## **Purdue ECE Senior Design Semester Report**

## **(Team Section)**

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| **Course Number and Title** | ECE 47700 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2025 |
| **Advisors** | Phil Walter |
| **Team Number** | 20 |
| **Project Title** | Encrypted USB Drive |

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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Brandon Liu | CompE | Software, PCB Design, Soldering, Wire Crimping | May 2025 |
| Abhijay Achukola | CompE | Software, PCB Design, Soldering | May 2025 |
| Joshua Wai | CompE | Mechanical | May 2025 |
| Stanley So | ElecE | Software, PCB Design, Soldering, Wire Crimping | May 2026 |

**Project Description:** Provide a brief (2-3 page) technical description of the design project, as outlined below:

1. Provide a general description of the product to be delivered by this design project.

## This product features a USB Drive that can be used by multiple people with each user having access to its own bank of memory. To access memory, each user must undergo authentication by entering user ID and password.

1. What is the purpose of this product? For whom is it intended?

## The purpose of this product is to have an encrypted thumb drive that meets functional requirements while keeping costs as low as possible; a great additional feature includes segmented memory such that different users using the same thumb drive can only access certain files depending on their credentials via passwords, ID etc. The drive should provide an extra layer of security for access to user data. The intended audience for this product includes people who want to keep their data private. It can be bought by companies to be used by employees who want to transfer information via the drive, even if there is other sensitive data on there not erased yet, or even interest anyone involved in government or the military.

1. Describe how the engineering design process used to create your product was utilized in this project. Include how you were able to develop and conduct appropriate experiments, analyze and interpret data, and use engineering judgment to draw conclusions related to the development of your product.

## The main engineering design process used to create this product began with defining the problem and solution. The first task completed came up with a problem to be solved which ultimately led to the decision to develop an encrypted USB drive to solve the issue of data security. The next step was planning. This included looking at specifications of parts to meet goals and functionalities that the solution seeks to provide and then prototyping each part before making a PCB design and systematically integrating everything into one device (PCB connected to external components). There was lots of testing to debug issues not found in initial prototyping such as bridging the connection between USB host and flash memory. At the time of writing the initial draft of this document, the project is not fully complete, but for future improvements on the product, optimized speed and a better user interface is considered for later development.

1. Describe the design constraints, and resulting specifications, incorporated into your product (list a minimum of 3).

## The key constraints to this project are computational, electrical, and thermal. To start off, the computational constraints will use a linear scan algorithm to check user id against all known records and then comparing passwords. Additionally, the goal is to have at least 100kB/s speed for reading / writing files between the computer and the flash drive. The microcontroller should be able to allow each user should have at least 4Gb of memory via allocation (no partitioning). However, the fingerprint sensor takes care of storing fingerprints and comparing fingerprints already so the microcontroller doesn’t have to do that. Our thumb drive will use an STM32 microcontroller to interface with a fingerprint sensor, LCD display, keypad, USB-A host, and flash memory. The fingerprint sensor will communicate using UART. The LCD display will communicate using SPI or I2C. We will interface with the keypad by polling each row and checking the corresponding column. The USB communication will be handled by the onboard peripheral inside the microcontroller itself. The flash memory will communicate using SPI. There will be a 5V to 3.3V regulator to provide power to the microcontroller and whatever peripherals need it. There will also be a crystal to make sure the USB data is transmitted at the correct frequency. There will also be a mosfet so we can turn off power to the fingerprint sensor with a GPIO pin when it’s not needed. The input voltage from the USB should be between 4.75V and 5.25V. The device should draw less than 500mA from the USB. The maximum operating temperature should be at least 110 degrees Fahrenheit. The minimum operating temperature should be at most 32 degrees Fahrenheit. The device is powered by the USB so there is no battery.

1. Describe how each of the following factors influenced your design specifications and constraints.

## **Public Health, Safety, and Welfare:** The main source of danger comes from the user accidentally damaging the board with static charges with anything via human input, so we had to add a bunch of ESD diodes for USB, keypad, and fingerprint sensor. There aren’t any other risks associated with the device so there was not a need for consideration of public health, safety, and welfare.

## **Global Factors:** This product does not consider geopolitics in any shape or form, so global factors were not considered in this project.

## **Cultural Factors:** The encrypted USB drive is not necessarily associated with a particular culture (except for avoiding cultures that do not wish to actively participate in modern technology), so no cultural factors were considered, especially because the proposed users of this device would have already had exposure to USB drives in the past.

## **Social Factors:** Besides the consideration of only selling this product in a capitalist society, no social factors were considered.

## **Environmental Factors:** The only environmental factor in consideration is the climate and weather condition that the device will be used in. For example, it is under the assumption that the product will not be used in extreme heat or cold, and it will not be used in an external environment where there is precipitation.

## **Economic Factors:** The only economic factors that come into play are the prices of competing products, so the design in question aims to not be too much more expensive compared to products already on the market.

1. Describe the appropriate engineering standards incorporated into the creation of your product.  
     
   The main standards used in this project are the communication protocols implemented to interface external components with the microcontroller including USB, SPI, and UART. Other followed conventions include using ESD protection for components that may interact with human input as well as other rules set for PCB design involving ERC and JLC PCB dimension constraints.
2. Describe the final status of your product.

Place At the time of writing this report on April 23, the product can transition between user select, receiving password, unlock, change fingerprint / pin, and locking states via the fingerprint sensor input, keypad input, and LCD display. While the microcontroller can interface with a host computer over USB and interact with the flash memory chip via SPI, the microcontroller is unable to bridge the connectivity between the flash IC and host computer (USB).

1. Describe the makeup of your project team and how you were organized to establish goals, plan tasks, and meet the objectives of this project.

## Each team member worked on tasks based on skillset and interests. Although each team member took similar ECE courses prior to the senior design course, there were new tasks that required learning and interest such as soldering, CAD (for casing), and PCB design. Joshua was interested in the mechanical tasks of the project, so he primarily did the CAD. Stanley, Brandon, and Abhijay each prototyped approximately 1-2 external devices ie. LCD, fingerprint sensor, flash ICs, and keypad due to their experience in working with these devices. Although Stanley was the most experienced in PCB design, Abhijay took a keen interest in it and therefore was the main contributor to this task. Brandon had an interest in PCB design as well and took a more minor role in routing and drawing ground planes. However, due to Stanley’s more extensive experience in PCB design, he would often be tasked to review the PCB layout before submissions. Finally, when it came to soldering, Brandon was the main contributor to soldering parts to the PCB due to his surgeon-like steady hands.

1. Did your project require the production of any written documentation other than this document (i.e., manuals, educational materials, etc.)? If so, describe the types, composition, and nature of the audiences for whom these materials were intended.

## This project involved the production of several written documentations other than this document including engineering journals and design documents. The engineering journals include the thoughts, progress, and achievements of each team member’s individual work. The design documents include the planning of the various systems of the project including software and hardware, as well as analysis on the comparison between design components.

1. Describe the types, composition, and nature of the audiences in attendance for the final oral design review. Discuss how you prepared for this audience.

## In the final oral design review, the main audience are student peers and the instructional staff. The student peers are likely interested in seeing the functionality of the design and the process involved since they never conducted weekly check-ins to see the progress of this project throughout the semester. The instructional staff may pose more sophisticated questions as they were involved in seeing how the project progressed over time. To prepare for both audiences, it was key to reflect on the responsibility and achievement of each team member as this is what we will be presenting in addition to the demonstration of the project design.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Advisors** | Phil Walter |
| **Team Number** | 20 |
| **Project Title** | Encrypted USB Drive |

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Brandon Liu | Computer Engineering | Software, PCB Design, Soldering, Wire Crimping | May 2025 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## My main contribution includes prototyping the LCD, prototyping read JEDEC ID for the flash IC, routing the PCB layout and ESD protection. I’ve also crimped wires & soldered wires together to establish connections between external components and the PCB which has a bunch of components that I soldered on including but not limited to the MCU, flash ICs, connectors, diodes etc.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## My contributions towards prototyping components involved skills developed primarily in ECE 36200; I learned to work with GPIOs, communicate with external devices using SPI and UART, and configure interrupts.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## For all other skills such as soldering, PCB layout, and working on the physical wires, I had to develop them by watching tutorials online (for PCB and wire work) and attend workshops hosted in the senior design lab room (for soldering).

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## My ethical responsibilities involve being honest about my progress and what I am struggling with. It is important that other team members know what I have worked on and what I have not completed yet, so they have full transparency on other aspects of the project that they are not working on. My professional responsibilities primarily consist of following conventions for updating parts of a project shared and accessed by multiple members including but not limited to version control.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## Because this product has no consideration of societal or global contexts, I will not make any informed judgements as to the product’s impact in those areas. For the product’s impact in the environmental context, I would only think about what the product uses or releases, and since it does not release any substances to the environment, I would determine that the only environmental impact is electricity usage. As for economic impact, I would determine that this product has one by being a competing product in the marketplace.

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Stanley So | Electrical Engineering | Software, PCB Design, Soldering, Wire Crimping | May 2026 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## I wrote the code for the keypad by using a timer interrupt to poll each row using GPIO. I wrote the code for the fingerprint sensor using UART. I made adjustments to the PCB based on feedback from the professor and the TAs. I ordered all the parts for the project (PCB, on-board components, and off-board connectors). I soldered some of the components to the board. I taught myself how to crimp wires, and I taught my teammates how to do the same thing. I turned Brandon’s state machine pseudocode into real code.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

ECE 36200 taught me most of the protocols used in this project (SPI, UART). ECE 2k7 and 2k8 taught me how to use special oscilloscope functions (trigger, different horizontal modes). ECE 264 helped familiarize me with C syntax and how to use a debugger.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## My PCB and soldering experiences come from prior personal projects, and I learned how to crimp terminals after watching YouTube videos for this project. I also learned how to use the oscilloscope to read serial data by watching YouTube videos.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## Whenever I saw that something needed to be done, I would jump in and take care of it (everything in part A was something I volunteered to help for). At the very least, I always tried my best to be there when someone else was working. There are some unlogged hours missing from my journal where I’m just there for mental support, and ready to help with any small tasks that I could (they’re missing from my journal because I don’t know how to log those hours without points being deducted for not describing enough). I always tried my best to communicate with my teammates on Discord (about progress and also about my schedule), and I made sure I received all notifications from that Discord server so I could constantly be aware of what needed to be done.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## (If we polished our product more), some societal and global impacts this product might have are that this might be used by companies to protect their data, leading to more secure data storage since you have to physically get your hands on it to break into it. This might also be used by criminals to hide their data and communicate, like how mass criminal networks have used encrypted phones, but this is much less of a concern than encrypted phones because it has no internet access. We mainly avoided adding internet access because it would be too much work, but it would also make it another encrypted phone, leading to really big ethical concerns regarding criminals using it. Like many electronic products, this product has environmental impacts on both the manufacturing and disposal stage. Every single component (PCB, ICs, LCD display) uses hazardous chemicals in the manufacturing process, along with a lot of energy. During the disposal stage, you have to smelt the electronics to get the metals back, which is more energy usage. To account for this, we made the PCB as small as possible and chose the smallest possible components that met our requirements. In terms of economic impact, we might be able to sell this to a lot of big companies that want to secure their data.

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Abhijay Achukola | CMPE | Software, PCB Design, Soldering | May 2025 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

I researched which flash IC to utilize, read through the data sheet, and implemented software interfacing with the flash IC from the microcontroller over SPI. I also designed a majority of the PCB Design and kept the schematic up to date with our updates prior to starting the PCB design. I also helped solder all the parts onto the PCB, helping place parts in place.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

I was able to utilize the datasheet reading knowledge I gained from prior classes like 2k1 and 362. I also was able to utilize the KiCAD and stm32 knowledge from ece362.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

I acquired the knowledge of how to utilize stm32cube and interfacing with flash ics by reading through forums and online datasheets on how to utilize it. I also learned how to design PCBs by listening to 477 lectures and watching videos online

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

I was in charge with keeping the team organized and ensuring that everyone knew which priorities had to be handled. I also ensured that we met together and ensured that the design process went smoothly, to avoid any malfunctions due to miscommunication.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

I think we had a decent informed judgement on the product’s impact, with it having a slight influence in the corporate space, looking at the global, environmental and societal contexts. It might also save the amount of USBs utilized and disposed of as our device can be utilized by four separate people, looking at the environmental context.

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| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Josh Wai | CompE | Mechanical | May 2025 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## For this project I was in charge of the mechanical aspect of this project

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## I used the skills learned from 2k7 and 362 lab and built on that

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## I had to learn how to use onshape the CAD software from scratch, I mainly used youtube as a reference

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## To be transparent with problems when they arose

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

Our project has security impacts for society.