GNG1103

Design Project User and Product Manual

Accelerated Erosion Testing User and Product Manual

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Table 1. Glossary

Term	Acronym	Definition
Rotations per Minute	RPM	The measured amount of times an object rotates around a fixed center per minute
Direct current	DC	A type of current which continuously flows through the wire in one direction
Universal Serial Bus - B type	USB-B	A port connection which can transfer data signal through a cable
Integrated Development Environment	IDE	An IDE is a software which translates english based programming languages such as Python or C++ into binary to be processed by the computer running the software

1 Introduction

The client has requested the students of the University of Ottawa to make an erosion testing system that could test the wear of materials within a few weeks. Various ideas and needs were conceptualized to create a safe functional system that is durable and can yield repeatable results. A complex system consisting of different electronic gadgets, programming, components manufactured with engineering machines, and also easy to move and use. The dimensions of the system were assumed, as well as the appropriate rpm for accelerated erosion, benchmarking of

other creations and research on the materials and the operation of erosion were carried out to better understand what is being faced.

2 Overview

Erosion occurs on many different materials, and could cause catastrophic failure if not properly attended to after a long period of time. This can cause issues with bridges, buildings or other long term solutions to issues which are in constant contact with liquids and most often water. In the case of nuclear power, large power plants as well as expended nuclear fuel cells are often affected by erosion, as the power plants will have large exhausts which tower to let out steam, and the expended fuel cells will oftentimes be placed in a large pool of water. In order to create estimates for when these items need to be replaced with each type of material, as well as determine which material would be best suited in order to have the longest lasting building for the cheapest price, an accelerated erosion testing system must be developed in order to compare and collect data in regards to erosion of differing materials.

Our machine offers a cheap alternative to testing build materials which can test high density polymers as well as other low durability materials such as chalk or sandstone. Our machine offers a variety of features such as modulated rpm and varied amount of abrasive sand in the slurry which increases erosion speed of the sample.

 A laptop controls the motor through an arduino board, this causes the motor to spin in one direction constantly unless turned off by the laptop, or by a manual shutoff by unplugging the power supply. The system is set up in a plastic bucket which contains the slurry as well as the motor on the top of the lid. Within this bucket there is a metal rod which is connected to the motor through a friction fit and attaches the sample to the motor. Then the motor is connected to a motor shield which carries the signal from the arduino board as well as the external power source. To enable the device, run the code on the laptop and then to disable the device either stop running the code or unplug the power supply from the outlet.

2.1 Conventions

N/A

2.2 Cautions & Warnings

- Be careful in opening the bucket door while the engine is running as it may fill with fluid or abrasive particles, and may also damage your eyes, nose, etc.
- Do not touch the axle while it is moving, as it rotates at a very fast speed that can hurt you and due to the high friction it can scratch the skin, hair, surroundings.
- Do not bring the electronic components close to any liquid substance or food, it may cause a short circuit, smoke and possibly a fire.

3 Getting started

## 3.1 Configuration Considerations
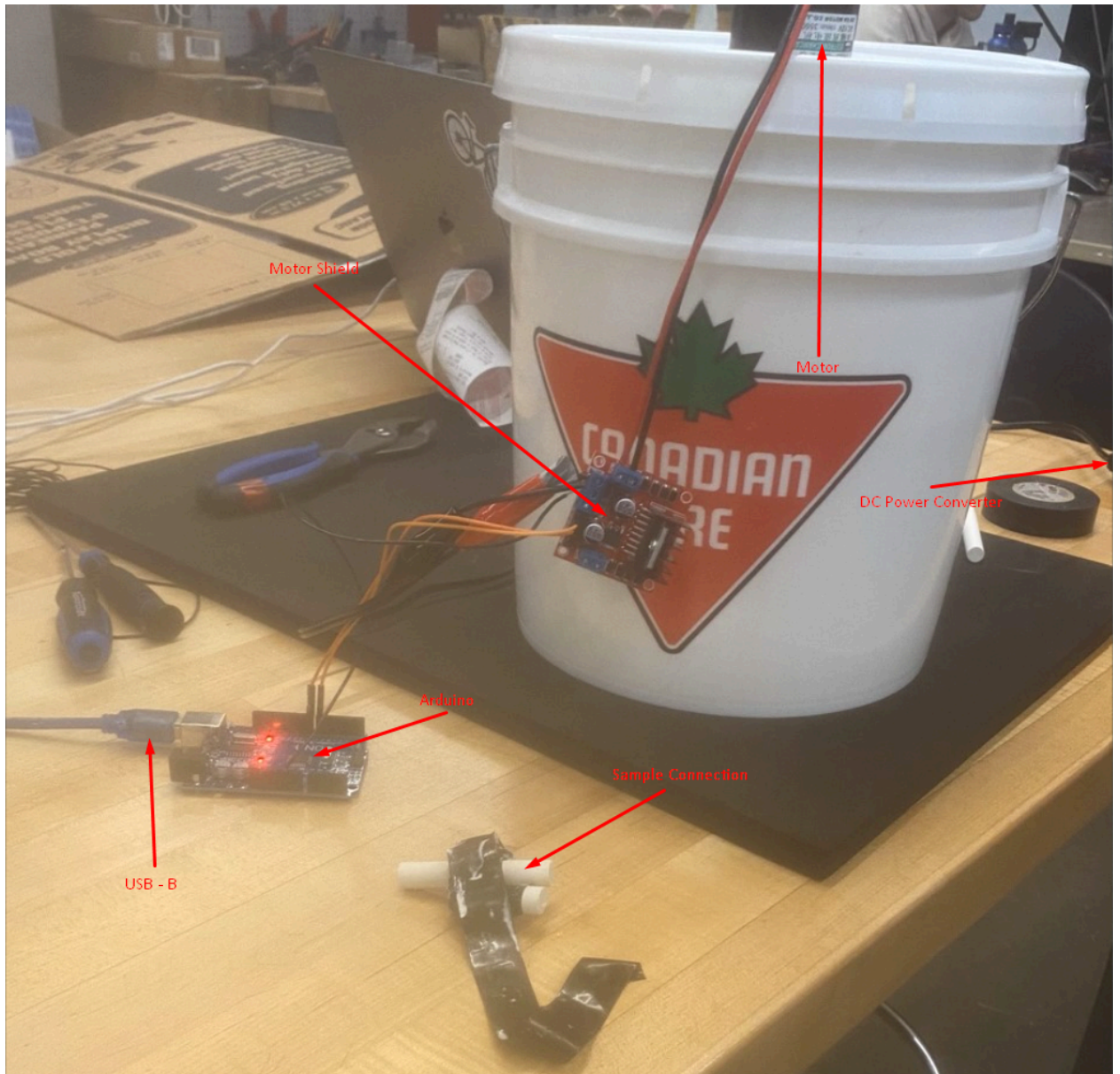
3.2   User Access Considerations

Users may include lab techs, maintenance crews, and other lab hands. Restrictions may include speed control, sample size and emergency stop button.

3.3   Accessing/setting up the System

- Before you begin the process of setting up the physical system, download the Arduino IDE.

- To begin the setup, identify the USB-B cable and connect the cable to the laptop, ensuring that the USB-B connection is plugged into the arduino board.
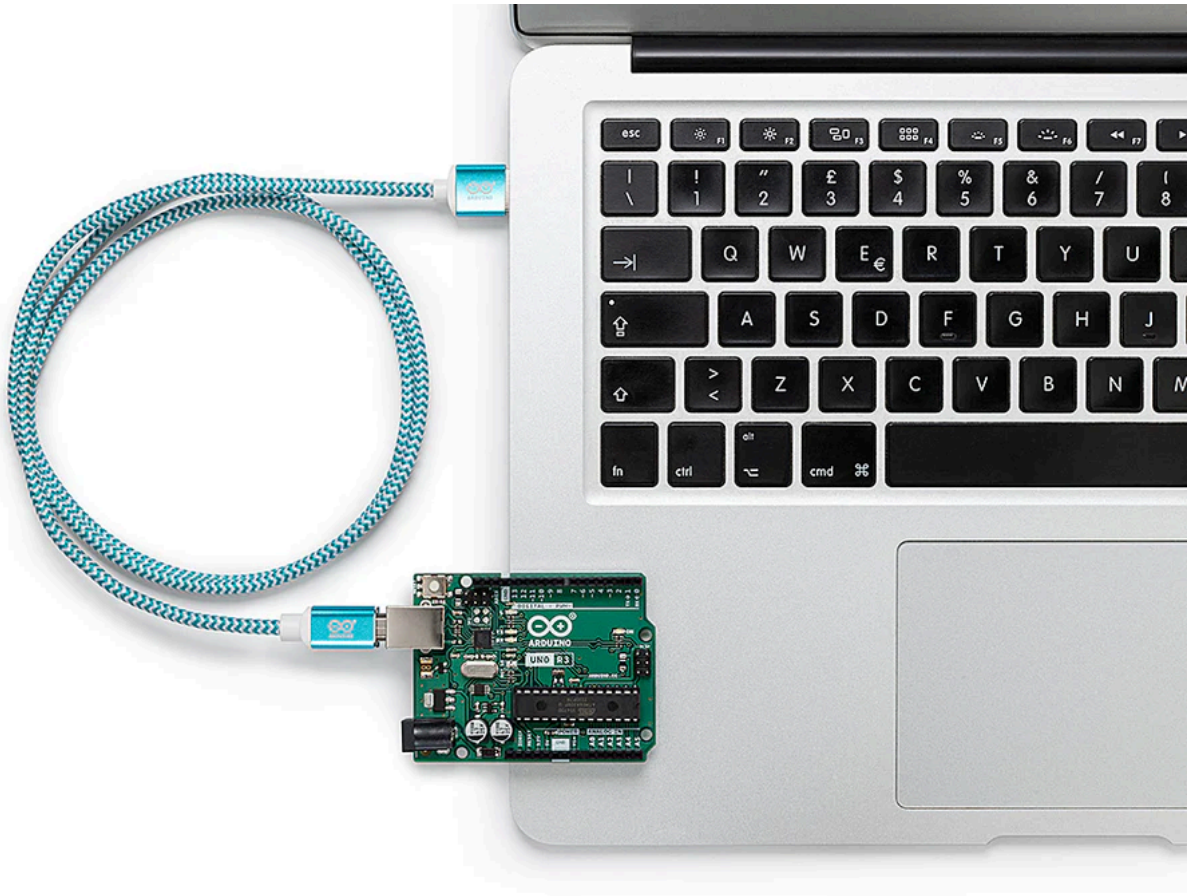
- Once this is complete you may paste the code below into the IDE.

```
void setup() {
        pinMode(7,OUTPUT);
        pinMode(8,OUTPUT);
}

void loop() {
        digitalWrite(7,HIGH);
        digitalWrite(8,HIGH);
}
```

- Attach your sample to the external of the rotating shaft, and secure it with tape.

- Plug in the DC converter into an outlet.
- Fill the bucket with water, make sure not to damage any electrical components by spilling water onto them.

3.4   System Organization & Navigation

The system works as such: the sample is connected to the shaft which is spun by the motor. This motor is powered by the DC converter and is passed through the motor shield. This motor shield is passed the data signal from the laptop through the arduino

3.5   Exiting the System

- To shut down the system, unplug the power source from the outlet.
- Then unplug the arduino from the laptop.
- Remove the lid from the bucket and remove the sample from the shaft.
- Once this is completed you can empty the bucket of water in an appropriate disposal station, be considerate of where to put the slurry depending on the concentration of sand which is in the water.
- Then once the individual components are dry, the lid can be secured to the tank, and placed in storage.

4   Using the System

4.1   <Given Function/Feature>

Functionality:

You need to connect Arduino to computer using a USB cable. Once you load the code onto your computer you can then enter it into the IDE and then compiled. Lastly, upload it to the Arduino board. This procedure programmed the Arduino so that it could follow the directions precisely making the erosion system more efficient.

Characteristics of Required Input:

The input here is the Arduino code written in the input area which is a unique code designed for an accelerated erosion system. This codes consists not only commands and configurations, but precisely commands and configurations that dictate how the process will go, for example, the erosion rate, the time and other functions may also be concerned as well. The code should be neat for formatting and properly crafted to meet the user's erosion material type.

System-Produced Output:

The task is executed after the code is successfully uploaded to the Arduino card and system can reconstruct the erosion as a result. At this point whatever physical output is generated in any form is only possible after the system is connected to a power supply. This means to plug the power supply into the wall and allow the system to begin.

5 Troubleshooting & Support

5.1 Error Messages or Behaviors

An issue that the system ran into when testing was the power supply not able to output enough amperage to the motor. This may cause the power supply to short, which is unrepairable. In order to combat this, a new power supply would be needed to purchase in order to replace the current one. This is relatively simple, but will require a Phillips screwdriver. The first step is to unscrew the original wires which connect the power supply to the motor shield. Once this is complete, put the red wire into the 12V+ slot and the black wire into the GND slot, be sure to connect the black wire from the arduino into the GND slot as well and tighten the screw until both wires are firmly secured.

Another possible issue could be software based with the arduino. If a serial comm connection error arises, there are ways to reset the board which weren't available to our team. If you possess such a hardware resetting system and understand the process of factory resetting the arduino board, this is a valid solution. In any other case however, you must replace the arduino board from the system. To do this, you will need to disconnect all connections from the arduino board and acquire a new arduino UNO board. Then plug in the connections to where they were situated before. That means the black wire into GND, and the 2 male to female jumper cables in output pin 7 and 8 (the order of these 2 wires

doesn't matter), then plug in the USB - B and as long as the board is functional, it should fix the issue.

5.2 Special Considerations

Avoid shaking or moving the system while it is in operation since the water, fluids and particles inside can reach the motor and damage it. Try to keep the tank on a fixed surface and support it with something, if there is an opportunity to waterproof the system; cables and the lower part of the motor, this can be a good opportunity to avoid risks.

5.3 Maintenance

Erosion causes a lot of physical artifacts when done for long periods of time. In order to ensure the best performance while testing erosion, once you are done with a test a thorough clean of the tank must be done, as well as a replacement for the slurry, as to not create uncontrolled variables when testing the next sample.

5.4 Support

If you require external help with the system, you make contact George Lau, at glau051@uottawa.ca for any questions or concerns. Within your email, ensure that the problem is stated as the headline, and that the issues are described in detail considering the names for each component.

6 Product Documentation

6.1 Electrical Components

6.1.1 BOM (Bill of Materials)

Artifact	Link	Price
Single Brushless Motor	https://www.amazon.ca/Electric-3500RPM-Permanent-Magnet-Torque/dp/B0B14NWBRL	$33.40

|		
Motor Shield	https://www.amazon.ca/Diymall-Module-Stepper-Modules-Arduino/dp/B00NJOTBOK/ref=sr_1_13?crid=3II2MKYEP037P&dib=eyJ2Ijoi MSJ9.0_M1-I8UhoT1D21IV6q0jv_8ilnpinCev83TJipJI_rODTzK-_tM1MAABXccliSvgU6svMJiM9HmC-5LaWPQ9qEBWsBc5wiMnqWAgJxYCPgpfhx2d1TlOFJe1x3T2uC4F8YOjpZ49vHhXJnwDgVzeBsW5MG1udw7wH5aNak4us310IyXC1eyFPeoOitPh0VpKFnczqdsw7Dc11n_UWO97048rqt-zkUpJQlo6v1CqScb3FDz5_vLNJa2EzErV8UfO8qeqe0O7FxbV462M4zu5ISLkhF0RLNlonehB-rVEgY.G0ms1fIuX4z4xpB-yxBJiBAp0Wojbdhvu5dVuo0zIyc&dib_tag=se&keywords=motor+driver&qid=1711577935&sprefix=motor+drive%2Caps%2C137&sr=8-13	$10.97
Arduino	https://makerstore.ca/shop/ols/products/arduino-uno-r3-clone/v/MC001-A	$15.25
DC Converter	https://www.amazon.ca/Charging-Multi-Protections-Auto-Stop-Function-Motorcycles/dp/B07RWLX5GZ/ref=asc_df_B07RWLX5GZ/?tag=googleshopc0c-20&linkCode=df0&hvadid=335159601771&hvpos=&hvnetw=g&hvrand=2189621382074435730&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9000680&hvtargid=pla-819651460960&psc=1&mcid=9dff2faf8d333e2498e67135276bf479	$16.99

|		
Wire	https://makerstore.ca/shop/ools/products/5ft-hook-up-wire-22awg-black	$1.60
Total		$78.21

6.1.2   Equipment list

- Motor
- Motor shield
- Arduino
- Wire
- DC Converter

6.1.3   Instructions

- Connect the motor to the motor shield on the output side by attaching each individual wire to one of the terminals for A or B but not both, and tighten the screw until the connection is secure.
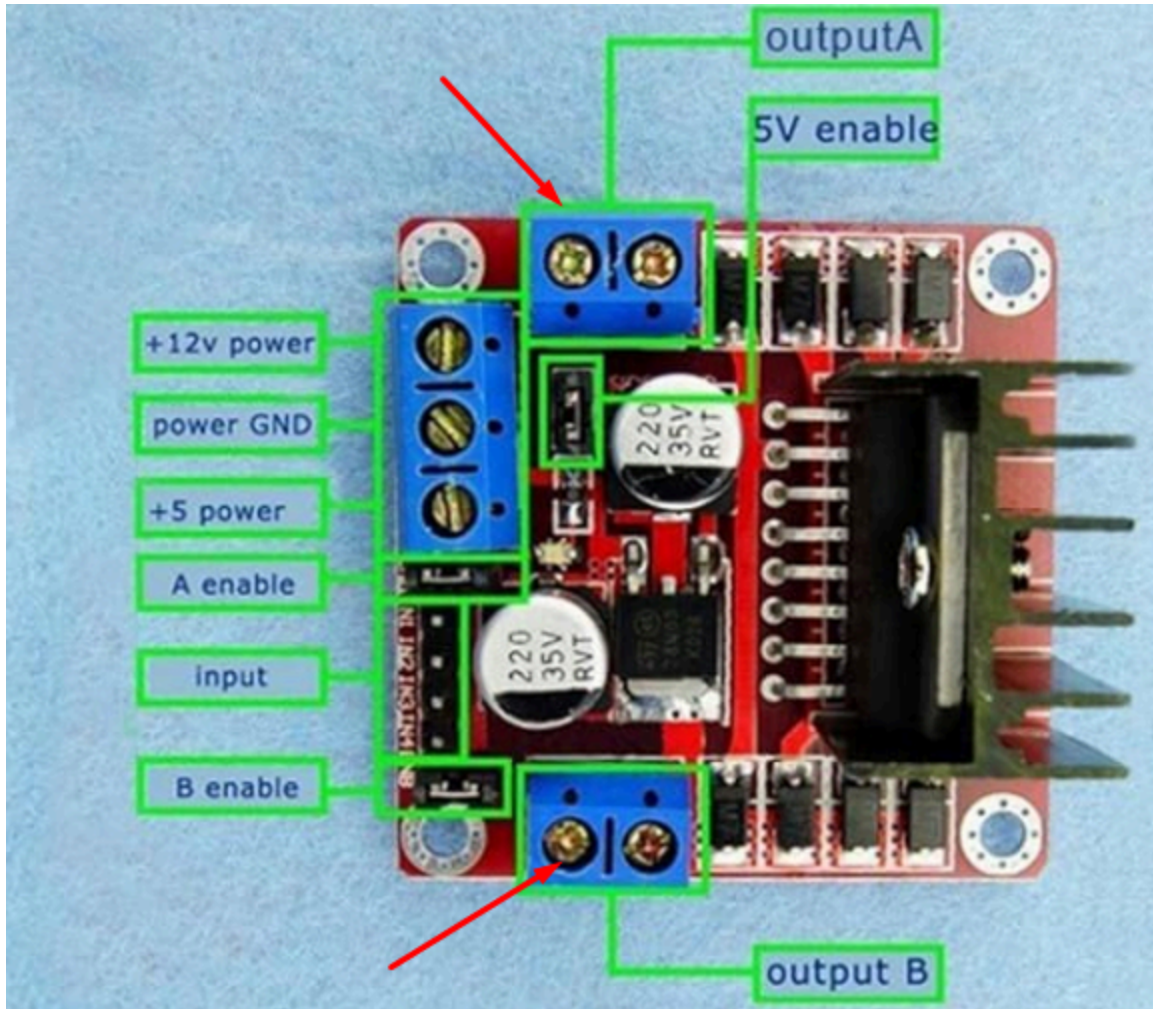
- Connect the DC converter positive wire, which should be marked as red to the +12v power terminal, and tighten the screw until the connection is secure.
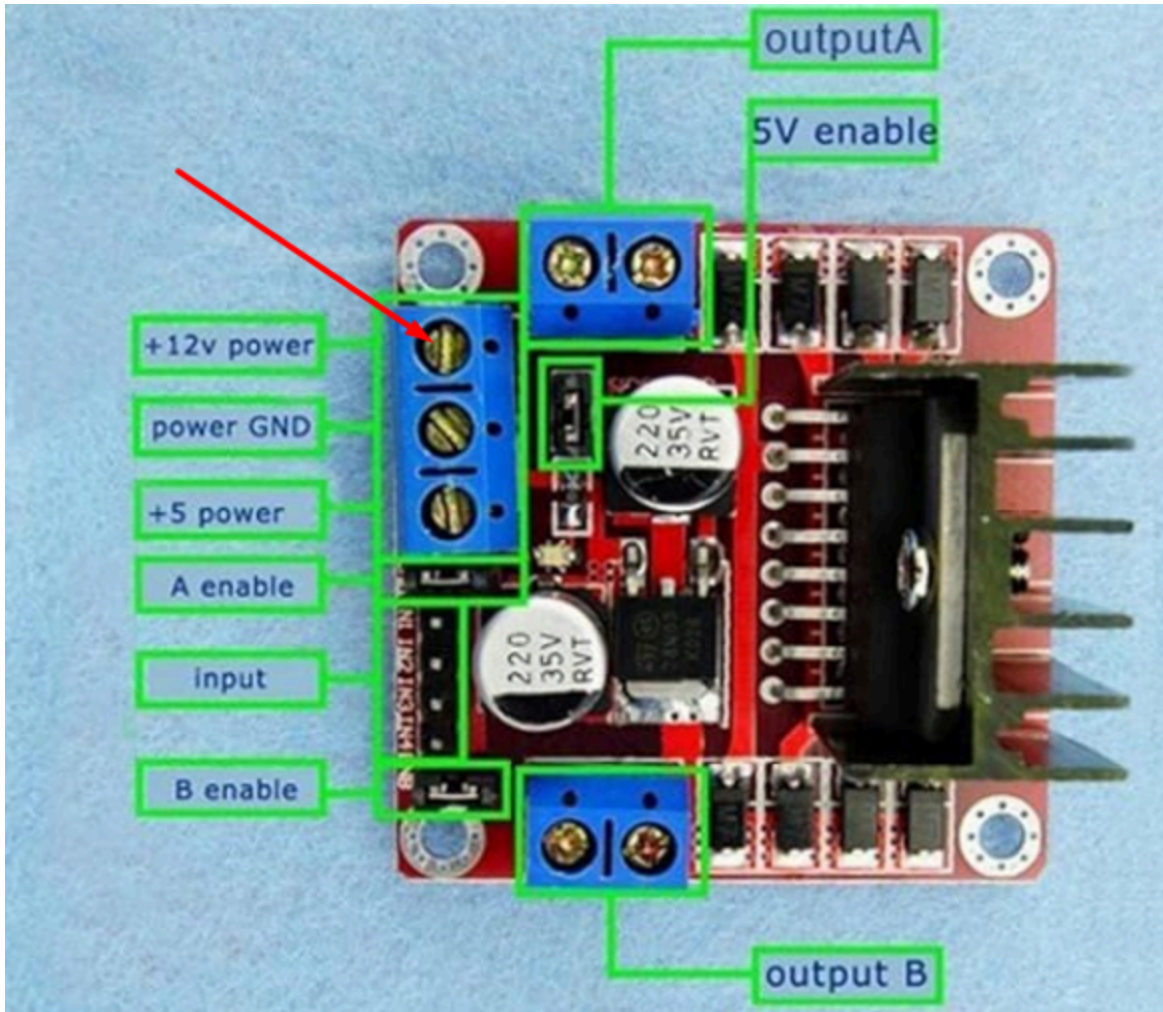
- Connect both the DC power converter and Arduino GND to the power GND terminal, and tighten the screw until the connection is secure.
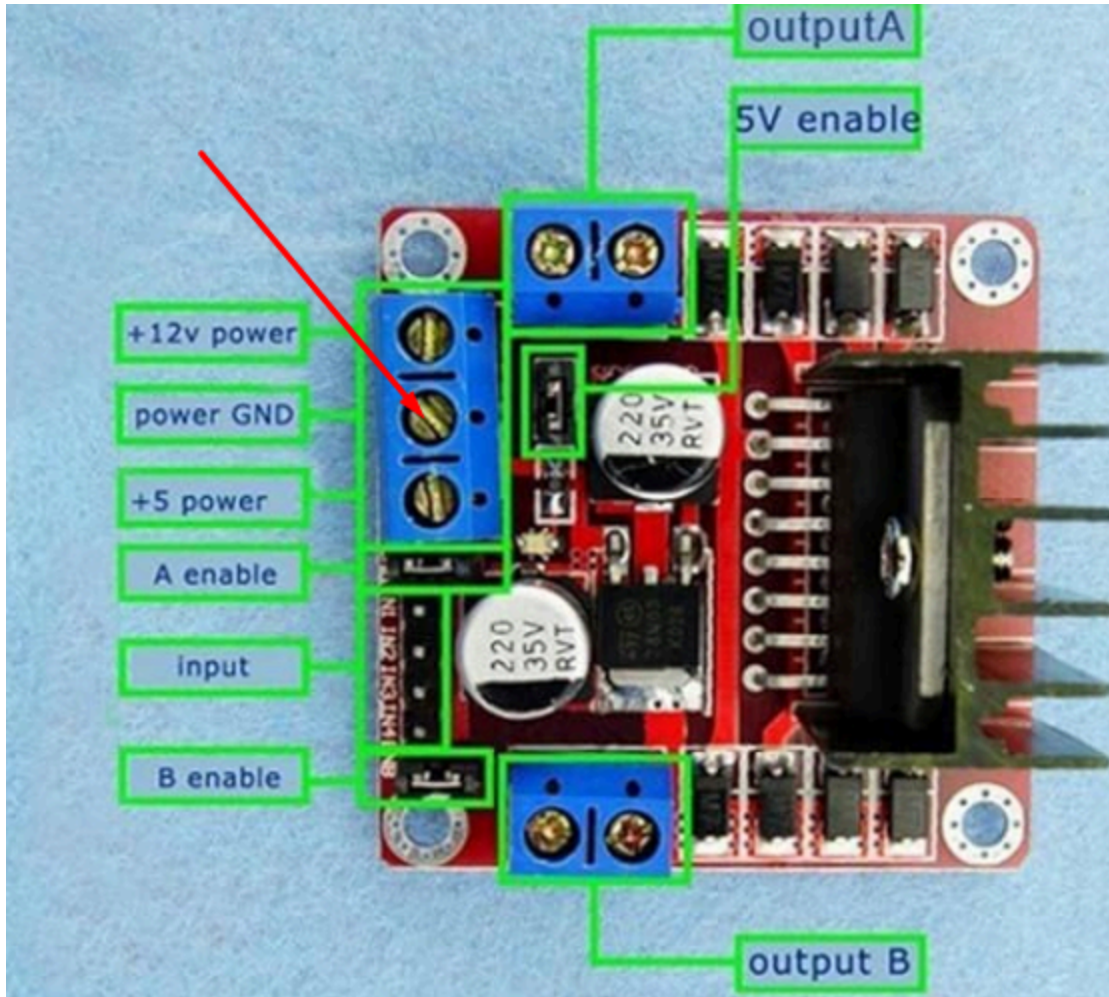
- Now connect the male to female jumper cables from the arduino 7 and 8 outputs to the set of 2 input pins which are closest to the motor output you connect to (if connected to A, input pins 1 and 2, if B input pins 3 and 4).
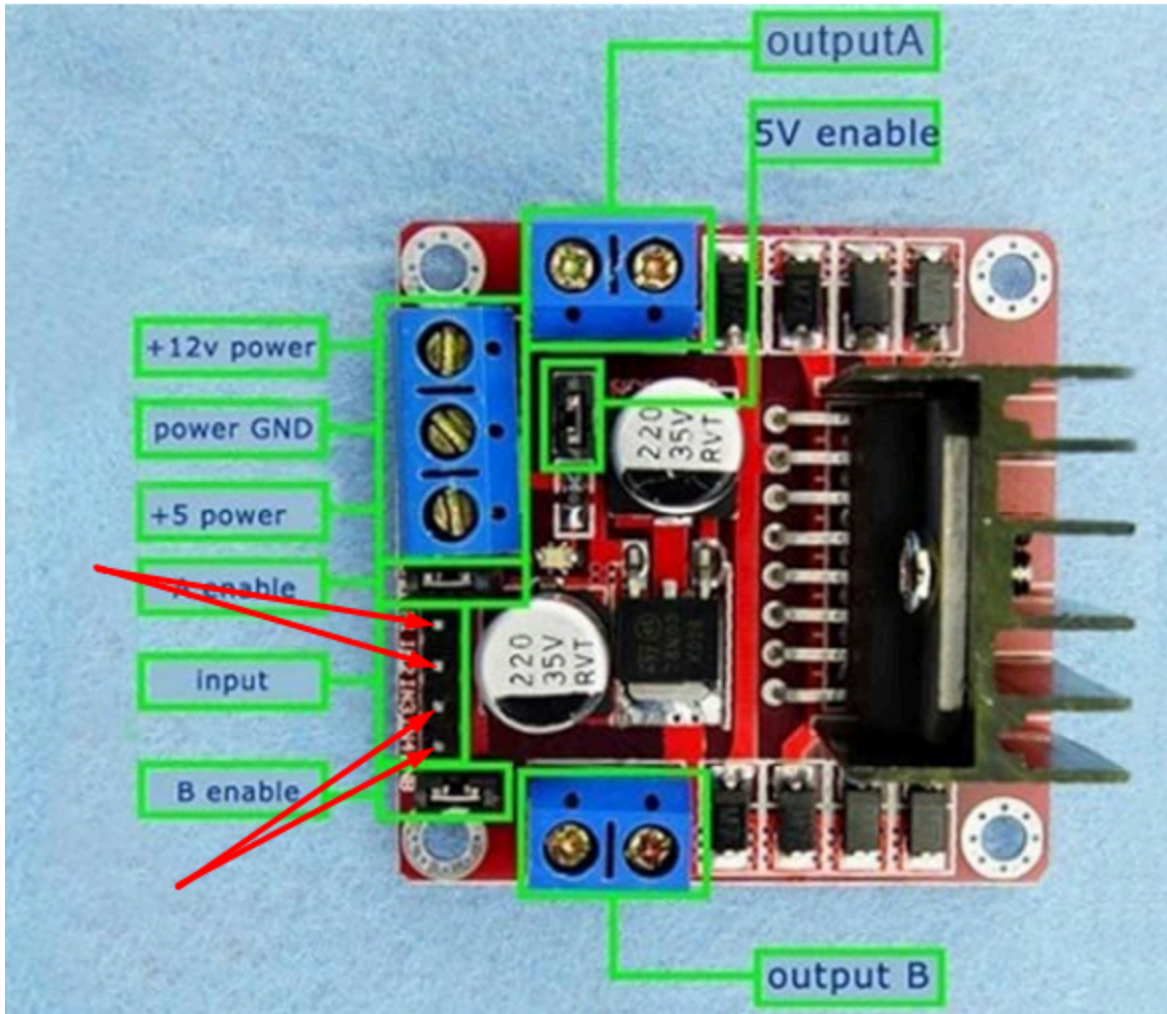
- Ensure that the USB - B is connected to the arduino board.

6.2 Tank and housing

6.2.1 BOM (Bill of Materials)

Artifact	Link	Price
Bucket	https://www.homedepot.ca/product/the-home-depot-8l-orange-home-depot-logo-bucket/1000784938	$3.47
Metal Rod		
Total		

6.2.2 Equipment list

- Bucket
- Hollow Metal Rod

6.2.3 Instructions

- Cut a hole in the top center of the lid, which fits the diameter of the metal rod.
- Cut a 6 inch piece off the metal rod, in order to be placed on the motor.
- Cut 2 more small holes the diameter of the mounting screws on the motor on either side of the center hole with the distance from the center of the motor to the mounting screws in order to stabilize the motor when spinning.
- Place the motor on top of the tank and mount the screws to secure the motor.
- Put some tape around the tip of the motor to ensure a good connection with the shaft, then place the shaft on the motor head.
- Once this is complete the whole system should be done and ready to be tested.

6.3 Testing & Validation

Once the system is set up, you can run the entire system in order to ensure that all components are working together seamlessly and smoothly. Record the RPM of the motor in order to ensure its effectiveness with the rated RPM.

7 Conclusions and Recommendations for Future Work

For future advances in this project, better quality materials must be obtained and all electrical components must be waterproofed, different experimental tests must be carried out with various materials for various periods of time, so a more precise certainty of the degree of erosion achieved by this system can be obtained. in certain materials and conditions.

Time is a great advantage in a team that wants to achieve better results. You have to get an engine that does not need so much power and that supports sudden movements, vibrations and even light exposure to water and friction.

8 Bibliography

- Tian, H. (2007). A new impact erosion testing setup through Coriolis approach. *ELSEVIER*. https://www.sciencedirect.com/science/article/abs/pii/S0043164807004024
- Momber, A. & Kovacevic, R. (2008). Accelerated High Speed Water Erosion Test for Concrete Wear Debris Analysis. https://doi.org/10.1080/10402009608983616
- Oka, Y. (). Control and evaluation of particle impact conditions in a sand erosion test facility. https://doi.org/10.1016/S0043-1648(01)00710-4

- ASTM B611 – 21: Standard Test Method for Determining the High Stress Abrasion Resistance of Hard Materials https://www.astm.org/b0611-21.html

9 APPENDIX I: Design Files

Deliverables available in:

https://makerepo.com/lukabraculj/2022.group-14-deliverables-for-makerrepo