Electric Motorcycle Testing Conceptual Design

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Introduction

Electric Vehicles (EVs) are evolving and exhibiting presence in almost all areas of the world. With this development, there is difficulty in complying with the various charging requirements to support worldwide usage. To address these challenges, Proton Power is developing a battery that will demonstrate significantly faster charging and expanded range. In response, this project will display the utilization of an integrated data acquisition system (DAQ) into a constructed chassis dynamometer to obtain important data to enhance and prove this battery's capabilities. Correctly choosing and integrating sensors into the system is a predominant factor in receiving accurate input and delivering the optimal output. Therefore, extensive testing will take place throughout the design. In addition to ensuring product effectiveness, the device must comply with necessary standards and engineering ethics to validate overall safety. In the following sections, this conceptual design will precisely outline the overall system but allow fluctuation in decisions considering certain hardware and software selections.

Formulated Problem Statement

This dynamometer system is expected to capture the data necessary to develop a software model of the motorcycle. This model will mathematically predict the differences and impacts of changing the battery types that supply power to the motorcycle. The function constraints and expectations of the dynamometer are listed below. The dynamometer shall:

1) Be transferable and not permanently fixed to one location.
   a. This constraint comes from Proton's request to ship the apparatus to various locations.
2) Be able to safely operate the motorcycle up to 85 km/h.
   a. This constraint comes from the specification sheet of the Bob motorcycle, which states a max speed of 85 km/h (see appendix Figure 6).
   b. The stand should be able to support safe operation up to speeds of at least 85 km/h.
3) Capture and display relevant testing data in real-time and be transferable.
   a. This is a requirement from Proton to monitor and operate the motorcycle effectively and efficiently.
   b. Having transferable data allows Proton to share the motorcycle's capabilities with other parties.
4) Be able to be fully operated remotely.
   a. This constraint was created for safety and approved by the customer.
   b. This allows the stand to test a motorcycle with minimum safety risk to operators.
5) Comply with all relevant codes and standards listed in *II. Ethical, Professional, and Standard Considerations,* Section B below.
   a. This is required to ensure safe operation and compliance with all relevant regulations.
6) Contain a standalone harness with sensors that can be temporarily fixed to the bike to verify the dyno data.
   a. This requirement comes from Proton to verify the accuracy of the measurement from the dyno stand.
   b. This constraint also incorporates redundancy, which will identify sensors on the dyno or harness that distribute inconsistent data.
7) Support incline/decline testing up to 8% road grade.
   a. This constraint comes from Proton wanting to verify the motorcycle's ability to handle different road grades (hills).
   b. This requirement contributes towards developing a model of the motorcycle's dynamics.
8) Support repeatedly testing the bike from 0km/h to 50km/h and then back down to 0km/h.
   a. This constraint is a direct request from Proton.
   b. These are specified values required to build a Hamiltonian model of the motorcycle.
9) Be able to adjust operating speed in 1km/h increments and measure response time.
   a. This constraint is a direct request from Proton.
10) Display values on a single PC using pre-existing dyno software.
    a. The PC display is a customer requirement to see the data being gathered.
    b. The customer advised using existing dyno software to prevent too much time spent developing software.
    c. This could prevent the project from being completed within the capstone duration.
    d. The customer agreed the team should find something available to purchase.
11) Support weights up to 400kg on the motorcycle.
    a. This constraint is a testing requirement given by Proton.

b. The customer wants to test the motorcycle with various weights up to 400kg.

12) Be tested with motorcycle batteries having a charge of at least 50% capacity.
    a. This is a constraint from Proton.
    b. The motorcycle should not be tested with batteries with less than a 50% charge.
13) Be able to operate the braking system of the motorcycle.
    a. The customer has specifically requested the ability to conduct brake testing from 50 km/h to 30 km/h.
14) Support the motorcycle being powered and operated with the original 72V-20A batteries until the prototype batteries are available.
    a. The customer plans to have new battery technology available for testing in the Fall of 2024.

I. Ethical, Professional, and Standard Considerations

With this project, there are a large number of ethical, professional, and safety considerations that must be considered. This stand will be tested with extremely heavy and fast-moving loads along with dangers that must always be considered when working with electricity. To make sure that safety is the top priority there will be several codes and standards followed as well as safety measures put into place. Therefore, there must be a detailed review of the broader implications that this project produces to ensure that all safety considerations have been accounted for.

A. *Ethical*

With this project, a primary ethical consideration lies in ensuring complete transparency and accountability with all direct stakeholders involved. This entails providing comprehensive information about testing procedures, the obtained results, and any significant limitations or challenges encountered throughout the project. By prioritizing transparency, trust can be fostered between the project team and stakeholders, ensuring that customers always have access to accurate information.

Furthermore, safeguarding the safety and security of any private data utilized is paramount. IEEE 7002-2022 serves as an ethical code governing data privacy and security, and it will be diligently implemented to prevent unauthorized access or misuse of data.[10]

Proton Power and Bob's mission is to develop affordable and efficient electric motorcycles that can be widely distributed, particularly in third-world countries. As part of this project's ethical considerations, it's crucial to uphold this mission. This will be achieved through exhaustive testing of the motorcycles, providing Proton Power with valuable insights for making future improvements. By doing so, the project ensures accessibility to all members of society, irrespective of their socioeconomic status or geographic location.

B. *Standards*

Within the IEEE [1], NFPA 79 [2], NEC[2], IEC, and OSHA codes, a comprehensive list of standards and regulations is provided that must be complied with. Below these are listed but not limited to:

C. *Broader Impacts*

The impact of this project extends beyond its immediate goals, encompassing broader implications within the realm of electric vehicles (EV) and societal advancement.

The primary broader implication of this project lies in its contribution to the advancement of electric vehicle technology by providing Proton with the necessary information to develop a battery with vastly extended range. This contribution facilitates the ongoing advancement of EV technology. The integration of the data acquisition system (DAQ) into the EV bike stand enables comprehensive testing, thereby optimizing battery performance and efficiency. This technological advancement not only benefits Proton Power and Bob's mission to produce affordable and efficient electric motorcycles but also propels the entire EV industry forward.

Furthermore, by aiding in the development of the EV industry and facilitating the adoption of EVs in third-world countries, this project significantly reduces carbon emissions and mitigates the environmental impact of transportation. Prioritizing the development of sustainable and accessible transportation solutions, this project aligns with global efforts to combat climate change and promote environmental sustainability.

Additionally, this project contributes to Proton Power and Bob's ultimate goal of making affordable and efficient electric motorcycles accessible to individuals worldwide. A broader implication of this project is providing communities with efficient transportation solutions.

D. *Constraints Derived From Broader Impacts*

II. Block Diagrams

To fully capture the design and functionality of the test stand, 3 main subsystems have been developed and are portrayed in Fig. 1. Within these, branch a combination of 6 more subsystems. The following sections describe each subsystem in more detail and how they will meet previously stated requirements and constraints.

A. *Data Acquisition (DAQ)*

Data Acquisition refers to the transfer of the motorcycle’s physical operation into visual and numerical data for the customer to use for further modeling.

1) Signal Conditioning: Certain types of sensors may have messy signals and need manipulation to be as accurate and easy to read as possible.

2) Signal Conversion: Analog sensors output voltage values that must be converted to digital form using an ATD. This allows the signal to be analyzed and sent elsewhere for analysis if necessary.

3) Hardware: a DAQ system will require hardware for relevant sensors to be wired/tapped into.

- Controller: a controller system will likely be needed as a form of hardware in an active DAQ

4) Software: Along with hardware, there will be a requirement to have dyno-specific software that will be able to read from a dynamometer and aid in outputting bike metrics. This software may work with examples such as LabVIEW, MATLAB, Python, etc.

B. Sensor Integration

This system works to bring all the different sensing systems together, with each functioning as expected.

1) Interfacing: Each sensor will need to be researched to learn its forms of input/output and how they typically operate in the expected environment.

2) Torque: The rear wheel torque of the tested bike will need to be actively measured.

3) Voltage: The input voltage being supplied to the motor of the bike (by the batteries/control module) will need to be measured.

4) Current: The input current being supplied to the motor of the bike (by the batteries/control module) will need to be measured.

5) Acceleration: The acceleration of the bike on the stand needs to be measured. This data along with time will also allow for the speed of the bike to be calculated (due to acceleration being the derivative of speed with respect to time).

C. User Interface

1) Input: The system will allow for user-loaded parameters in order to visualize real-time adjustments.

2) System Feedback: The system will deliver precise data back to the user for optimal analysis and changes to be made.

3) Data Visualization: This system will allow for real-time performance metrics to be displayed in a visually appealing format.

D. Throttle Control:

Due to constraints 4,8, and 9, the test subject must have external throttle control that will ideally be operable from the display location.

1) Actuator: The system will have the ability to physically or digitally turn the throttle of the bike remotely.

2) Controller: This will be a closed-loop control system having the ability for feedback typically to a controller.

E. Brake Control

Due to constraints 4 and 8, the test subject must have external brake control that will ideally be operable from the display location.

1) Actuator: The system will have the ability to brake the bike remotely.

2) Controller: This will be a closed-loop control system having the ability for feedback typically to a controller.

F. Road Simulation

The road simulation system is intended to actively work to simulate levels of roads including smooth surfaces, bumpy surfaces, and also different road grades (slopes).

1) Drum/Roller Resistance: The stand must be able to simulate an 8 percent road grade, equal to 4.574 degrees, from constraint 7. The team will need to apply resistance to the drum to either increase or decrease demand on the motor. The grade resistance can be found by multiplying the weight of the vehicle by the sine of the angle that the surface makes with the horizontal. The weight of the bike is 120 kg and the customer wants the bike to be tested at 150, 200, and 400 kg, from constraint 11. This means that the max grade resistance that must be added to the drum will be 21.5316 kg, 25.5189 kg, and 41.4682 kg.

III. Timeline

The Gantt chart shown in Fig. 7, in the Appendix, outlines the general tasks for detail design.

IV. Conclusion

V. Works Cited

References

[1] "IEEE code of Ethics," IEEE, https://www.ieee.org/about/corporate/governance/p7-8.html (accessed Mar. 8, 2024).

[2] NFPA 70: National Electrical Code, 2017 Edition. In NFPA National Fire Codes Online. Retrieved from http://codesonline.nfpa.org (accessed Feb. 13, 2024).

[3] National Fire Protection Association. (2020). NFPA 70: National Electrical Code, Article 430: Motors, Motor Circuits, and Controllers (2020 ed.). Quincy, MA (accessed Feb.17, 2024)

[4] NFPA 79: Electrical Standard for Industrial Machinery, 2024 Edition. In NFPA National Fire Codes Online. Retrieved from http://codesonline.nfpa.org (accessed Feb. 13, 2024).

[5] IEC "Conductive charging of electric vehicles" https://www.dalroad.com/wp-content/uploads/2016/08/Type-II-connector-product-spec.pdf (accessed Feb. 13, 2024).

[6] International Electrotechnical Commission. (2006). IEC 60204-1: Safety of machinery — Electrical equipment of machines — Part 1: General requirements (4thed.) https://www.iec.ch/scr/meetings/national/detail_2080.html

[7] "IEEE Standard for Sensor Performance Parameter Definitions," in *IEEE Std 2700-2017 (Revision of IEEE Std 2700-2014)* , vol., no., pp.1-64, 31 Jan. 2018, doi: 10.1109/IEEESTD.2018.8277147.

[8] OSHA "Occupational Safety and Health Standards" 1910, https://www.osha.gov/lawsregs/regulations/standardnumber/1910/1910.303 (accessed Feb. 14, 2024).

[9] International Electrotechnical Commission. (2019). IEC 61439-1: Low-voltage switchgear and control gear assemblies - Part 1: General rules (3rd ed.). Geneva, Switzerland

[10] IEEE. (2022). IEEE 7002-2022 - Standard for Consumer-Related Privacy and Security Considerations. New York, NY: IEEE.

VI. Appendix

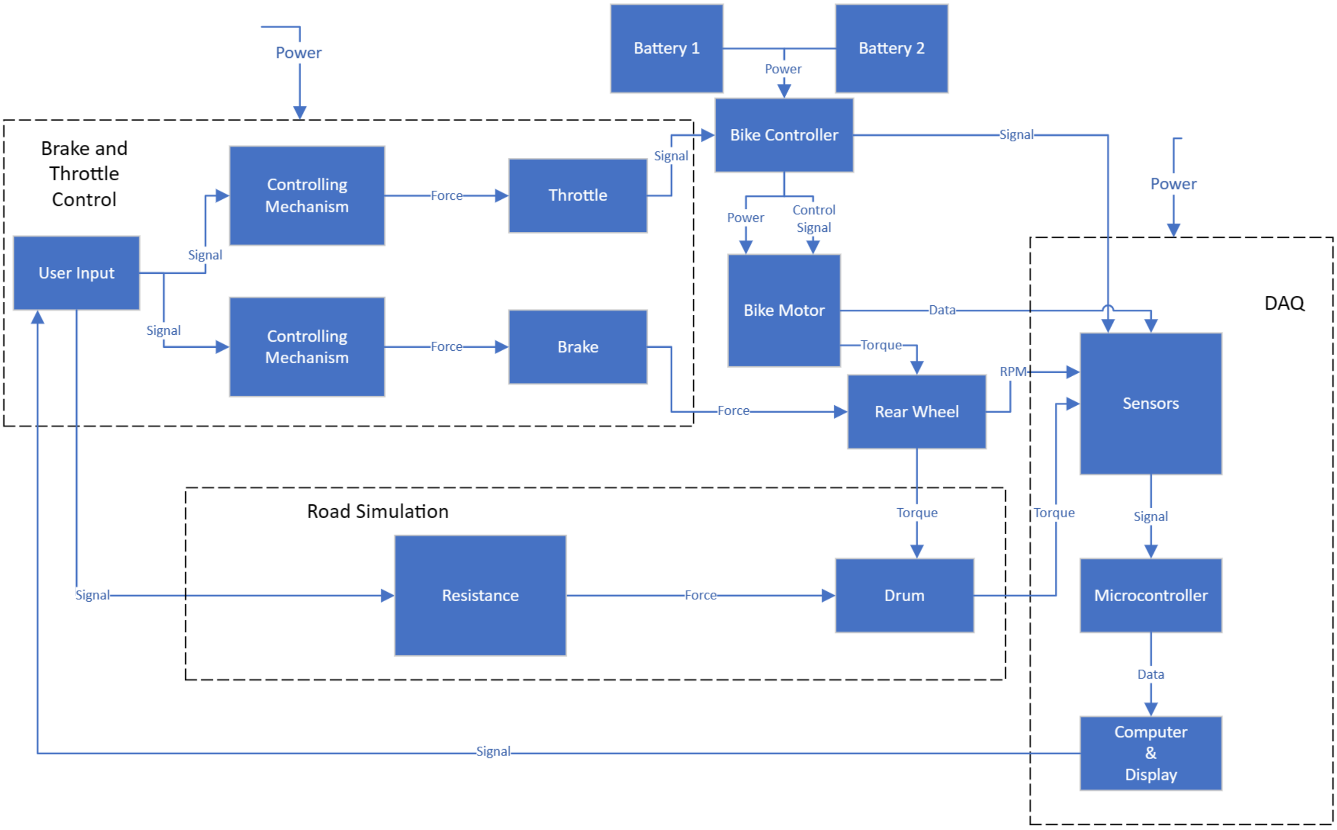

Fig. 1. Overarching Block Diagram
(This and all other block diagrams will be correctly added to the Block Diagram section once the document is fully constructed to avoid formatting issues)

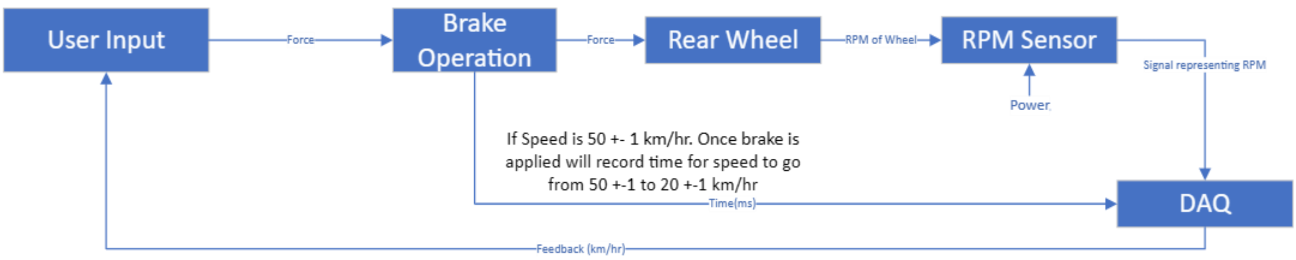

Fig 2. Braking Operation Block Diagram

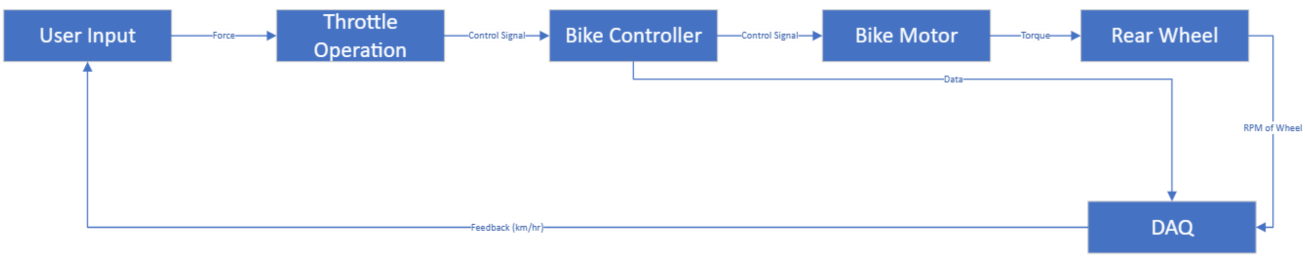

Fig 3. Throttle Operation Block Diagram

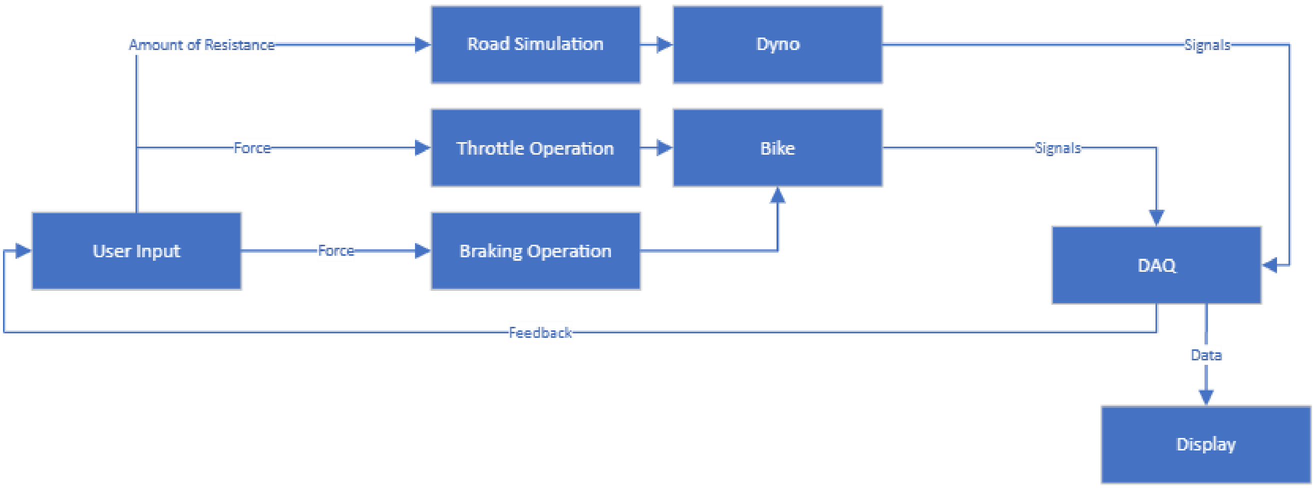

Fig 4. User Interface Block Diagram

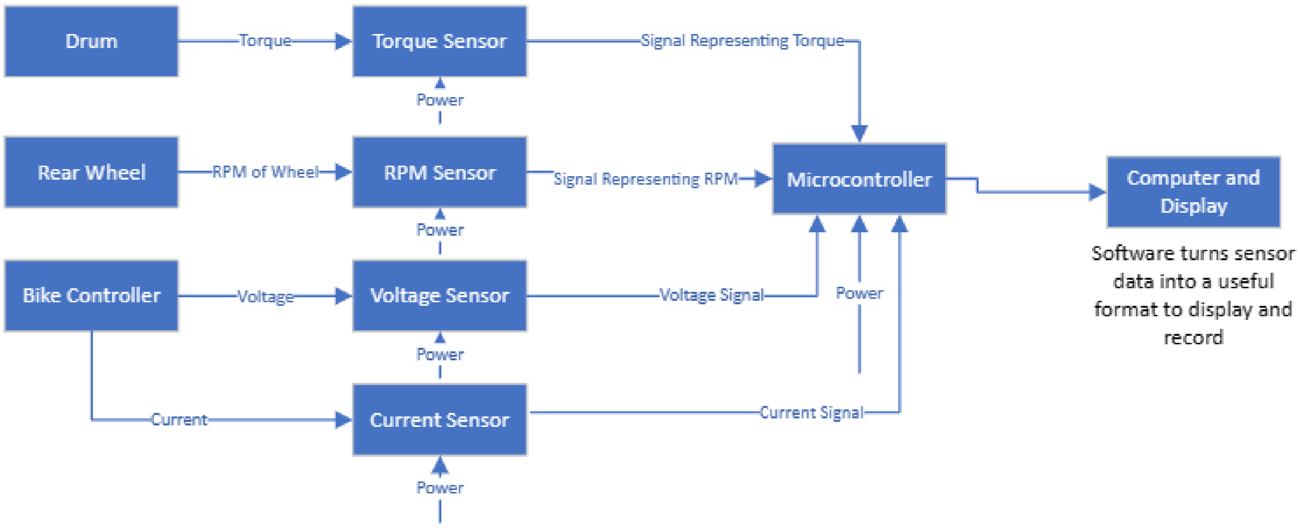

Fig 5. DAQ Block Diagram

Item		Content	Note
Length		1975 ng/2050mm	Without shelves/with shelves
Width		710mm	/
High		1050mm	/
Wheelbase		1300mm	/
Weight		120kg	Battery pack included (Contain the battery pack)
Seat height		815mm	Driver/crew
minimum ground clearance (Minimum ground clearance)		160mm	/
Maximum climbing angle (Maximum Angle of climb)		19°	/
Motor	Motor type (The motor type)	Wheel huh motor	/
	Rated output power (RP)	3500w	/
	The rated voltage	65V	/
Battery(Power Battery)		65V30Ah/unit	Lithium iron phosphate battery (Lithium Iron Phosphate lithium battery)
Battery pack quantity (Number of battery packs)		2(One)	Removable
Maximum speed (MAX-Speed)		60km/h (ECO) 75km/h (SPORT)	A single
Constant speed range		110KM	40km/h (ECO), single (A single) battery remaining 10% 10% battery remaining)
Working condition endurance		90km	GB14622-2016-RS1+RS1 (SPORT), A single, 20% battery remaining
Tire Size		2.75-17	front wheel
		110/70-16	rear wheel
instrument		LCD instrument	/
Braking System		Front, rear disc, CBS	/
Reverse Gear		√	/
Driving Mode		ECO、SPORT	/
communication method (Communication Isolation)		CANBUS	Instrument, battery, controller
Charger		650w (65V10A)	
Loading Quantity		SKD 105pcs	40HQ

Figure 6: Bob Motorcycle Technical Document

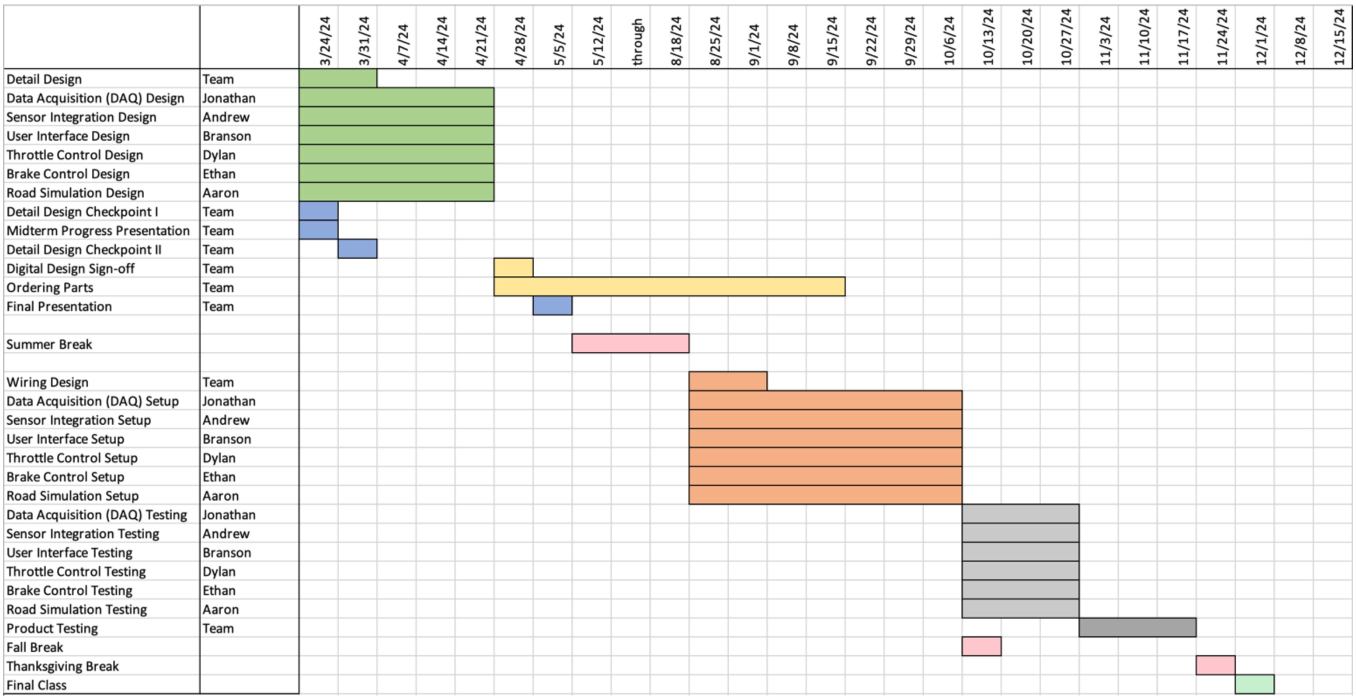

Figure 7: Gantt Chart