# Watts Scientific Division F

Progress Report 2

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Week 8

March 7, 2018

## Weeks 5 – 7

Situation

In weeks 5-7 of the AEV project, Team F underwent advanced research and development topics to gain a better understanding of how the AEV operates under different conditions. The team chose two research topics: Motor Configuration and Motor Quantity. The goal of Motor Configuration was to observe the effects of propeller orientation on the overall efficiency of the AEV. This testing yielded the optimal configuration for motors which Group F will be carrying forward the rest of the project. Similarly, the Motor Quantity research gave the team a chance to test effects of various numbers of motors on the efficacy and efficiency of the AEV. The result again, was the optimal number of motors for the most efficient AEV design. Although these two research projects proved to be beneficial to the team, there were quite a few limitations to these research projects, which will be discussed in this report.

Results and Analysis

**Motor Configuration:**

The motor configuration portion of the Advanced Research and Development series called for the experimentation of different The AEV travels a further distance when the propellers are in the pushing position. Team F conducted 4 different trials, each with a unique motor configuration. The images of the configurations can be found in Appendix C. Trial 1 began with the motors in the forward pushing position with the wings propped up; this trial was one of the two options that allowed the AEV to travel the furthest at 10 meters. Trial 2 had the propellers facing the forward pushing position with the wings in a downward position at 45 degrees. This run produced better results as it pushed the AEV by 0.67 meters as shown in Figure 2. A backwards motor and upward facing wings was tested for Run 3 and produced results that seemed to be 3 meters less than Trial 1 and stopped at roughly 7.2 meters. The backwards motor is in the pulling position where the motor is pulling air through its propellers. Trial 4 had the motors facing backwards in the pulling motion with the wings at 45 degrees propped downwards. The final distance for this run was at about 9.5 meters and 1.5 meters less than Trial 2. There is no change in power consumption and the results are consistent.

Results show that that forward pushing propellers allow the AEV to travel at a further distance. The positioning of the wings does not have a significant effect but allows the AEV to overcome drag. Trial 2 and 4 show that the wings propped downwards at 45 degrees produced better distances than Trial 1 and 3. Analysis shows that Trial 2 produced the best results with the wings propped downwards and the motors in a backward position. This allows the AEV to be more aerodynamic and overcome drag. One error that occured was the first runs on a fresh battery, so Team F had to test the AEV on one run first, then conduct the experiment afterwards. Overall, the pushing configuration of the motor is more efficient than the pulling method along with the wings facing downwards that produced less drag. Figures 4 and 5 of Appendix C shows the pushing configurations of the motors. Figure 5 shows the ideal motor configuration that would produce the best results.

**Motor Quantity:**

For the second advanced research and development experiment, the team investigated the effects of varying the number of motors on the AEV. Of particular interest, were power efficiency and relative displacement performance. To accomplish these objectives, the team compared the best 2-motor configuration (wings up, motors pushing) with a 1-motor configuration as shown in Figure 7 in Appendix D. Each setup was run through the same test code used in the Motor Configuration study as listed in Appendix A. A fresh battery was used at the start of the series of tests for each configuration. Conclusions were drawn from analysis of the plots of power dissipated vs time and power vs distance.

The plots in Figures 8 and 9 in Appendix D show power dissipation was consistent between the trail runs for each setup. The average energy dissipated by the 1-motor setup was approximately 46% less than the 2-motor setup, as summarized in Table 1. An energy savings of almost half was expected due to using half the number of motors.

Table 1 also summarizes the second major finding: that distance traveled by the 1-motor configuration was on average 79% less than distance traveled by the 2-motor setup. Therefore, despite the power savings of using only one motor, adding a second motor was more efficient since the performance gains outpaced the increased energy draw.  In addition, the 2-motor setup suffered far less performance degradation than the 1-motor setup through successive test runs (Figs 10 & 11, Appendix D).  This suggested that performance deficits of the single motor vs the dual motors would increase with workload due to battery voltage depletion.

**Table 1:** Summary of average values for 1-motor and 2-motor test setups

| Test Configuration | Average Energy Dissipated (J) | Average Distance Traveled (m) |
|---|---|---|
| 2-Motor | 38.4 | 5.6 |
| 1-Motor | 20.7 | 1.2 |
| Percent Difference[1] | 46% | 79% |

[1] % difference determined as:  (2-motor — 1-motor) / 2-motor

Motor Quantity Takeaways:

- Power output was consistent between runs for each configuration
- Power consumption of the 1-motor setup was 46 % less than the 2-motor
- Distance traveled by the 1-motor setup was 79 % less than the 2-motor
- Battery fatigue affected the performance of the 1-motor setup significantly more than the 2-motor
- Two motors will be more efficient and effective during future trial runs

**Limitation Analysis:**

In completing the procedure for aR&D, a few limitations were encountered. For example, in the Motor Configuration test, there was a lot of time needed to reconstruct each AEV design for testing. The team felt this as a limitation because it was time that could have been spent being more productive elsewhere, such as developing final code. An overall limitation for any group would have been the AEV design. Group F's AEV design and position of wires limited the clearance for propellers, and therefore limited the number of configurations available for testing.

Also noted by the team was that only one propeller size was tested in the Motor Configuration lab, as opposed to the two options that were available. This may have had a small impact on the data gathered. For the second research project conducted, Motor Quantity, the team was able to test only up to two motors. Although the aR&D testing protocol allowed for three motors, time did not permit. This limited the ability of the team to find the most efficient quantity of motors for the AEV. A final limitation found when completing aR&D was the code used. Throughout the research process, the team only used the test CSS1 code (Appendix A), which is mainly time based function calls, like "goFor();". However, this is now seen as a limitation by Group F, as using a code with more position based function calls, such as "goToPosition();", would have proven to be more effective for the final test code.

## Weeks 8 – 12

Situation

Using the results from aR&D, it was decided that the AEV would function most efficiently with two pushing motors mounted on "wings" that were tilted upwards. Using this final design, the next task will be to write the final code for the AEV track project. In addition to determining whether to use absolute or relative positioning, which brake method to apply will also need to be decided (allowing the AEV to coast to a stop, pumping the motors in reverse, or constructing a brake servo). Multiple Performance Tests will also be conducted in the next couple weeks and will provide further assistance in determining how well the AEV code is functioning.

Weekly Goals

1) Determine whether to use relative or absolute positioning in the final code.
2) Write a first draft code for the final task, breaking before the gate does not need to be accurate at the beginning stage.
3) Test different braking methods and determine which method is the most accurate.
4) If servo brake is chosen: build the servo and determine the angle needed to stop the wheels efficiently.
5) Revise the final code to include the braking method.
6) Test this final code and make sure all requirements are fulfilled.
7) (Use the Performance Tests to further observe the AEV's progress and document any errors that occur during the tests for future discussion.)

Weekly Schedule

| Task | Due Date | Time Needed | Teammates(s) |
|---|---|---|---|
| • Decide whether to use absolute or relative positioning.<br>• Write the first draft of the final code (forward part only).<br>• Test different braking methods with the code and determine which method is the most efficient. | 3/8/2018 11:59PM | As needed | Everyone |
| • (Possibly build the servo arm if needed and determine the angle for accurate breaking.)<br>• Revise the code to include the breaking method. | 3/19/2018 11:59PM | As needed | Everyone |
| • Performance Test 1<br>• Document any errors that occur during the Performance Test.<br>• Discuss possible ways to increase efficiency.<br>• Revise the code in response to any errors that occured. | 3/21/2018 11:59PM | As needed | Everyone |
| • Continue the code revisions to include the rest of the AEV track requirements.<br>• Test and revise the code until repeatable positive results occur. | 3/26/2018 11:59PM | As needed | Everyone |
| • Performance Test 2<br>• Document any errors that occur during the Performance Test.<br>• Discuss possible ways to increase efficiency.<br>• Revise the code in response to any errors that occured. | 3/28/2018 | As needed | Everyone |

# Appendix A: Arduino Code

| Function Call | Function |
| --- | --- |
| celerate(m,p1,p2,t); | Accelerates or decelerates motor(s) m from start speed (%) p1 to end speed (%) p2 over a duration of t seconds |
| motorSpeed(m,p); | Initializes motor(s) m at their percent power p |
| goFor(t); | Runs the motor(s) at their intialized state for t seconds |
| brake(m); | Brakes motor(s) m. Note: Just stops the motors from spinning |
| reverse(m); | Reverse the polarity of motor(s) m |
| goToRelativePosition(n); | Continues the previous command for n marks from the vehicle's current position. n can be positive or negative with positive meaning the vehicle is moving forward, negative meaning the vehicle is moving backward |
| goToAbsolutePosition(n); | Continues the previous command for n marks relative to the overall starting position of the AEV |

**Figure 1:** Arduino function calls.

CSS1 Test Code:

```
reverse(4); //Reverses polarity of all motors, used to counteract direction of motors on AEV
celerate(4,0,25,3);// Accelerates all motors from 0 to 25% power in 3 seconds
motorSpeed(4,25); // Initializes all motors at 25% power
goFor(1);// Runs motor at initialized power for 1 seconds
motorSpeed(4,20); // Initializes all motors at 20% power
goFor(2); // Runs motor at initialized power for 2 seconds
reverse(4); //Reverses polarity of all motors
motorSpeed(4,25); // Initializes all motors at 25% power
goFor(2); // Runs motor at initialized power for 2 seconds
brake(4); // Stops all motors from spinning
```

# Appendix B: Team Meeting Minutes

# Watts Scientific Team F Meeting Minutes

**Date:** 1/17/18
**Time:** 5:00 – 7:00 PM (In person)
**Members Present:** Keith Cummings, Madison Morgan, Norbert Ung, Tessa Gilmore
**Topics Discussed:** Team introductions, Website Update 1, Initial AEV setup

**Objective:**
The objective of this meeting was for the team to get to know each other, assign initial responsibilities, discuss the upcoming first set of deliverables and build the initial setup for the AEV.

**Progress Prior to Meeting:**
- Company landing page was created (MM)

**To Do / Action Items:**
- Set up TA's as administrators for the website (MM)
- Set up team member contact page on website (NU)
- Each team member will fill in their own contact info on webpage
- Upload minutes to Carmen (KC)
- Upload website link to Carmen (KC)

**Decisions:**
- Initial prototype of the AEV was built according to sample documentation
- Team roles:
  - KC: Team notetaker
  - MM: Website manager
  - NU: Lead programmer
  - TG: Transporter
- The team developed an outline for our approach to designing the AEV, which is on the website

**Reflections:**
- TG: Our team should work on taking better pictures during construction revisions

# Watts Scientific Team F Meeting Minutes

**Date:** 1/31/2018
**Time:** 5:30-7
**Members Present:** All members Present
**Topics Discussed:** Website update 2, Creative Design Thinking

**Objective:**
To compile individual team concepts into one initial AEV design concept for further testing. Also, organize jobs for website update 2.

**To Do / Action Items:**
– Upload pictures under "Team Contact Information"(All)
– Create new team design(All)
– Sketch new team design-(Tessa)
– Upload reflectance sensor picture/info(Keith)
– Work on Website 2 update(Maddie and Norbert)

**Decisions:**
– Use cross shape base for design
– No wings on design
– Battery location moved

**Reflections:**
-Be thorough in documentation as research in lab progresses (pictures, sketches, notes, etc.)

# Team F Meeting Minutes

**Date:** February 3, 2018
**Time:** 10:00am – 12:30pm
**Members Present:** Tessa Gilmore, Madison Morgan, Norbert Ung, Keith Cummings
**Topics Discussed:** Concept screening and scoring; Progress Report Deliverables

**Objective:**
The objective of this meeting was to screen and score our possible designs and decide which to carry forward. Additionally, we assigned duties for the upcoming progress report.

**To Do / Action Items:**

- 10:05: Discussed Meeting goals
- 10:15: Completed concept screening for each design
- 11:00: Complete concept scoring for each design
- 11:45: Chose designs to carry forward and assembled Keith's design
- 12:00: Assigned responsibilities for the progress report

**Decisions:**

- We decided to carry forward Keith's and Norbert's designs with modifications
- Tessa and Madison will lead progress report on past accomplishments
- Keith and Norbert will lead progress report on future plans

# Team F Meeting Minutes

**Date:** 2/14/18
**Time:** 5 – 6 pm
**Members Present:** Keith Cummings, Tessa Gilmore, Madison Morgan and Norbert Ung
**Topics Discussed:** Grant Proposal and Committee Meeting 1

**Objective:**
- To prepare a grant proposal for a 3-D printed part for our AEV.
- To prepare for upcoming committee meetings

**To Do / Action Items:**
- Prepare Solidworks drawing for grant proposal (TG & MM)
- Prepare Powerpoint slide (NU)
- Gather and submit documents for committee meetings (KC)

**Decisions:**
- Our team decided to focus on proposing a battery case for the AEV
- Committee meeting assignments:
  - Human Resources: (NU)
  - Research and Development: (TG & KC)
  - Public Relations: (MM)

# Team F Meeting Minutes

**Date:** 2/28/18
**Time:** 5 – 6 pm
**Members Present:** Keith Cummings, Tessa Gilmore, Madison Morgan and Norbert Ung
**Topics Discussed:** Website Update 3; R&D Oral Presentation

**Objective:**

- To prepare determine website updates and assign responsibilities.
- To prepare for upcoming R&D presentation

**To Do / Action Items:**

- Update website with design evolution (TG)
- Add aR&D 1 info to website (NU, MM)
- Add aR&D 2 info to website (KC)
- Create Powerpoint slides (TG, MM, NU, KC)

**Decisions:**

- Presentation responsibilities:
    - TG: design evolution / background / intros
    - NU: aR&D 1: Motor configuration
    - KC: aR&D 2: Motor quantity
    - MM: limitations / looking forward

# Appendix C: Motor Configuration Figures

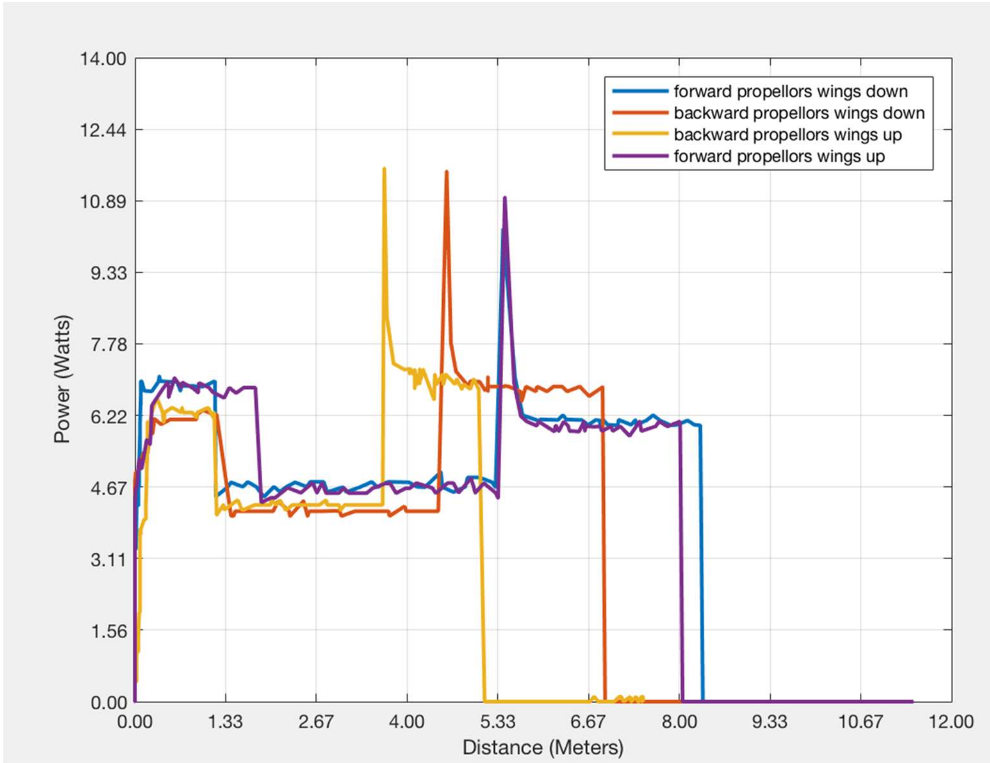


**Figure 2:** Two Motor Configuration: Power vs. Distance

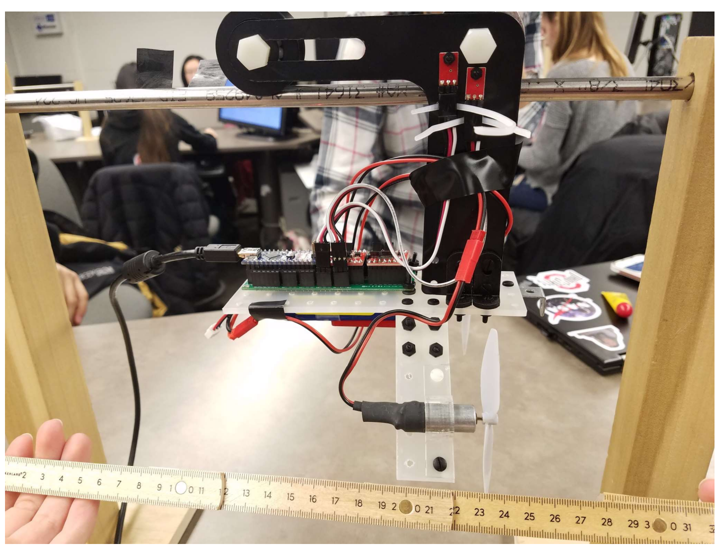

**Figure 3:** Motor configuration: motor backward, wings down

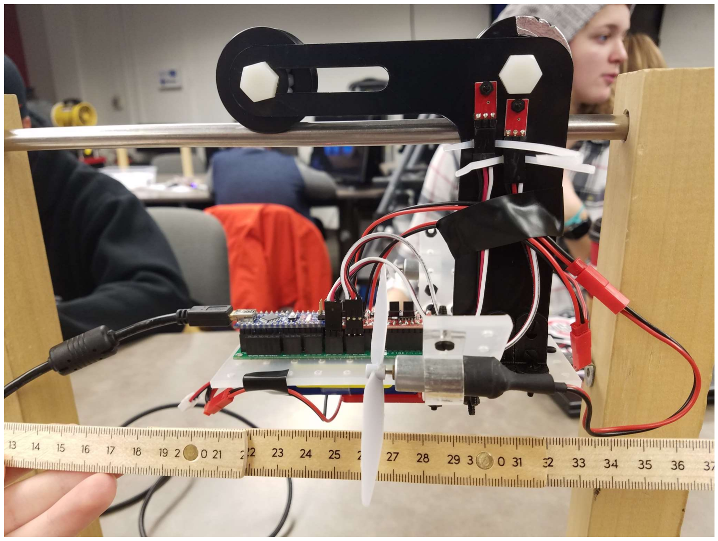

**Figure 4:** Motor configuration: motor forward, wings up

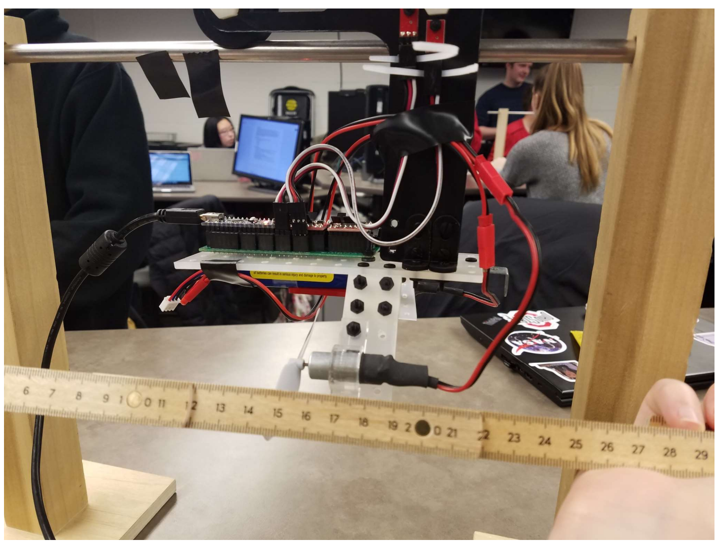

**Figure 5:** Motor configuration: motor backward, wings down

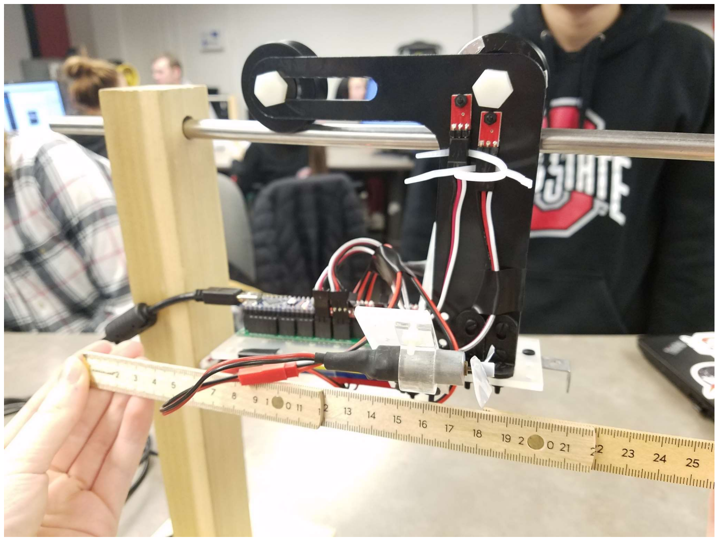

**Figure 6:** Motor configuration: motor forward, wings up

# Appendix D: Motor Quantity Figures

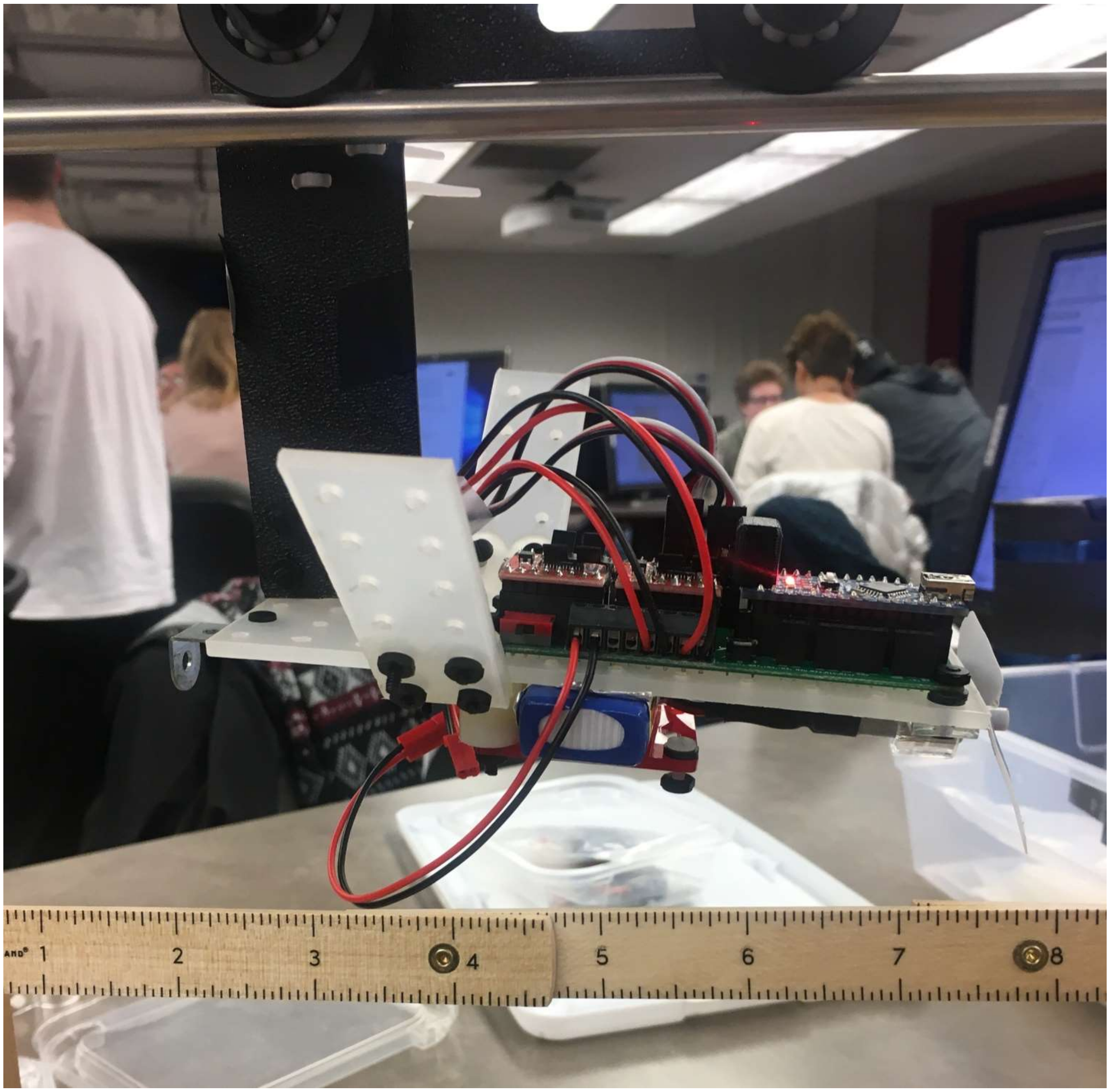


**Figure 7:** Configuration of the 1-motor test setup

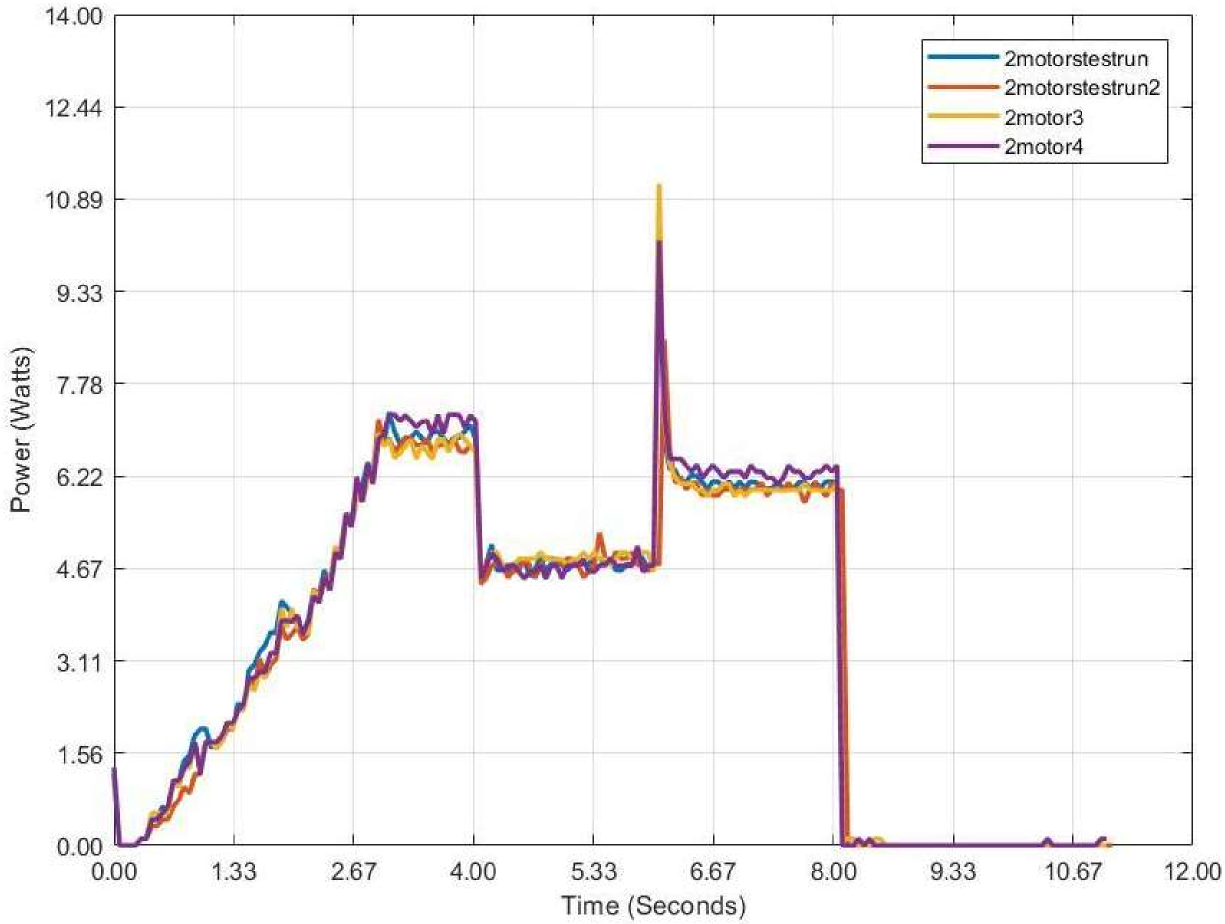


**Figure 8:** Power vs time for two-motor configuration

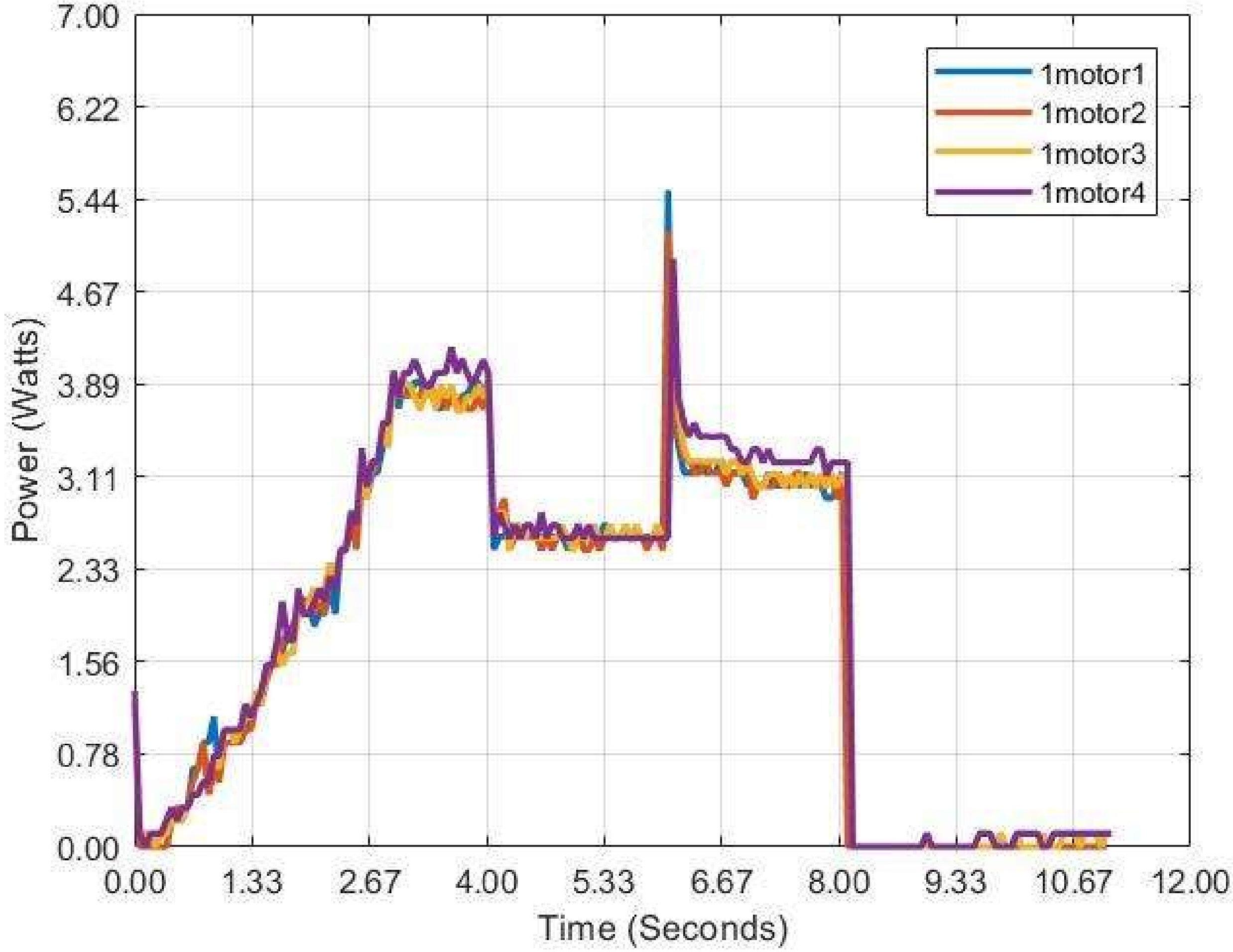


**Figure 9:** Power vs time for one motor configuration

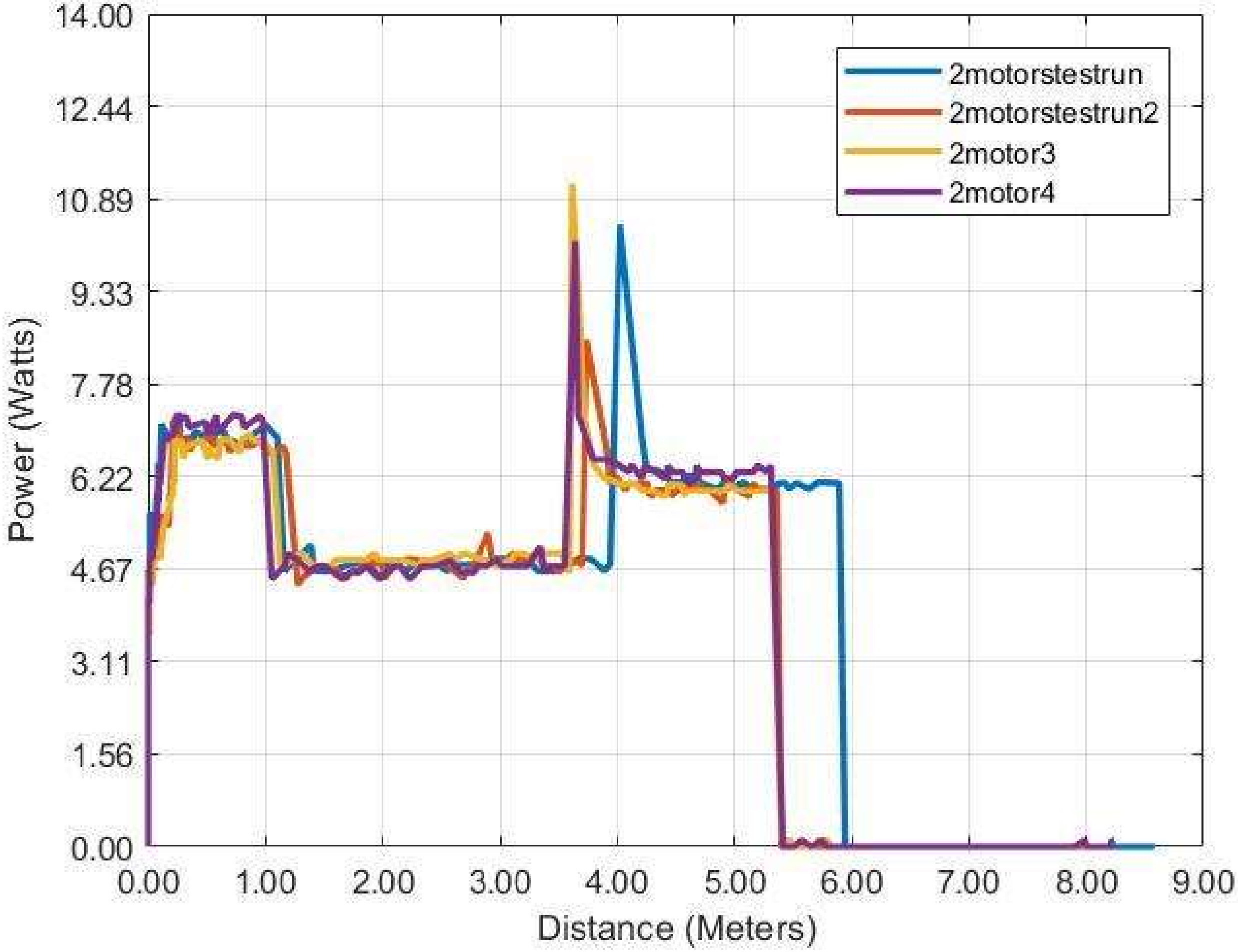


**Figure 10:** Power vs distance for two motor configuration

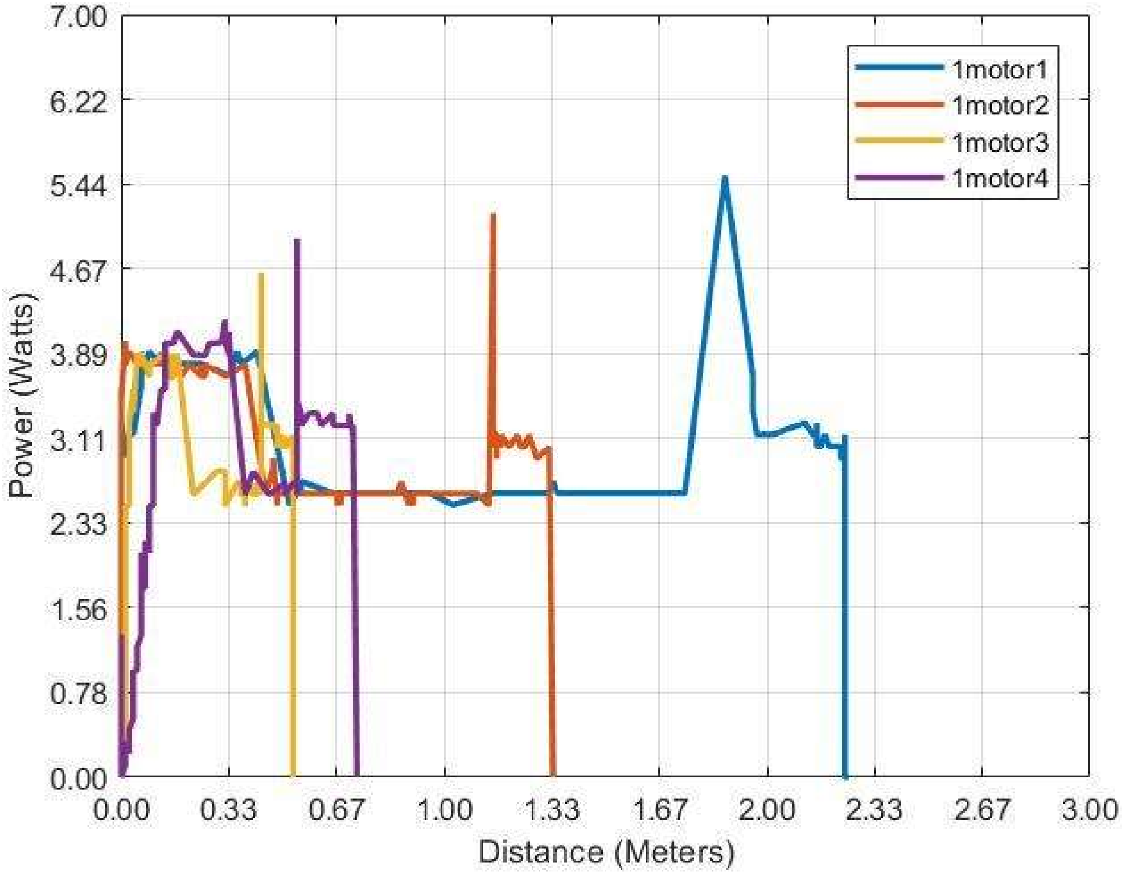


**Figure 11:** Power vs distance for one motor configuration