Hand Cranked Charger

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14

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Introduction: Objective and Background

Goals: What problem is being solved?

In the current age of technology, it is quite important and necessary to ensure that our electronic devices are powered at all times. However, due to this increased dependence on such devices, people find themselves often relying too much on them. In emergency situations, people require their phones to call for help and access a host of other applications, which becomes impossible when the device does not have any power. To solve such a jarring problem in the modern world, our product allows users to generate sufficient electricity to charge their phones by a few percentage points, enough to give them some more time to run.

Functions: What is the product supposed to do?

Our product is a hand-cranked charger, which will allow users to generate electricity through their own kinetic energy, in order to be able to supply sufficient power to charge their devices by a few percentage points. This enables the device to run long enough to be of use during emergency situations.

Benefits: How is it good for the consumer?

The hand-cranked charger[1] does without the bulky extra survival features, found commonly in existing products. It is common knowledge that a large amount of electricity will be required if the device is dead, so the typical use case is when the device is at 1-2%, the user charges the device to be able to use it for longer. The product is affordable and compact enough to be carried along with the user. This product can also be placed at various stops in different locations (shoulders of highways, rest stops, etc.), to supply the need for power.

Features: What aspects make it marketable?

- [ ] By implementing a hand crank, we allow the user to generate electricity through arm rotations, and this would in turn use their kinetic energy to provide current through a voltage regulator helping charge a battery or the device directly.

- [ ] There is a 1000 mAh battery that can also be charged as a power back, and thus, when the user anticipates longer usage, the battery can be charged and used later.

- [ ] The product is affordable due to a relatively simple use case, rather than having 10 different features driving up cost, this focuses on charging a device and therefore we can reduce the price.

High-Level Requirements of Product

- ☐ We should be able to get a stable 5V output from the motor, even with fluctuations in crank frequency.
- ☐ We should be able to successfully control the flow of power between the hand crank and either the battery or the USB. Power should not flow into both components at the same time.
- ☐ We should be able to obtain a 5V output at the USB out from the battery when the crank is not powered. The battery should not be running otherwise.

Visual Aid of Product

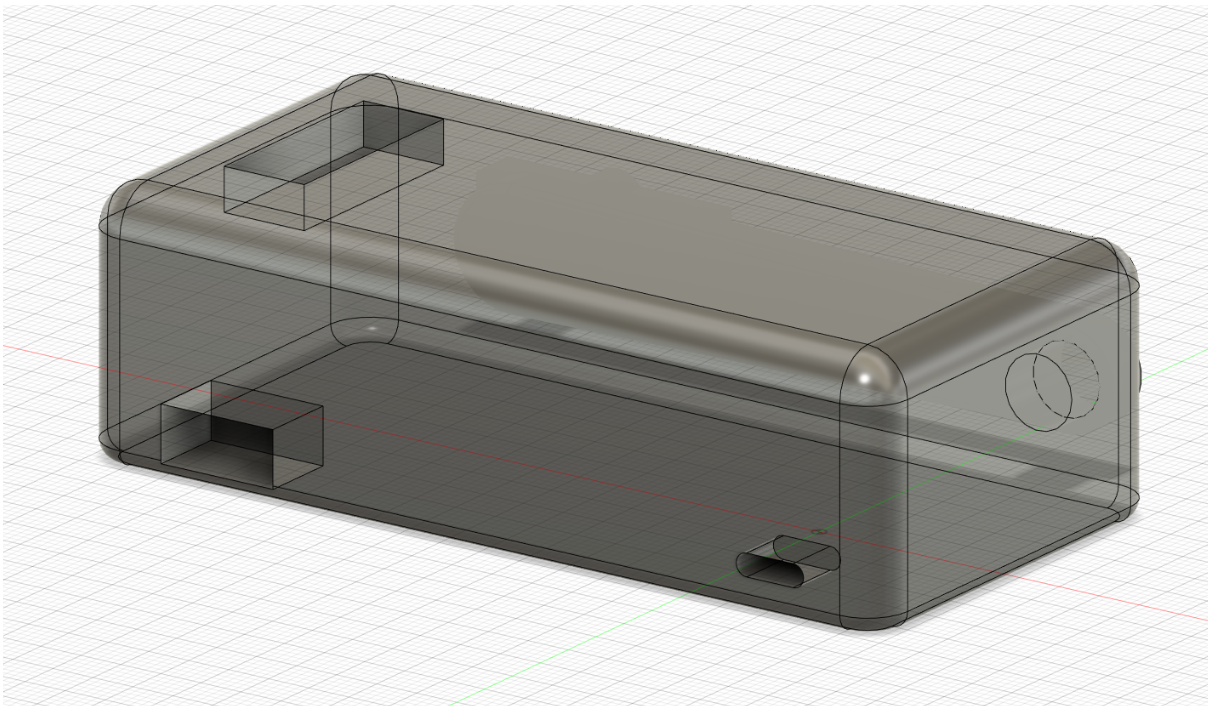

Figure 1. Charging side

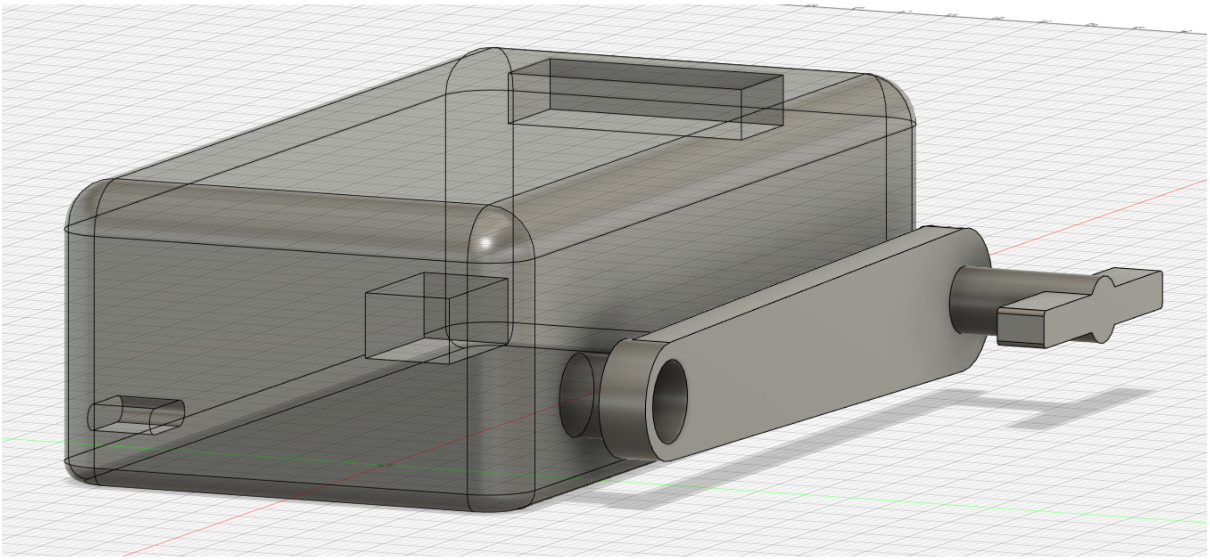

Figure 2. Hand Crank side

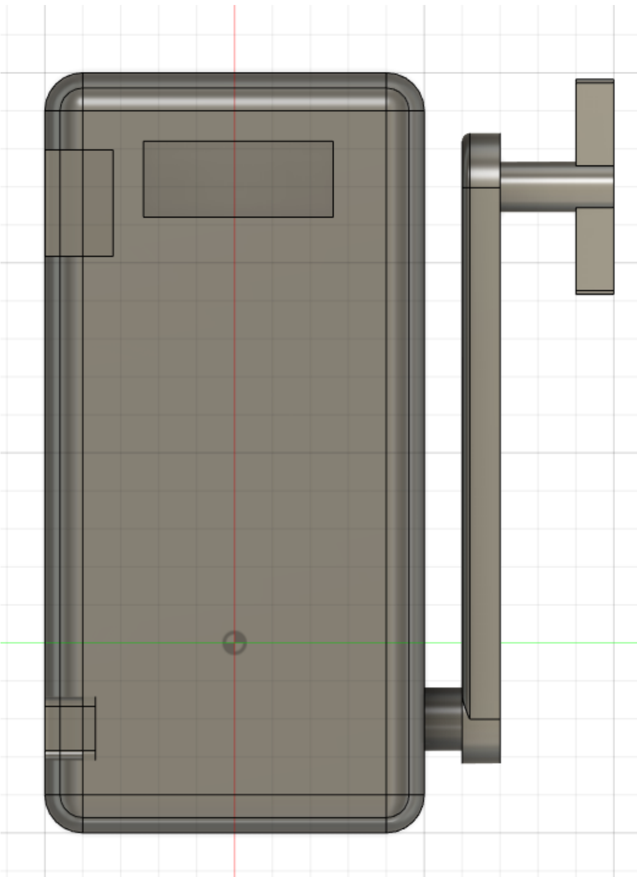

Figure 3. Top View (Display)

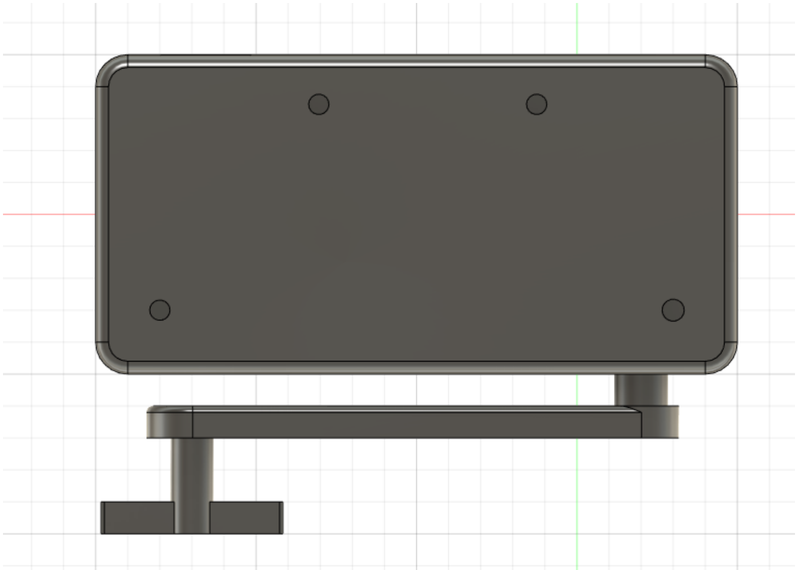

Figure 4. Bottom View

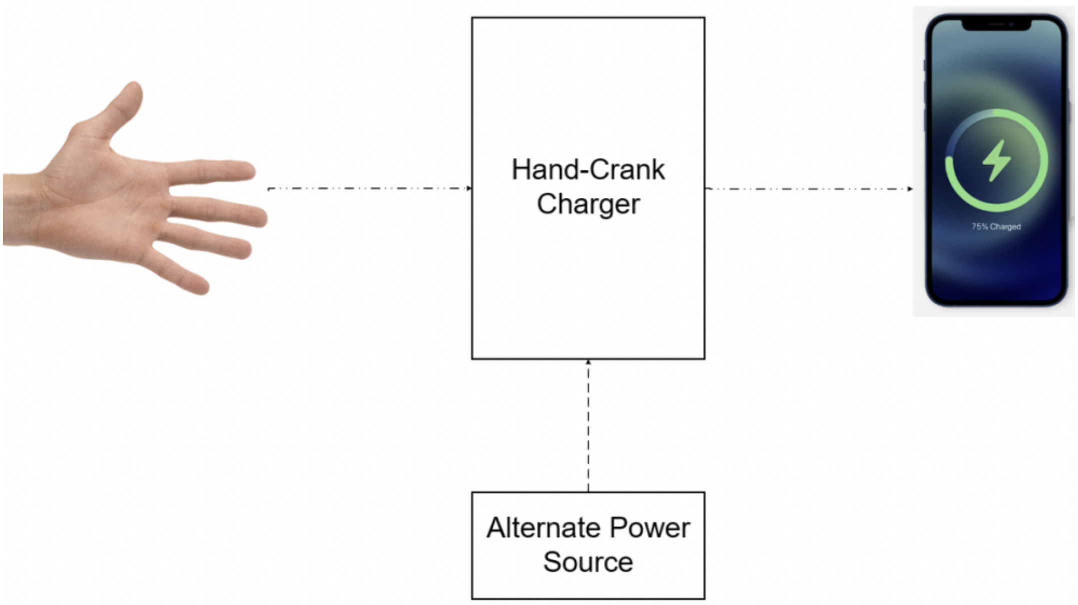

Figure 5. Overall Use Case

Note: The dashed lines represent direct physical connections

Design

Block Diagram

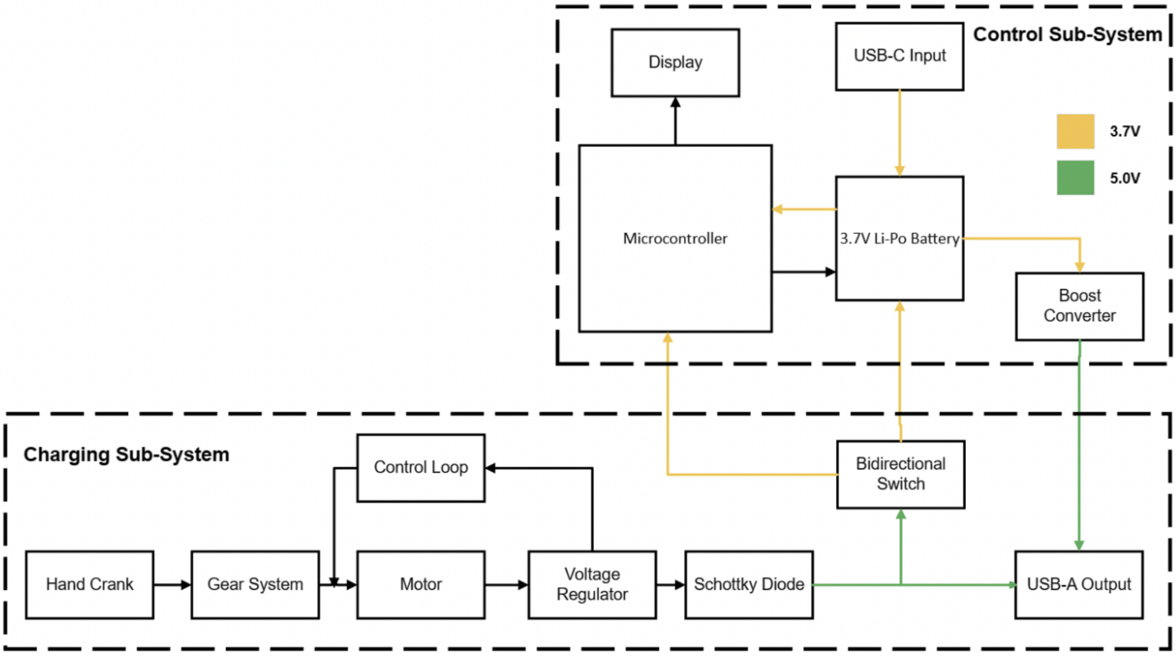

Figure 6. Block Diagram (with subsystems)

Subsystem Overview

The product consists of two main subsystems, the **electromechanical** and the **microcontroller subsystems.**

- ☐ The *electromechanical subsystem* is where the kinetic energy generated by hand-cranking is converted into electricity. It will include the necessary voltage conversion, along with the required circuit design to ensure that the charging of the battery is taken care of, including the bidirectional switch.

- ☐ The *microcontroller subsystem* is part of the same product, but it does not handle the charging portion, hence, we have decided to keep it as a separate subsystem. The microcontroller handles certain parts such as the automated switching between mobile and battery. The microcontroller also processes the information from different parts of the circuit and displays key metrics on the 7-segment display

Subsystem Requirements

Electromechanical Subsystem

- [ ] The hand crank should be able to provide a 6V output at optimal crank speed.
- [ ] The voltage regulator should make it a steady 5V output even if the crank speed is not optimal.
- [ ] The subsystem runs on 3.7V tracks for most of the circuitry until it reaches the voltage regulator after which it is 5V. It will communicate with the microcontroller subsystem through the 3.7V tracks as well.
- [ ] The Schottky diode should ensure the directionality of the circuit since we do not want the battery to power the motor.
- [ ] The current should flow through the bidirectional switch and go to only one of the two outputs (the device or the battery), never both.
- [ ] The battery should be able to charge the device if the hand crank is not being turned.
- [ ] All the parts or pieces of the product are critical and they are all connected in series, therefore if any part is damaged, the whole product will fail.

Microcontroller Subsystem

- [ ] The microcontroller subsystem will be reading information about the voltage levels from the hand crank, the battery, as well as the device. Using these values, it will first evaluate if there is a device connected to the product. If there is one connected to it, then the battery will directly charge the device (unless the hand crank is cranked), and in the case where there is nothing connected to it, then it charges the battery.
- [ ] The subsystem runs on 3.7V tracks and will communicate with the electromechanical subsystem through the 3.7V tracks as well.

- [ ] The product will have voltage readings from the hand crank, and the 7-segment display will display if the hand crank is moving too slowly or too fast for optimal electricity generation.

- [ ] The 7-segment display will also contain information about the battery, it will output the current battery charge level indicating how much hand crank will be required to charge the battery

- [ ] In case the microcontroller was to fail, then the entire automated switching would not work, and this would lead to the device never being charged directly (since we would have the default case be hand-crank -> battery and battery -> device)

- [ ] If the 7-segment display is malfunctioning, we also would not be able to tell if the hand crank is being rotated optimally, leading to poor efficiency of the product.

Tolerance Analysis

- [ ] The most integral component in our design of the product is the motor.

- [ ] Considering the fact that humans are not expected to crank at a stable frequency, it is important that our motor has enough headroom to ensure that even with sub-optimal cranking, the product can still output a stable 5V as expected.

- [ ] The motor we have currently in mind is a high-power motor that can generate 6V± 20% at 150 rpm[2]. Having a voltage above 5V allows us to regulate the voltage for a stable output, as we cannot expect human cranking to be consistent.

- [ ] The motor also generates 100 mA at no load, which allows us to charge both the phone and the reserve battery faster. This may also enable us to go for a gearless design.

- [ ] We believe that the reasonable rpm and 1V headroom will be enough, but we still need to test the output at a lower rpm. If we realize that the headroom is not enough, we plan on changing to a 10V motor at 220 rpm, while using a 1:2 gear ratio for a reasonable crank frequency.

Ethics[3]

The IEEE Code of Ethics expects us to commit ourselves to the highest ethical and professional conduct while acknowledging our personal obligation to other members and communities. This helps us recognize and realize the importance this technology might have in affecting the quality of life around the world.

- ☐ *We agree to uphold ourselves to the highest standards of integrity, behave in a responsible manner and maintain ethical conduct in every activity we undertake.*
  1. We will consider the safety, health and welfare of the public while working and it is important to comply with ethical design and sustainable development practices, it is crucial to keep in mind security and privacy of others and their information, additionally never disclosing anything that might endanger the public or the environment;
  2. It is our responsibility to help individuals understand the capabilities, implications and consequences of our project in order to help others be well-informed, and make known the intentions, results, and expectations;
  3. We will avoid real/perceived conflicts of interest whenever possible, and if they do occur we should disclose them to the involved parties and solve these problems using effective communication among team members and those involved;
  4. We will avoid unlawful conduct while we work and reject any sort of bribery;
  5. It is our duty to expect, accept and also offer honest criticism of technical work, be mindful of errors and correct such instances, while being transparent about the our claims and estimates based on available data while acknowledging the contribution of others while giving them credit;
  6. We are expected to uphold and maintain technical competence working within the team and undertake the tasks we have the appropriate training or experience for, and fully disclose limitations in such situations in order to avoid any unwanted hazards or dangerous situations;

- ☐ *We agree to treat all people fairly and respectfully, while not engaging in any kind of harassment or discrimination, and avoiding injuring others.*
  7. It is our responsibility to treat others with respect and fairness, and not engaging in any kind of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;

8. We will not engage in harassment of any kind, including sexual harassment or bullying;
9. We will avoid injuring others along with their property, reputation, or employment by false or malicious intent and actions, rumors or any other kind of verbal or physical abuse;

- ☐ *We agree to strive to ensure this code of conduct is upheld by all members of the team and its immediate surroundings.*

10. We will support others in following the aforementioned code of conduct, and work to ensure it is being upheld and followed, and not act harshly or retaliate against individuals reporting a violation.

Safety

Electrical Safety

- ☐ As our product contains a battery (roughly 1000mAh) we would need to ensure that it is stored easily.
- ☐ As the battery is a flammable component, it is important to ensure that the circuit is designed carefully to prevent any short circuits or facilitate any fires.
- ☐ The device is meant to be used by an individual, so we need to ensure that the hand crank and the USB ports are shielded.
- ☐ To aid this, our design would make use of mostly plastic components to reduce any chances of shorts or potential static discharge.

Lab Safety

- ☐ To prevent any battery-related incidents, we will not use the battery for a lot of the testing phase of our product. However, since our product can also charge its battery, we will eventually have to test the battery charging system and how well it works with our electromechanical system.
- ☐ At this phase, we will make sure to follow protocol as per our lab safety training and follow the guidelines as indicated in the Safety Manual for Lithium Batteries[4].

Resources

[1] University of Illinois at Urbana Champaign, "ECE 445 Project Ideas," [Online] Available: *https://energy.ece.illinois.edu/lab-resources/ece-445-project-ideas/* [Accessed Jan. 17, 2023]

[2] Pololu Robotics and Electronics, "6V High-Power (HP) Micro Metal Gearmotors" Pololu #995 Datasheet, [Revised Feb. 2022]
Available:
https://www.pololu.com/file/0J1487/pololu-micro-metal-gearmotors_rev-5-1.pdf

[3] Institute of Electrical and Electronics Engineers, "IEEE Code of Ethics," June 2020 [Online]
Available: https://www.ieee.org/about/corporate/governance/p7-8.html
[Accessed Feb. 09, 2023]

[4] University of Illinois at Urbana Champaign, "Safe Practice for Lead Acid and Lithium Batteries," April.13, 2016 [Online]
Available:
https://courses.engr.illinois.edu/ece445/documents/GeneralBatterySafety.pdf
[Accessed Feb. 09, 2023]