Designing Portable Hydroelectric Power Generators for Recreational Use

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Abstract

Efficient, portable electronic products are a necessary commodity amid the widespread use of cell phones and smart devices. Unlike residential electronics users, who primarily rely upon wall mount charging devices, hikers, outdoorsman, and camping enthusiasts cannot enjoy the same convenience. Although portable batteries and car-based chargers exist, few products have the capability to generate reliable power outside of the power grid; developing such a product will supply outdoor enthusiasts with the ability to power personal smart devices for extended periods of time.

The Power Flow (PF) design team sought to address the aforementioned needs by developing a sustainable, reliable charging product for outdoor recreational use. The PF design team developed a portable, hydroelectric charger capable of generating electric power for smart devices. Designed for outdoor use, the PF can generate a continuous power output from creeks, rivers, and other flowing bodies of water.

By researching and developing the PF product, the design team was able to understand the customer needs of the target market–hikers and outdoor enthusiasts. Additionally, creative solutions were developed to address the practical problems associated with portable power generators. Problems with efficiency and portability were addressed.

The PF (and other similar products) are feasible for recreational use. With additional development efforts, the design team is confident that the developed product may be adapted to mass production and widespread market acceptance.

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Designing Portable Hydroelectric Power Gen. for Recreational Use

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ABSTRACT

Efficient, portable electronic products are a necessary commodity amid the widespread use of cell phones and smart devices. Unlike residential electronics users, who primarily rely upon wall mount charging devices, hikers, outdoorsman, and camping enthusiasts cannot enjoy the same convenience. Although portable batteries and car-based chargers exist, few products have the capability to generate reliable power outside of the power grid; developing such a product will supply outdoor enthusiasts with the ability to power personal smart devices for extended periods of time.

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PROJECT MISSION STATEMENT

Single sentence description:

Power Flow will empower outdoorsmen, hikers, and camping enthusiasts by providing an affordable, sustainable power source for recreational use; PF will provide a competitive, versatile, and portable power solution that is environmentally conscious, practically useful, and capable of charging portable electronic devices.

Benefit proposition:

There are few ready-to-use recreational, portable, renewable energy products tailored to the men and women of the outdoors. Producing a product capable of addressing the needs of recreational camping enthusiasts who also own portable smartphone devices (O'Dea, 2021) will expand smartphone usability..

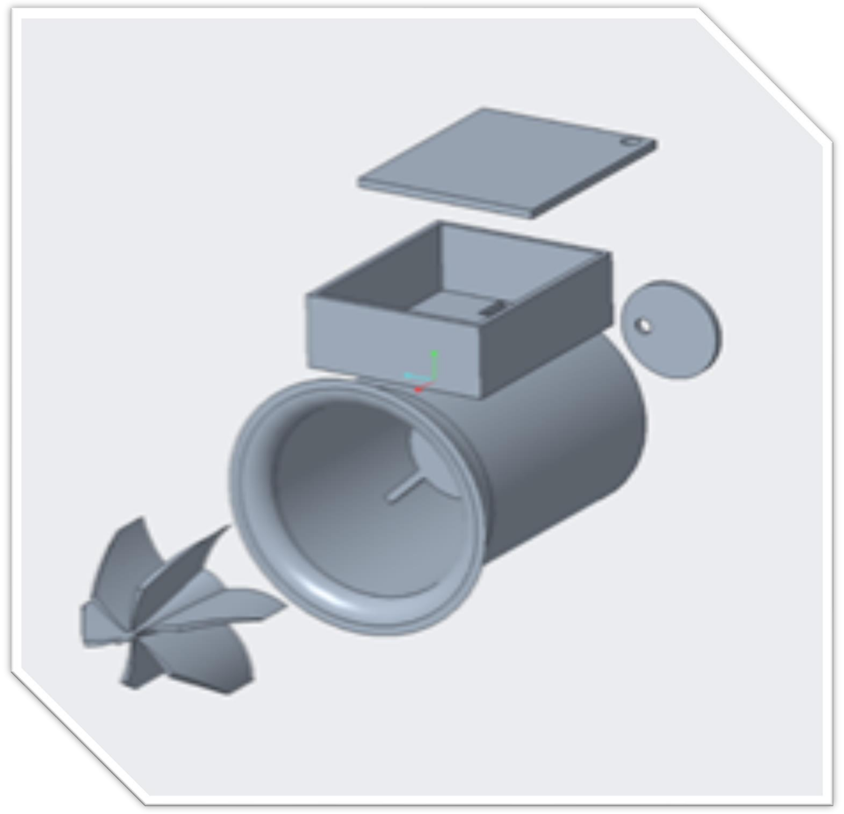
Key business Goals:

The PF product team will set a goal to develop a portable power generator within an academic semester (16 weeks). The development team will produce the product with a material cost of less than 150 dollars. Finally, due to widespread usage, the development team will produce a product capable of charging an Apple cell phone using hydroelectric power (O'Dea, 2021).

MECHANICAL DESIGN

The PF device will primarily operate by utilizing an efficient propeller to convert mechanical force into DC current. The design team recognized the necessity of developing a product that is simultaneously lightweight, durable, and efficient in shallow streams and rivers. To address these needs, the PF design team produced the CAD designs shown in figure 1, and 2 (UniqueCAD, 2021). The portable hydroelectric device has an weight of 2.2 lbs and can be disassembled for convenient storage.

Figure 1.)

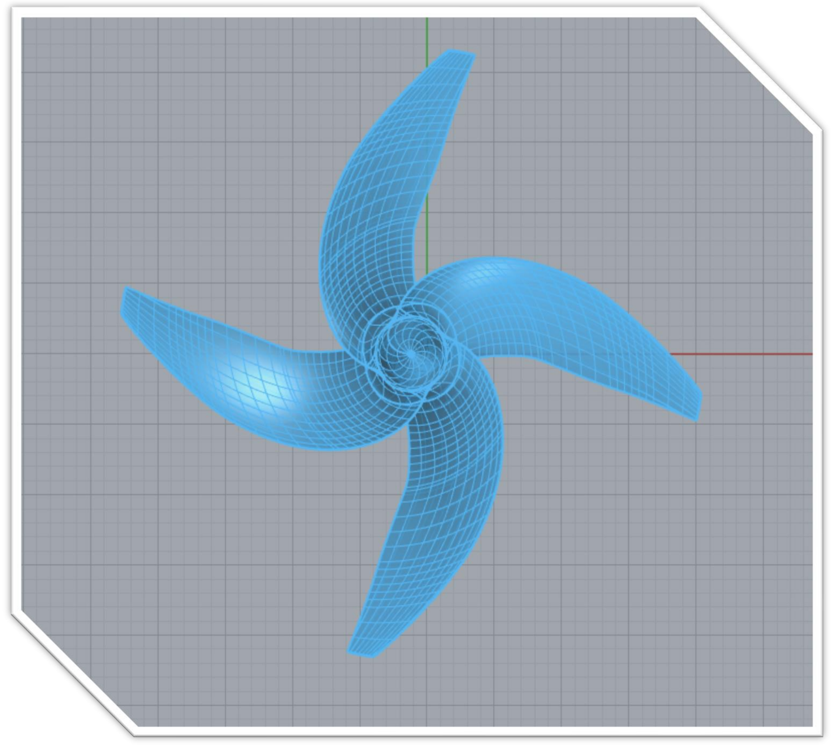


Exploded diagram of the PF hydroelectric device.

MECHANICAL GEAR RATIO

A ratio of 1:42 provided an effective rotation per minute (rpm) range between 62 and 2600 rpm.

Figure 2.)

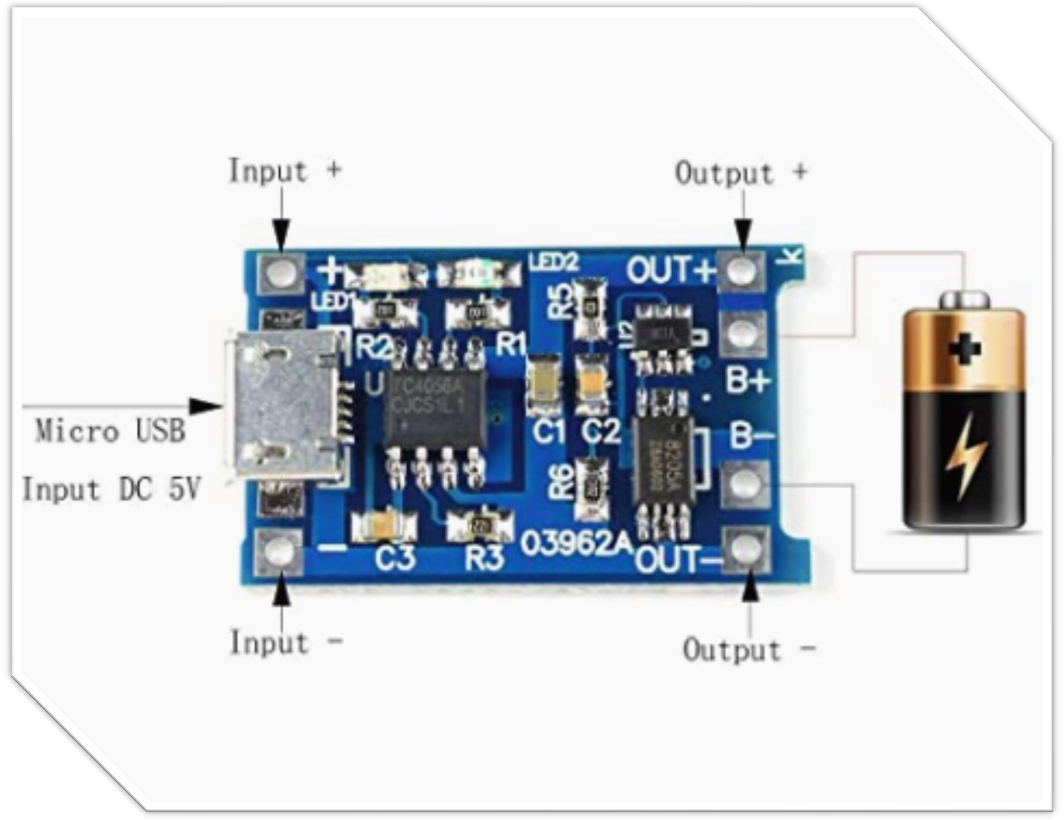


Top-down view of propeller design

ELECTRICAL DESIGN

To convert the mechanical energy of the turbine into current, a 40 W 0V – 24 V motor from *BUBUQD* manufacturing company was selected. The voltage and current range of the device fell within a suitable range of operation for a battery management system (BMS), and a 18650 lithium-ion battery bank. For these reasons, the DC motor was selected for the initial mock-up design. Figure 3 shows an image of the BMS circuit chip to be used as a Li-Ion charging board.

Figure 3.)

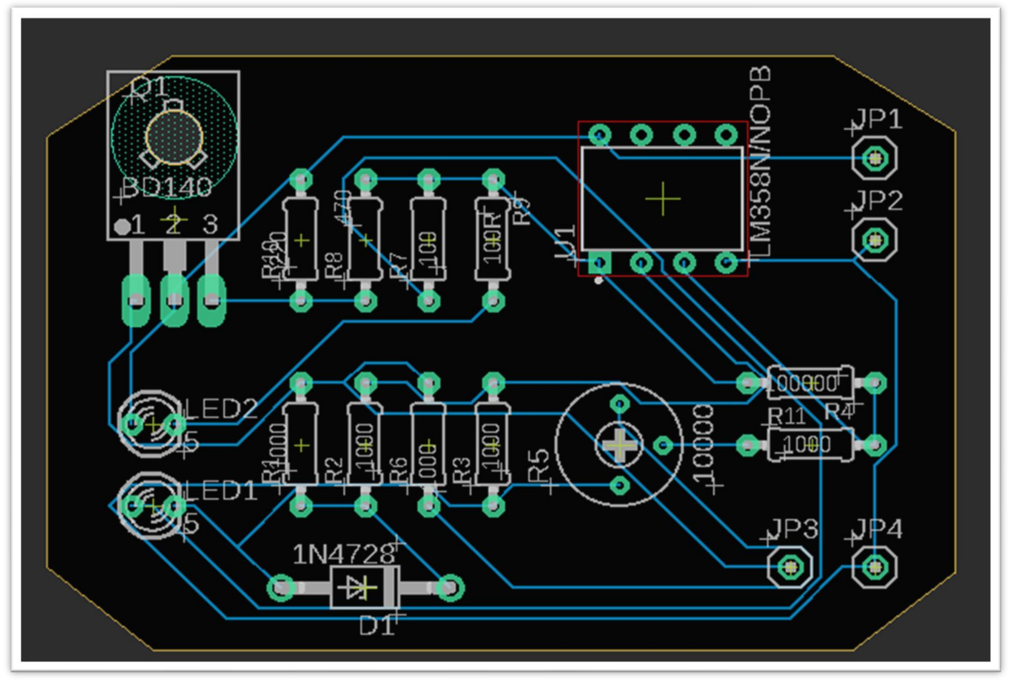


The HiLetgo circuit chip was selected as charge regulation system due to its direct compatibility with 18650 batteries.

PCB Design:

In addition to using the *HiLetgo* chip in the electrical design, the PF team utilized a custom PCB to provide overvoltage protection for the IC. The DC motor is capable of producing voltages up to 24 V—well beyond the absolute maximum the BMS input. Therefore, a cutoff circuit is necessary. A LM358N was used in the cutoff circuit design, as shown in figure 5 (Richards, et al. 2020).

Figure 5.)



MOCK-UP EVALUATION PLANS

In order to evaluate the circuitry and mechanical design, a detailed test procedure must be developed to identify and evaluate critical features of the mock-up. To accomplish this, the design team identified and outlined how design attributes may be evaluated.

Waterproof Testing:

The motor and electrical circuitry will be damaged if water penetrates the outer casing of enclosed containers. The casing of the mock-up must not leak when completely submerged.

Evaluation Method:

The mock-up design design will be evaluated by completely submerging an empty PLA, 3D printed case in water. The IPX rating system will be used to further evaluate the container design (Longman, 2021).

Overcharge Voltage:

Damaging the HiLetgo circuit will make the Li-Ion batteries susceptible to overcharging. A cutoff circuit must be optimized to prevent safety malfunctions.

Evaluation Method:

The cutoff circuit will be tested using a tabletop oscilloscope at a DC voltage setting between the ranges of 0-25 V. The exact cutoff voltage of the circuit will be experientially determined and adjusted.

PROJECT PROJECTIONS

The design team will utilize the results from the mock-up evaluation to optimize the overall design. Modifications to the electrical circuit will be completed, as necessary. Additionally, the design team will perform more calculations to predict various mechanical and electrical design features. The final PF design will be a highly optimized product fit for recreational use by outdoor enthusiasts around the world.

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