The SchedMed

Antoine Brown, Danny Mauricio, Waseem Isleem, Anthony Lingo

DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING, UNIVERSITY OF CENTRAL FLORIDA, ORLANDO, FLORIDA, 32816-2450

***ABSTRACT* — THIS PROJECT INVOLVES A PILL DISPENSER. IT INCLUDES 3D PRINTED COMPONENTS USED FOR THE CONSTRUCTION OF THE DISPENSER, HARDWARE COMPONENTS, A CUSTOM PCB DESIGN AND THE DEVELOPMENT OF A MOBILE APPLICATION. IN ORDER TO BUILD THIS PRODUCT, DIFFERENT ELECTRICAL AND COMPUTER ENGINEERING SKILLS HAD TO BE APPLIED.**

***INDEX TERMS* — MICROCONTROLLER, STEPPER MOTOR, 3D PARTS**

I. INTRODUCTION

Sometimes, it can be easy to forget for someone to take their daily pills or supplements. Everyone has their reasons for not taking them or forgetting to. They may have busy schedules every day from work or other activities and may feel too tired to take them. They may have a lack of motivation because they don't feel like getting up to pour some water and finding which pill or supplement they have to take at that certain time. Another reason people may forget is because they may have dementia. To give a brief explanation, Dementia is an impaired ability that makes people forget simple things and tasks. It is most common for people ages 65 and up to have Dementia. While some people may downplay it, forgetting a simple task such as taking supplements or pills every day can lead to terrible health issues. For example, if a person goes a few days without taking their daily supplements, the efficiency of the immune system can decrease. As a result, the person's body can be left vulnerable to any sickness or disease. Once a sickness enters the person's body, it'll become significantly more difficult for the immune system to fight back on it compared to someone that takes their supplements every day. Our group wants to create a machine that helps solve this issue

A. Project Goals

The goal of our project is to create an easier way for consumers to take their daily supplements. We also want to remind people of when to take said supplements. Additionally, we want to make one's life easier by creating a mechanism to facilitate everyday supplementation needs. A relatively small, robust, and interactive machine that will allow any user to have a professionally approved, yet personalized supplementation agenda. This includes dosage, schedule, and needed supplements. The SchedMed will also help prevent any inaccurate and potentially dangerous dosing amounts. This will be done by logging each individual user's supplement needs, and only dispensing the needed dosage at the scheduled time. This will eliminate any misuse of supplements, and prevent un-prescribed person(s) having access to said supplements. Authorized personnel will prescribe the SchedMed, along with the needed dosage, schedule, and of course supplementation. If appropriate, an administrator, such as a care-taker, and/or nurse will ensure proper supplement use, and scheduling, as well as new filling of necessary prescriptions. Ultimately we aim to make the SchedMed individually unique, and suited to each patient. Another goal for this project is to make and develop a portable and easy to use home device using some hand-on experience with the real world application and apply the knowledge we have learnt throughout our education career in college. We thought it would be a great idea to create a product that will genuinely help and make a difference and that's when this whole project becomes meaningful to us, when we see a difference has been to the people when it comes to taking medications and prescriptions.

B. Project Function

The function of this project is to develop a machine that dispenses pills. A mobile application will be developed to allow the user to make the proper settings and configurations for the dispenser. The application will also allow the user to set reminders for when they need to take their daily pills and supplements. The user or patient will be notified of what supplement is to be taken, and when to take it. Once notified, the user will interact with the user interface of the mobile application and communicate to the dispenser to dispense the pills by pressing the dispense button.

C. Specifications

In the following table below, it shows the specifications for the product that we had to take into account to obtain successful results. The parts used for this product were well researched, allowing this project to be efficient and relatively on the low-cost side. We also want our product to be more on the lightweight side, yet robust to promote portability, and structural integrity.

Pill Compartment Capacity	6 (MIN)
Production Cost	$200 (MAX)
Weight	4 lb (MAX)
Dispensing Speed	3.5 sec (MAX)
Application Response	2.5 sec (MAX)

Table 1: Engineering Specifications

II. ELECTRICAL OVERVIEW

The SchedMed requires a relatively low level of power to fully operate all the electronics. When deciding on the electrical components to include at the proto type stage, we wanted to keep the system as simple as possible, but still achieve the intended operating form. Meaning, we decided to use only what was necessary to have a pill dispensing system. Given the circumstances, the final goal is to have a working product within the given timeline. However, this prototype version of the Schedmed is simply a foundation upon which we could add more features, and extremities. Aiming to not only increase the capabilities of the SchedMed in general, but to also diversify its capabilities.

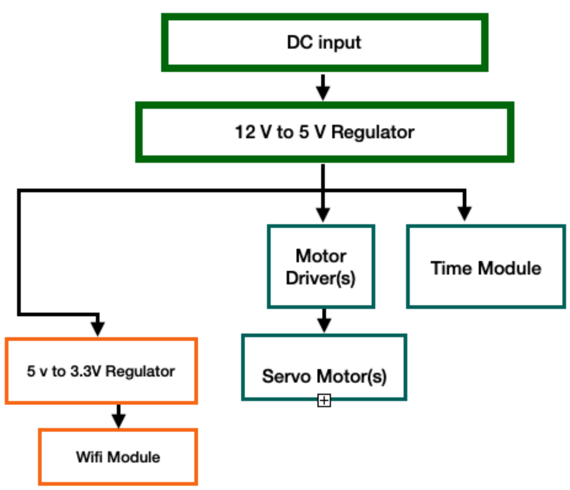

Figure 1: Power Supply Hierarchy

A. Power Supply

For the power supply of this project, a 12 V input is being used with a Male to Female Standard 2.1 x 5.5 mm power jack. A 12 V to 5 V voltage regulator was built to step down the 12 V input from a wall outlet to 5 V to power the stepper motor and motor driver. A 5 V to 3 V voltage regulator was also built to step down the first voltage regulator to 3 V. This voltage regulator is used to power the microcontroller and wifi module.

B. Electrical Components

The electrical components used for this project include a stepper motor, motor driver, ESP8266 wifi module, and our power supply system. Each component will work with another to reach an adequate level of operation. The power supply system will regulate and deliver the necessary amount of power to all other electricals. The ESP8266 wifi module allows the pill dispenser to connect to a router or modem and access the internet, and will be the main hub of communication between user interface, and motor system. When it is time for the user/patient to take their needed pills and the user presses the dispense button on the app, the stepper motor and motor driver will be activated. The stepper motor will rotate the pill storage unit ultimately placing the next pill compartment over the dispensing window.

C. PCB

For the PCB of this project, the ESP8266 WiFi module will essentially act as the microcontroller unit. Initially, we intended to use the typical surface mount package of the ESP8266. Due to some time sensitive issues we had to reprioritize our focus to the development of other aspects of the project, such as the UI. This meant that we had to revise our original PCB layout to include the ESP8266 throughhole package. This configuration of the wifi module was used throughout the development process as it facilitates prototyping, testing and circuit development. Another major influence on this decision was the challenge of successfully soldering a surface mount package to the PCB. Surface mount packages can be tricky to solder, and the Wifi module is arguably the most important component of our whole project in terms of operability. However, the goal was to include the Surface Mounted ESP8266(also shown below), as it would consolidate our electronics, and increase the efficiency of signal transmission. All of the other components used for the PCB are through-hole packages, making it straightforward to solder. The power supply connects to the bottom left side of the PCB via male-to-femal DC input Jack.. All of the other IC units are located in the upper region of the board away from power supply components in an attempt to mitigate any potential noise emissions amongst the copper tracing.

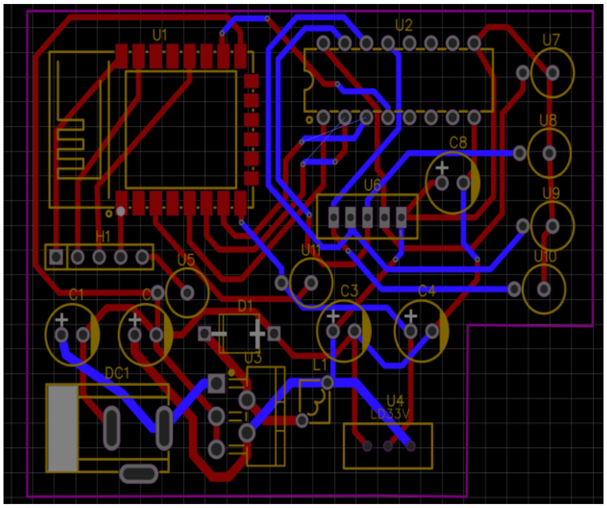

Figure 2: Stretch Goal PCB

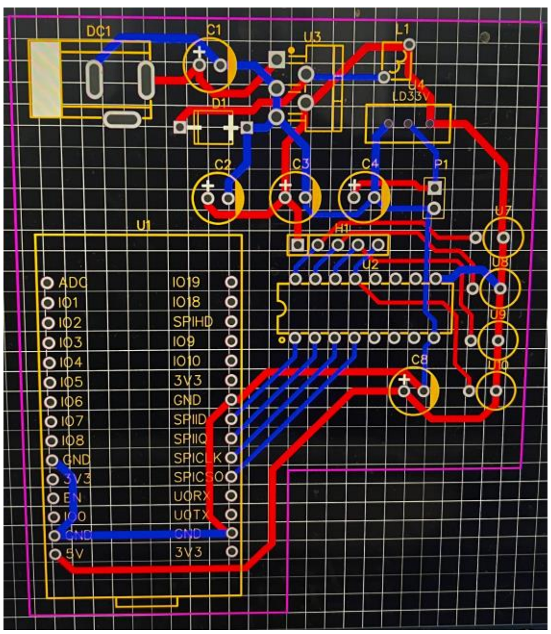

Figure 3: Operating PCB

D. Wifi Module

The wifi module for this project allows the pill dispenser to gain access to the internet by connecting to a router or modem. The module is programmed to produce its own hotspot that is discoverable to the user. This will allow the user to communicate with the pill dispenser through the mobile application. The ESP8266 also offers a number of general purpose input & output pins that we employed in order to control the stepper motor system. Enabling us to simplify the circuitry of our project a bit, and use this module as our MCU, or "electronic brain".

III. HARDWARE OVERVIEW

For this project, we decided that the material and structuring of the product would be 3D printed. The electrical and hardware components would be inside the pill dispenser, out of harm's way. The block diagram shown below shows how all the hardware components are connected to each other and communicates with the microcontroller of our choice.

C. 3D Printed Components

All of the main parts of the pill dispenser were 3D printed using the 3D printer in the innovation lab at UCF.

Figure 4: SchedMed Pill Dispenser

A. Hardware Design

When developing the hardware for the SchedMed there were a few critical characteristics that heavily influenced our thought process. Initially, designing the dispensing mechanism within the hardware was the main focus. The "wheel" dispensing concept that is shown below is one that proved to compliment other aspects of our hardware we were intending to include. Such as, facilitating the attachment of our electromechanical components such as the stepper motor. Essentially, the "wheel" piece of the hardware serves as the storage unit. This is where the user's pills will be organized, and stored. Thus, the rotating arm of the stepper motor will simply fasten directly into the bottom of the storage wheel. At the center point the arm will rotate as needed repositioning the wheel. As seen below, the wheel will rotate a fixed amount placing each pill compartment over the dispensing area, or hole. Lastly, the wheel provides a convenient, and user-friendly means to replenish the SchedMed. This process will simply consist of removing the lid of the wheel unit exposing the storage compartments, and replenishing each compartment when needed. As the wheel storage unit features 7 compartments that can potentially contain pills. Therefore, we wanted to ensure ease of use, and make the storage compartments as accessible for the user as possible.

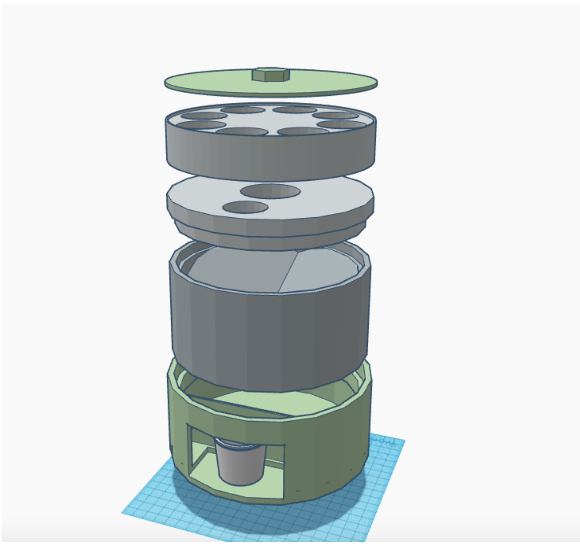

Figure 5: 3D Concept of SchedMed Dispenser

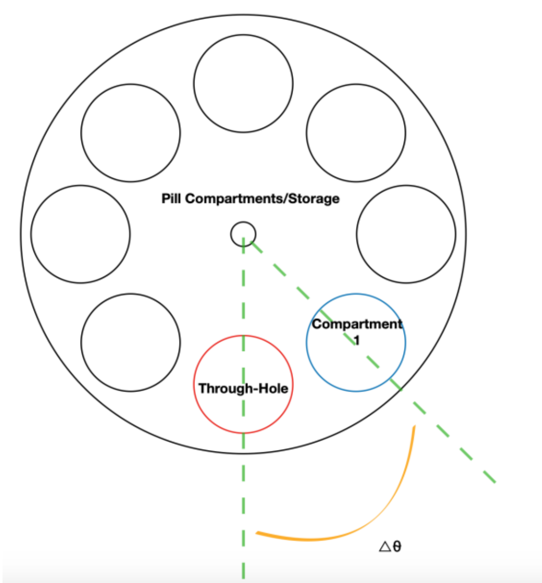

Figure 6: Motor Logic & Dispensing Mechanism

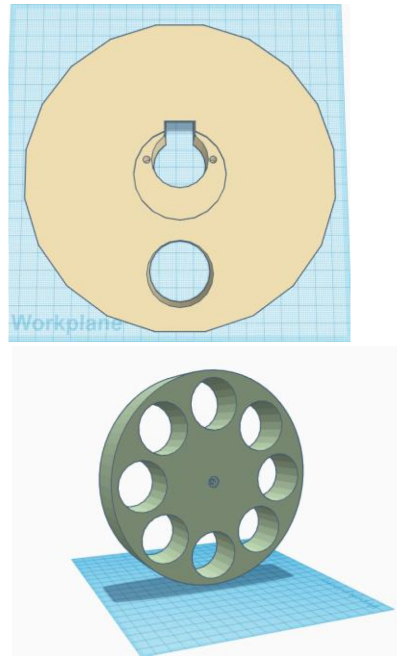

Figure 7: Stepper Motor Mount & Leverage Point Design

IV. SOFTWARE DESIGN

A. Mobile Application

Since the goal of the SchedMed is to remind the user about when to take their medications, it is important to have a user application that is easy to use for the consumer to understand. At its core, the application is meant to be personalizable, and exclusive to the user. Meaning, any useful information relative to their medication, or pills that need to be scheduled, dispensed, and administered could be stored and tied to a user account. This was achieved by the use of the software known as Blynk. We were able to construct a blank template to create our application, and ultimately give the user control over the SchedMed. Through this we were able to set up a notification system that gives the user the ability to schedule any notification or reminder pertaining to their medication. Also, it will give the user the option to perform an action brought upon by some condition. For instance, the user can simply display an alert message and notification icon(as shown below), or they can decide to email their pharmacist, or doctor's office to arrange the refilling of a prescription. Our main objective of the mobile application is to make it as dynamic, yet intuitive as possible for the user. Offering only the necessary features that are required to effectively, and conveniently control the SchedMed.

Figure 8: Main Notification Screen

As you can see in the above image the notification system can be used to notify the user of any information pertaining to the SchedMed, and their medication. The main intention of this notification system is to be able to remind the user to take any medication when needed. With frequency, and difference of time intervals not being an issue in the scheduling. In fact, you can see in the "Dispensing time 1" notification tab it is calling for the users attention as the notification to dispense meds has already passed that day. Below are images of the scheduling screens that will be presented to the user as they need.

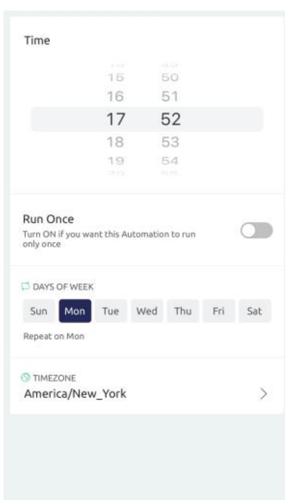

Figure 9: Notification Scheduling

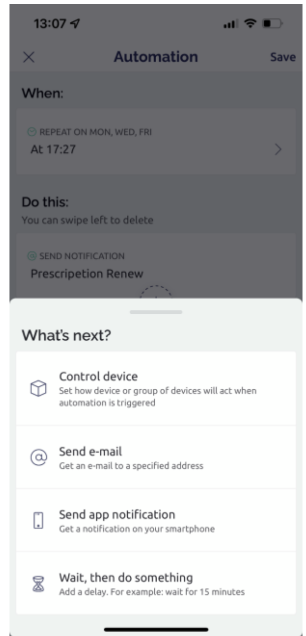

Figure 10: Options to perform when notification is triggered

The user will have a few options of what they would like done when a specific notification is triggered. This can be anything from a simple notification badge, alert message, and sound. Potentially having the medicine described in name, type, and quantity. Or it can be as proactive as triggering an automated email to inform whom it may concern of any user medication needs, such as the refilling of a prescription.

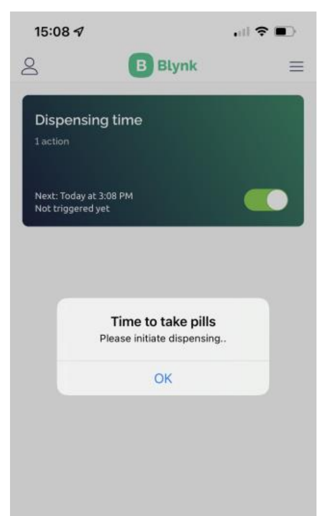

Figure 11: Example Notification

Say the user is prompted by a notification to dispense their pills that are scheduled(Above Figure Example). The user will see that screen, and be given the chance to interact with it as they see fit. As you can see in the below figure, once notified, the user can navigate to the dispensing screen and toggle the dispensing button. We wanted to provide the user with the option of initiating the pill dispensing or not. This seemed the safest solution to avoiding any mishandling, or mis-consumption of pills.

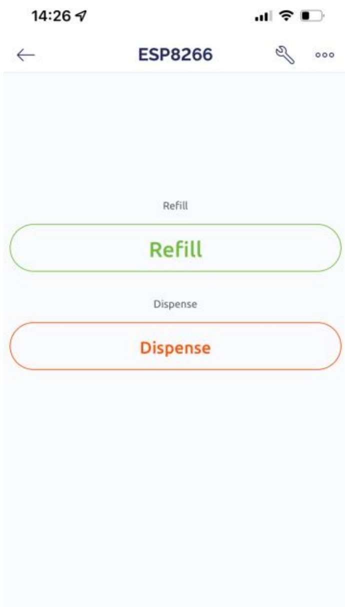

Figure 11: Dispense & Refill Screen

The above screen display gives the user the ability to toggle the motor dispensing system. When the orange dispense button is pressed the dispensing wheel will rotate clockwise 45 degrees dispensing the pills for the user. If needed, the user can rotate the wheel in the counter clockwise, perhaps for refilling purposes.

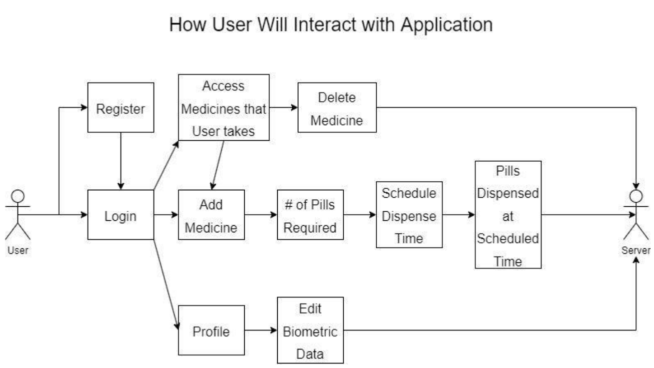

Figure 12: Flowchart of the user appliction

B. Code Compilation on ESP8266

For the ESP8266 module we have in the SchedMed, we used the Arduino IDE in order to compile code required to make the stepper motor rotate to the exact angle we need in order for the holster to line up with the dispensing mechanism exactly. As described in an earlier section, we have formulated the right delta theta in order to have the holster line up correctly. In order for us to correctly come up with our delta theta, we had to derive the formula for it, which is incredibly simple. There are two main factors in coming up with the correct theta value: how many pill holsters there and the weight of the entire pill holster unit. To find the delta theta for the stepper motor, we used the formula down below:

$$\Delta\Theta = 360°/8 \text{ pill compartments} = 45° \tag{1}$$

The formula is as follows: because the holster unit is a circle, the stepper motor also rotates around in a circle. There are eight different pill holsters for the pills to be stored in. The weight of the pill holster unit itself is about 82 grams. With that, the sufficient torque the stepper motor is capable of rotating is well within the range of capability of the stepper motor to be able to rotate the pill holster with no problem.

```
const int STEPS_PER_REVOLUTION = 2038;
const long ROTATION_RPM = 10;
const int ROTATION_DEGREES = 45;
// STEPS = STEPS_PER_REVOLUTION * ROTATION_DEGREES / 360
const int STEPS = 198;
```

Figure 13: Block of code for stepper motor

In the block of code above, we have set the rotation of the degrees the stepper motor will rotate when it is prompted to do so. We had the most success when setting the rotation of degrees to 45 degrees.

V. Design Challenges

There have been a number of challenges that we faced throughout the design process. We had a general consensus amongst our design group that we would need to prepare, and anticipate any of these challenges as best we can. With this mindset, we were able to set enough lead time aside for all components in order to have enough time for building, and testing. With the given timeline there was not much room for troubleshooting, and iteration so it was important we planned carefully, and effectively.
Another struggle we had was communicating the correction amount of rotation to the stepper motor. As we have shown

there is theory behind our approach to getting the motor to rotate the needed amount. Although the math worked theoretically on paper, we discovered empirically that there were still some consistency issues with the amount of rotation. After some trial and error we were able to narrow down the correct number of steps. The motor uses a step to angle ratio in order to translate speed, direction, and angular distance to its internal gear system. . Thus, the process of pinpointing the correct step value was a matter of marginally changing the motor parameter, or specifications within our code, then testing this code and analyzing the outcome.

Another challenge when it comes to the PCB of the project is that multiple revisions of the PCB had to be made in order for the project to function. First of which was due to incompatibility of the software and the hardware embedded in the PCB. Second of which, the original PCB development software failed to generate the proper tracing of the masks within the PCB. Third, footprint and throughole sizing were inaccurate, which caused the elements to be fitted into the PCB impossible.

Lastly, a major challenge was the hardware in general. As expected the design of the hardware was an obstacle that we knew we would face given the nature of our product. The hardware needed to adequately dispense pills and work injunction with the electrical components. This was no easy feat, but ironically we came up with a simple solution(please see above figures for demonstration). Also, 3D printing is a magnificent technology that is transcending the prototyping process for the better. However, it should be said that there are certain downfalls of 3D printing that are arguably inevitable. 3D printing is a delicate, and vulnerable process and small things like the printer machine vibration can cause errors in the printing process, and ultimately the final product. We ended up going through 2 full printing processes due to small errors such as warping, and layering issues.

VII. CONCLUSION

In conclusion, we wanted to create something that we thought could be useful. With the SchedMed not only do we believe we've accomplished that, but at the same time we have been able to relieve the burden of having to manage prescription pills. There were many issues, and challenges that we had to overcome throughout the development process but these are the things that will stick with us, and that we can learn from. This also lead to new experiences, and exposure to things that we as graduating engineering students have not yet been privy to, such as 3D printing, and the mechanical design of the SchedMed.

Learning how to use 3D modeling software and 3D printing the parts for our pill dispenser was something we never would have experienced if we did not work on this project. It allowed us to acquire a skill we did not expect to obtain coming into Senior Design. We will be able to apply this knowledge in the work field if we are ever tasked to 3D model something.

The development of the SchedMed pill dispenser and its mobile application over the past few months has been a challenging yet rewarding experience. It allowed us to apply the knowledge we obtained from our studies to complete a project we could proudly say we built on our own.

ACKNOWLEDGEMENT

The authors wish to acknowledge the assistance and support of Dr. Samuel Richie and Dr. Lei Wei over the course of Senior Design I and Senior Design II. This course has been a journey and is one that has been a great learning experience. For our group, this was the first time any of us have attempted to design anything from scratch. Seeing the project through has given us the opportunity to experience what one may encounter in the field working as a design engineer. The team of professors provided assistance at every step along the way, and were able to highlight the important aspects of the Senior Design courses. There is a lot to be taken away from our time spent on this project. and we are grateful to have been exposed to this knowledge.We would also like to thank the review committee members for taking their time out to review our product.

REFERENCES

[1] "What Is Dementia?" Alzheimer's Disease and Dementia, Alzheimer's Association, https://www.alz.org/alzheimers-dementia/what-is-dementia.

[2] "Power Blog." Ac-Dc Power Supplies and Dc-Dc Converters | CUI Inc, https://www.cui.com

[3] "What Is ABS Material? - Plastic Extrusion Technologies." Plastic Extrusion Technologies -, 31 Mar. 2022, https://plasticextrusiontech.net/resources/what-is-abs-material/.

[4] Robers, Ryan. "Electrical Engineering: Home." LibGuides, https://library.rose-hulman.edu/ee.

BIOGRAPHY

Antoine Brown is currently a Senior at the University of Central Florida and will receive his Bachelor's of Science Degree in Electrical Engineering in December of 2022.

Waseem Isleem is currently a Senior at the University of Central Florida and will receive his Bachelor's of Science Degree in Computer Engineering in December of 2022.

Anthony Lingo is currently a Senior at the University of Central Florida and will receive his Bachelor's of Science Degree in Electrical Engineering in December of 2022.

Danny Mauricio is currently a Senior at the University of Central Florida and will receive his Bachelor's of Science Degree in Computer Engineering in December of 2022.