Kensington E-Lock: Computer Security

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ENGR 1050 Product Realization

Sponsor: Dr. Marc Tobias

I. Executive Summary

Objective

The objective of the Kensington E-Lock project is to improve the current design of the Kensington Lock by offering a more modern, electronic design that provides a higher level of security and convenience for laptop users.

To reach this goal we created an electronic lock that alerts a laptop owner when their laptop is being moved or stolen. A successful design follows specifications of being minimal in size, able to plug into the Kensington slot on a laptop, includes a detachable cord for extra protection, and contains a rechargeable battery that lasts over 72 hours.

Our design was achieved through two separate housing units. The first being smaller, housing the actual Kensington lock, as well as the detachable cord with the ability to plug directly into the Kensington slot flush against the laptop. The second housing prototype was purely to house the working electronic components needed to make this electronic lock work. The imagined final design consists only of the smaller housing unit which would ideally be able to house electronics that would be sized down immensely by the Kensington team of engineers. Additionally, our team began working to implement wireless charging, Bluetooth connection capability, and covering our housing unit in metal to increase the durability of the product.

Market Opportunity

The market for this electronic laptop lock includes any laptop owner looking to secure the safety of their laptop without needing to be by their device at all times. Common examples of when this product may be useful are found when looking at students or any personal laptop user sitting in a coffee shop, the library, or a common space and needing to leave their laptop unattended while they order a beverage, use the restroom, or take a walk. Another common customer who may find this product useful would be businesses selling or holding an inventory of a large amount of laptops. Common examples of this include university computer laboratories, electronic stores, and libraries.

Marketing Strategy

The best way to market this product would be to market single locks to students who may want to protect their laptops for cheap. However, for businesses and electronic stores, a bundle pack should be offered to incentivise buying the product, since those customers would require more than one lock.

Over the course of the semester we also found that not many people know what a Kensington lock slot looks like. One good way to help market and sell the product would be to spread awareness about what model of computers have a Kensington slot installed.

<u>II. Background</u>

Project Origin

Leaving your laptop unattended in libraries and coffee shops to quickly run to the bathroom or pick up your order seems commonplace. However, in most cases when you return to your seat, your laptop will be nowhere to be found. Laptops are easy targets for thieves due to their portability, and are constantly stolen.

Historically, Kensington security locks for technology have relied solely on the integrity of a physical cable wrapped around a stationary piece of furniture, to keep said technology safe from theft. Over the last thirty years, these cables have been found to be easily defeatable by bolt cutters and portable heat sources. Additionally, the cables are fairly bulky and inconvenient to carry around. This creates an issue not only with the casual consumer looking to protect their technology, but within multiple industries who store sensitive information on their computers. Therefore, to improve their security locks for technology, Kensington has proposed a new solution.

Figure 1

The proposed solution to this problem is the use of electronics to replace the cable. These electronics should utilize multiple sensors to determine if the laptop is being stolen. If it detects a theft, the lock should alert the user (through audio, app, or both), that the laptop is being tampered with. At the time that this product enters the production phase, it should be able to lock into the Kensington security slot, detect when the laptop is being tampered with, and alert the user and possibly surrounding bystanders fast enough for them to intervene and prevent the theft.

Similar devices, such as the Apple Airtag, and the Square Tile tracker are already in production. These devices however, will not alert a user to theft, and simply track the object they're placed on. This feature helps when you lose your keys or misplace your phone. However, when malicious theft is involved, tracking your device to the thief's home won't help much unless the police are involved. Therefore, this product will utilize an accelerometer to detect theft immediately, not a GPS. Additionally the casing around the electronics should be strong enough to withstand bludgeoning, common solvents, and portable sources of heat. Previous groups have created a prototype 3d printed housing, and preliminary electronics.

The initial state of the project was very preliminary. The previous group who worked on the project created a small housing with a removable attachment for a physical cable. Inside was room for the lock core, small PCB, and small battery. Their electronics lacked a housing and sat separate from their lock housing. Additionally, the electronics only sent signals to iPhones. We saw a few issues with this design. Firstly, once the battery died, it would either have to be replaced or charged through a port, creating a security breach in the casing. Secondly, the device should connect to someone's phone regardless of what brand it is. Lastly, we felt that even if the electronics could not fit in the proposed housing, they should have some sort of protective case.

Our team's goal was to improve on the previous iteration by adding a "deadman switch" to improve battery life by automatically turning off the system when not in use. In addition, we looked to add wireless charging capability to the circuit to remove slots in the lock housing, making it more secure. Our resources and knowledge of electronics were limited, so there wasn't much we could do to miniaturize them. Therefore, we aimed to create an idealized housing that would be what is put into production when the electronics can be sized down by others with more knowhow and resources.

Short Term and Long Term Goals

All of our short term goals were the tasks we planned to accomplish this semester. This includes improving battery life, minimizing the electronics, and increasing the durability and security of the housing. We set out to improve battery life by researching lower current electronics, and by brainstorming ways to detect when the system was in use so it may enter a power save mode. We also spent time researching lipo batteries with a longer life span. Eventually we came to the consensus that the charging port for any battery introduced a crucial security breach so we decided to change routes to include a battery that could be wirelessly charged directly from the housing with no external cord necessary. Eliminating the charging port and changing the material of the housing unit to be aluminum, we increased the security of our product immensely. In another effort to further increase the product security we implemented screws which hold the housing lid on and face the laptop itself so that the lid can only be unscrewed when the lock is not plugged in.

In all, our goals for the semester became to create a metal housing, improve the battery life by implementing wireless charging, creating a new low energy circuit, and implementing a "deadman switch" that would detect when the system was plugged into a computer.

The long term goals of this project would be completed over multiple iterations by multiple groups, something our short term goals would help inch towards, but that we would not complete in a single semester. These long term goals include creating a Kensington specific app to receive signals from the lock, and continue to miniaturize the electronics until they fit within the housing. Another long term goal would be to optimize the main housing design to allow for efficient wireless charging.

III. Opportunity (Market, Application, etc.)

Unique Opportunity

As previously stated, current Kensington Lock designs use a cable to secure computers to a location. Kensington, as of 2014 controlled 70% of the computer security market with 99% of business laptops having a Kensington Security Slot installed (Kensington). With most consumers opting for portable laptops when working, and working from home increasing in popularity, this design does not fit the needs of users. Given the need to detach and set up the lock/cable system each time the user moves, the system creates a hassle when moving locations. The cable design is not portable enough for the everyday consumer to utilize. In addition, the locks can provide some security concerns as seen below where they can be broken with wire cutters.

Figure 2

Dr. Tobias' design can fill the needs of the consumer by creating a portable lock. The lock is durable and takes up an insignificant amount of space. It alerts the user remotely so they can leave their computer unattended. It also has the capability of incorporating the previous cable for users who work in office settings.

As stated in the executive summary, those most interested in this product will be stores that sell a large quantity of laptops, and students or business professionals who regularly work outside their homes or offices, and are looking to add an extra layer of security to their technology.

IV. Project Description

Initially approaching our problem, we decided to build on the last group's design, as it was minimal in size, contained some working electronic components, and provided a good starting point. We understood that the previous group's design imposed some issues such as a 3D printed housing prototype which was not sturdy enough for production, and electronic components that could not fit in the housing unit or Bluetooth compatible for all devices. The product was also limited in terms of battery life, containing a 9V battery which was not rechargeable and only lasted about 6 and half hours, and required a charging port on the housing which introduced a security breach.

We wanted to follow all the customer requirements outlined for us including alerting the user of theft, keeping the design small and compatible with the Kensington Lock, minimizing the size of the electronics, improving the battery life and including a rechargeable battery, and creating a secure housing unit with a detachable cord available for extra protection. We started by attempting to minimize the electronics as much as possible with the intent to fit them into the compact housing design. We iterated through two electronic component designs until we reached the smallest version we could create without the ability to manufacture miniaturized electronics.

To accomplish all of our objectives and cover the problem description, we created an aluminum housing that is roughly 37 x 32 x 24 mm in volume. This case is designed to fit around the Kensington lock core, while also having a hole facing the computer to accommodate the deadman switch. This allows the circuit to turn itself off while not in use, and immediately turn on and start transmitting when attached to a computer, therefore conserving battery life. Currently there is also a hole in the side of the housing. The intent was to cover this hole with fiberglass to allow our wireless charging coil to receive inductance from the charger, as well as allowing the bluetooth signal to pass through the casing.

As for the electronic components, we used an ItsyBitsy nRF52840, a Flora accelerometer, coin cell batteries and a button. These elements were contained in a side housing unit with the understanding that when Kensington is ready to manufacture this product, their team of specialized engineers would be able to miniaturize the electronics in order to fit them in the single housing unit. Pictured below is the accelerometer and button in its final, minimized size.

Functional Specifications

The Kensington E-Lock design we proposed had the following functionality specifications:

- Movement detection
- Bluetooth communication
- Battery efficient electronic circuit
- Durable enough to withstand aggressive tampering

These specs were representative of how we could improve the previous team's design. Concepts for our design were drafted using these objectives.

Initial Design Concepts

The previous group's initial design concept was a simple 1x1x1 housing to surround the lock with a micro-USB port for charging. The housing was made out of 3D printed filament. As for the electronics, they created a circuit with an accelerometer and bluetooth transmitting but it was limited to a breadboard. Pictures of both the housing and initial circuit are shown here:

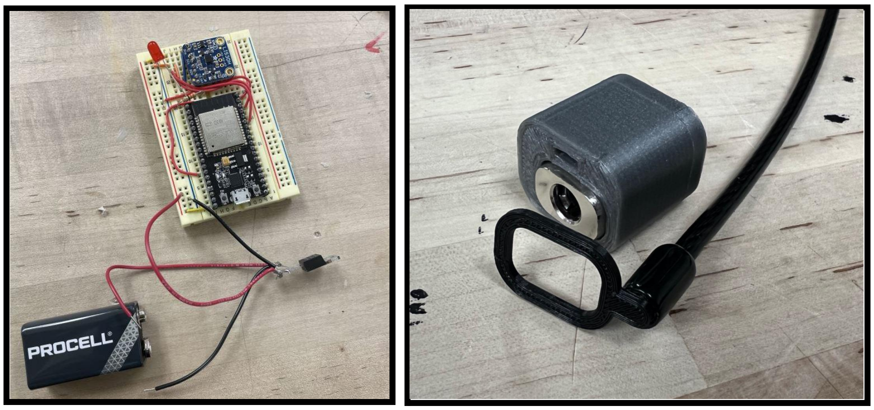

Figure 3

Evolution of the Design and Development

From this design, we realized that we needed to improve the security of our housing, and additionally include features to lengthen battery life. We decided to aim for improved security by removing the micro-USB charging port from the housing to protect the internal circuit. We also moved the detachable lid to face the laptop so the screws couldn't be tampered with when the lock was in use. As for battery life, we researched more efficient batteries to find ones that had the longest lifetime and met the small size requirement. In addition, Marc Tobias provided us with the idea of implementing a deadman switch into our circuit, so that power would only be used when the E-lock was plugged into the user's laptop. Eventually, we settled on using a lithium polymer battery for our circuit, and began working on creating the deadman switch.

As we continued to work, we realized that if we wanted to remove the charging port from the previous housing design, we would need to figure out a new way to recharge the battery of our internal circuit. It was at this point that we decided to pursue implementation of wireless charging through magnetic induction. The main circuit would have the receiving end of the induction circuit wired into it, and the transmitter end would be separate and serve as the E-lock charging cable. Pictures of this circuit can be see here:

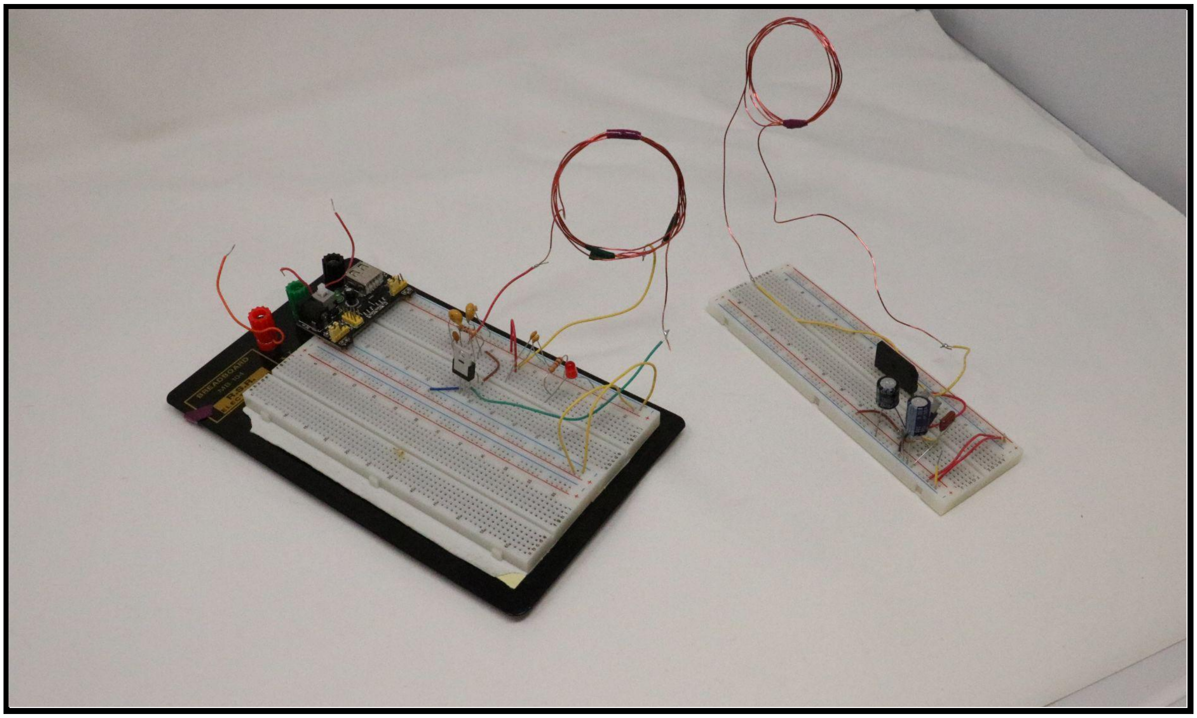

Figure 4

Final Description

Our final design is a 37 x 32 x 24 mm aluminum box with a hole for the deadman switch, and another hole for wireless charging. The housing has a removable side in order to still make usage of the Kensington lock cable. However, this side is screwed in and faces the laptop, making it irremovable while the E-lock is plugged into a user's laptop. Our electronics are wired in two different circuits separate from the housing (miniaturization of the electronics to fit in the aluminum housing are part of the future steps for this project), those being the wireless charging circuit which is still breadboarded, and the accelerometer bluetooth circuit with the deadman switch included. This final design incorporates a more durable housing along with the circuit components necessary to implement wireless charging and long battery life, and pictures of our final design are included below.

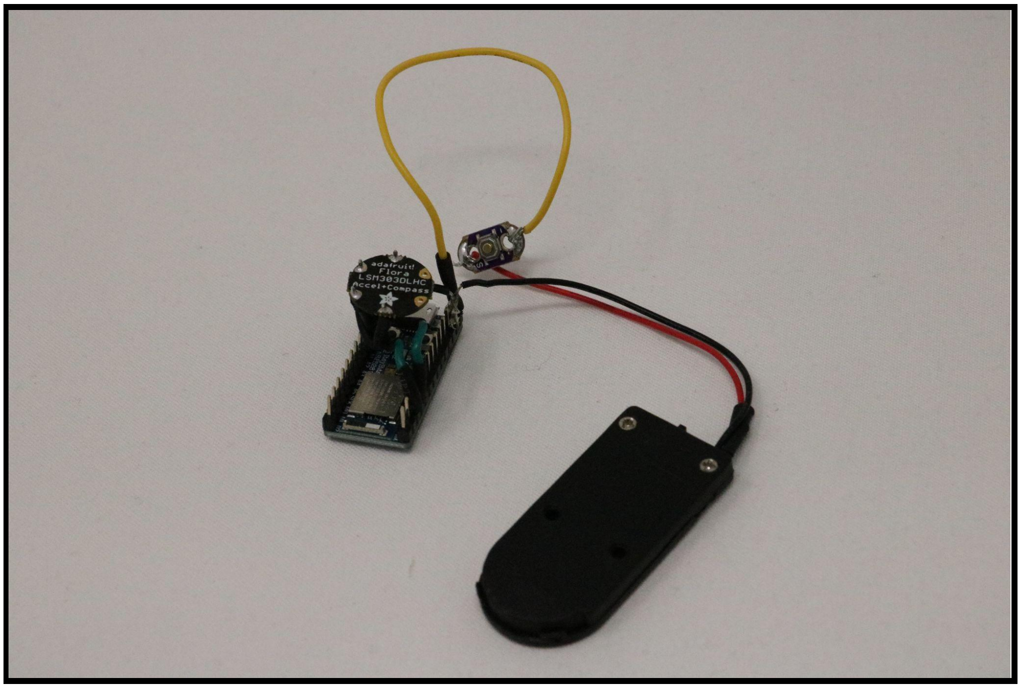

Figure 5

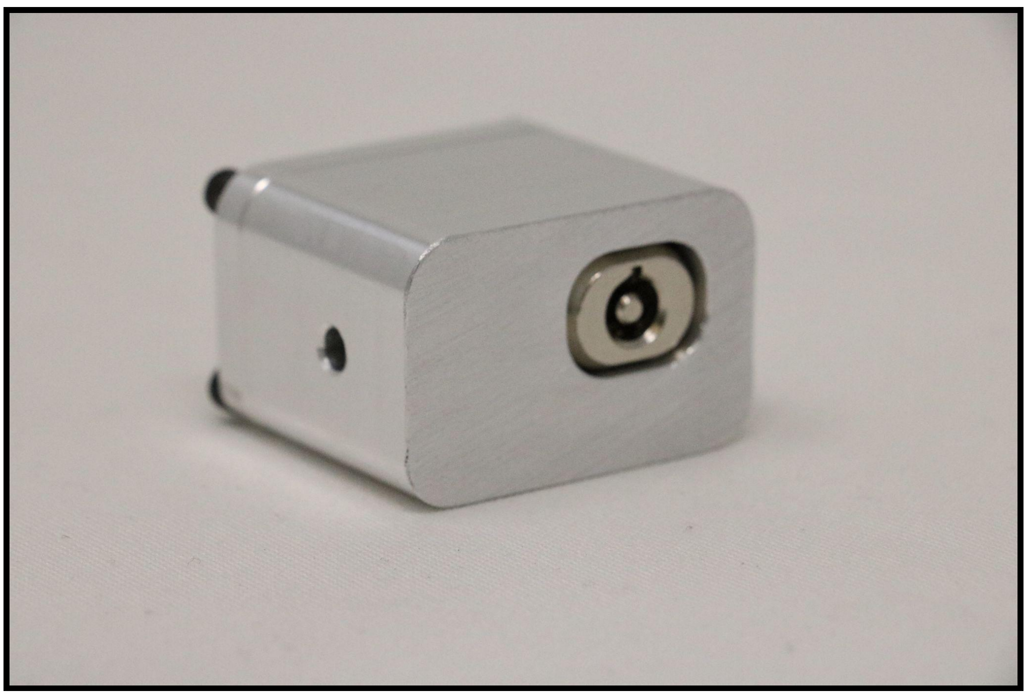

Figure 6

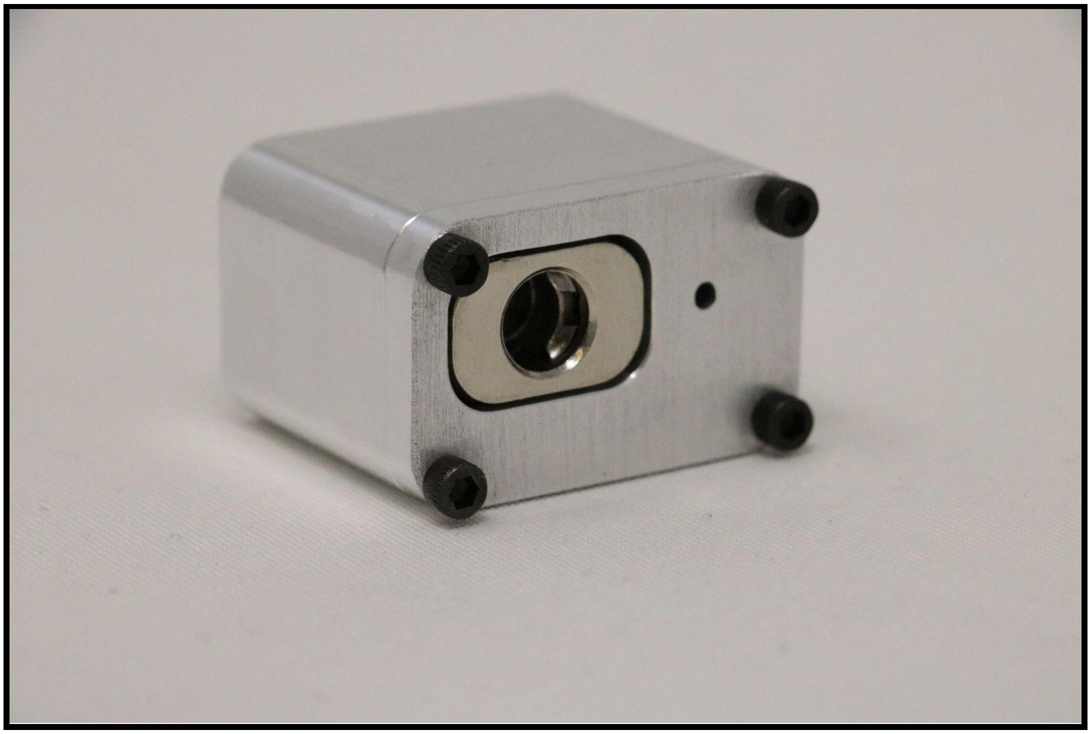

Figure 7

V. Conclusions

Accomplishments

In conclusion, we were able to meet our main project goals while maintaining the desired customer needs and wants. We set out to create a compact, durable electronic lock using Kensingoton's laptop lock design, and we successfully sized down our electronic components, enabled a Bluetooth feature to be able to connect to either Apple or Android user's devices, constructed a deadman switch to provide power to our device only when plugged into the laptop, and generated a wireless charging feature to. We produced a sturdy, metal coated housing to protect the lock, added screws to the laptop facing lid, and included a detachable wire for use of extra protection.

Unfortunately, we could not house all of the needed electronics in the same housing unit as the lock. Due to our constraints in not being able to manufacture small enough PCB electronics, we created a second side housing to hold our electronics instead. This is only to showcase functionality of our product as Kensington engineers will be able to produce the electronics in the necessary size.

Ultimately, with our finalized product we have improved the battery life, sized down the electronics, and created an indestructible housing.

Comparison of prototype performance vs. measurements of success

In the end, we feel that we have succeeded in creating a Kensington E-lock prototype. The prototype circuits are able to send a signal to a phone to alert the user of theft, which is exactly what the problem statement asked us to do. Our other endeavors this semester have been in the interest of increasing the security of the lock, and increasing battery life. The wireless charging project increased security by eliminating the need for any charging ports in the housing. The deadman switch increased battery life by automatically shutting down the system when not in use. Additionally, we successfully reduced battery life by using lower power electronics. Overall the system currently has a battery life of 17-34 hours using coin cell batteries. These were used for ease of replacement during demos, but if the LiPo battery were implemented the system would have a battery life of 28-57 hours.

The only aspect in which we have failed is sizing down the electronics enough to fit into the case. However, while our electronics don't fit in the case, we have significantly sized them down from the previous group. We are confident that in a few more iterations the circuitry will be able to fit within our proposed housing.

What was learned

Through this project our team learned to effectively work together to plan, organize, and produce a long-term project. We gained experience working in different fields of engineering we may have had less experience with, as well as communication skills such as public speaking and presenting to the class on a normal basis. These skills will be useful in our future careers as professional engineers should we be faced with long term projects similar to this course. From our project we learned how to plan out reasonable milestones to accomplish, properly budget time,and recover from obstacles along the way that pushed our project off schedule. We learned to think creatively, consider all aspects of our product on a detailed level, and make use of helpful resources to achieve our goal.

Recommendations for improvements or follow-on projects

Our team believes we have taken this project as far as possible with our electronic constraints. We have demonstrated fully working electronic components and have met the required customer needs and wants while keeping durability and protection as a top priority. In the hands of Kensington, the product electronics can be fully minimized to fit inside the housing unit while making use of all the aspects of our design.

If another student group were to further work on this project, they could attempt to further size down the electronic components, improve the wireless charging output, and consider other possible safety breaches we have not noticed and correct those. Another major component that could be useful to this project would be a web-developed app that can be connected to the user's phone via Bluetooth and allow for tracking of the device.

A good starting point would be to fix the issues that were created when transferring to a metal housing. One of these issues would be to produce a new cable adaptor to allow the Kensington cable to be attached or removed from the housing. This cable should be made of a sturdy enough material to withstand any attempts at tampering. Another issue would be to countersink the screws in the housing so that it may sit flush with the side of a computer. The next group should additionally integrate the wireless charging while also replacing one side of the housing with fiberglass or a similar inductance transparent material.

VI. Acknowledgements

Our team would like to express gratitude and thanks towards our project sponsor, Dr Marc Tobias, as well as our product realization instructor, Dr. Eric Winter.

As our project sponsor, Marc met with us for many virtual meetings and provided helpful advice and suggestions for our project. He supplied us with background information on the product and pointed us in the right direction for making improvements and reaching our end goal.

Dr Eric Winter provided us with great skills for not only planning and organizing a project of this magnitude but also with skills that will greatly help us in our future careers.

We would also like to thank SERC and SCPI from the Swanson School of Engineering who helped us create our wireless charger and metal housing implementation.

VIII. Appendices

A. Wireless Charger
B. Housing
C. Code

A) To create the wireless charger, we followed the demonstration of the video linked below.

https://www.youtube.com/watch?v=eNZ8KPHYDvg

The circuit diagram of the transmitter side of the circuit:

The circuit diagram of the receiver end of the circuit:

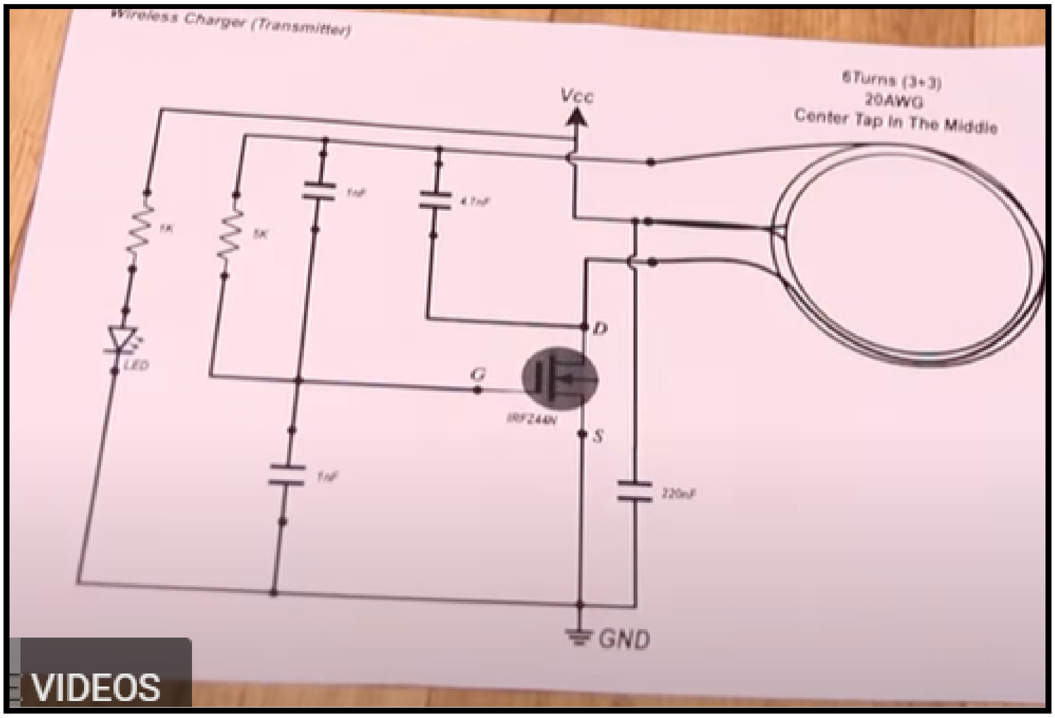

Figure 8

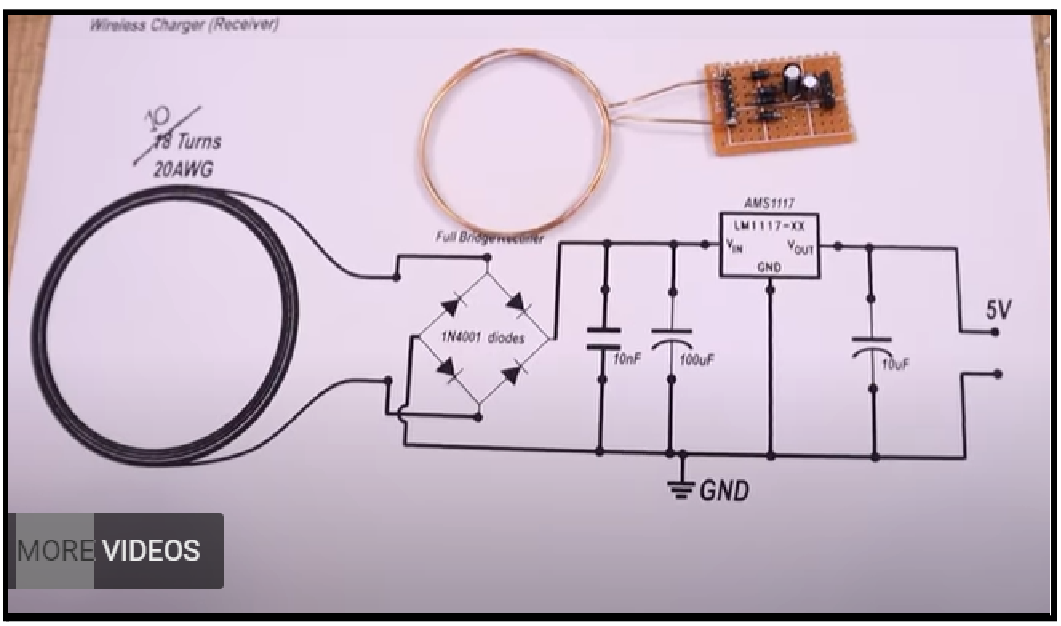

Figure 9

The end result of our wireless charger:

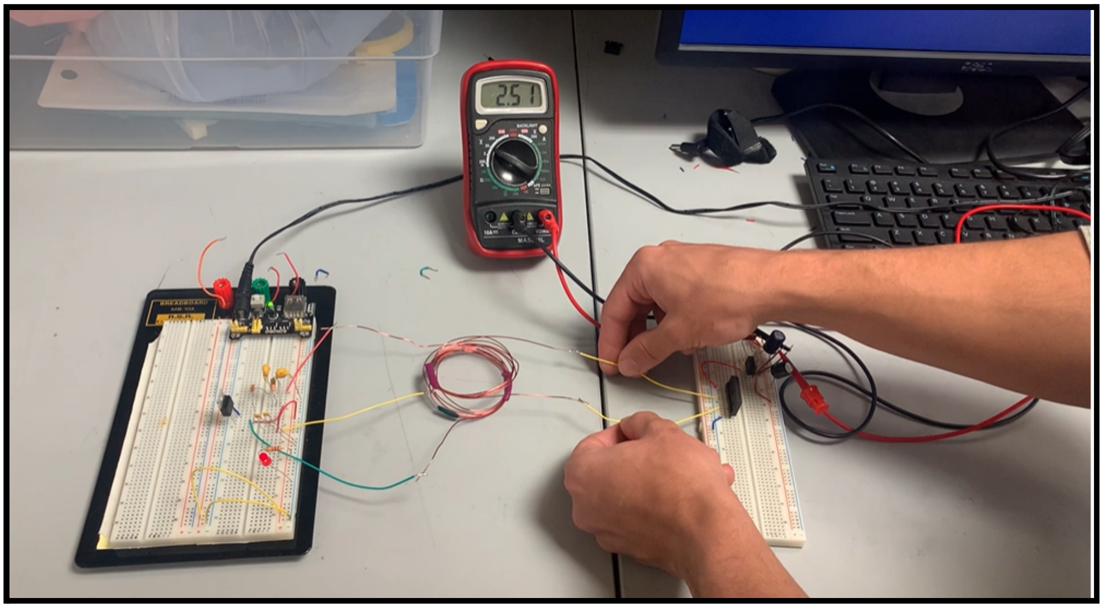

Figure 10

The wireless charger was successfully functioning in the end. When supplying 5V to the transmitter side of the circuit the receiver side received 2.5V through magnetic flux exchange. To increase this voltage level the number of coils will need to be increased and the loops will need to be wound tighter.

B) Housing

Figure 11

Figure 12

Figure 13

Dimensions for the lid:

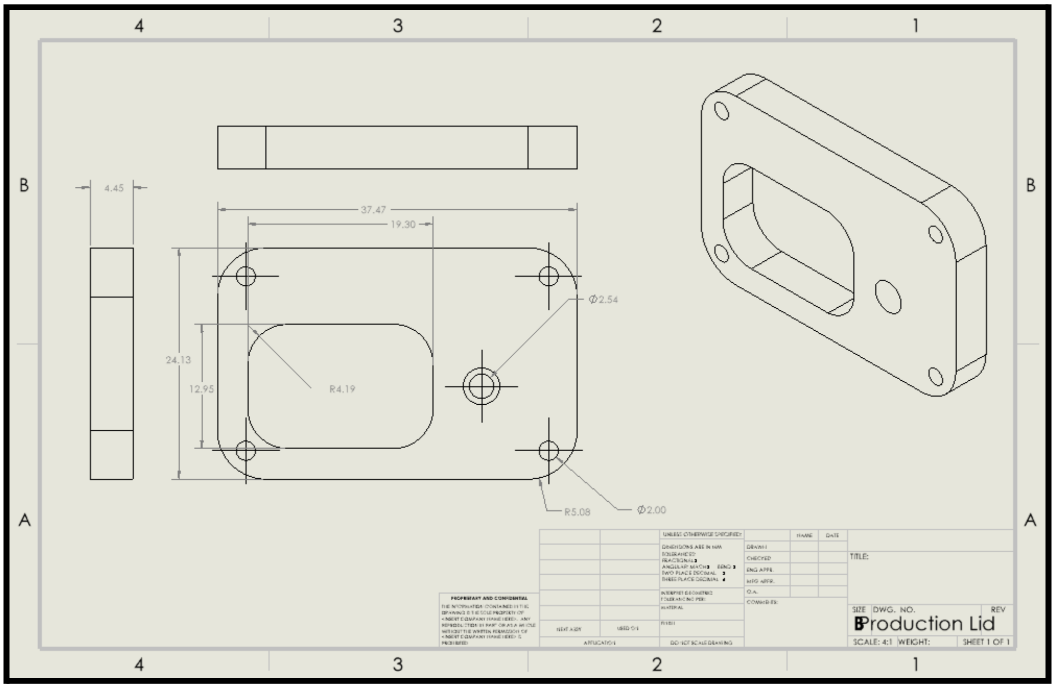

Figure 14

Dimensions for the Housing:

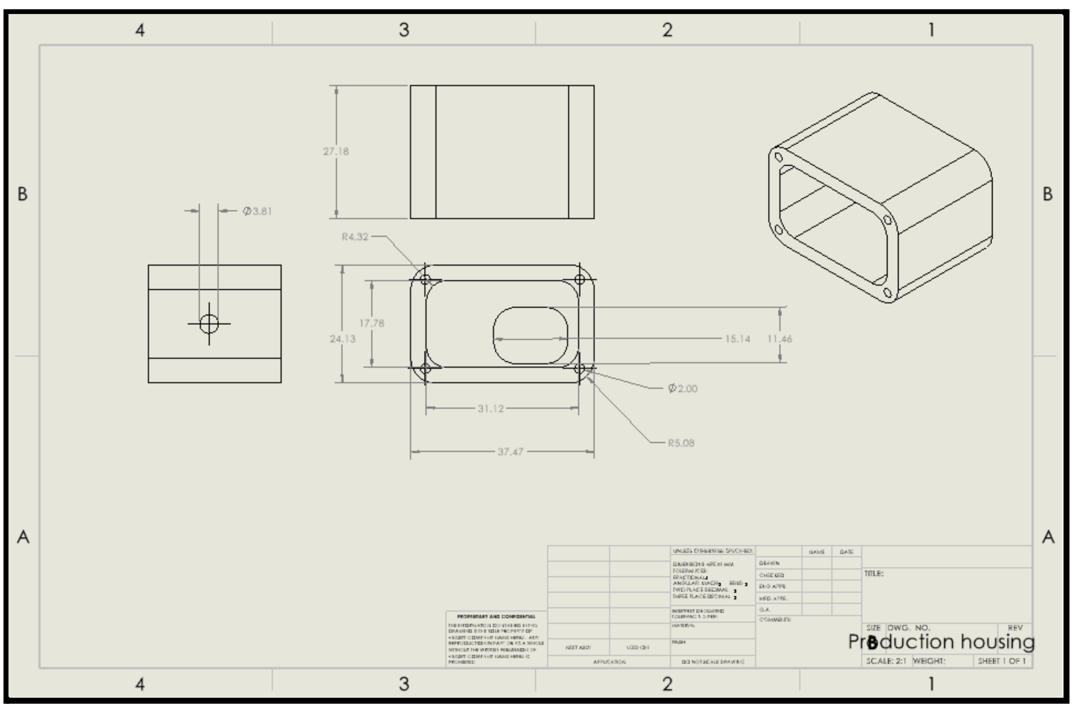

Figure 15

Pictures of CAD models:

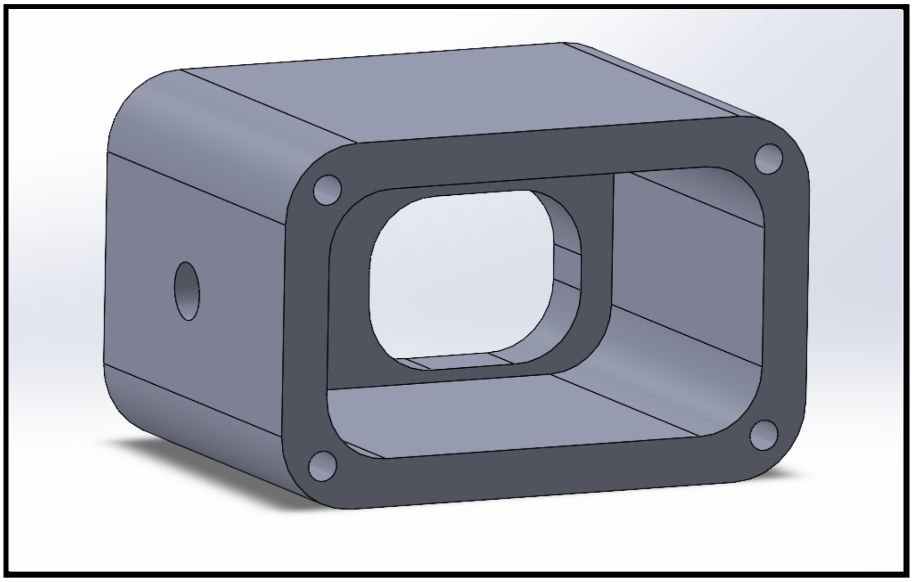

Figure 16

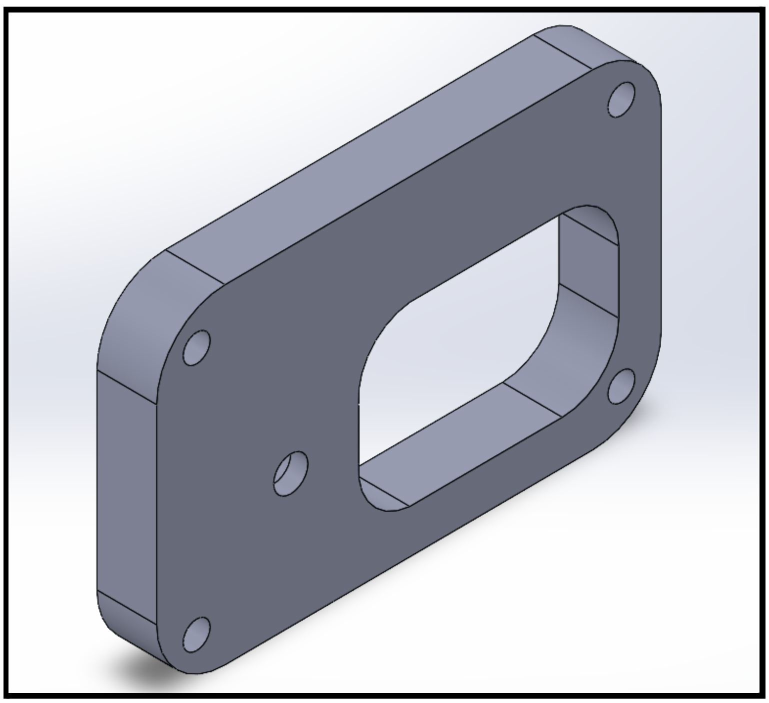

Figure 17

C) Code
Bluetooth Code:

```
import time
import board
import adafruit_lis3dh
import digitalio
from adafruit_ble import BLERadio
from adafruit_ble.advertising.standard import ProvideServicesAdvertisement
from adafruit_ble.services.nordic import UARTService

ble = BLERadio()
uart = UARTService()
advertisement = ProvideServicesAdvertisement(uart)

i2c = board.I2C()

# Lock the I2C device before we try to scan
while not i2c.try_lock():
    pass
# Print the addresses found once
print("I2C addresses found:", [hex(device_address) for device_address in i2c.scan()])

# Unlock I2C now that we're done scanning.
i2c.unlock()
int1 = digitalio.DigitalInOut(board.D6)
# Create library object on our I2C port
lis3dh = adafruit_lis3dh.LIS3DH_I2C(i2c, int1=int1)

while True:
    ble.start_advertising(advertisement)
    print("Waiting to connect")
    while not ble.connected:
        pass
    print("Connected")
    while ble.connected:
        try:
            disable =str(eval(uart.readline()))
        except Exception as e:
            disable = repr(e)

        s = lis3dh.shake(shake_threshold=10)
        if s:
```

```
uart.write("Shaking")
```