Project Closeout

Future Recommendations

The team has come up with a variety of technical, global impact, and teamwork recommendations in order to assist future teams who may work on this project.

Technical Recommendations

The team has come up with several technical recommendations which could help improve a related project in the future. These recommendations include inspection of timing conflicts, especially in relation to the OLED display, utilizing an I2C multiplexer for the joysticks, improving the 3D-printed enclosure, and developing a test for the latency of the system. These recommendations are discussed in detail in this section.

The first recommendation the team would like to address regards a closer inspection of all timing conflicts in the system, and pursuing a more optimized implementation. Most notably, there is a noticeable delay on the OLED display. Although all joystick and button response time includes no noticeable delay between user input and system output, the OLED display's current implementation includes a forced delay of about one second before the user is able to see the available keymappings for the selected left joystick direction, as any shorter timing interferes with other processes on the microcontroller. Although there was not sufficient time in our team's schedule to determine a solution for shortening this delay while still meeting the accuracy requirement (Section 2.1.5), there may be a resolution given more time in future endeavors. Possible solutions include looking further into applications for implementing interrupts into the design, options for these can be referenced in Section 11 (pg. 49) of the ATmega328 datasheet [1]. A lower priority solution option would be to consider implementing another microcontroller that could control the OLED display quickly and without risk of interfering with the joystick and button performance. For this solution it is recommended that the team consider a lower-performance controller with at least an 8MHz internal clock, for the sake of project costs.

The next technical recommendation considers an optimization that can occur with regards to the microcontroller's I2C bus. Currently, the team-built ATtiny85 modules that are connected to the analog joysticks are flashed so that each module was programmed with identical firmware, save a different I2C address. However, in the case that more modules or components that utilize the I2C bus are implemented, perhaps for the purpose of different adaptations or further functionality in future redesigns, the team may want to consider finding a way to use the same I2C address to reference similar modules. A possible solution for this would be using an I2C multiplexer, which allows for distinction to be made between different modules that use the same I2C address. For example, all joystick modules could be programmed to have the same I2C address, and so forth. Furthermore, even if no further modules are implemented into the system, the use of an I2C multiplexer would save the need to edit the addresses in the firmware to flash onto each module and allow for higher-level software control. A viable multiplexer may include one such as the TCA9548, or a breakout module using that [2].

The enclosure in the project may also need to be redesigned in order to fit components easier. The enclosure which has been currently designed cannot fit all components very easily, and most of the holes meant for screws were not able to fit them or fit the devices that were supposed to be supported for the screws. As such, the team recommends better designing for assembly by being more careful about the size of parts, but also adding more empty space to allow for these parts to actually fit in the enclosure. The team found an article which discusses tips for improving the eventual assembly of 3D printed components [3].

The team also wants to be able to find the correct tolerance for the 3D printer which results in a durable design but also reduces cost. Furthermore, the team also wants to reduce the amount of supports the final design will contain in order to reduce 3D printed waste. This would also hopefully reduce the cost of the final design. The current design required a lot of supports in very small places. While the team attempted to reduce the amount of supports through the use of inclines, this did not end up being completely successful and the design still utilized many supports. The team did find an article which should help with starting research on how to reduce the amount of supports a final design would require [4].

The team wanted to focus on the accuracy and perceived delay of the system, but was unable to figure out how to measure such a delay. This made verifying the final design more difficult, even though the delay given was perceivably small. This could either be improved by focusing solely on the perceivable delay of the system, which would not require measuring the delay, or find a program that would help measure this delay. In this case, the metric the team must observe is the latency of the mouse or the keyboard. The team was able to find an article which describes latency in the context of a mouse, and the types of programs which could be used in order to measure this latency [5].

[1] ATMega328 datasheet: https://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf

[2] TCA9548 datasheet: https://cdn-shop.adafruit.com/datasheets/tca9548a.pdf

[3] T. Packer, “How to design an assembly for 3D printing,” *Fictiv*, 04-Oct-2019. [Online]. Available: https://www.fictiv.com/articles/how-to-design-an-assembly-for-3d-printing. [Accessed: 05-May-2022].

[4] K. Stevenson, “How to significantly reduce use of 3D print support material,” *Fabbaloo*, 06-May-2020. [Online]. Available: https://www.fabbaloo.com/2020/04/how-to-significantly-reduce-use-of-3d-print-support-material. [Accessed: 05-May-2022].

[5] “How to perform mouse latency test in windows computers,” *The Windows Club*, 11-Feb-2022. [Online]. Available: https://www.thewindowsclub.com/how-to-perform-mouse-latency-test. [Accessed: 05-May-2022].

Global Impact Recommendations

The team has also considered potential global impact recommendations for a future team. These can include finding a user which the team can consider in their design, as well as ensuring a lower cost of materials, and thus a lower cost for the product.

The team recommends finding a specific user for the project so that they can be considered within the design. Throughout the duration of this project, the team designed the controller so that it could, in theory, be utilized by someone without a hand. However, all of the engineers on the project were able-bodied and thus did not have any personal insight on how to design the controller. This is very important when utilizing inclusive design, as the engineers must understand how users would operate the product and use it, as otherwise these products can cause unnecessary frustration and exclusion [1]. In order to understand the specific UX needs that a disabled user may have, the team should find a member of the desired user group to help test the design. Furthermore, the team should consider many other concepts related to inclusive design and implement them in their own design, in which an article was found which discussed important concepts related to inclusive design [2].

Furthermore, the final product may cost the end user a lot of money, which is not ideal. The team would want to reduce the cost of the final product so that it could be affordable to the end user. It was found that the part of the project which increases its cost would be the 3D-printed enclosure. All of the 3D printed parts cost $115, which means that the 3D-printed enclosure was the most expensive part of the project. As such, in order to reduce the cost of the final design and thus the cost of the product, the cost of the print would need to be reduced. This could be done by reducing the amount of filament which would be used in the final design, or by finding other ways to reduce the cost of the print. The team found two different resources which would help in order to reduce the cost of 3D-printing [3][4].

[1] "What is inclusive design?," *Inclusive Design Toolkit*. N.d. [Online]. Available: http://www.inclusivedesigntoolkit.com/whatis/whatis.html. [Accessed: 05-May-2022].

[2] A. Heylighen, V. V. der Linden, and I. V. Steenwinkel, "Ten questions concerning inclusive design of the built environment," *ScienceDirect*, 29-Dec-2016. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0360132316305005. [Accessed: 05-May-2022].

[3] M. von Übel, "20 great ways to reduce the cost of 3D printing," *All3DP*, 31-Jul-2019. [Online]. Available: https://all3dp.com/1/20-thrifty-tips-to-help-reduce-the-cost-of-3d-printing/. [Accessed: 05-May-2022].

[4] R. Brockotter, "How to reduce the cost of 3D printing," *Hubs*. N.d. [Online]. Available: https://www.hubs.com/knowledge-base/how-reduce-cost-3d-printing/. [Accessed: 05-May-2022].

Teamwork Recommendations

In order to work on the project efficiently, the team recommends looking through two different textbooks which discuss project management. These include *Project Management for Engineering Design* [1] and *Effective Interpersonal and Team Communication Skills for Engineers* [2].

Throughout the course of the project, the team found that they could benefit from more synchronous meetings in the future. This way, the team would be encouraged to work together more frequently and direct feedback and communication would especially be encouraged. The team would also be able to work together and help other team members when they need it. During the course of this project, the team utilized Discord for communication. While asking questions and working together on Discord did work, it did have the drawback of response time, something which would not be an issue with more synchronous sessions.

The team also recommends assigning tasks early and clearly for team members. Near the beginning of the project and throughout block validation, the team was able to efficiently delegate tasks. However, when going into system verification, it became more difficult to delegate tasks for team members. This resulted in long sessions where only a part of the team was capable of working on system verification, without any clear tasks for the rest of the team. Being able to properly delegate tasks this late into the project could avoid this issue and also allow for it to be completed in less time.

[1] C. S. Lessard and J. P. Lessard, *Project Management for Engineering Design*. San Rafael: Morgan & Claypool Publishers, 2012.

[2] C. A. Whitcomb and L. E. Whitcomb, *Effective interpersonal and Team Communication Skills for Engineers*. Oxford: Wiley-Blackwell, 2013.

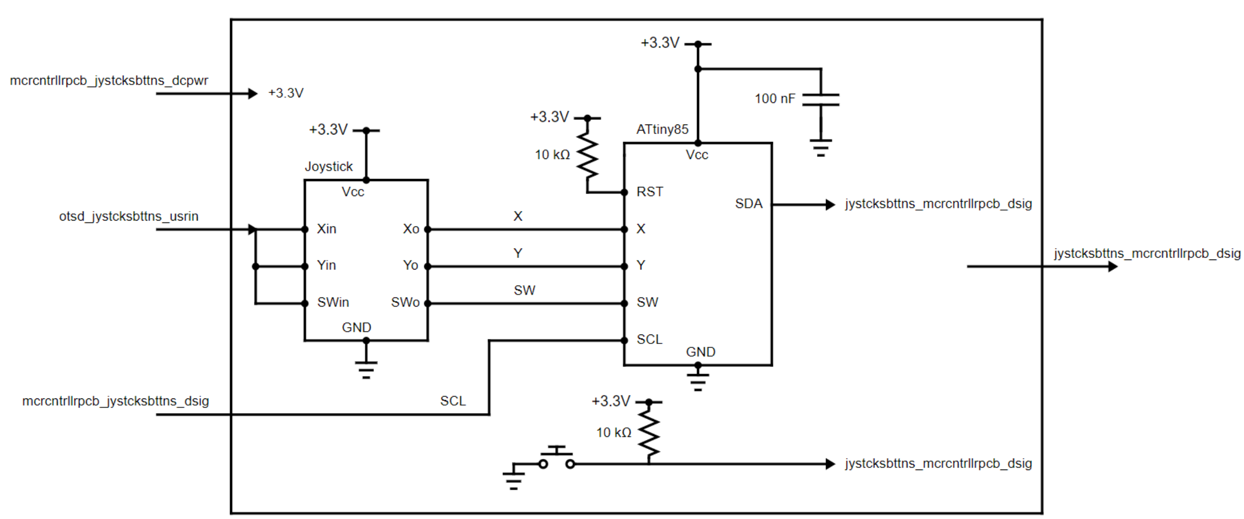
Project Artifact Summary with Links

Code

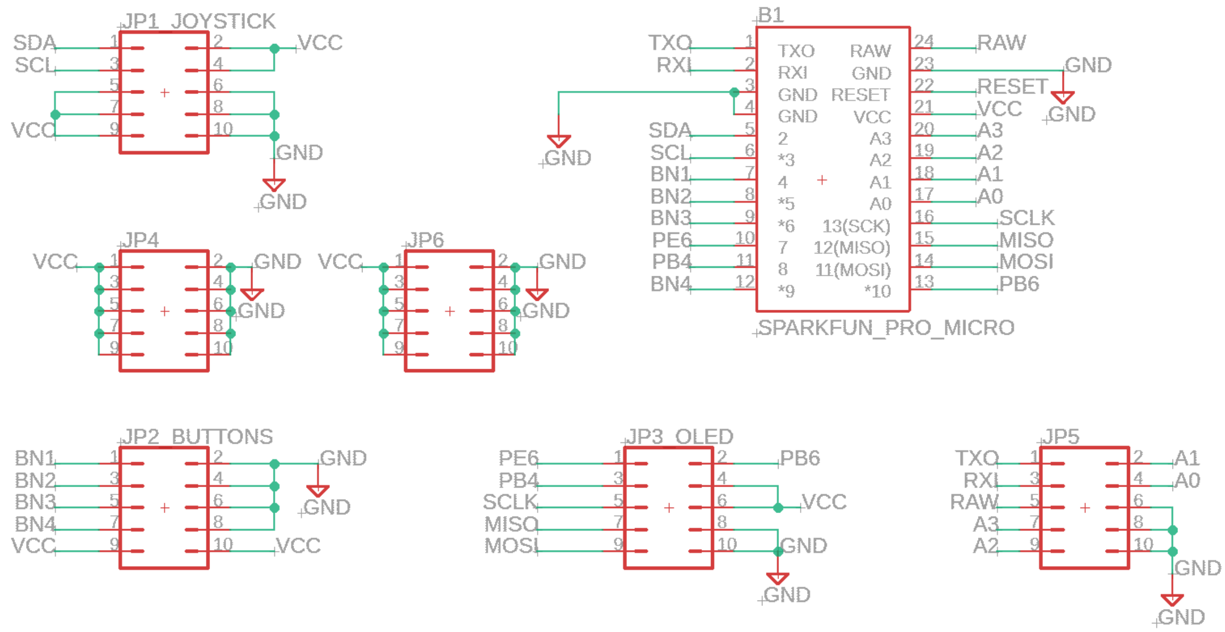
[Code: with github links]

Schematics

Schematic for Joystick and Button module:

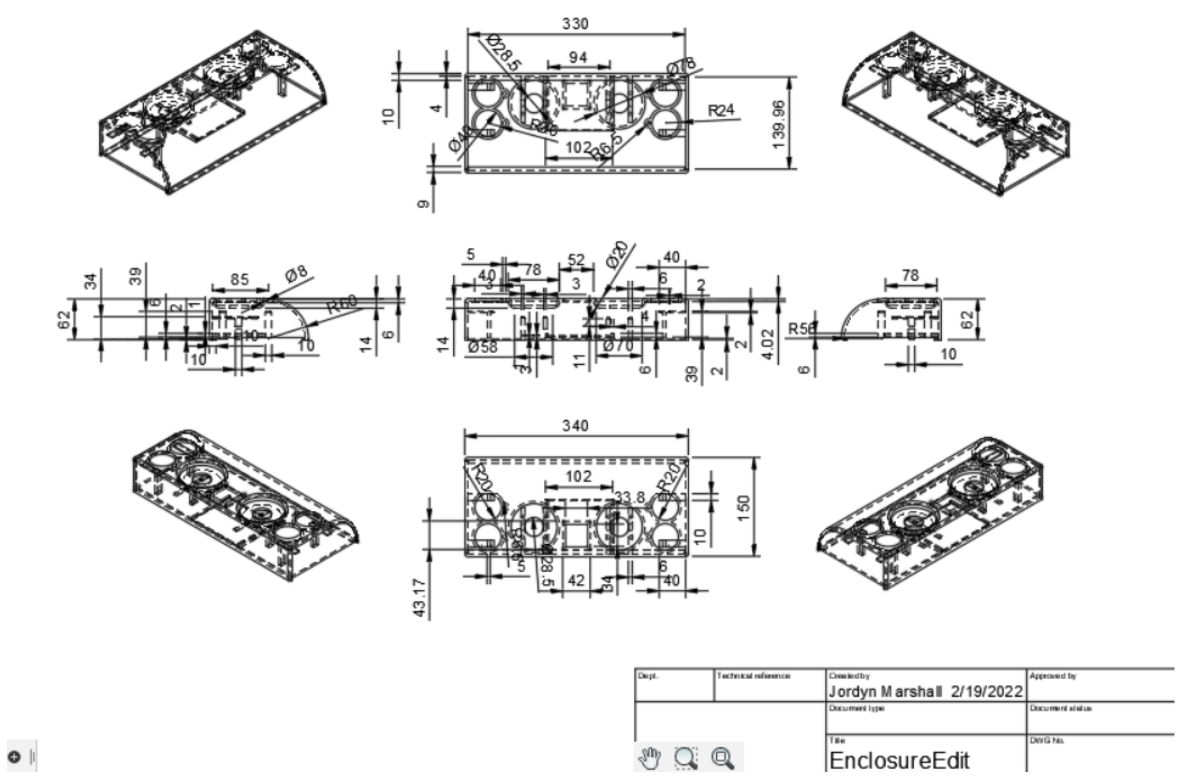


Schematic for PCB:

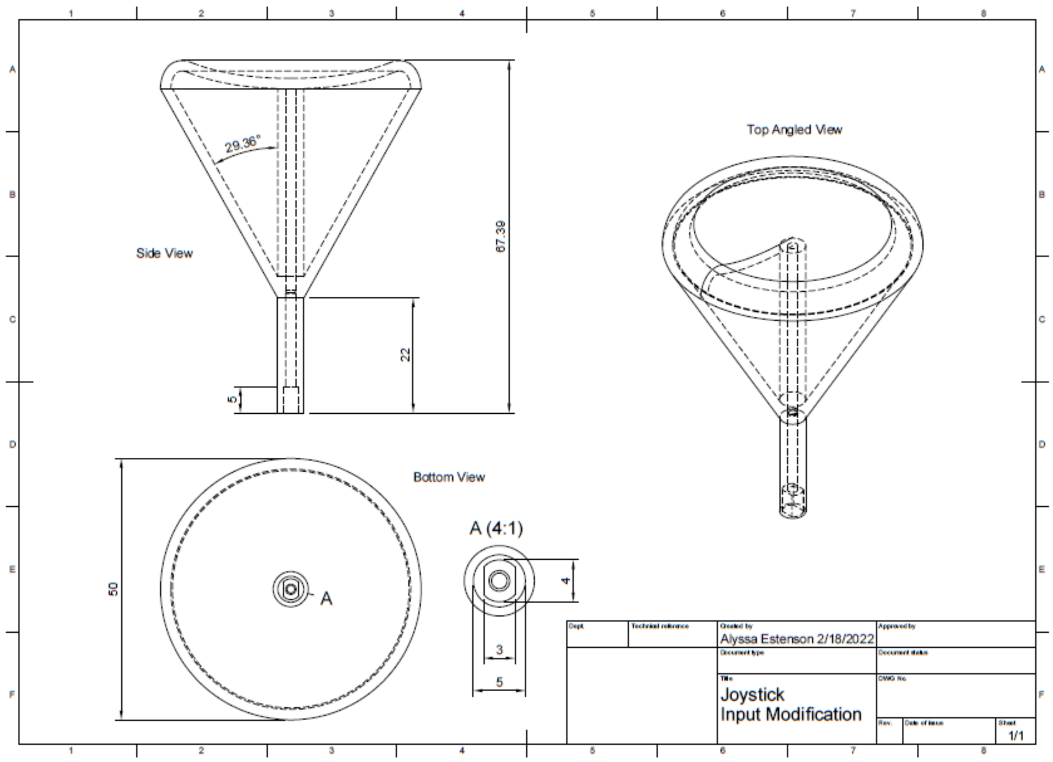


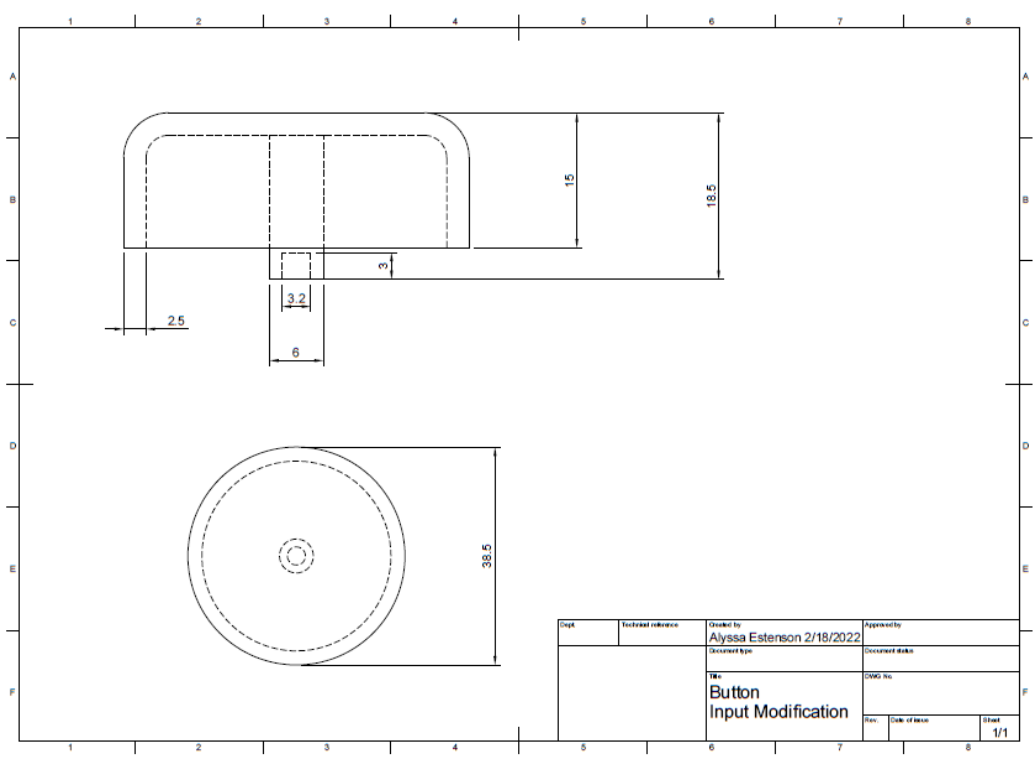
Mechanical Drawings

Mechanical Drawing for the Enclosure:



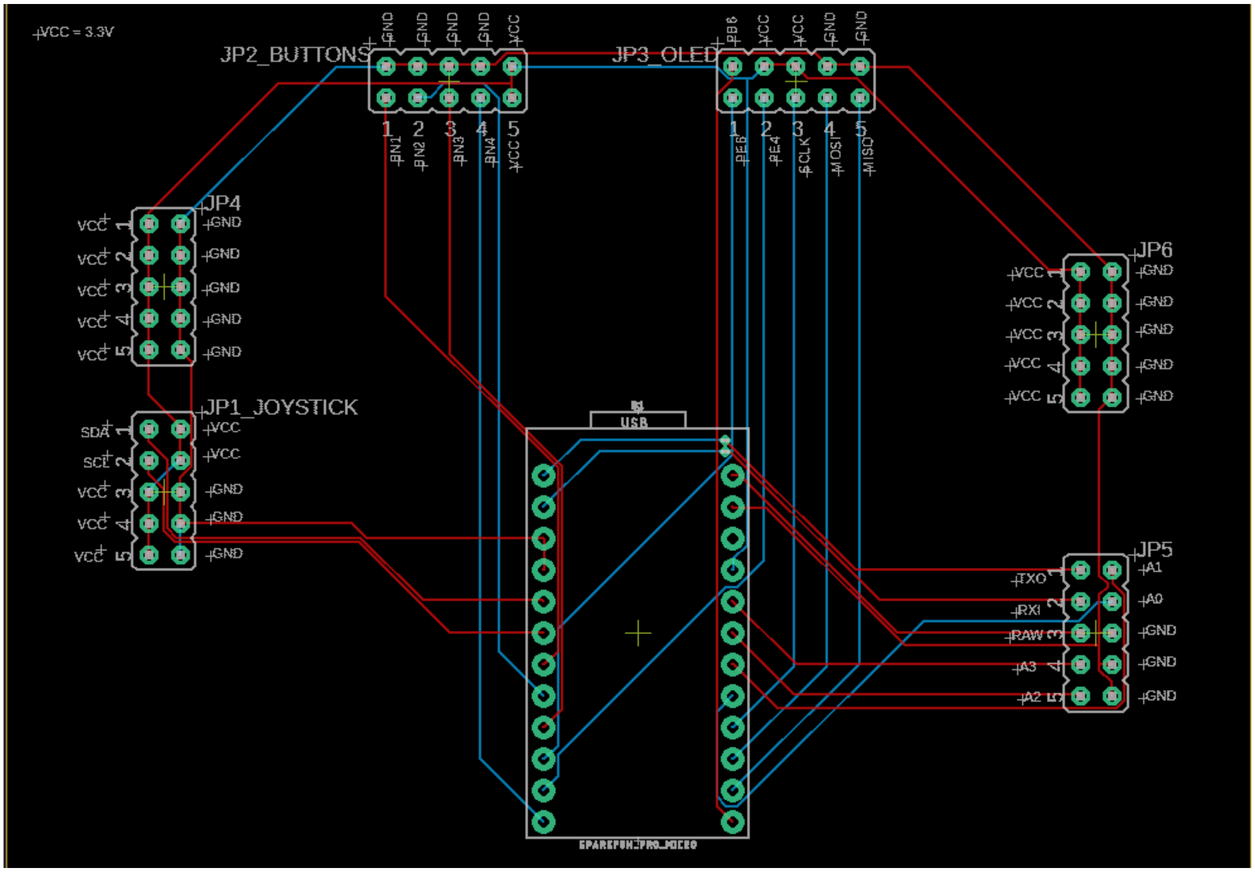
Mechanical Drawing for the Input Modification (Joystick and Button):





PCB Design

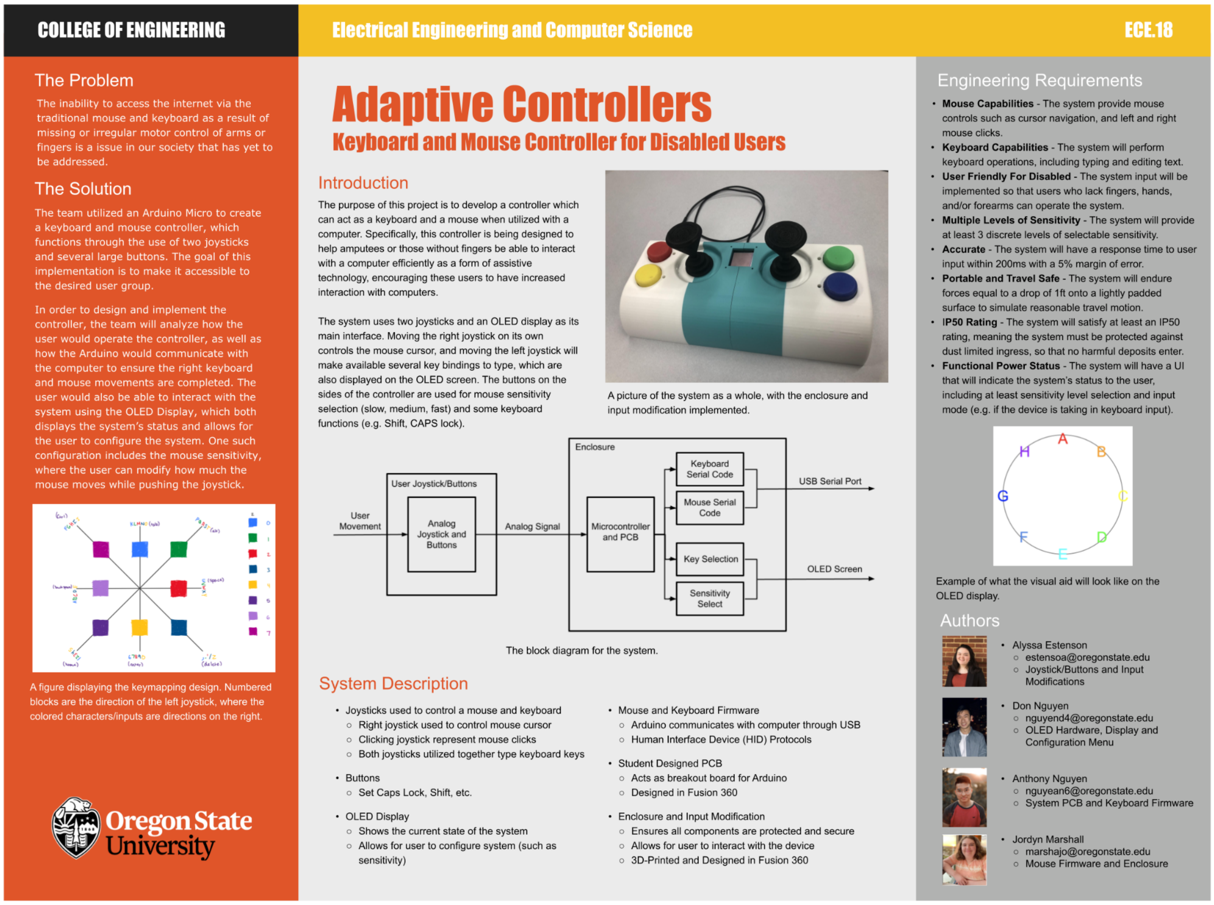
[PCB Design]



Other Project Artifacts

[GitHub readme]

Presentation Materials



The team has created a project poster in order to present information about the project at the Engineering Expo. This poster is seen above. The team will also create a project website in order to present project artifacts and demonstrate the project's functionality in videos. This website can be found here: https://eecs.oregonstate.edu/project-showcase/projects/?id=dvNoBaSVptpGct7d