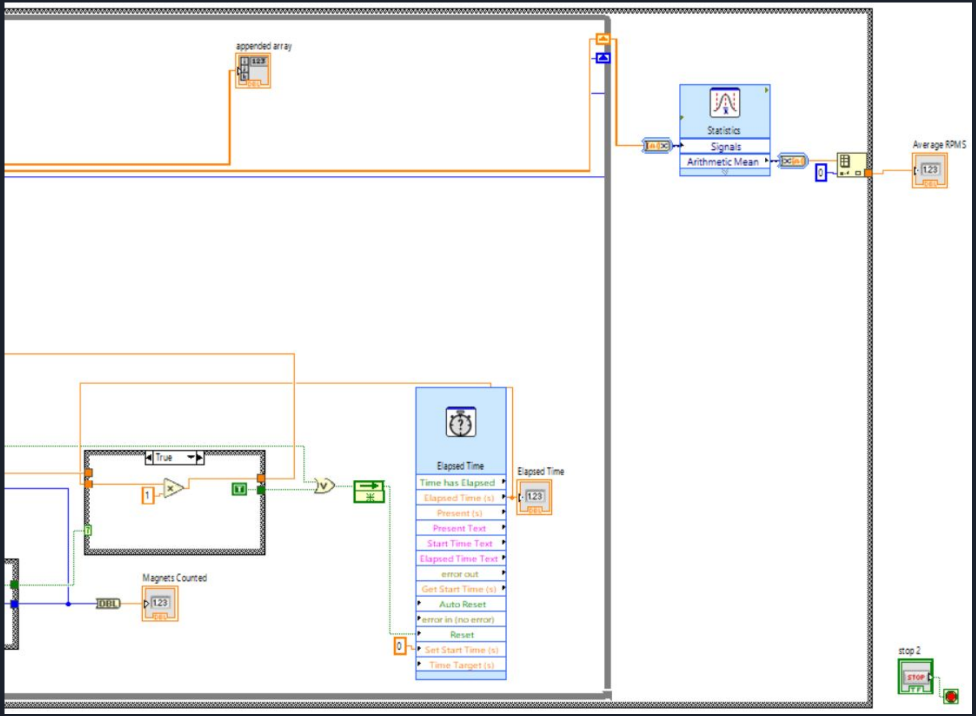
Overall Schematics Done - When Voltage is acceptable



Overall Programming Done - When Voltage is acceptable



Overall Programming Done - When Voltage is acceptable



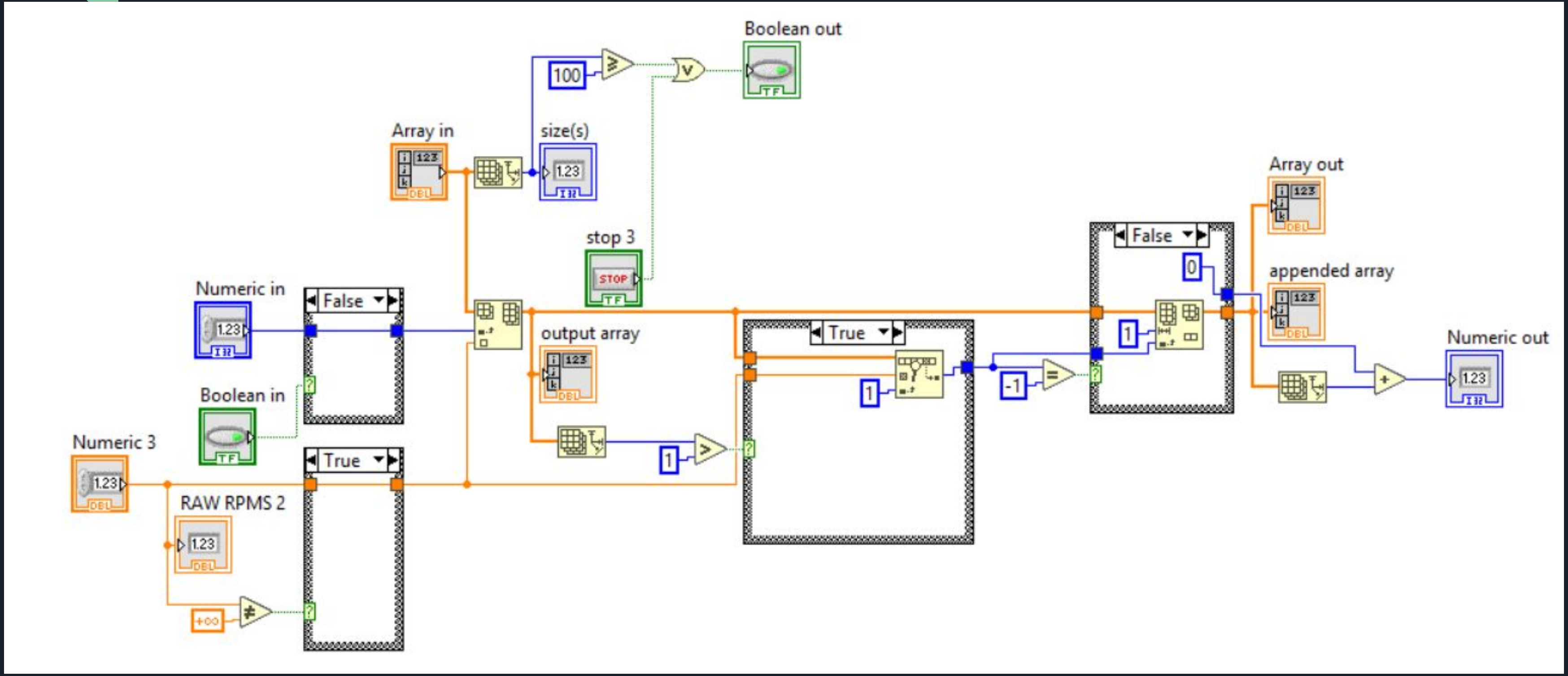
Averaging SubVi - Description

This SubVi allows us to send the RAW RPM Value as an input and it will decide if it is a repeated value which is very unlikely to happen except when we initialize the system and we start with an RPM of 0 or Inf .

We then store that specific and unique value into an empty array and then store that array as the shift register of our big while loop.

Once we get the complete 100 values we will stop the while loop and then get the arithmetic average using the complete array_size. This value will be displayed in the averaging RPM indicator.

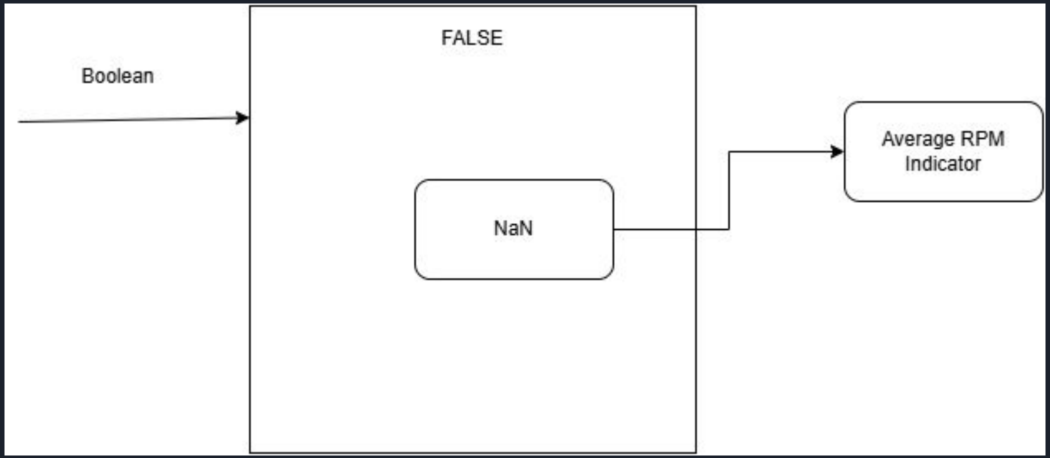
Averaging SubVi - Programming



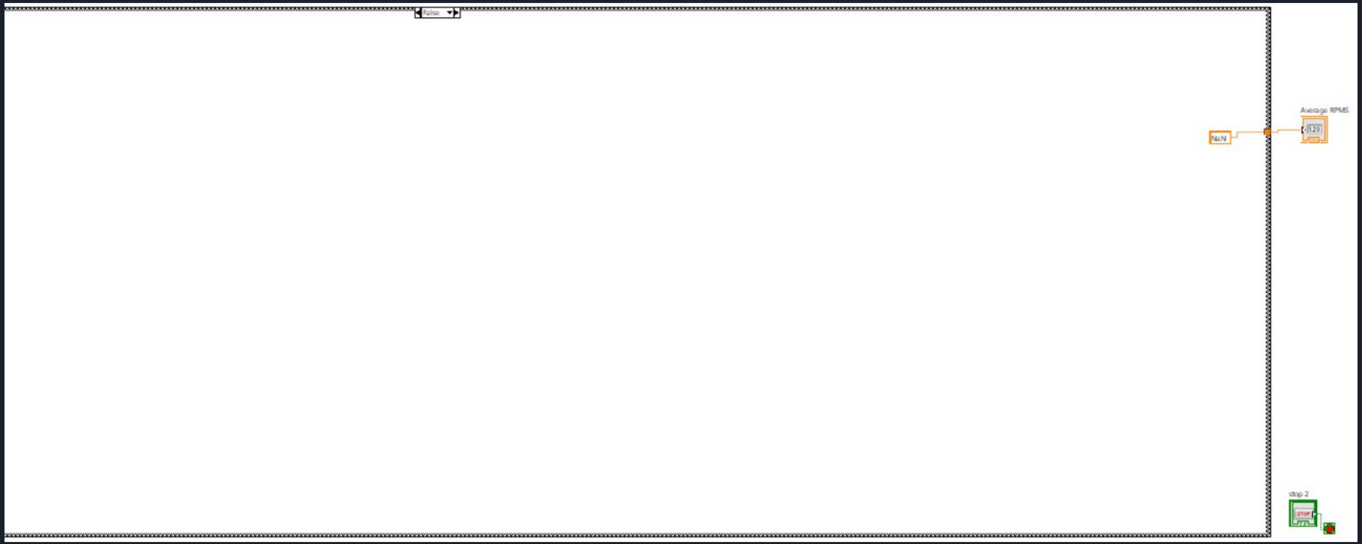
Overall Schematic - When Voltage is not acceptable

When the voltage is between the undesired ranges we will have the false case statement.

We will then receive a “NaN” response from our average RPM indicator.



Overall Programming Done - When Voltage is not acceptable



Motor Demonstration

Problems We Encountered.

- The minimum operating voltage of the Hall effect sensor.
  - The operating voltage did not allow us to run the motor under 5 volts.
- We encountered the Power Supply turning off and on after each 100 samples taken.
- Rotor design issues

Future Improvements

Features that we would like to add / improve upon for future modifications would include:

- Including a PI (Proportional Integral) controller that will correct the error between the desired setpoint and actual value of the motor's RPM keeping the motor at a set speed
- Investigate other Hall Effect sensors that have different output characteristics
- Improve upon the VI
- Improving the overall cosmetic appearance of the motor stand

Thank you!

Any Questions?