Internship report at Delta X Automotive

Mechanical Design Intern

Submitted by:

Avva Sai Pranav **PES1201800861**

Under the guidance of

Kithir Kareeb Navaz Ahmed Zackariya,

Director, Co-Founder, Delta X Automotive

&

Harit Trivedi

Electronics Head, Delta X Automotive

5 months (29th November 2021 – 30th April 2022)

DEPARTMENT OF MECHANICAL ENGINEERING PES UNIVERSITY

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INTERNSHIP CERTIFICATE

This is to certify that Mr **Avva Sai Pranav** worked as a Intern – IOT Engineer under Delta X Automotive from **January 2022** to **April 2022**. *(The candidates were allowed to continue if they wish)*

During this phase, he demonstrated good design skills with a self-motivated attitude to learn new things.

We wish him all the best in his future endeavours.

Warm regards,

KITHIR KAREEB NAVAZ AHMED ZACKARIYA
Director, Co-Founder

DECLARATION

I hereby declare that I have undergone an internship at Delta X Automotive for 5 months under the guidance of Kithir Kareeb Navaz Ahmed Zackariya, Director, Co-Founder, and Harit Trivedi, and submitted in partial fulfillment of the credits for the degree of Bachelor of Technology in Mechanical Engineering of PES University, Bengaluru during the academic semester. The matter embodied in this report has not been submitted to any other university an institution for the award of any degree.

Avva Sai Pranav

PES1201800861

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ACKNOWLEDGEMENT

I would like to express my gratitude to my guide **Kithir Kareeb Navaz Ahmed Zackariya, Director, Co-Founder, Delta X Automotive** and **Harit Trivedi, Electronics Head, Delta X Automotive** for their continuous guidance, assistance and encouragement throughout the development of this internship.

I take this opportunity to thank **Dr. Rajesh Mathivanan, Chairperson, Department of Mechanical Engineering, PES University,** for all the knowledge and support I have received from the department.

I am deeply grateful **to Dr. M. R. Doreswamy, Chancellor, PES University, Prof.Jawahar Doreswamy, Pro Chancellor – PES University, Dr. Suryaprasad J, Vice-Chancellor, PES University** for providing to me various opportunities and enlightenment every step of the way.

Finally, this internship could not have been completed without the continual support and encouragement I have received from my parents and my friends.

1. ABOUT THE COMPANY:

Delta X Automotive is a fore front runner in the micro-mobility space, the future transportation ecosystem of the world. We aim at the last mile connectivity while looking at the standardization of the micro-mobility ecosystem's various subsystems, ranging from vehicle authorization to standardized batteries, swappable battery systems, and many more. While aiming to provide a sustainable ecosystem for the deployment of our vehicle in various uses cases. The path to achieving this is by introducing our first product, "KIX." A play on the works KICK scooters. KIX is a personal micro-mobility concept aimed at customers who regularly travel for about 5-10 km.

The uses cases that we are aiming towards are:

i) The last mile connectivity ranges, ranging from metros and other public transport areas to work places

ii) large campuses and IT parks

iii) Factories

iv) Delivery Services

The main features of the vehicle are:

i) Quick locking and unlocking feature, and keyless activation using a fingerprint sensor.

ii)A range of 50 kms on a single charge.

iii)A swappable battery this is carriable in the vehicle increasing the overall range of the vehicle.

iv) A portable battery that can be charged anywhere, this possible as the charger fits into standard wall plug ports.

Fig 1 The various iterations of the vehicles

2. ROLES AND RESPONSIBILITIES

The role of the IoT Engineer Intern encompassed the design of the hardware architecture to the manufacturing and testing of the architecture. Generation of diagnostic reports, technical manuals, and software development documentation. The work also includes meeting with clients, designers, and engineering teams to define technical requirements.

The duties began with getting up to speed with an existing code base partially developed in python and integrating the raspberry pi family hardware with a daughterboard. Work also entailed understanding the future scope and the improvements in the upcoming iterations and testing individual modules before being implemented as a complete system. The task required understanding the high voltage electronics with particular emphasis on the Electronic Speed controller and the tuning of various parameters, which would be crucial for achieving the company's targeted range for the vehicle.

Simultaneously, the company assigned responsibilities of integrating and fitting the mechanical and electrical components on the chassis. It was essential that the module-wise testing was standardized and the solutions proposed would be immediate fix and long-lasting solutions.

The task assignment during my internship was toward the testing of the manufactured prototypes and the design and manufacturing of the subsidiary electronics systems. It was to ensure that the MVP (Minimum Varying Prototype) could be demonstrated to potential investors or customers. The MVP work ranged from integrating electromechanical components, wire harnessing, finalizing the electronics, and Human Machine Interface to the combined testing of the system.

3. SCOPE OF WORK:

   Before the commencement of the internship, the company already had a prototype of the authorization and a list of features that needed to be implemented. The company had a new iteration in the pipeline while the high voltage electronics included throttle, the electronic speed controller, the swappable battery, and the motor.

   There was a need to implement the required features and source the components for the necessary development, research, and implementation. It was essential to ensure that the parts used had a viable supply chain concerning the current global chip shortage.
   Simultaneously multiple discussions were held regarding the various addition of features and the necessary steps. The parts were then organized into priority charts and worked on based upon the immediate priority and long-term goals.

   The discussion was also held with the mechanical team regularly for the sensor's design and mounting and to ensure that the sensors are not load-bearing components and are protected from any moving parts. An example of this would be covering the face of the Hall effect sensor from the stand.

   The work gave high importance to the user flow and the human-machine interaction. This would be the defining feature of a product and inevitably affects software and hardware development. The project management system and the code maintenance through the GitHub organization were also worked on during the internship. The scalability of the system was also looked at. It is to be noted that the electronics system remains constant irrespective of the various prototype; hence the development of the electronics happened parallel while the integration of the system was a collaborative between the multiple domains of the company.

4 DETAILS OF THE WORK DONE

The start of the internship included getting used to the workspace, the work environment, and knowing the inventory of the electronics at hand. It was crucial to understand the workspace as multiple companies shared it.

The first week of the internship was to understand the existing code base, the working of the electronics, and the previous problems faced. It also included learning the required soldering skills, which have the usage of silicon wire and the issues with solid core wire for the application of the vehicle, and finally, soldering battery connectors.

This was followed by making the pinout for the raspberry pi upgrade the existing system to a raspberry pi architecture. As time progressed, more tasks were assigned, and the work went in the following manner:

4.1 ITERATION 1

This is the iteration that was present before my commencement of the internship. The electronics system is divided into two subsystems. The high voltage subsystem was mainly fixed. The voltage electronics system had the locking mechanism and the authorization systems. The opening and closing of the swappable battery door were already implemented using a hardware button and a solenoid.

4.1.1 Addition of Features

The first task given was the addition of an RPM sensor which would act as an additional security feature for locking. This is to ensure the vehicle doesn't lock during movement.

It was also noticed that a supplementary code had to be run for the enrollment of a fingerprint, hence this was made into a hardware button-based.

4.1.2 Addition of Raspberry pi

First, the pinout of the system was made such that the existing daughter board could be used. Each component was individually tested. It was later found that the rpm sensor wasn't compatible with the system; hence, an ADC (Analog to Digital Convertor) was used to check the system.

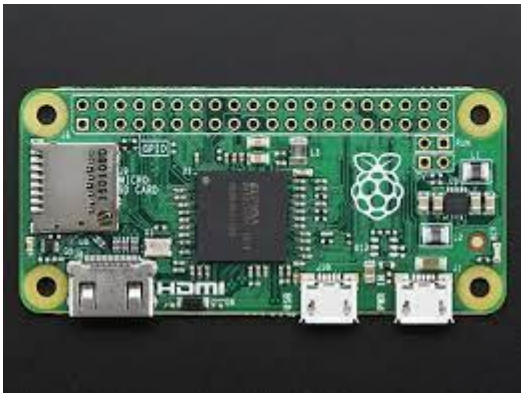

Fig 2: Raspberry pi zero

It was also noticed that the relays which were used for the locking of the system would not activate due to the raspberry pi only being able to dish out 3.3Volts as compared to the required 5V and unable to handle the Ampere rating of the raspberry pi.

4.1.3 Software

The python code was further improved by adding the required flags and also ensuring that all the functions work. The hardware button for enroll button was also implemented simultaneously.

4.1.4 Testing for Bluetooth Commands

As the system didn't have an app, hence the possibility of using Bluetooth libraries to send commands from a second raspberry pi was explored. To ensure this, the theory of Bluetooth was explored and also implemented, such that when a command from one raspberry pi is sent, it is received by the other raspberry pi. This was verified by switching an LED on and off when the required command was sent.

4.1.5 Problems faced and further improvements

The locking of the system was dependent on the stand. The stand locking was detected using a hall effect sensor. It was also noted that due to the failure of the solenoid which was used for the locking of the battery door, 14 Volts was running on the chassis, which caused various misbehaviors of the system. The above problems were taken into consideration with the cooperation of the mechanical team, and the isolation of the components was improved. The mounts of the system were also improved to prevent shorting and protection of the components. The enrolling using fingerprint and locking of the solenoid was solved using a subsidiary system to achieve the functioning. The next improvement to be done was the wire harness.

4.2 ITERATION 2

There weren’t any major overhauls to the functionalities of the system rather it was a hardware upgrade of the system. It began with the design and placing the order of the PCBs. There was initially a procurement list of all the required components compiled and procured through various sources.

4.2.1 Manufacturing

There were SMD components soldered onto the board and continuity was checked between each component and ensuring all the components are soldered correctly with the right polarity.

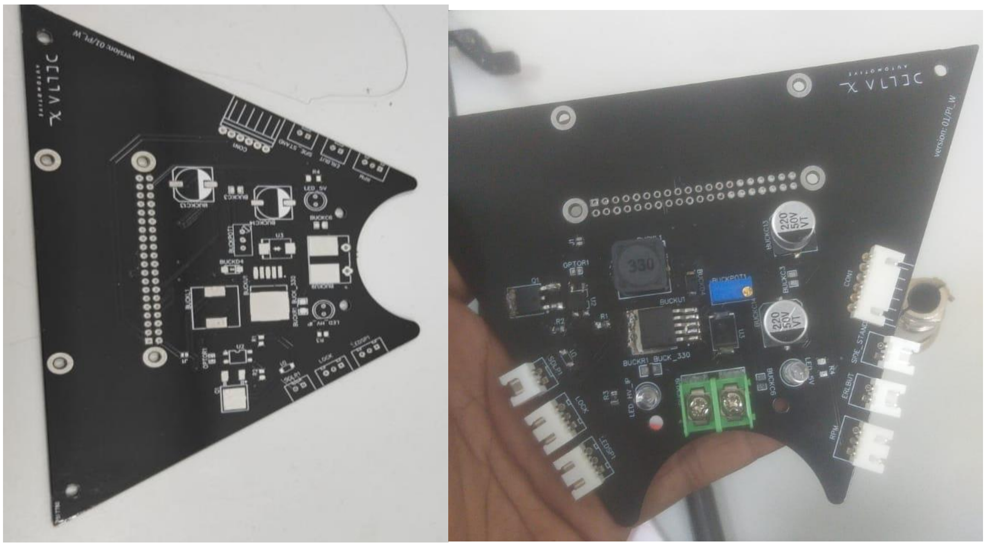

Fig 3 (a): Unsoldered board Fig 3 (b): Soldered board

4.2.2 Testing of soldered board

Test code was run for each individual component and upon further testing, it was found that one of the procured components was faulty and wasn't behaving as expected, this led to further complications as it ended up damaging the CPUs of the system. This turned out to be a problem greater than expected as due to the global chip shortage raspberry pi zeros were out of stock worldwide, and the official company had published a post saying stock won't be available until the end of 2022. This forced our hands and an immediate decision needed to be taken as to how to proceed further with respect to the hardware architecture. A significant period of research went into understanding the available supply chains, wait times for automotive-grade chips, and their viable and reliable options for the company in the long run. this also meant that the chosen chip shouldn't act as a limiting factor. This also meant that there shouldn't be any compromises on the functionality of the system.

During testing, it was also found that the raspberry pi system isn't suitable for the amp rating of certain components which leads to further damage to the board making certain pins unusable.

4.2.3 Wiring Harness

The usage of the solid core wire, improper wire lengths, and the loose wire possessed a lot of failure points in the system in Iteration 1, this was taken seriously as threads were used to measure the required wire length and connector length, slack was also considered for the system. The accurate wire length also ensured avoidance of resoldering. The wires were wrapped in tape to ensure no free wires, this was the rudimentary harness.

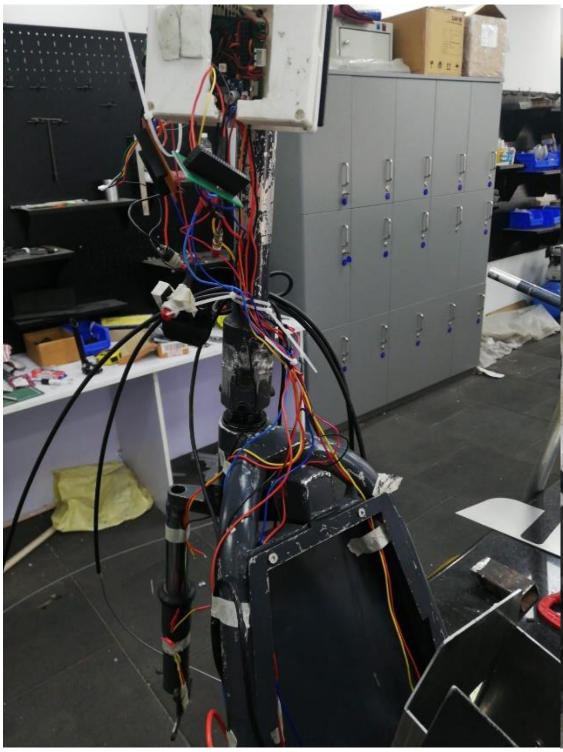


Fig 4(a): Wire harness for iteration 1 Fig 4(b): Wire Harness for Iteration 3

4.3 Iteration 3

The latest iteration is closest to Minimum Varying Prototype. The first step was to ensure we had a list of features that we would like to implement:

- Fingerprint Sensor
  - Enroll Function
  - Authorization Function
  - Deletion of fingerprint if the entire space of fingerprint is occupied.
- Relay Locking
- Human-machine interface using LED’s for status indication
- Replacement of hardware buttons with software for Enroll and Battery Function
- The decision of the sensor for the stand, the option was hall effect, reed switch, and a z-stop switch

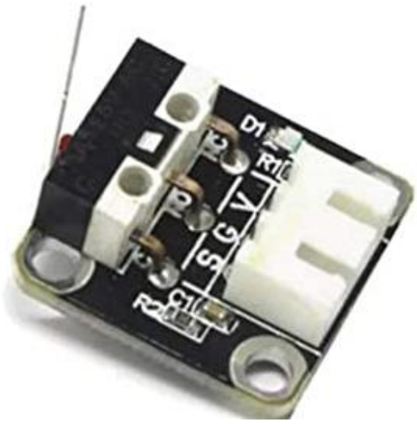

Fig 5: Z-stop Switch

Fig 6: Reed switch

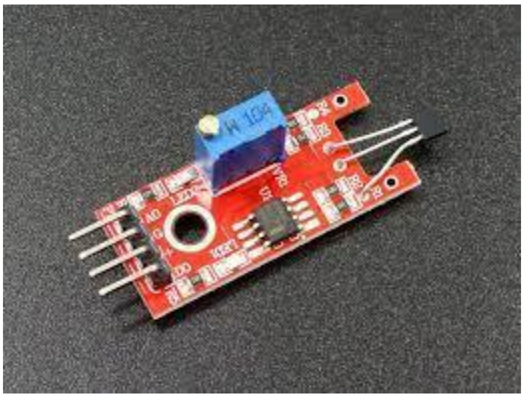

Fig 7: Hall Effect Module

- Rpm sensor and its integration
- Porting of code
- LV Charging Circuit
- Mounting and isolation of sensors and the required mounts for hall effect sensors.
- Software feature addition and porting of code to C/C++

4.3.1 Porting of code

There were initially compatibility problems with the fingerprint sensor. This was solved through further debugging, and trying out various libraries. Further features were added as stated above.

4.3.2 Blynk

The enroll and battery opening buttons were hardware buttons. To upgrade the functionality, it was decided to move them to a software button, which was accomplished using an app. The implementation was achieved using the Blynk IoT platform. The app had the following functions:

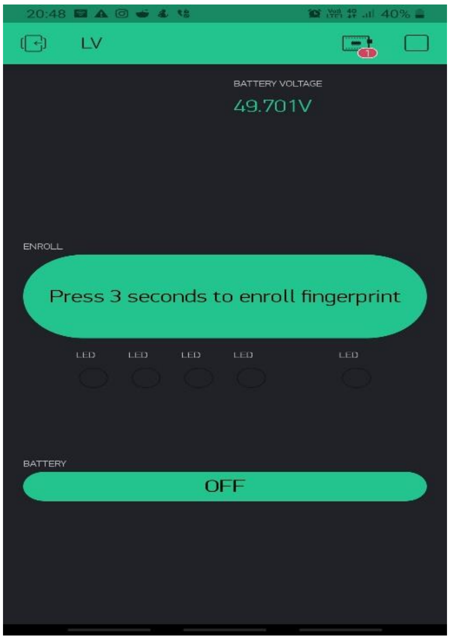

Fig 8: Bluetooth App

The app also incorporated the high voltage and low voltage battery percentages. Hence it showed the voltages of the battery, and it is planned to convert this voltage in terms of percentages further on.

4.3.3 Manufacturing of PCB on protoboard

Once the basic code was ported and tested manufacturing of a PCB board began. It initially starts with drawing out the 5 volt and ground lines of the side of the PCB and the signal wires through jumpers. There were standard connectors used known as JST. The connections and solders were triple-checked and ensured no shorting occurs.

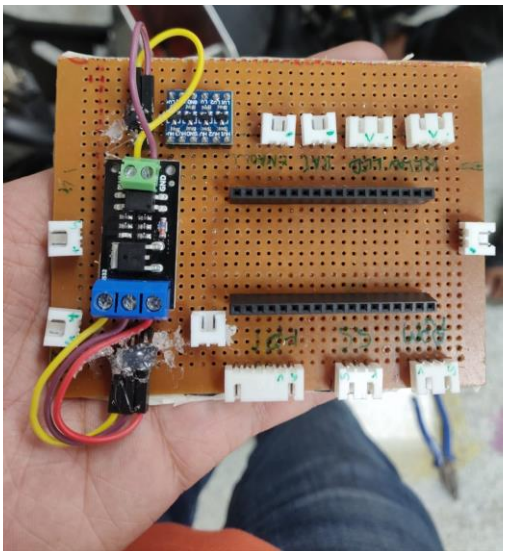
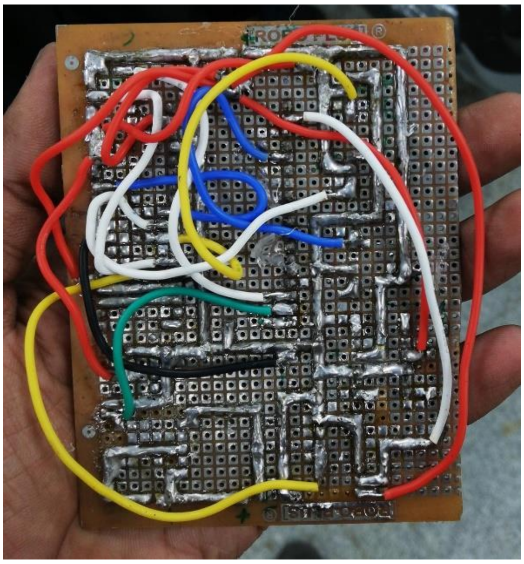

Fig 9(a): Top side of manufactured board Fig 9(b): Backside of the protoboard

4.3.4 Wiring Harness

The harness was made such that it could be reused and that it allows for the addition of new connections, this was to ensure that in the prototype stage it allows for the addition of new components and experimentation.

4.3.5 Problems faced and further additions

During the Range test it was noticed that there was a huge amount of back current which would fry the relay and cause permanent locking. Hence to avoid this a solid-state relay prevents connection and prevents the back currents. The next addition of voltage detection additionally helped as detection if the battery is present in the battery bay. The rpm couldn’t be integrated as a safety-features as it obstructed with the flow of code due to various programming styles implementation. The human-machine interface was further optimized.

4.4 CHARGING AND DISCHARGING CIRCUIT

4.4.1 Discharging Circuit

There was a need for making a custom discharging Circuit for the High Voltage Battery. The reason for discharging the battery was that the ESC could not handle the voltage due to the fluctuations of the voltmeter in the ESC. This caused the Motor Controller to activate its over-voltage protection circuit. Hence to ensure that it would be in the applicable range, it was required to build a load that could handle its current and voltage; therefore, multiple 12V CPU fans were set in series to discharge the batteries to get into the working range of the motor controller.

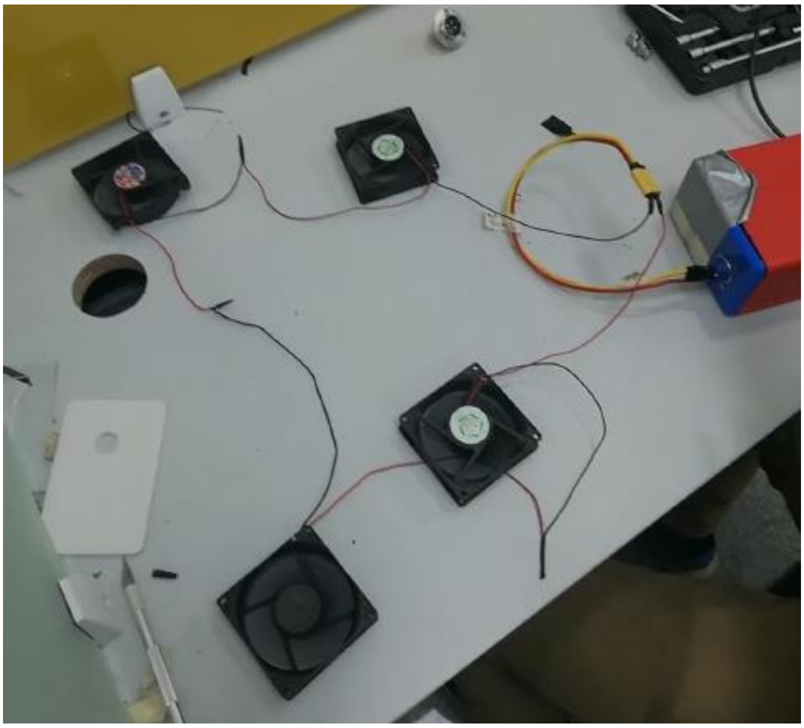

Fig 10: Discharging Circuit

4.4.2 Charging Circuit

The system has a high voltage and a low voltage battery. The low voltage system is placed inside the floorboard; hence isn't a swappable battery. Therefore, it's required to include a charging circuit. The first stage of the charging Circuit is verifying the charging of the 4s lithium-ion battery using the power supply and the charging board, which was confirmed.

The next step is dropping the 60-voltage battery to 30 Volts. Hence it can be plugged into the existing charging Circuit to charge the LV.

4.5 MOTOR CONTROLLER COMMUNICATION

The Motor Controller is the speed controller used for the vehicle. The Motor Controller is a very advanced controller with a variety of data that would play a crucial role in designing dashboards and understanding the usage of the vehicle. The data is possibly be extracted in the following manners:

4.5.1 The UART Communication Protocol

Based on the receiver-transmitter concept, it is a very standard protocol that most hobby boards support using this attempt to establish communication was done. Unfortunately, it failed due to the lack of updated and supporting libraries for the extraction and writing of data to and from the Motor Controller.

4.5.2 The CAN Protocol

The CAN protocol stands for Controller Area Network, a standard protocol used in the automotive industry known for its high reliability and feature-rich protocol that accommodates failure modes and the isolation of failed systems. The communication was successfully established, and the required data frames for reading the status and writing data were also understood.

After reading the data, it was possible to decipher it and store it manually. The next set of steps would convert the data from Hexadecimal format to decimal format in terms of readable data.

5 TESTING AND TUNING

5.1 Range Tests

The various battery pack configurations were tested, this began with tuning of various motor controller parameters. This began with testing the wattage and the amount of kilometers run. The kilometer run was collected through Strava app. This was to reach the required range of 50 kms.

5.2 E-brake Testing

The E-brake were proposed as a possibility; hence experimentation began by testing the various strength of the e braking and weighing the effects on the feel and ride of the vehicle with the introduction of E-brake.

6 RESULTS

- The delivery of a stable and reliable electronics closest to the minimum varying prototype with all the required features.
- Ensuring isolation and safe mounting of electronics to prevent shorts and damage to sensors.
- A variety of range test with various motor controller parameters were conducted to achieve the required range of 50 kms

- The possible upgrades of the system is by the addition of RTOS which makes the system more responsive than the existing code.
- The human-machine interface LEDs show if the vehicle is locked or unlocked and the battery percentage. It also shows the steps required for the enrolling of a new fingerprint.
- There was a project management system set up using Click up for the assignment of task and the initiation of an organization using GitHub and ensuring all have access to the codes and branching of the codes such that parallel working on the codes could be work on simultaneously.

7 CONCLUSIONS

The internship provided a great learning experience, and has helped develop essential skills required to flourish in the industry. Working with manufacturers and vendors has provided insightful knowledge on how to design for the required function, while keeping the design simple enough to manufacture effectively. The use of localized sources has cut down on the manufacturing time as well as the cost. Working with the team on ideation sessions and design meetings has provided perspective on various challenges that would be forthcoming, as well as different ways to solve them. This also cultivated essential skills like teamwork.

Finally, the manufacturing and assembly stage has provided with quick thinking and problem-solving skills. Repurposing old components to serve as a quick and effective solutions to existing problems has incorporated efficient manufacturing skills that require less investment as well as time. All the learnings from the internship will definitely be beneficial for upcoming prospects.

8 REFERENCES

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