Harris Design Project

Team 3-Awesome

EDSGN100 Section 016
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Abstract

Through extensive research, including analysis of existing models and principles of electronics; data collection; and group dynamics, we have designed a versatile and convenient personal charger. This unit is small enough for the user to carry on his/her person, yet it supplies enough power to adequately charge a small electronic device (including smartphones). The unit draws power from two different types of generators, both of which work by kinetic energy. The current then flows directly into a lithium-ion battery which in turn will be able to charge a wide range of electronics. This project was initiated by telecommunications company Harris, Inc., and this emphasizes the importance of practicality and marketability during the entire process. Our final product operates with virtually no restrictions, and can be produced at a favorable cost.

Introduction

When tasked with creating an alternative energy charging device, we first had to come up with a “use case” to base our findings around. For us, our use case would be a logger in the forests of Oregon. We chose this because when out in the field, loggers don’t necessarily have easy access to the traditional forms of charging available now, but they still need to use their devices as much as any other person. To remedy this predicament, we proposed a device that will employ two different types of alternative energy, allowing people in the field to charge their devices and to be able to carry on their work in a safe and comfortable manner. There are many factors that must be taken into account when contemplating possible forms of alternative energy, due to limitations of the environment and conditions at hand. Like many design processes, ours was initiated by extensive research and brainstorming concepts which would be favorable for our use case.

Mission Statement

To design a device that charges a cell phone without the use of a wall or vehicle power outlet. The device will be employed in a field of use where the user may not have access to standard power sources; thus an alternate, remote source of energy will be utilized. Due to the nature of employment in a field, versatility is a key value in this design. The user’s work patterns will coincide with the method of charging their cell phone, or in other words, users can charge their phone while at work. Additionally, the device will use at least two alternative power sources to maximize versatility and convenience. The rugged conditions of employment field, such as a logging industry, will necessitate a rugged and durable design. Furthermore, this device will not be a risk to the user’s safety nor the environment. This design will benefit industrial companies and their employees as it will improve communication and promote overall safety, security, and efficiency in the field.

Customer Needs

Using research, verbal surveys, and the guidelines given to us by Harris Inc., we generated a list of customer needs shown below.

	Customer Needs
1	The device does not use standard wall or vehicle power.
2	The device will be specific to the field in which it is used.
3	The charging of the device will be effective for the usage patterns of all fields in which it is employed.
4	The device will use two different sources of “alternative energy”
5	User safety will not be at risk.
6	The economics of the system will be favorable for the user.
7	The device will have minimal environmental impact.

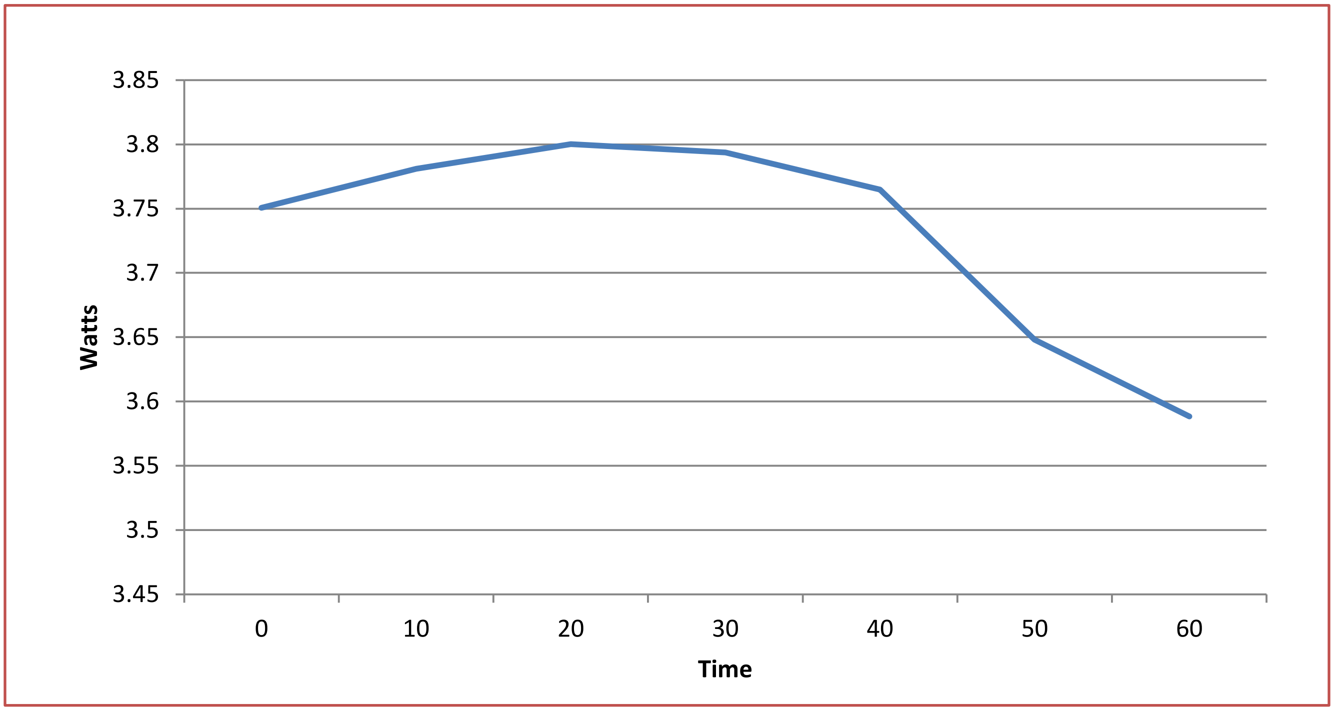
Background Information on Location

Because of the need for “starting ground”, we were required to define a specific scenario early on. Choosing the forests of Oregon presented us with a few interesting parameters, such as the natural resources (or lack thereof) in the area. One such resource is sunlight, which can be used for photovoltaic generation. Oregon, however, does not receive an adequate amount of sunlight, with cities such as Astoria receiving as little as 50 sunny days annually. When in a dense forest, the shading from the trees makes solar power an unrealistic idea. Wind power can also be assessed with the same mindset.

The average shift for a worker in the logging industry is 10 to 12 hours. According to many sources, this work shift outlasts the daily life of many smartphone batteries. These challenges provided us with a basis for the direction our group would take.

Data Collection

One of our first tasks was to experiment with cell phone charging to determine some values and numbers upon which we could build. Using a fully-drained DROID Incredible 2 smartphone and a voltage meter, we measured the voltage and current flowing through the phone battery during a one-hour period of charging. We could then Watts, Watt-hours, milliamp-hours.



Time(mins)	Volts	Amps	Watts	Watt-hours	Total Wh	Total Amps	mA	mAh	Total mAh
0	4.79	0.783	3.75057	0.625095	4.3544217	5.453	783	130.5	908.833333
10	4.78	0.791	3.78098	0.630163333		or 5453 mA	791	131.83333	
20	4.78	0.795	3.8001	0.63335			795	132.5	
30	4.79	0.792	3.79368	0.63228			792	132	
40	4.79	0.786	3.76494	0.62749			786	131	
50	4.8	0.76	3.648	0.608			760	126.66667	
60	4.81	0.746	3.58826	0.598043333			746	124.33333	

What we found is that we would need a source of about 5v, 4 W, and 900 mAh in order to charge a smartphone.

Preliminary Research

Each member of the group independently researched different types of alternative power which could be applied to a personal charger. We also found a variety of existing products and devices that are commercially available (or soon to be). The following products are examples of the different options for alternative energy.

PowerTrekk

This is a portable hydrogen fuel cell charger that uses sodium silicide cartridges in combination with water to produce hydrogen, which is converted into electricity.

<u>Pros</u>: Quick charging time, wide range of devices supported, outputs at 5v, truly portable.

<u>Cons</u>: The cost is very high (over $200) plus the cartridges have short life spans and must be replaced.

nPower PEG

A linear generator consisting of a spring, magnet, and wire coil which builds up a charge from walking motion throughout the day. This is one of the most convenient designs we encountered and served as inspiration.

BioLite

This backpacking stove uses a thermoelectric generator, which operates from temperature differentials. Immediate disadvantages include its portability.

XTG Solar Charger

This solar cell uses the sun's rays to charge an internal rechargeable battery, which can discharge into the mobile phone. Disadvantages include the fact that it cannot fully charge a phone, and relies on prolonged amounts of sunlight.

Tsen Wind Power Charger

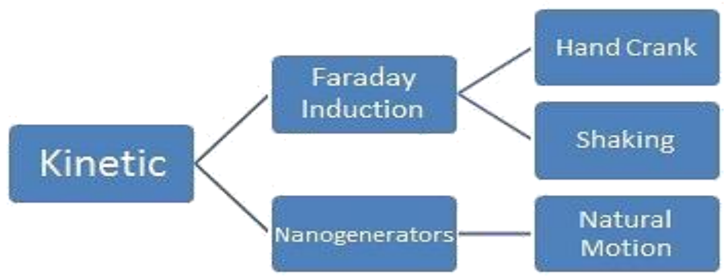
This charger utilizes wind power to charge an internal rechargeable battery to then use to charge a cell phone. Disadvantages are mainly that it requires an area where there is an ample amount of wind, and once the battery is fully charged it takes a fair amount of time to fully charge the phone.

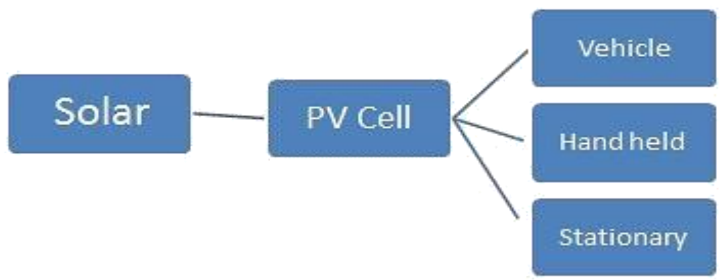
Most existing products supply an output of about 5v which makes them near universal for all smartphones. For kinetic energy chargers, the voltage generated is proportional to the number of passes the magnet makes through the wire coil. This means that a very fast shaking/hand cranking motion would cause high voltage output which is dangerous for delicate phone circuitry. The solution to this, more often than not, is to regulate the voltage output through a rechargeable battery which would connect between the phone and the power supply. We would later apply this concept to our design.

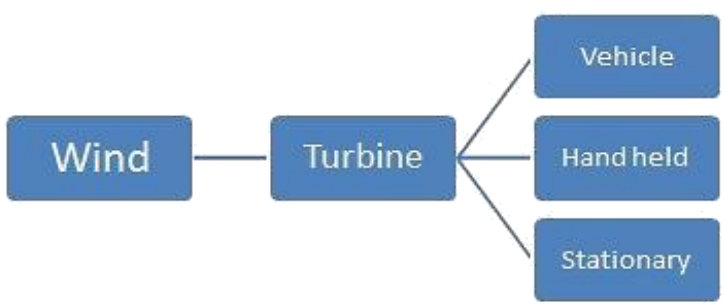
Another key takeaway from our research is the disadvantages of both expensive products and products relying on some form of natural resource (solar, wind) as these are ultimately restrictions on portability and marketability.

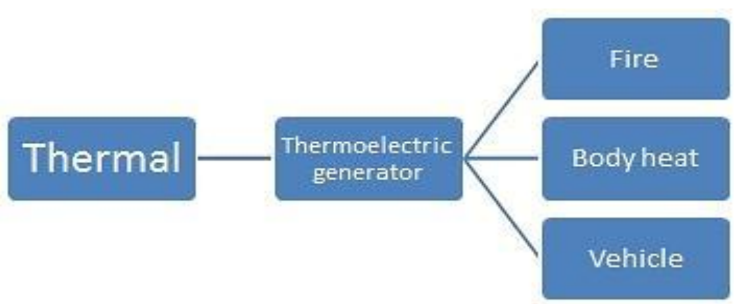
Concept Generation

Our brainstorming process began with a broad range of energy sources and can be summarized by the charts below.









Establishing Target Specifications

Based on our list of customer needs, we developed a set of selection criteria by which we would evaluate our various concept ideas.

Selection Criteria #	Metric	Units
1	Time to fully charge mobile phone	hours
2	Amount of voltage in circuit	Volts
3	Initial cost	$
4	Usage life	years
5	Maintenance cost	$
6	Net energy generation	Watt-hours

Concept Selection

Concept Screening Matrix

Selection Criteria	Concepts	Electromotive Induction	Nanogenerator	Turbine	Photovoltaic	Electrolysis	Thermoelectric generator
		1	2	3	4	5	6
Time to fully charge mobile phone	1	-	-	0	0	-	0
Amount of voltage in circuit	2	0	-	0	0	+	0
Initial cost	3	+	-	-	0	0	+
Usage Life	4	0	0	-	0	0	-
Maintanence cost	5	+	0	-	0	0	+
Net energy generation	6	-	-	0	0	-	-
Sum +'s		2	0	0	0	1	2
Sum -'s		2	4	3	0	2	2
Sum 0's		2	2	3	6	3	2
Net Score		0	-4	-3	0	-1	0
Rank		1	5	4	2	3	1
Continue?		yes	no	no	yes	yes	yes

After screening our ideas the first time through, we eliminated the idea of using nanogenerators or a wind turbine. We used photovoltaic electricity generation as a reference concept because we were most familiar with it from our previous design project, so we knew how all of the other concepts would compare to it. The criteria were then weighted based on importance and the remaining concepts were scored. We used a ranking system as follows:

Relative Performance	Rating
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

Concept Scoring Matrix

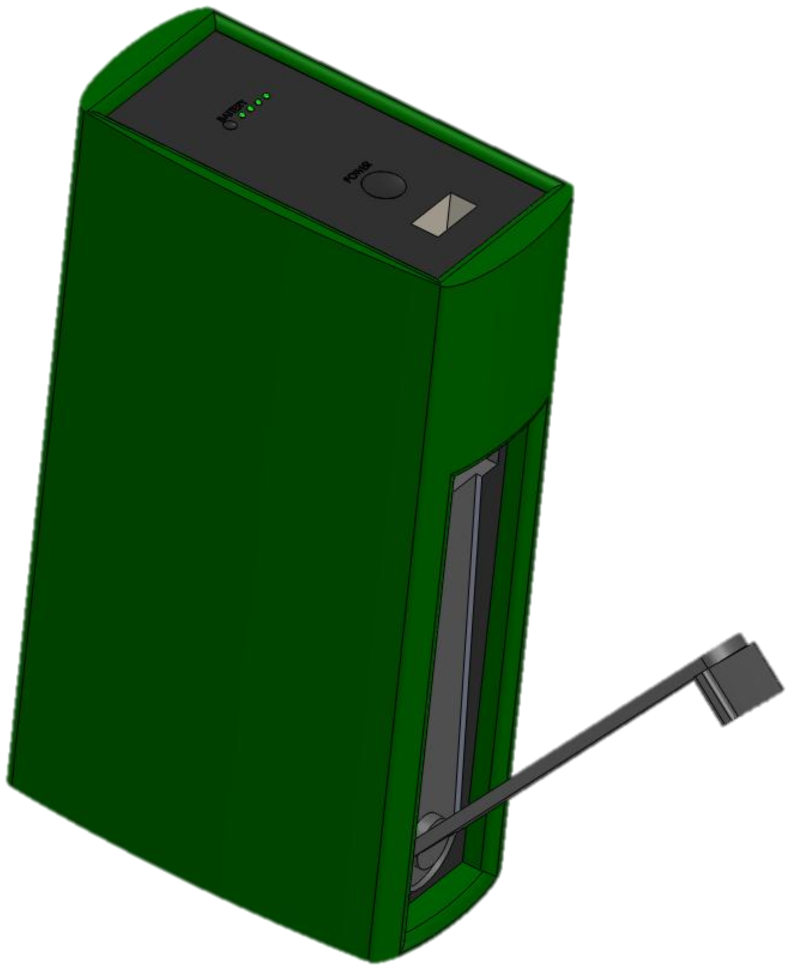
Selection Criteria	Weight	Thermoelectric Generator Rating	Thermoelectric Generator Weighted Score	Photovoltaic System Rating	Photovoltaic System Weighted Score	Electromotive Induction Rating	Electromotive Induction Weighted Score	Electrolytic Fuel Cell Rating	Electrolytic Fuel Cell Weighted Score
Time to fully charge mobile phone	15%	3	0.45	3	0.45	2	0.3	1	0.15
Amount of voltage in circuit	15%	3	0.45	3	0.45	2	0.3	2	0.3
Initial cost	20%	4	0.8	3	0.6	4	0.8	4	0.8
Usage life	15%	2	0.3	3	0.45	4	0.6	3	0.45
Maintanence cost	15%	2	0.3	3	0.45	4	0.6	3	0.45
Net energy generation	20%	3	0.6	3	0.6	3	0.6	2	0.4
	Total Score		2.9		3		3.2		2.55
	Rank		3		2		1		4
	Continue?		no		no		yes		no

Our final concept decision was electromotive induction, which relies on Faraday's law of induction to show how a current can be generated using a magnet and a wire coil. Further research into this topic led us to choose two methods of induction.

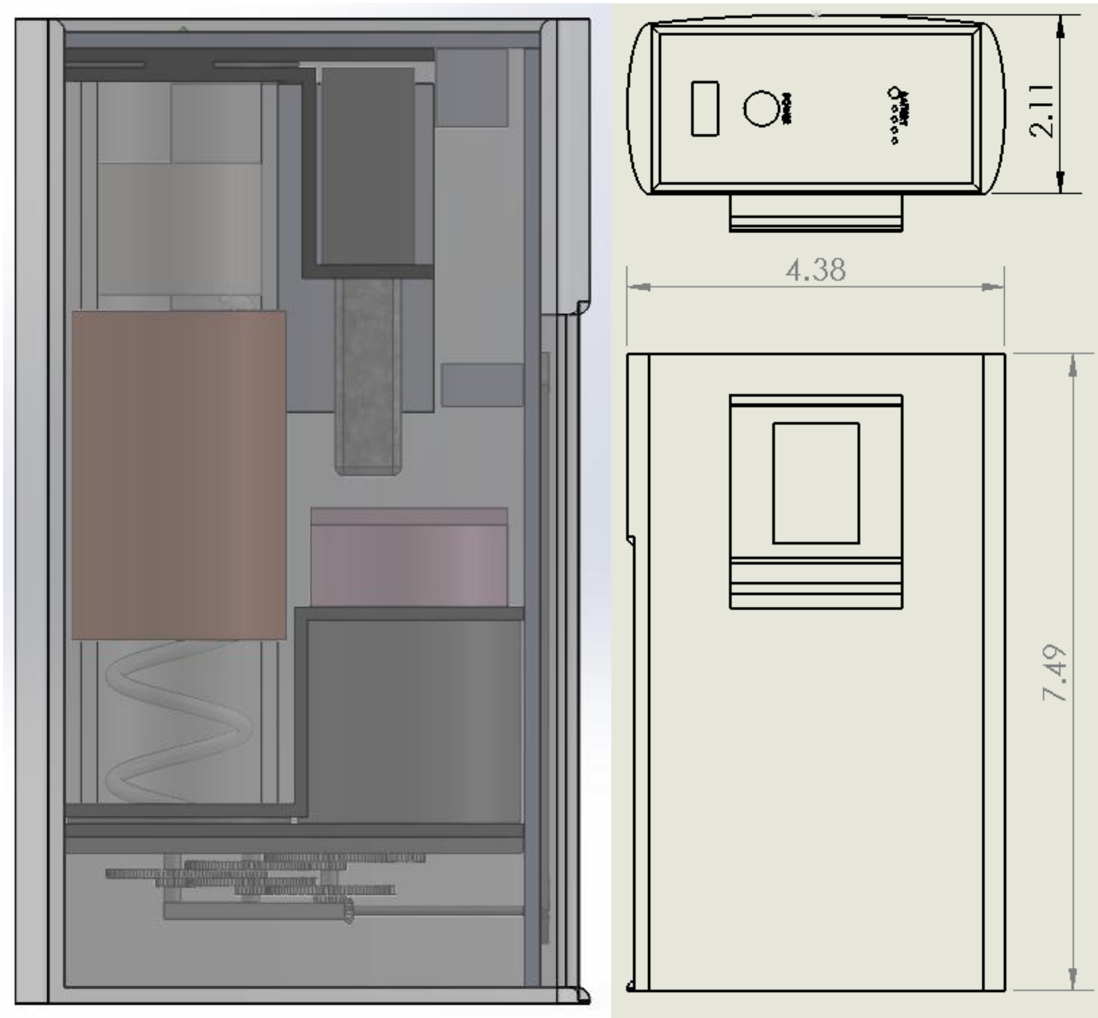
The first method of electromotive induction is known as linear induction. In this method a charge is created by repeatedly passing a magnet back and forth through a coil of wires. We integrated this method into our product by attaching a spring to the magnet, allowing it to oscillate through the coil as the user moves.

The second method consists of rotating a coil of wires in between a set of magnets. In order to amplify the power created by the generator we utilized a set of gears to where every one revolution of the hand created 500 revolutions of the engine, also known as a 500:1 ratio.

Embodiment Design




BATTERY
POWER



Notes from the Final Design

The main necessity of this design, as we saw it, was that the final product needed to be compact, so that it would not deter the possible customer from purchasing the product. As a result, the energy generating sources were shrunk down so as to fit in a small device, but still large enough so that they could generate enough energy to make the device usable.

Once the size of the device was determined, it was necessary to make sure that with the hand crank, the gearing was of a high enough ratio that it would not be extremely tedious to use the crank. To achieve a high gear ratio, it was necessary to make sure that the sizes of the gears were different to the point where they would generate a large ratio. However, as a result of shrinking down the device, we were left with a fairly small space to mount the gear train. In order to keep the small space, but maximize the gear ratio, we chose to compound the gear train, and as a result we were able to achieve a ratio of 500:1.

It was also necessary to make sure that the device was durable and could withstand the conditions present in the use case. As a result, we chose to use a thick plastic cover around the device to ensure the safety of the inner mechanisms.

Cost Model

Qty	Name of Component	Material	Total Volume	price per cubic Inch	Price per single item	Total price
1	Battery	Tenergy 31134	N/A	N/A	$ 14.5600	$ 14.5000
1	Bottom Plate	Plastic	1.4541	$ 0.0751168	$ 0.1092	$ 0.1092
1	Crank Handle	Plastic	0.375	$ 0.0751168	$ 0.0282	$ 0.0282
1	Crank Knob	Plastic	0.0804	$ 0.0751168	$ 0.0060	$ 0.0060
1	Crank Pin	Stainless Steel	0.0303	$ 0.5771285	$ 0.0175	$ 0.0175
5	Gear 1	Plastic	0.0468	$ 0.0751168	$ 0.0035	$ 0.0176
1	Gear 2	Plastic	0.0284	$ 0.0751168	$ 0.0021	$ 0.0021
1	Gear 3	Plastic	0.0009	$ 0.0751168	$ 0.0001	$ 0.0001
1	Magnet	Neodidium	N/A	N/A	$ 6.4950	$ 6.5000
1	Motor	7.8 Volt 32,000RPM	N/A	N/A	$ 4.0000	$ 4.0000
1	Outer Shell	Plastic	16.3166	$ 0.0751168	$ 1.2257	$ 1.2257
1	Pins	Stainless Steel	0.0397	$ 0.5771285	$ 0.0229	$ 0.0229
1	Shell 1 (Battery)	Plastic	1.3672	$ 0.0751168	$ 0.1027	$ 0.1027
1	Shell 2 (Motor)	Plastic	1.6348	$ 0.0751168	$ 0.1228	$ 0.1228
1	Spring	Stainless Steel	0.3509	$ 0.5771285	$ 0.2025	$ 0.2025
1	Tube	Plastic	3.2398	$ 0.0751168	$ 0.2434	$ 0.2434
1	Wiring	Copper/36 Gauge	200ft. (36 Gauge)	$ 0.0054438	$ 1.0888	$ 1.0900
					Total Price:	**$ 28.1906**

One of the major goals of creating this product was making it affordable for the user, and upon the analysis of the cost we are thoroughly satisfied with the final cost of $28.19(without labor).

Conclusion

Through the effective use of the design process we have created a product that satisfies all the needs of the customer in a very affordable way. While we would have all liked to incorporate more “creative” or “cutting-edge” methods into this design process, we kept our focus on what would realistically please our demographic as well as Harris, Inc , who would potentially produce it in bulk. Our design balances the charging power and portability very well, and we are confident that it would do well if it were produced and sold.

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