

Reflection Report

MECHTRON 4TB6

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1 Changes in Response to Feedback

1.1 SRS and Hazard Analysis

1.2 Design and Design Documentation

1.3 VnV Plan and Report

2 Design Iteration (LO11)

2.1 Printed Circuit Board Design

Robust electrical connections between the electronic components of the device were a major point of focus for our project. The main electronics requiring robust power and signal electrical connections were the Arduino (microcontroller), ESP8266 (Wi-Fi module), and micro-SD card (local memory storage).

The first iteration in electrical connections occurred between the Proof of Concept and Revision 0 Demonstrations through the transition from a breadboard and jumper wire electrical implementation to a custom design PCB. The power and signal connections made on the breadboard were translated onto an electrical schematic in KiCad, a schematic capture and PCB design software. The PCB layout and trace routes were then created using the schematic to complete the PCB design.

The second iteration in electrical connections occurred between the Revision 0 and Revision 1 Demonstrations through the transition from a custom design PCB to a custom design PCB with a smaller form factor. The second custom PCB design achieved a reduction in board size by 53% from 151 mm x 112 mm down to 97 mm x 81 mm. The use of both planes of the PCB to solder the electronic components was the primary driver in area reduction from Revision 0, which required all electronic components to solder onto the same plane.

2.2 Chassis Design

During the design phase of the device's chassis, the team meticulously considered its size and form factor. The primary objective was to create a sturdy housing that would securely house all of the essential components, including the Arduino, ESP8266, and micro-SD card reader, while shielding them from external elements.

The first version of the chassis was developed between the Proof of Concept and Revision 0 stages. Initially, a pre-made cardboard box was used. However, this was later replaced with a smaller, custom-designed 3D printed chassis with large holes for all the ports and

connections.

The second iteration was developed between Revision 0 and Revision 1. The aim was to create a more compact and durable chassis. With the reduction in the size of the PCB, the team was able to decrease the chassis size by 53%. It went from $1.36 * 10^6 mm^3$ to $0.64 * 10^6 mm^3$. Additionally, the second version featured a more uniform design as it was printed as a single solid piece

2.3 Sensor Configuration Interface

2.4 Data Visualization Page

3 Design Decisions (LO12)

3.1 Custom Printed Circuit Board

The choice to design a custom PCB to interconnect all electrical components was driven by a PCB's ability to maintain electrical connectivity in high vibration environments. Particularly in McMaster Formula Electric's application as a vehicle driving on top of a road, the device was expected to maintain functionality in high vibration environments such as high vibrations due to rough road surfaces.

Furthermore, PCB's provided a space effective solution to electrical connections relative to jumper wires connected to a breadboard circuit because of the planar copper connections between components. As a result, the overall height required by the electrical circuit was minimized using a 2-layer PCB. The PCB's permanent connections were also desirable for power and signal connections between the Arduino, local memory module, Wi-Fi module, and terminal blocks because those component and their respective connections were always the same irrespective of the test setup.

3.2 3D Printed Chassis

When the team was considering the manufacturing process for the device's chassis, purchasing a preexisting enclosure was initially deemed unsuitable. This decision was driven by the realization that a ready-made chassis would not be able to hold all the essential components securely within the smallest possible form factor, which was a crucial requirement for the device. Instead, the team opted to design and print the chassis themselves, which provided the freedom to tailor it to the specific dimensions of their components.

The custom design allowed for a perfect fit, ensuring that the major components, such as the Arduino, ESP8266, and micro-SD card reader, would be safely housed within the device. Moreover, the team was able to create custom pass-through holes and slots for ports.

3D printing allowed us to create a a very precise and strong chassis with a tolerance of 0.1mm.

Overall, the decision to design and print the chassis in-house enabled the team to overcome the limitations of preexisting enclosures, resulting in a more compact, robust, and customized solution.m.

3.3 Code that Writes Code

3.4 Data Visualization Page

4 Economic Considerations (LO23)

Formulate is an open source product for any University's Formula team. Our public GitHub repository allows teams to freely download the Gerber files to manufacture the PCB, chassis CAD model to 3D print the enclosure, executable to run the user interface, and PBIX file for the data visualization template.

The market for Formulate is sizeable, with over 600 Formula series teams (combustion, hybrid, and electric) active across more than 20 countries, with 75 of those teams competing in the Formula Electric competition in the 2023 North American series alone.

Our team plans to create a promotional video on social media platforms such as LinkedIn to attract the attention of the global market of Universities who compete in the Formula Electric competition. Even within the Formula Electric team at McMaster, we aim to attract the attention of members through testing sessions with the product to increase product exposure and educating interested members on the benefit of the product.

The overall capital expenditure (Capex) for teams to build a Formulate device was intentionally small to increase the product's economic viability for all Formula teams. The current cost to purchase the electrical and mechanical hardware using our open source build files is \$50 Canadian. The software cost for the user interface and the data visualization platform is \$0. Our team estimates the build time with the required hardware at hand to be 2 hours, assuming reasonable workmanship skills at a senior University student level.

5 Reflection on Project Management (LO24)

5.1 How Does Your Project Management Compare to Your Development Plan

Our team followed the weekly Monday team meeting plan consistently throughout the duration of the course. The consistency with which our team followed this plan was a result of

the need to share and receive updates on tasks with upcoming deadlines or tasks blocking the progress of sequentially related tasks.

The team communication plan and workflow plan were also followed throughout the course, similarly to the team meeting plan. The team found consistency with the plans because the team had experience with chat messaging through Microsoft Teams and GitHub's issue tracker through course work or internship experience. As a result, our team was comfortable following these plans.

Team member roles evolved naturally throughout the duration of the course to reflect interests gained as the project progressed. With that said, each member's role was maintained from November 2022 until the end of the course due to the increased aptitude in the sub-system's specific development and increased ability to quickly meet technical goals.

5.2 What Went Well?

Meetings at a weekly frequency was a good process for our team because we were able to find the appropriate balance between having frequent meetings to update the whole team on progress and having adequate development time to provide notable updates during meetings.

In addition to weekly meetings, using GitHub's project dashboard feature to streamline our workflow helped our team create and assign specific work modules more efficiently. As a result, our team was able to create a systematic process to assign and complete work modules.

All technological tools outlined in the Development Plan were effective for our team, but specific technologies such as Autodesk Inventor, KiCad electrical schematic and PCB editor, PyQT Designer, and Microsoft PowerBi were very effective because of the relative ease of use to achieve functional prototypes and the large amount of readily available documentation for development. This enabled our team to be agile with feature development and overall project iteration.

5.3 What Went Wrong?

5.4 What Would you Do Differently Next Time?