Week 4

Situation

This week's lab was split into two halves, in which the group was familiarized with data gathering and analysis. The first half of the lab introduced the idea of downloading, converting, calculating and analyzing data, while the second half unveiled the MATLAB design analysis tool, which could perform those same conversions and calculations much more efficiently. In the first half of the lab, the group created a program which had the AEV travel to the first stop. After running the AEV on the monorail, the group downloaded the data to an Excel file. After the data was downloaded, the group moved onto the second half of the lab, due to time constraints. The group finished the conversions, calculations and graphs outside of lab, at a later time.

After the data was downloaded, the group moved on to the second half of the lab. The pre-built MATLAB design analysis tool was downloaded, and the data was imported into the tool. This was done by connecting the AEV controller to the PC via the given USB cord, and the "Download Arduino Data" command, which was listed under Tools. The group then created two graphs, one depicting power vs. time while the other displayed power vs. distance. The graphs were exported to be used for future documentation.

From this point on, the AEV project will be transitioning into the main design cycle. This cycle will consist of analyzing data, building improvements on the AEV based on the data and comparing the new design to the old. Given this, it is important that the group knows how to calculate, convert and understand the recorded data in the future. Lab 04a allowed the group to understand all the intricacies of AEV data, as the group calculated all relevant values. However, the data calculations in Lab 04a were cumbersome and time-consuming, but the introduction of the MATLAB design analysis tool will allow for more efficiency with data analysis, which in turn allows for more time to be spent focusing on other aspects of the project, namely AEV design development.

Results & Analysis

The Arduino code written for the AEV's test run simply reversed the motors to orient them correctly for forward motion, set the motor speed to 25%, ran to a relative position corresponding to the desired location on the track, reversed to begin slowing down the motors, and then braked all motors. The team had issue properly uploading the code to the Arduino due to a software error and therefore had multiple failed runs, but once the code was successfully uploaded, the run was completed.

The EEPROM data collected from the Arduino for this run was converted into usable units with MATLAB array math commands. From this data, a plot of power vs. time was created, as shown below:

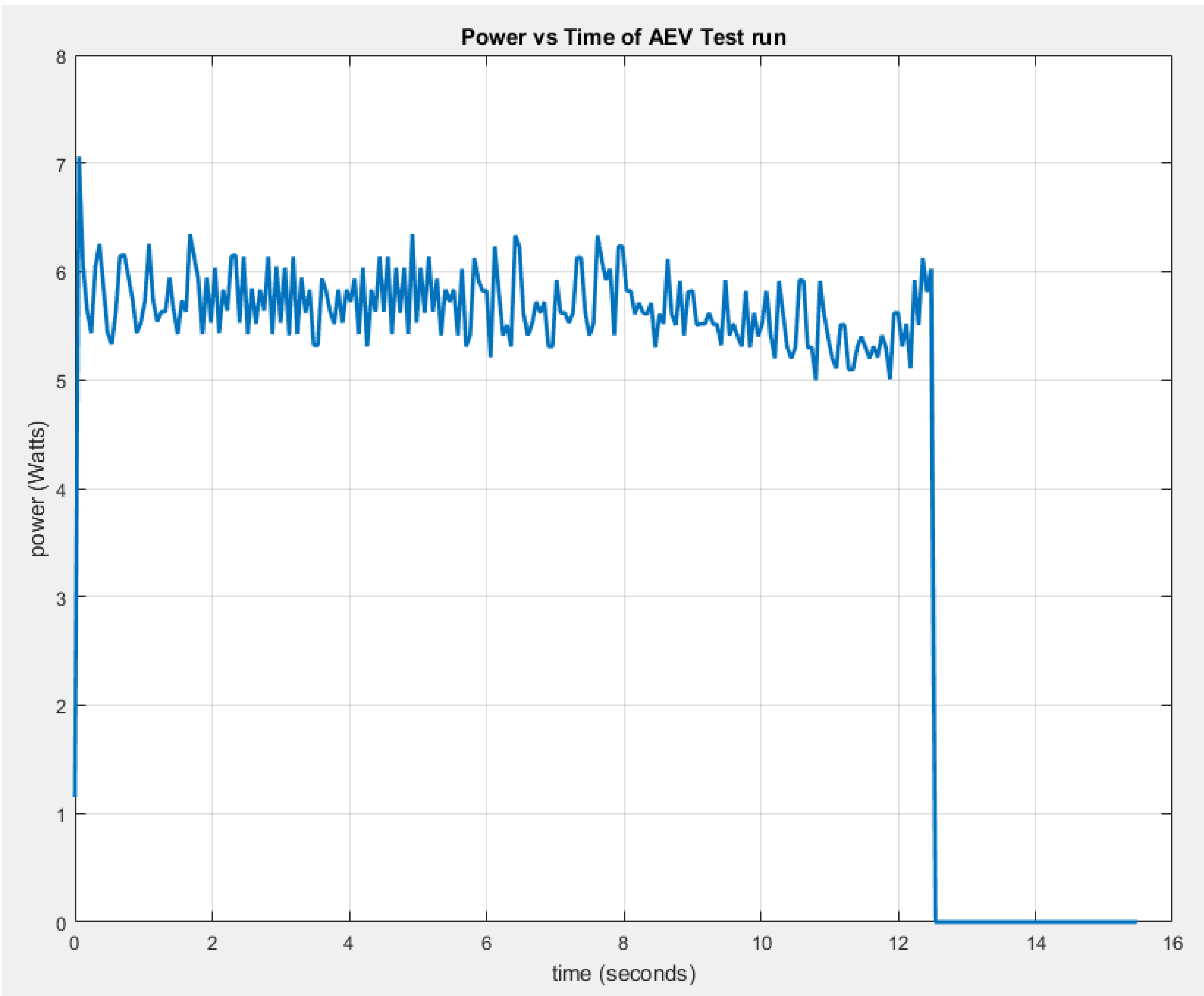

Figure 1: MATLAB Power vs Time graph

From the MATLAB programming in Lab 4A, the following phase breakdown plot was also created:

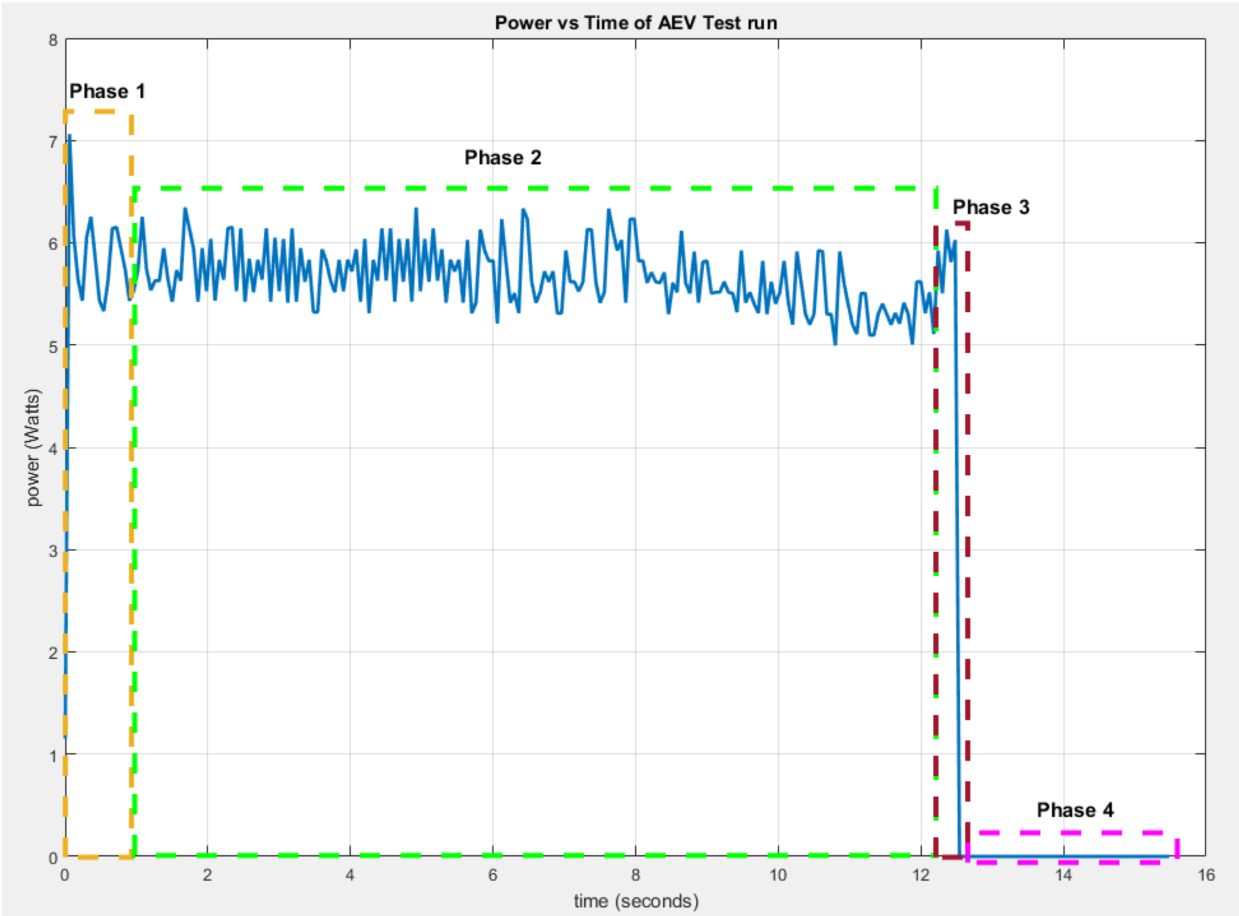

Figure 2: Phase Breakdown Graph

The power vs. time plot was broken into four phases which each highlight a different part of the task as well as the Arduino code. The following table reflects the phase breakdowns:

Phase	Arduino Code	Time (seconds)	Total Energy (Joules)
1	reverse(4); motorSpeed(4, 25);	0 - 0.96	5.4901
2	goToAbsolutePosition(380);	0.96 - 12.121	63.1831
3	reverse(4);	12.121 - 12.48	2.055
4	brake(4);	12.121-15.48	0.1808
		Total Energy Used:	70.9090

From these data, it is shown that our power usage was fairly constant through the actual running portion of the test. This is likely due to the fact that the motors were set to run at a constant speed for the entire duration of the run, until the destination was reached. Only when the AEV slowed to a stop did the power change. In order to optimize power in the future, it may be ideal to not have the motors running at a constant speed the entire run but rather in shorter bursts. This could propel the AEV while using less power.

The graphs gathered during the second half of the lab are listed below. The graphs show the data of the created program, which detailed power with respect to both time and distance.

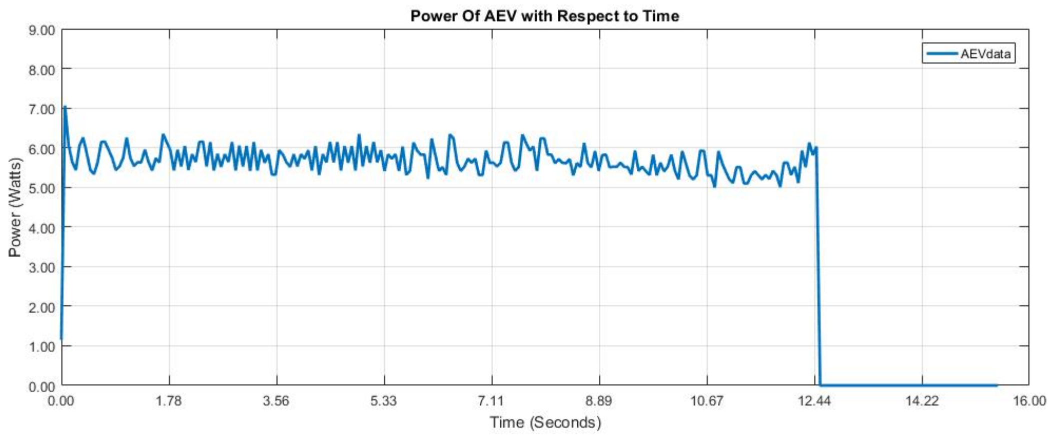

Figure 3: Analysis Tool Power vs. Time Graph

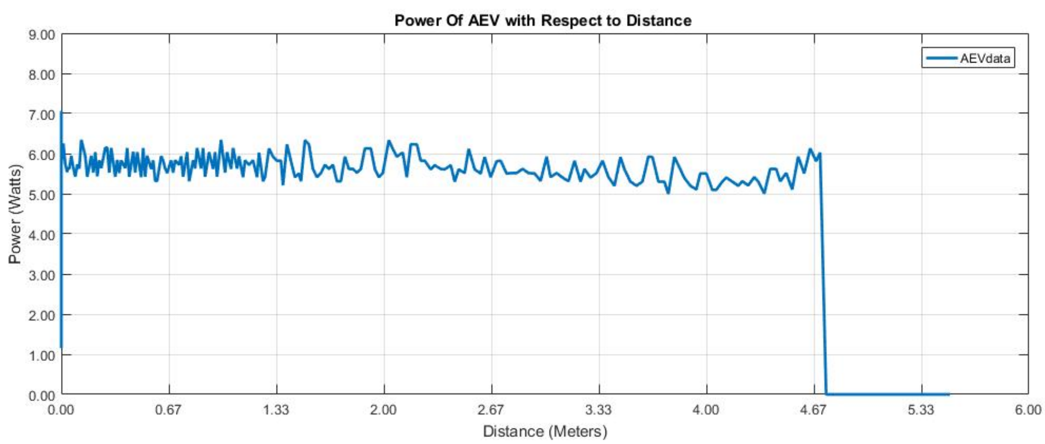

Figure 4: Analysis Tool Power vs. Distance Graph

The data of the graphs reflected the actions of the code used to run the AEV. At first, motors were set to run at 25 percent power, which was signaled by the sharp increase of power in the very first part of the graph. The AEV was coded to go to the absolute position of 380 marks at 25 percent power. It was noted that 380 marks is approximately 185.25 inches. 185.25 inches was calculated to be about 4.71 meters. The group observed that this was approximately where the radical decrease of power occurred in the power vs. distance graph. This was due to the fact that once the AEV reached the absolute position of 380 marks(4.71 meters), it was coded to reverse the motors to slow down the AEV and then break.

Moving forward, there will be numerous tasks to be completed in a timely manner to finish the goal of the AEV project on time. The following rough schedule was created to aid in planning for the balance of the project:

Task	**Teammate(s)**	**Start Date**	**Due Date**	**Time Needed**
Organize Project Portfolio	All	2/13/17	2/21/17	30 Minutes
Add Unincluded Progress Reports to the Project Portfolio	All	2/13/17	2/21/17	15 Minutes
Complete PDR Worksheet	All	2/15/17	2/21/17	30 Minutes
Prepare for PDR Presentation	All	2/15/17	2/28/17	5 Hours
Complete PDR Report	All	2/29/17	3/27/17	6 Hours
Complete Oral Presentation Draft	All	3/28/17	4/7/17	5 Hours
Prepare for Oral Presentation	All	3/28/17	4/18/17	>5 Hours
Complete Final Project Report	All	3/28/17	4/21/17	>5 Hours
Finalize Project Portfolio	All	4/1/17	4/21/17	3 Hours

Takeaways

1) General-Team J used the method of trial and error when coding the AEV for Lab 4. The main objective of the lab was to create a code that would move the AEV a quarter of a revolution around the overhead tracks, and cause it stop at least almost precisely at that exact point on the track. At first the group struggled to use the correct position command with the correct distance. The AEV would easily surpass the distance it was required to stop at numerous times before the team discovered that there was a problem with the sensors causing them to not read the AEV's distance properly. Once that problem was fixed, the team successfully created a code that caused the AEV to complete all required actions for Lab 4.
2) AEV Code-It was required of the AEV to travel approximately a quarter of a revolution around the overhead tracks during Lab 4. Our code included position commands that can be used in later labs, and during performance tests when trying to complete the Mission Concept Review. The team at least now has an idea as to what will need to incorporated into the position commands when trying to complete the Mission Concept Review.

Week 5

Situation

In the coming week, the group will be exposed to various methods of decision making. More specifically, the group will learn of concept screening and concept scoring. Concept screening is a more generalized method in which several designs can be compared to one baseline design. Certain features of the considered designs will be evaluated, and if any feature is better or worse, a '+' or '-' will be assigned respectively. Also, if a feature is deemed to be equal to the baseline design's feature, then a '0' will be assigned. The addition signs, subtraction signs and zeros will all be summed to get a general idea of the best design tested. A more advanced method that will be used is concept scoring. Concept scoring has the same general idea as concept screening, but instead of using signs, concept scoring will incorporate numbers. Concept scoring will lead to a more definite solution.

The group will build an AEV design created from the Creative Design Lab, taking care to not mount the wheel sensors. After the design has been created, the group will then proceed to create a program to use with the AEV, and then test said program. Following the test, the group will create criteria which will be used to evaluate AEV designs. Using this criteria, the group will then evaluate all of the design ideas created in the Creative Design Lab, with the sample AEV serving as a baseline of comparison. The method of evaluation the group will use will be concept screening. In the future, the group will have to evaluate many different types of AEV designs. It is important that the group learns of effective and efficient ways of comparing designs, as the group will benefit from this in the long-term, when many different designs will need to be compared.

Weekly Goals

1) Properly prepare for the lab by reading through the lab manual on Carmen, and completing the pre-lab quiz.
2) Finish the Progress Report for Lab 5 before the deadline of Tuesday, February 14th, and submit it on Carmen.
3) Organize the Project Portfolio on U.osu.edu to incorporate the proper format, and only the pertinent sections of all lab documentation.
4) Add any additional progress reports, specifically the Progress Report for Lab 5, that have not yet already been included into the Project Portfolio.

Weekly Schedule

Task	Teammate(s)	Start Date	Due Date	Time Needed
Progress Report for Lab 5	All	2/7/17	2/14/17	4 Hours
Preparation for Lab 5	All	2/13/17	2/14/17	30 Minutes
Organize Project Portfolio	All	2/13/17	2/28/17	30 Minutes
Add Unincluded Progress Reports to the Project Portfolio	All	2/13/17	2/28/17	15 Minutes

Appendix A

Date: 2/13/17
Time: 5:30 P.M.
Members Present: Tarun Pilli, Matthew Caldwell, John Kim & Jacob Phillips
Topic(s) Discussed: Progress Report for Lab 5, and organization of the Project Portfolio.

Objective:
Team J met on Monday, February 13th in order to complete the Progress Report for Lab 5, and to organize the project portfolio in order to stay on track with the various AEV project deadlines.

Tasks:
-Progress Report for Lab 5
All team members met before the deadline day for the Progress Report for Lab 5 in order to complete it on time with a satisfactory quality that the group was pleased with. The report had been started before the team meeting, and was completed before the team members had adjourned.
-Organization of the Project Portfolio
The team briefly discussed how it intended to organize the Project Portfolio on U.osu.edu before completing the task. Although it was discussed during the team meeting, it was not completely until after the meeting had ended and the final copy of the Progress Report for Lab 5 had been completed.

To Do/Action Items:
-Prepare for Lab 5 by reading the lab manual and completing the quiz on carmen before coming to class(All Members)

Reflection:
Team J was able to complete the Progress Report for Lab 5 on time before the dealing of February 14th. Also, each team member was able to complete the required individual sections of the progress report. The organization of the Project Portfolio was briefly discussed, and was completed after the team meeting with all team members contributing. Thus far the team has not come up against any hindering obstacles whether it be in lab or outside of class to complete lab documentation .

Appendix B

<u>Team Role: Matthew</u>

As necessary tasks have been divided to be completed amongst all of the team members, each individual's role will be to contribute what they are most suited to in order to complete the goal optimally. This has thus far meant that Matthew's role has largely been writing most of the code for the Arduino and data analysis. As a computer science major, Matthew is able to complete the code quickly and efficiently. He has also been able to contribute technical writing skills to the creation of the lab reports. Going forward, Matthew's role will continue to call for coding and technical writing but will also require utilization of creative design and problem-solving skills.

<u>Team Role: John</u>

Among all the group member's works in preparation for the AEV labs, John's role in the group can be mostly appreciated by his works of construction of the AEV. His ideas, as a pre-Aerospace Engineering student, can be considered to produce the best and the most efficient AEV. John also assists with understanding the lab and contributes his own ideas to the group during the lab. He helps with the production of progress reports in small works, and helps do many small, yet crucial things to help the group. John's role will continue to grow and focus on making sure the labs are done correctly.

<u>Team Role: Jacob</u>

The AEV project consists of many different parts, and usually there is a deadline for a progress report every week. Jake's role within Team J is to organize the progress reports, and the overall schedule for the team. Overall the work has been distributed well between the team members, and having a set schedule every week to organize everyone's work helps in meeting all of the various project deadlines. Also, at the beginning of the project, Jake did have the responsibility of holding onto the AEV between classes, but eventually that duty fell to Matthew simply due to convenience. Since then Jake's main duty has been keeping the lab documentation organized along with the team as whole by setting schedules and weekly goals, and he works every week on the progress reports with the other team members.

<u>Team Role: Tarun</u>

Tarun's responsibilities will be focused mainly around the progress reports and the design of the AEV. Bringing forth his technical writing skills, he will primarily write the situations for both the forwards looking plan and the backwards looking summary. Also, he will contribute to the results and analysis. Alongside his writing responsibilities, Tarun will also assist with the physical aspects of the AEV project. In the future, Tarun will be sure to cooperate with the others to improve upon the AEV's design.

Appendix C

Sample Calculations
Matthew Caldwell
Team J; Seat 37; Dr. Phil Schlosser
Data Point 60

Time

$t = Time\ (seconds) = 3.541\ s$

$t_e = EEPROM\ time\ (milliseconds) = 3541\ ms$

$$t = \left(\frac{t_e}{1000}\right)$$

$$t = \left(\frac{3541}{1000}\right)$$

$$t = 3.541\ seconds$$

Current

$I = Current\ (amps) = 0.6753\ Amps$

$I_e = EEPROM\ Current\ (ADC\ Counts) = 52\ Counts$

$V_r = Arduino\ Reference\ Voltage = 2.46\ Volts$

$$I = \left(\frac{I_e}{1024}\right) * V_r * \left(\frac{1\ Amp}{0.185\ Volts}\right)$$

$$I = \left(\frac{52}{1024}\right) * 2.46 * \left(\frac{1\ Amp}{0.185\ Volts}\right)$$

$$I = 0.0508 * 2.46 * 5.4054$$

$$I = .6753\ Amps$$

Voltage

$V = Voltage\ (volts) = 7.8809\ Volts$

$V_e = EEPROM\ Voltage\ (ADC\ Counts) = 538\ Counts$

$$V = \frac{15 * V_e}{1024}$$

$$V = \frac{15 * 538}{1024}$$

$$V = 7.8809\ Volts$$

Distance

$d = Distance(meters) = .5952\ meters$

$marks = wheel\ counts\ accumulated\ by\ reflectance\ sensors = 48\ marks$

$$d = 0.0124 * marks$$

$$d = 0.0124 * 48$$

$$d = .5952\ meters$$

Position

$$s = 0.0124 * pos$$

$$s = 0.0124 * \ 46\, marks$$

$$s = \ .5704\, meters$$

$$\text{s} = AEV\ Position\ (meters) = .5704\, meters$$

$$pos = wheel\ counts\ recorded\ by\ reflectance\ sensors = 46\, marks$$

Supplied Power

$$P = V * I$$

$$P = 7.8809 * \ .6753$$

$$P = 5.3220\, Watts$$

$$P = Input\ or\ Supplied\ Power(watts) = \ 5.3220\, Watts$$

$$V = Voltage\ (volts) = 7.8809\, volts$$

$$I = Current\ (amps) = \ .6753\, amps$$

Incremental Energy

$$E_j = \left(\frac{P_j + P_{j+1}}{2}\right) * (t_{j+1} - t_j)$$

$$E_j = \left(\frac{5.3220 + 5.9356}{2}\right) * (3.601 - 3.541)$$

$$E_j = 5.6288 * \ 0.06$$

$$E_j = \ .3377\, Joules$$

$$E_j = Incremental\ Energy(Joules) = \ .3377\, Joules$$

$$j = Data\ Point = 60$$

$$P_j = Power\ at\ Data\ Point(watts) = 5.3220\, watts$$

$$P_{j+1} = Power\ at\ Next\ Data\ Point(watts) = 5.9356\, watts$$

$$t_j = Time\ at\ Data\ Point(seconds) = 3.541\, seconds$$

$$t_{j+1} = Time\ at\ Next\ Data\ Point\ (seconds) = 3.601\, seconds$$

Sample Calculations

John Kim

Team J; Seat 38; Dr. Phil Schlosser

Data Point 50

Time = EEPROM time (ms) / 1000

Time

$$t = \left(\frac{t_e}{1000}\right)$$

$$t = (\frac{2941}{1000})$$

$$t = 2.941\ seconds$$

$t = Time\ (seconds) =$ 2.941 seconds
$t_e = EEPROM\ time\ (milliseconds) =$2941 milisecons

Current = (EEPROM current / 1024) * V_R * (1 Amp / 0.185 Volts)

Current

$$I = \left(\frac{I_e}{1024}\right) * V_r * (\frac{1\ Amp}{0.185\ Volts})$$

$$I = (\frac{59}{1024}) * 2.46 * (\frac{1\ Amp}{0.185\ Volts})$$

$$I = 0.1417 * 5.4054$$

$$I = 0.7662\ Amps$$

$I = Current\ (amps) = 0.762\ Amps$
$I_e = EEPROM\ Current\ (ADC\ Counts) = 59\ Counts$
$V_r = Arduino\ Reference\ Voltage = 2.46\ Volts$

Voltage = (15* V_E) / 1024

Voltage

$$V = \frac{15 * V_e}{1024}$$

$$V = \frac{15 * 539}{1024}$$

$$V = 7.6442\ Volts$$

$V = Voltage\ (volts) = 7.6442\ Volts$
$V_e = EEPROM\ Voltage\ (ADC\ Counts) = 539\ Counts$

Distance = 0.0124 * marks

Distance

$$d = 0.0124 * marks$$

$$d = 0.0124 * 36$$

$$d = \ 0.4464\, meters$$

$$d = Distance(meters) = \ 0.4464\, meters$$

$$marks = wheel\ counts\ accumulated\ by\ reflectance\ sensors = \ 36\, marks$$

Position = 0.0124 * pos

Position

$$s = 0.0124 * pos$$

$$s = 0.0124 * \ 34\, marks$$

$$s = \ 0.4216\, meters$$

$$\mathrm{s} = AEV\ Position\ (meters) = 0.4216\, meters$$

$$pos = wheel\ counts\ recorded\ by\ reflectance\ sensors = 34\, marks$$

Supplied Power = Voltage * Current

Supplied Power

$$P = V * I$$

$$P = 7.8955 * \ 0.7662$$

$$P = 6.049\, Volts$$

$$P = Input\ or\ Supplied\ Power(watts) = \ 6.148\, watts$$

$$V = Voltage\ (volts) = 7.8955 volts$$

$$I = Current\ (amps) = \ 0.7662\ amps$$

Incremental Energy

Incremental Energy

$$E_j = \left(\frac{P_j + P_{j+1}}{2}\right) * (t_{j+1} - t_j)$$

$$E_j = \left(\frac{6.0492 + 5.5263}{2}\right) * (3.001 - 2.941)$$

$$E_j = 5.78775 * \ 0.06$$

$$E_j = \ 0.3473\ Joules$$

$$E_j = Incremental\ Energy(Joules) = 0.3473\ Joules$$

$$j = Data\ Point = 50$$

$$P_j = Power\ at\ Data\ Point(watts) = \ 6.0492\ watts$$

$$P_{j+1} = Power\ at\ Next\ Data\ Point(watts) = \ 5.5263 watts$$

$$t_j = Time\ at\ Data\ Point(seconds) = 2.941\ seconds$$

$$t_{j+1} = Time\ at\ Next\ Data\ Point\ (seconds) = \ 3.001\ seconds$$

Sample Calculations
Jacob Phillips
Team J; Seat 39; Dr. Phil Schlosser
Data Point 70

Time

$$t = \left(\frac{t_e}{1000}\right)$$

$$t = (\frac{4441}{1000})$$

$$t = 4.441\ seconds$$

$$t = Time\ (seconds) = 4.441\ s$$

$$t_e = EEPROM\ time\ (milliseconds) = 4441\ ms$$

Current

$$I = \left(\frac{I_e}{1024}\right) * V_r * (\frac{1\ Amp}{0.185\ Volts})$$

$$I = (\frac{53}{1024}) * 2.46 * (\frac{1\ Amp}{0.185\ Volts})$$

$$I = 0.0518 * 2.46 * 5.4054$$

$$I = 0.6888\ Amps$$

$$I = Current\ (amps) = 0.6888\ Amps$$

$$I_e = EEPROM\ Current\ (ADC\ Counts) = 53\ Counts$$

$$V_r = Arduino\ Reference\ Voltage = 2.46\ Volts$$

Voltage

$$V = \frac{15 * V_e}{1024}$$

$$V = \frac{15 * 538}{1024}$$

$$V = 7.8809\ Volts$$

$$V = Voltage\ (volts) = 7.8809\ Volts$$

$$V_e = EEPROM\ Voltage\ (ADC\ Counts) = 538\ Counts$$

Distance

$$d = 0.0124 * marks$$

$$d = 0.0124 * 61$$

$$d = 0.7564\ meters$$

$$d = Distance(meters) = 0.7564\ meters$$

$$marks = wheel\ counts\ accumulated\ by\ reflectance\ sensors = 61\ marks$$

Position

$$s = 0.0124 * pos$$

$$s = 0.0124 * \ 59\ marks$$

$$s = \ 0.7316\ meters$$

$$\text{s} = AEV\ Position\ (meters) = 0.7316\ meters$$

$$pos = wheel\ counts\ recorded\ by\ reflectance\ sensors\ 59\ marks$$

Supplied Power

$$P = V * I$$

$$P = 7.8809 * 0.6888$$

$$P = 5.428\ Volts$$

$$P = Input\ or\ Supplied\ Power(watts) = \ 5.428\ watts$$

$$V = Voltage\ (volts) = 7.8809\ volts$$

$$I = Current\ (amps) = \ .7792\ amps$$

Incremental Energy

$$E_j = \left(\frac{P_j + P_{j+1}}{2}\right) * (t_{j+1} - t_j)$$

$$E_j = \left(\frac{5.4239 + 6.0379}{2}\right) * (4.2010 - 4.1410)$$

$$E_j = 5.7309 * \ 0.06$$

$$E_j = \ 0.3439\ Joules$$

$$E_j = Incremental\ Energy(Joules) = \ 0.3439\ Joules$$

$$j = Data\ Point = 70$$

$$P_j = Power\ at\ Data\ Point(watts) = 5.4239\ watts$$

$$P_{j+1} = Power\ at\ Next\ Data\ Point(watts) = 6.0379\ \ watts$$

$$t_j = Time\ at\ Data\ Point(seconds) = 4.1410\ seconds$$

$$t_{j+1} = Time\ at\ Next\ Data\ Point\ (seconds) = 4.2010\ seconds$$

Sample Calculations
Tarun Pilli
Team J; Seat 40; Dr. Phil Schlosser
Data Point 75

Time

$$t = \left(\frac{t_e}{1000}\right)$$

$$t = \left(\frac{4441}{1000}\right)$$

$$t = 4.441\ seconds$$

$$t = Time\ (seconds) = 4.441\ s$$

$$t_e = EEPROM\ time\ (milliseconds) = 4441\ ms$$

Current

$$I = \left(\frac{I_e}{1024}\right) * V_r * \left(\frac{1\ Amp}{0.185\ Volts}\right)$$

$$I = \left(\frac{60}{1024}\right) * 2.46 * \left(\frac{1\ Amp}{0.185\ Volts}\right)$$

$$I = 0.0586 * 2.46 * 5.4054$$

$$I = .7792\ Amps$$

$$I = Current\ (amps) = 0.7792\ Amps$$

$$I_e = EEPROM\ Current\ (ADC\ Counts) = 60\ Counts$$

$$V_r = Arduino\ Reference\ Voltage = 2.46\ Volts$$

Voltage

$$V = \frac{15 * V_e}{1024}$$

$$V = \frac{15 * 538}{1024}$$

$$V = 7.8809\ Volts$$

$$V = Voltage\ (volts) = 7.8809\ Volts$$

$$V_e = EEPROM\ Voltage\ (ADC\ Counts) = 538\ Counts$$

Distance

$$d = 0.0124 * marks$$

$$d = 0.0124 * 68$$

$$d = .8432\ meters$$

$$d = Distance(meters) = .8432\ meters$$

$$marks = wheel\ counts\ accumulated\ by\ reflectance\ sensors = 68\ marks$$

Position

$$s = 0.0124 * pos$$

$$s = 0.0124 * \ 66\ marks$$

$$s = \ .8184\ meters$$

$$s = AEV\ Position\ (meters) = .8184\ meters$$

$$pos = wheel\ counts\ recorded\ by\ reflectance\ sensors = 66\ marks$$

Supplied Power

$$P = V * I$$

$$P = 7.8809 * \ .7792$$

$$P = 6.1408\ Volts$$

$$P = Input\ or\ Supplied\ Power(watts) = \ 6.148\ watts$$

$$V = Voltage\ (volts) = 7.8809\ volts$$

$$I = Current\ (amps) = \ .7792\ amps$$

Incremental Energy

$$E_j = \left(\frac{P_j + P_{j+1}}{2}\right) * (t_{j+1} - t_j)$$

$$E_j = \left(\frac{6.1408 + 5.6286}{2}\right) * (4.5010 - 4.4410)$$

$$E_j = 5.8847 * \ 0.06$$

$$E_j = \ .3531\ Joules$$

$$E_j = Incremental\ Energy(Joules) = \ .3531\ Joules$$

$$j = Data\ Point = 75$$

$$P_j = Power\ at\ Data\ Point(watts) = 6.1408\ watts$$

$$P_{j+1} = Power\ at\ Next\ Data\ Point(watts) = 5.6286\ watts$$

$$t_j = Time\ at\ Data\ Point(seconds) = 4.5010\ seconds$$

$$t_{j+1} = Time\ at\ Next\ Data\ Point\ (seconds) = 4.4410\ seconds$$

Appendix D

Arduino Code

```
reverse(4);
motorSpeed(4, 25);
goToAbsolutePosition(380);
reverse(4);
brake(4);
```