APPLICATION OF WIRELESS POWER FOR CHARGING THE BATTERY OF A WIRELESS MOUSE

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ABSTRACT:

Electronic devices are a part of all modern homes, but restricted by available outlets and the hassle of wires. With the modern wireless mouse, this is also the case. When the battery is low the consumer has several options: it is replaced with a new battery, it can be recharged using a USB wire, or the mouse is placed on a charging dock. This project provides an alternative to these options and allows the mouse’s battery to be charged via wireless inductive coupling. The wireless power charging system that was implemented in this project was successful in its ability to utilize close proximity inductive coupling to charge the battery of a wireless mouse. A 5.0V input representing the voltage of a USB port was inverted using a push pull oscillator circuit. A sinusoidal 27.9Vpk-pk signal across the primary coil at 10.9 Mhz was achieved. A 40.2V pk-pk sinusoidal voltage at 8.21Mhz on the receiver coil is successfully rectified to a DC voltage of 8.0V. However, the maximum efficiency achieved with a battery load is a mere 0.80%, and only 5.98% with no load. The internal resistance of the battery heavily loads the rectifier and drops $V_{out}$ to 0.2V. Other reasons for such a low efficiency as well as recommendations to improve the system will be discussed in this report.
CHAPTER ONE: INTRODUCTION

The purpose of this project is to simplify life for the average consumer. This idea sparked from MIT’s experiment proving electrical energy could be transmitted across two meters without much loss of power [1]. Utilizing known physical properties of electronic magnetic waves, energy transfers between outlets to anything tuned to the correct frequency.

The focus of this project is on charging a wireless mouse via close proximity induction. The basic design of this project has two main components. Firstly, the emitter transfers a typical 5V USB signal to a sinusoidal electromagnetic wave. This wave is then picked up wirelessly by secondary coil tuned to the same frequency and is located inside the mouse. This signal is then rectified and then interfaced with the mouse.

Nicholas Tesla is the originator of harnessing wireless power. Tesla imagined that wireless energy could be transferred effectively and challenge traditional means of electricity transfer. Unfortunately, his research was abandon up until 2006. MIT took a closer look at Tesla’s work and successfully turned on a 60W light bulb across the room [1]. Since then many universities, companies, and electrical philanthropist explore the possibilities of highly efficient wireless power.

The phenomenon from inductive resonating frequencies is based primarily on the physical properties of the Transmitter (Tx) and Receiver (Rx) antennas. Large coiled Inductors are used due to the Electric flux produced from the magnetic. Maxwell equations and Faraday’s Law state that current through a conductor produces a magnetic field. Researchers in wireless energy are looking in the most efficient way to harness this energy. At a given frequency, a system will have the greatest response. This frequency is called the resonant frequency, and is the reason wireless power transfer is possible. In theory, a single transmitter could drive multiple receivers.

Along with the efficiency, concerns about safety and control of wireless energy transfer is required. Fulton’s basic diagram shown below includes all key components in a safe successful energy [3] transfer: input, driver, coils, communication, monitoring, and voltage control for a given load. A
specific antenna for a given impedance load for max energy transfer. Additional circuitry may be added to help solve this problem. Semiconductor companies are looking into solutions, and some have some power management solutions out. External antennas are still required for max energy transfer.

![Wireless Power Design of Fulton](image)

**Figure 2: Wireless Power Design of Fulton [3]**

Texas Instruments (TI) developed a set of wireless power management chips. Two of the solutions are shown below. These chips are all inclusive besides the coils. The bq500xxx includes a synchronous rectifier, output voltage and current conditions, as well as WPC communications with the receiver side as well as capability to visually display power transfer. The controller includes an idle state which will shut down the power when the receiver is out of range. The controller on the receiver end includes WPC communication to the controller and can be configure to a specific identification. The voltage conditions is to maintain a specific DC voltage for the load.

![TI Wireless Power Solution](image)

**Figure 3: TI Wireless Power Solution**
The market for these chips is for portable electronic devices, such as cell phones and mp3 players. Due to size restraints, the chips are extremely small, less than 350mm x 210mm. In addition to the size, the lead pitch is as small as .4mm. This drives cost of fabricating these chips up. For this design, these chips are unusable, as a computer mouse has more free space. Therefore, a simpler, cheaper uncontrolled design is implemented.
## CHAPTER 2: SPECIFICATIONS AND REQUIREMENTS

Table 1: Wireless Power Station Specifications and Requirements

<table>
<thead>
<tr>
<th>Marketing Requirements</th>
<th>Engineering Specifications</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2</td>
<td>Power Efficiency Transfer from 50% to 70% for up to three devices.</td>
<td>Previous research shows efficiency of 70% transfer with copper coils for a single device. [4]</td>
</tr>
<tr>
<td>4</td>
<td>Smooth top surface for the mouse pad.</td>
<td>Looks nice, and allows person to work on the desk. Adds to the aesthetic of the device</td>
</tr>
<tr>
<td>5</td>
<td>Standard 265mm x 210mm mouse pad</td>
<td>Standard Mousepad size.</td>
</tr>
<tr>
<td>1</td>
<td>Max Power transfer at least 1 Watts</td>
<td>9W should be enough to power the mouse [5]</td>
</tr>
<tr>
<td>2, 7</td>
<td>Must be able to deliver a minimum voltage of 5V @ 0.2000A.</td>
<td>The mouse requires a 5V input with 0.5A in order to charge the battery and power the device</td>
</tr>
<tr>
<td>6</td>
<td>Cost under $50 per Unit</td>
<td>$50 is a reasonable price range which is still obtainable for this device</td>
</tr>
<tr>
<td>3, 7</td>
<td>Resonating Frequency less than 30MHz</td>
<td>Low enough frequency that device’s output energy is safe for human interaction according to IEEE Standards [6]. This will not interfere with most devices as well. Also needs to hold this frequency if something interferes with it.</td>
</tr>
<tr>
<td>7</td>
<td>Includes on “Off” state</td>
<td>This is to insure the customer is not wasting power when nothing is being charged. This includes a switch and/or a feedback network to tell the emitter nothing is being charged.</td>
</tr>
<tr>
<td>8.</td>
<td>Operate between temperatures of -10C and 60C</td>
<td>This range reflects the temperatures of the operating environment (homes and businesses). The extreme high and low temperatures reflect “worst case scenarios.”</td>
</tr>
<tr>
<td></td>
<td>Scratch Resistant</td>
<td>A lifespan of 5 years is competitive compared to current models out in the market. Everyday use must not damage the surface.</td>
</tr>
</tbody>
</table>

### Marketing Requirements
1. Full charge in 24hrs
2. Sustains output power
3. Not interfere with any other devices
4. Be aesthetically pleasing,
5. *(Removed)*
6. Cheap
7. Safe for Living interaction
8. Function under normal temperatures
9. Lifespan of 5 years
10. *(Removed)*
All of these requirements elaborate on the final goal of this project, to create a hassle mousepad charging a wireless mouse. These requirements are with the integrated mouse pad idea in mind, but there is another design worth considering, where the emitter stands alone. The final $50 price estimate is the market goal, after the prototype is built, and with a reasonable scheme for mass production. The TI chips proved to be too expensive for practical purposes. Fulton’s research warned of wireless power transmission costs compared to the effective gains [3].
CHAPTER 3: FUNCTIONAL DECOMPOSITION

Block Diagram Level 0:

![Block Diagram](image)

**Table 2: Functional Requirements Wireless Power Station**

<table>
<thead>
<tr>
<th>Module</th>
<th>Wireless Power Station</th>
</tr>
</thead>
</table>
| Inputs    | - USB DC input Power: 5V  
|           | - Switch: Simple On/Off Switch |
| Outputs   | - DC Power: Minimum of 5V, up to 0.5A of current |
| Functionality | Converts the power from a USB to a useable power to small battery. |

This block diagram demonstrates the goal of the Power Station; convert the standard home DC usb cable to useable voltages. The switch is to save energy, allowing the user to turn off the station when nothing is being charged. The Power Station includes an internal feedback sensor to automatically turn off when nothing is charging.
This diagram demonstrates the two large components of the Mouse Pad. The emitter is connected inside the pad and produces the electromagnetic waves at the specific frequency. These waves are picked up by the receiving antenna, which is tuned to the same frequency. The receiver is contained within the mouse, and transforms the power to charge the battery. The mouse’s power line is being modified, while the communications of the mouse is unchanged. This project works on managing and of the power line from mousepad to internal power line of mouse.
Table 4: Functionality of detailed block diagram

<table>
<thead>
<tr>
<th>Module</th>
<th>Oscillator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>USB: The transmitting</td>
</tr>
<tr>
<td>Outputs</td>
<td>EMF: Electromagnetic Fields tuned at a specific frequency.</td>
</tr>
<tr>
<td>Functionality</td>
<td>Converts the power from a USB to an Electromagnetic fields.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module</th>
<th>Receiver Coil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>EMF: Electromagnetic Fields tuned at a specific frequency.</td>
</tr>
<tr>
<td>Outputs</td>
<td>9MHz Wave 10V&lt;sub&gt;pp&lt;/sub&gt;</td>
</tr>
<tr>
<td>Functionality</td>
<td>The tuned resonant frequency picks up the EMF as a sinusoidal voltage wave</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module</th>
<th>Rectifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>5V Sinusoidal Voltage wave</td>
</tr>
<tr>
<td>Outputs</td>
<td>2.8-3.5V DC voltage</td>
</tr>
<tr>
<td>Functionality</td>
<td>Converts the AC Voltage to DC Voltage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module</th>
<th>Buck Boost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>DC Voltage in: Between 3-5V</td>
</tr>
<tr>
<td>Outputs</td>
<td>Main terminal for battery: constant 5V output.</td>
</tr>
<tr>
<td>Functionality</td>
<td>Increases the voltage to be interfaced with the mouse module.</td>
</tr>
</tbody>
</table>

This diagram illustrates the four components that are necessary to convert energy wirelessly and interface with the mouse. The oscillator, rectifier, and receiver coil used discrete components shown in the schematics. The chosen Boost converter is necessary to maintain the 5V output. Circuit and Simulations

![Schematic of Oscillator](image-url)
The oscillator of choice is a push-pull model which utilizes the transmitter coil to produce a sinusoidal oscillation across both inductors. L1 and L2 add up to be the total inductance of the physical transmitting inductor. This inductor is center tapped to the 5V source and is turned with C4 capacitor to produce a resonating LC circuit. This provides minimal losses and allows control over the oscillation frequency. C2 and C3 are both feedback capacitors to help produce and sustain oscillation. The biasing resistors are to start oscillation and maintain a voltage across the MOSFets. R5 is included for simulation purposes only. C1 is to filter out any supply noise. The 2N7001 MOSFETS we chosen due to their ability to handle up to 200mA [7]. This is safe enough for USB applications, while still allowing enough power to be transferred.
The NMOS rectifier is used in an assortment of wireless power converters instead of standard full wave, half wave or switching converters. This is due to the tuning capacitor, $C_1$ needs a buffer from the filtering capacitor $C_2$. Simple rectifiers end up allowing $C_1$ and $C_2$ to be in parallel, thus increasing the tuning capacitor and changing its resonant frequency. This causes a loss of power, or complete coupling loss. Without the filtering capacitor, this rectifier acts like a half wave rectifier. The 1N4000 diodes were chosen due to their cheap cost and widespread availability. For simulating purposes, a transformer is necessary to allow voltage change without immediate change in current.

The DC output voltage $V_{dc}$ of our rectifier is on the left side of the schematic shown above. Diode D1 protects the rectifier circuit in the event the user installs the batteries backwards, resulting in reverse polarity. The additional LED D2 provides the user visual feedback that the battery is charging.

To insure no wires shorted and the coil could be easily adjusted, the oscillator was built on a pcb board. The layout schematic and the layout are shown below. The two holes on the left are for supply,
and the three holes are for the transmitting coil. The design and layout were both done in PCB Artist, as well as fabricated by Advance Circuits. The rectifier was put together on a perf board. This is chosen based on cost and it being a less complex circuit.

Figure 12: Layout for Schematic
Figure 13: Layout of PCB of Oscillator
Figure 13: Oscillator Circuit with Primary Coil

Figure 14: Close up of Oscillator Circuit
Figure 15: Rectifier Circuit Attached to Mouse

Figure 16: Primary and Secondary Coil
CHAPTER FOUR: EXPERIMENTAL RESULTS

Figure 17: Transmitter Coil Output Voltage

Figure 18: Receiver Coil Voltage
Table 5: Coil Voltage Waveform Characteristics

<table>
<thead>
<tr>
<th>Coil*</th>
<th>$V_{pk-pk}$ (V)</th>
<th>Frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter</td>
<td>27.9</td>
<td>10.2</td>
</tr>
<tr>
<td>Receiver</td>
<td>40.2</td>
<td>8.21</td>
</tr>
</tbody>
</table>

*Both coils were matched with 15 turns each, radius of 1.5cm, turns ratio $N_p/N_s = 1$. 

**Figure 19**: Rectifier DC Output Voltage ($V_{out} = 8.0v$)

Table 6: Efficiency Under Different Distances and Loads

<table>
<thead>
<tr>
<th>Coil Distance</th>
<th>Load</th>
<th>Vin (V)</th>
<th>$I_{in}$</th>
<th>$P_{in}$</th>
<th>$V_{out}$</th>
<th>$I_{out}$ (mA)</th>
<th>$P_{out}$</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right on Top</td>
<td>1kΩ</td>
<td>5.03</td>
<td>0.16</td>
<td>0.8048</td>
<td>1.89</td>
<td>1.89</td>
<td>0.003572</td>
<td>0.443849</td>
</tr>
<tr>
<td>Right on Top</td>
<td>10kΩ</td>
<td>5.02</td>
<td>0.15</td>
<td>0.753</td>
<td>7.09</td>
<td>0.709</td>
<td>0.005027</td>
<td>0.667571</td>
</tr>
<tr>
<td>Right on Top</td>
<td>N/A</td>
<td>5.01</td>
<td>0.15</td>
<td>0.7515</td>
<td>21.2132</td>
<td>2.121</td>
<td>0.045</td>
<td>5.988024</td>
</tr>
<tr>
<td>Right on Top</td>
<td>no rectifier</td>
<td>5.00</td>
<td>0.15</td>
<td>0.75</td>
<td>7.778175</td>
<td>0.778</td>
<td>0.00605</td>
<td>0.806667</td>
</tr>
<tr>
<td>Mouse Pad (1mm)</td>
<td>Battery</td>
<td>5.00</td>
<td>0.14</td>
<td>0.7</td>
<td>16.19275</td>
<td>1.619</td>
<td>0.026221</td>
<td>3.745786</td>
</tr>
<tr>
<td>Mouse Pad (1mm)</td>
<td>no rectifier</td>
<td>5.00</td>
<td>0.14</td>
<td>0.7</td>
<td>16.19275</td>
<td>1.619</td>
<td>0.026221</td>
<td>3.745786</td>
</tr>
</tbody>
</table>
CHAPTER FIVE: RECOMMENDATIONS

Due to the nature of the project and its emphasis on wireless power transfer, improving efficiency will be one of the primary focuses of this discussion.

The push-pull oscillator shown in Figure 3 produces a sinusoidal 27.9V pk-pk signal across the primary coil at 10.9 Mhz. A 5V input is used to represent the typical output voltage supplied by a USB port. The oscillator utilizes two 2N7002 MOSFETs in its operation. The first source of power loss comes from the internal resistance of the MOSFET, $R_{DS(ON)}$. According to the datasheet, with a $V_{GS} \approx 5V$, $R_{DS(ON)}$ has a value of 6Ω. Power is dissipated as current is conducted through the transistor. During each ON transition 150mA is pulled through a single MOSFET. This results in 135mW dissipated by $R_{DS(ON)}$. A second source of power loss lies with the switching losses of the MOSFET. This is a direct result of the internal parasitic capacitances within the transistor structure: During each switching transition, power is stored and then dissipated by these capacitances. This is very apparent when the MOSFETs begin to heat up after only being on for less than a minute. In future applications it is recommended that larger MOSFETs designed specifically for power applications be used instead. The 2N7002 model, though it serves its purpose, is small and cannot dissipate heat effectively without the use of heat sinks.

The receiver-rectifier circuit shown in Figure 4 rectifies a sinusoidal 40.1V pk-pk signal at 8.21 Mhz to a DC voltage of 8.0V across its output terminals. As mentioned in the section above, using different MOSFETs in this circuit is also recommended to improve efficiency and reduce power loss. Another recommendation is to replace the 1N4001 diodes with Schottky diodes instead such as a 1N5711. Because the 1N5711 has a lower forward voltage drop of 0.41V compared to the 1N4001’s 1.0V voltage drop, less energy is wasted as heat, thus making it the more efficient choice. In addition to the small forward voltage drop Schottky diodes in general have fast turn off times which reduces the chance of reverse current leakage.

The primary and secondary coils used in each circuit were pre-matched to have the same circular dimensions, wire gauge, and a turns ratio $\approx 1$. Using a push pull oscillator for the transmitter, however, required that the primary coil be center tapped. This proved difficult for us to accomplish with the coil already pre-wound and glued. We were only able to estimate where to place the center tap. Because of this lack of perfect symmetry, we believe that this had a major effect on how efficiently the power was transmitted from one coil to the other. In order to avoid this in future implementations of this project, it is highly recommend that the user wind the coils themselves in order to determine beforehand the location of the center tap.

The battery charging circuit in Figure 5 is able to charge two 1.2V NiMH batteries via trickle charging. However, battery is heavily loading the rectifier voltage and dropping it from 8.0 $V_{DC}$ to almost 0.2$V_{DC}$. It is suspected that the batteries’ internal resistance (measured to be 120MΩ) is the cause. At present, only about 0.1mA is being drawn by the battery. The battery charger circuit accomplishes its expected task but has many other drawbacks in its simplicity. Most modern consumer battery chargers on the market today can supply constant current or voltage in a manner that is optimum to the specific type of battery being charged. Charging can be stopped once a certain voltage is reached, it detects the battery is full, or if an unsafe temperature is detected. The battery charging circuit used in this project does not have any of these features nor does it protect against overcharging. If this product were to go into
production for consumer use, it is recommended that a different battery charging circuit configuration be used, one that has the auto-shut off and over voltage protection features previously mentioned.

CONCLUSION

The wireless power charging system that was implemented in this project was successful in its ability to utilize close proximity inductive coupling to charge the battery of a wireless mouse. A $40.2\, \text{V}_{\text{pk-pk}}$ sinusoidal voltage at 8.21Mhz on the receiver coil is successfully rectified to a DC voltage of 8.0V. However, as seen in the Table 6 results, the maximum efficiency achieved with a battery load is a mere 0.80%, and only 5.98% with no load. The internal resistance of the battery heavily loads the rectifier and drops $V_{\text{out}}$ to 0.2V. Further analysis has concluded that a majority of the power loss is a direct result of power losses from the diodes and MOSFETS used in the rectifier circuit. While we were not able to achieve efficiencies over 50% as expected, as students we have both earned valuable experience with power electronics, circuit design, PCB layout, and wireless power. This paper not only highlights some of the drawbacks of utilizing wireless power, but it also brings to light the some of the potential it has as well. There is growing interest in this particular field and because of our project, we are now fully aware of the constraints involved when designing a wireless power system.
REFERENCES

APPENDIX A: PROJECT ANALYSIS

• 1. Summary of Functional Requirements

This senior project aims to utilize the properties of wireless power to charge the internal battery of a wireless mouse. The mouse pad will be designed in a way that will allow the mouse to charge when placed within the primary coil’s magnetic field.

• 2. Primary Constraints

The technology for wireless power has existed for quite some time but the major hindrance to its implementation in modern day use is its poor efficiency when transmitting power over long distances. Because a magnetic field spreads in all directions, the use of electromagnetic radiation results in an increase of power lost to the surrounding environment as the distance from transmitter to receiver increases.

The use of inductive coupling, such as used in charging electric toothbrushes, is also a viable option but is limited to the requirement that both inductors must be within very close proximity (usually centimeters) of each other to be effective. As the distance increases, the inductors’ size must also be increased in order to compensate.

• 3. Economic

The potential economic gains of this project depend greatly on whether the idea takes off and goes into production. The design and prototype stages of the project lead to a slight increase in sales within the San Luis Obispo area for required parts, as well as housing for the design team. The need of basic initial monetary supplies is illustrated in the cost estimate table.

Production scale of the wireless power system leads to a greater increase in monetary gains. The initial investment from investors to start the company leads to long-term monetary gains for the investors. Part of the initial investment is for parts, facility, machinery, shipping, and a workforce is required to keep production for the consumer. Basic electronic components, such as resistors, capacitors, and inductors, are required to create the prototype and all final components. The investors will receive their reward as time progresses, such as through stock gains.

The consumers must be aware of their role in the products sustainability. This product requires energy to work, and therefore a slight increase in the consumers electric bill needs to occur. For the product to be effective, the consumer will be spending small amount monetary payment in order to gain comfort, and easier lifestyle on a daily aspect. Also, due to requiring electricity to function, power companies convert natural resources (solar, oil, nuclear, etc) into electricity to power the device.

As mentioned above, the natural capital required is in the parts. Raw earth materials such as silicon, copper, iron, etc. are needed by suppliers to create their products. More than likely, this product will use copper wiring in the design of the magnetically coupled inductors.
4. If Manufactured on a Commercial Basis:

The current estimates are 1000 units sold per year at a cost of $10 per unit. Selling the product at $25 per unit leads to profits of $15,000 a year. Customers pay their own power company the low increase to their energies bill. Any repair work can be return and fixed for a fee.

5. Environmental

Manufacturing and distributing this product will have an indirect impact on the environment. Tracing all the way back, raw materials like silicon and copper must be mined in order to obtain the necessary “ingredients” to create the components required for this device. Mining can be destructive to the surrounding area in which it occurs and, if not regulated properly, can damage the local ecosystem and wildlife. Other species’ habitats can be destroyed, pollution can occur when waste from the refining process is dumped into the environment, water contamination can occur, and many others.

Along with the indirect impact on the environment, this product will also have a direct impact as well. The site in which the factory will be located will take up space where previous ecosystems use to thrive. Air and land pollution from the manufacturing process and distributing the product using transportation services (trucks, boats, etc) will also occur. The power needed to run the factories and offices may come from “unclean” sources such as coal powered power plants that pollute the surrounding air.

The wireless power station is an indoor device, and will only affect those in the immediate proximity. The immediate home environment will be improved through the loss of wires and chance of harm from tripping over a cord. The only other species of animals which will interact with this device comes from house pets and pests. This is a small safety risk for large pets such as dogs and cats which are sometimes known to chew through wires.

6. Manufacturability

Some of the potential issues or challenges that may arise with manufacturing are getting a business license, finding a place to set up a factory, finding the most cost efficient machinery to create the product, deciding the quality of the components purchased, or deciding whether to outsource the manufacturing process to another country in order to save on costs.

Another challenge that arises is obtaining components all within the same tolerance ranges. The power efficiency of this device relies on the resistor, inductor, and capacitor components to all be within their expected tolerance ranges. This will be very difficult to achieve on a large scale. Keeping the cost low for consistent and reliable components, which are very specific to our project when dealing with resonating frequencies, proves to be a challenge.

7. Sustainability

As previously mentioned in the environmental section from the previous page, raw materials must be used in order to create the components needed for this device. In order to be more sustainable, this product aims to use components and packaging material that can be recycled. There now exists programs at electronic stores in which consumers can donate their used electronic equipment [14]. Some materials can be harmful to the environment if disposed of improperly in waste containers. An example of a harmful material is found in old lithium batteries. Companies that specialize in the recycling of old electronics can take apart old devices and properly dispose of or reuse specific components or materials.
Using information labels on the device to inform the consumer, the company can promote the use of these recycling services.

The greatest concern of overusing the device is when it is on but not charging anything. This causes unnecessary wear and shortens the lifespan of the emitter. A useful upgrade to make the supplier automatically shut off when nothing is being charged. This eliminates the users’ error of leaving the device on. Since all entire project is hardware, it becomes difficult to hardwire any upgrades on a mass consumer scale. If any changes are made, a new model is a likely choice.

8. Ethical

The IEEE’s code of ethics provides a solid framework for a rule-based ethical outlook of this project. The report contains citing of information in which we used our data. This project is taking the provided materials and applying them in a useful manner. This project provides a means to provide application to safe wireless energy transfer. The appropriate warnings are provided for those in which this energy might affect physically. The most concerning fall-point of this project is “to be honest and realistic in stating claims or estimates based on available data.” The device is subject to environmental factors, and is difficult to give accurate ratings due to the environment. Not all environmental situations can be conducted on campus, and so an approximated range will be provided.

One major ethical implication for this product can arise in regards to the location of its manufacturing process. It is often much more cost effective to outsource the manufacturing process to a country outside of the US. Places such as Thailand, Malaysia, or China, some companies choose an abundance of cheap labor, lower costing materials, and sometimes lower taxes for companies that decide to set up factories in their countries. This approach can save the company millions of dollars on financial costs compared to if they had instead decided to manufacture their product(s) within the US. However, this is often seen an exploitation of foreign workers. Especially in third world countries, these workers make extremely low wages, work longer than normal hours, have very low standards of living, and in some cases, employ the use of child labor. If this company decides to outsource the manufacturing process for the wireless power hub to another country, it is important to first make sure that the working conditions for the workers in that country meet high ethical standards. This is related to the first ethical framework from the IEEE code of ethics which deals with the “responsibility in making decisions consistent with the safety, health, and welfare of the public.”

A second major ethical implication for this product also arises in regards to the potential pollution and other negative affects the manufacturing and distribution process may have on the surrounding environment. As previously mentioned in the ‘Environmental’ and ‘Sustainability’ sections from the previous pages, the mining of raw materials and the use of non-recyclable components can negatively affect local ecosystems. Potential solutions and ways to reduce harm have already been discussed.

A third potential ethical implication for this product can arise in the design and promotion of this product. In order to boost sales and gain a better image, there is the unethical possibility of providing false claims and overestimates on the actual performance of the wireless power hub. Avoid falsely stating that our experimental results shows that the device had an effective range of 3 meters when in actuality, the effective range is 2.5 meters. This goes against the third ethical framework from the IEEE code of ethics which states one agrees “to be honest and realistic in stating claims or estimates based on available data.”

9. Health and Safety
The safety of the consumer must always be taken into account when designing an electronic device. A strong warning is issued for anyone with heart transplants, or other clocked and sensory devices. One safety concern is the effect the wireless power system on consumers with pacemakers. When designing the device, additional research will be done on the properties of pacemakers, their basic features, and what factors increase the risk of negatively affecting them. The wireless power follows all government bylaws concerning safety, and is deemed safe for human and animal interaction. This project meets all IEEE safety and standards. [6] This insures users’ safety and comfort. Following these guidelines protects the designers from any legal issues as well.

• 10. Social and Political

This project influences Jacob Keast and Vincent Jison, the designers and developers, the most. They are investing their time in order to better our education and resume. This provides experience in project managing, design, troubleshooting, and teamwork. Tina Smilkstein is our advisor, and this work will be a reflection of her oversight. Her stake in this project is not as large as Jison’s and Keast’s, but her influence observed. This project has the potential to redefine how power is connected, which could affect all.

Politically, Keast and Jison gain experience with current codes and regulations with wireless energy. This experience will last throughout their careers. This project may also lead to future concerns and future regulations.

All employees and workers involved in the development, manufacturing, or distribution of the wireless power hub all benefit from having a job and income. The suppliers of the components are given business, the shareholders have a return on their investment if the product is successful, retail stores make profit selling the product, and the consumers are able to benefit from what the product has to offer them. Competitors must invest time and money in order to develop similar products. As discussed in the ‘Environmental’ and ‘Sustainability’ sections, local species and ecosystems are usually affected negatively with pollution, the loss of land, destruction of natural habitats, and reductions in population.

Literary Research:

Bibliography


