Ethical and Environmental Analysis

Year: 2020 **Semester: Spring** **Team: 8** **Project: AudioBeamer**
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Assignment Evaluation:

Item	Score (0-5)	Weight	Points	Notes
Assignment-Specific Items				
Environmental Impact		x6		
Ethical Challenges		x6		
Writing-Specific Items				
Spelling and Grammar		x2		
Formatting and Citations		x1		
Figures and Graphs		x2		
Technical Writing Style		x3		
Total Score				

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

Comments:
Comments from the grader will be inserted here.

1.0 Environmental Impact Analysis

The manufacture of printed circuit boards produces a variety of hazardous waste products. During the "board preparation" stage in which the board is baked and through holes are drilled, according to the EPA the following wastes are produced:

- Abrasive and alkaline cleaning compounds
- Ammonium persulfate or peroxide-sulfuric acid etchant, for removing the oxidation inhibitor in the copper foil
- Tin and palladium catalyst
- Cupric chloride or copper sulfate plating bath containing formaldehyde or hypophosphate reducing agents, and amino acid, carboxylic acid, hydroxy acid, or amine chelating agents
- Rinse waters

[4]

Airborne particles created during production are collected and disposed of at landfills. Both toxic fumes and organic vapors are collected through chemical fume hoods and treated or condensed and sent offsite to be treated. Spent acid and alkaline solutions are treated and released to the sewer or sent offsite to be treated [4]. The water waste "containing suspended solids, metals, fluoride, phosphorus, cyanide, and chelating agents" [4] are treated at a wastewater treatment facility.

The EPA suggests several methods for reducing waste during the PCB manufacturing processing including:

- Use abrasive instead of aqueous cleaning
- Use non-chelated cleaning chemicals
- Reuse/recycle cleaning agents
- Reuse/recycle rinse water

[4]

While we do not directly oversee the PCB manufacturing process, we can choose a manufacturer that employs some of the above methods. Additionally, we can inquire as to how the fumes and vapors are collected and treated, how the solutions are treated, and what is done to minimize toxic wastes. With that knowledge, we can choose a manufacturer with minimal waste production. Because we are soldering components to the PCB, we do have the ability to choose non-leaded solder and attempt to use physical de-soldering rather than chemical de-soldering to minimize chemical waste.

During normal use of the product, the two top concerns are the power consumption and the possibility of component failure. To address the latter, the product's lifetime can potentially by increased by making the product repairable. To do this, specific values can be given for passive components, part numbers can be given for ICs and the specifications of the Lithium-Ion battery can be given. In addition, the physical container for the device would be able to be opened such that the board and components could be accessed for replacements if need be. As for energy usage, our device can operate in low power modes. We have already set the communication between the Android App and the device to Bluetooth Low Energy. This means that messages do not need to be sent constantly and this saves on power consumption compared to standard Bluetooth. In addition, we could implement a "low energy" or "sleep" mode in the code which

reduces the clock rate and reduces power consumption. Such a mode could easily be implemented by a physical switch or button which toggles the operating mode. While we do not currently plan to implement such an operating mode, it is certainly possible and would be implemented in a final iteration of the product.

It is important to prepare for the end of life for the product. Our project includes a rechargeable, Lithium-Ion battery which should not be disposed of via normal trash collection. Batteries in landfills can leak toxins over time, which could eventually reach water supplies. We can provide a link in our product documentation to help users find a place for disposing of the product at the end of life. I found a website "earth911.com" which includes a search feature for both battery disposal and electronics disposal. While we cannot physically force users to dispose of the product properly, providing this information should help to guide them toward correct methods of disposal. The recycling process for PCBs includes three steps: removal of reusable or toxic parts, physical separation of parts via magnets, density separation, etc. and chemical recycling by dissolving or melting remaining parts [1]. To facilitate this process, we can also provide instructions for separating the PCB from the physical container and the battery from the PCB.

2.0 Ethical Challenges

Outside of environmental concerns which were addressed above, this product has ethical challenges with respect to reliability and safety.

The desire is to have a product that performs audio effects both reliably and consistently in a variety of conditions. When using our product, the user will likely be indoors because that is the typical use environment for a guitar. It is worth testing the product in different environments, however, as a user could want to play guitar outside on a hot summer day. In practice, this can be emulated either by testing the product outdoors in the summer or in a warm room. Additionally, music played through a speaker can cause physical vibrations which could damage the product. To ensure that the product is safe from damage caused by vibrations, it could be tested while sitting on top of a loud, bass heavy amplifier for extended periods of time. These two modes would likely be the most common, most extreme risks to reliability which would have to be considered. If either situation proved to be potentially damaging to the product, new considerations in the design would have to be made. If the physical vibrations caused damage, the physical casing for the device could be altered. If the product became too hot in warm weather, a heat sensitive shutdown could be implemented to prevent damage.

The other major concern with the product is safety. This is most important when considering the Lithium-Ion battery the product uses. Physical puncturing and extreme temperatures can lead to fires or explosions. To avoid this, as stated above, the device's container must be tested for physical safety; the vibrations caused by loud music or a drop from a short height should not damage the battery. The Occupational Safety and Health Administration have several additional recommendations for hazard prevention including:

- Certification from a Nationally Recognized Testing Laboratory
- Include instructions for storage, use, charging, and maintenance
- Replace batteries only with those which are specifically designed for use with the device
- Remove device from charging once fully charged

- Store battery in a dry, cool location
- Avoid damaging batteries
- If battery is damaged, remove from service and place in a fire-resistant container with sand or another extinguishing agent
  [3]

This information can be provided to the user with the instruction manual. Ideally, because this is some of the most important information about the product, warnings about the safe use of a Lithium-Ion battery would be placed in the front of the manual and be easily recognizable. The user would be told to remove the battery from service and placed in an extinguishing agent if there is any sign of damage (i.e. smoke, noise, gas). Finally, as noted in the environmental considerations we will provide resources such as "earth911.com" which can be used to find local battery recycling facilities.

3.0 Sources Cited

[1] A. Esfandyari, S. Harter, T. Javied, J. Franke, "A Lean Based Overview on Sustainability of Printed Circuit Board Production Assembly," *Procedia CIRP,* vol 26, p. 305-310, 2015. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2212827114008725

[2] "NEED HELP RECYCLING? SEARCH FOR A RECYCLING SOLUTION BELOW" 2020. [Online]. Available: https://search.earth911.com/?utm_source=earth911-header&utm_medium=top-navigation-menu&utm_campaign=top-nav-recycle-search-button

[3] Occupational Safety and Health Administration, "Preventing Fire and/or Explosion Injury from Small and Wearable Lithium Battery Powered Devices" [Online]. Available: https://www.osha.gov/dts/shib/shib011819.html

[4] United States Environmental Protection Agency, "Guides to Pollution Prevention: The Printed Circuit Board Manufacturing Industry," June 1990. [Online]. Available: https://archive.epa.gov/sectors/web/pdf/01050.pdf