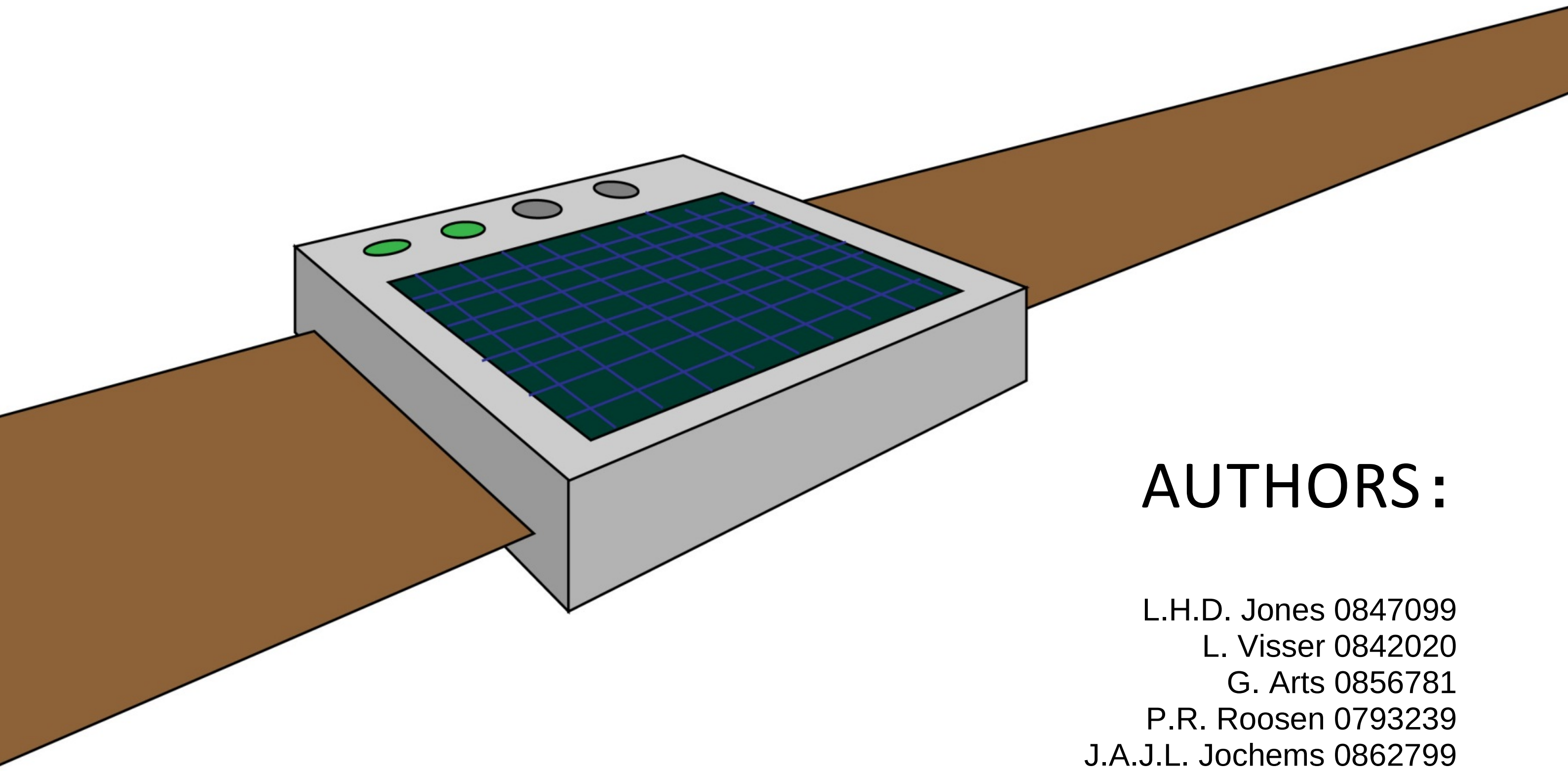
ENYCHARGE

“Bringing zero energy one step closer„



AUTHORS:

L.H.D. Jones 0847099
L. Visser 0842020
G. Arts 0856781
P.R. Roosen 0793239
J.A.J.L. Jochems 0862799

24 October 2014

Technische Universiteit Eindhoven
University of Technology

TABLE OF CONTENTS

INTRODUCTION

The Enycharge is a wearable device that let you recharge your mobile devices anywhere you want. Below you can find an example of the use of the Enycharge described in a scenario.

Now a days often when people are out of their house they use their mobile phone intensive for long period of times. For example for navigating, gathering information , contacting people or for entertainment. However most of these mobile phones only have a battery span of a few hours when they are used intensive for these functions. This will cause the phone to run out before the user is home again, which may cause him not to be able to contact the person he needs or find the information to get home when he or she is in a foreign city. However with the Enycharge, that gathers energy from multiple sources, the user can charge their phone on the go. This by simply connecting the phone to the bracelet.

Within this report the concept of the Enycharge is described in more detail. This concept description will be split in different parts, which are:

1. Overal concept
2. Visuals
3. Techniques for gathering energy
4. Applicability

The visuals will mainly contain concepts in regard to the looks of certain parts but will also contain some information about how the electronics will be used within the looks of the device. In the techniques for gather energy a small description of the concepts used to gather energy will be given, these will be further described within the applicability chapter in this document. The applicability chapter will also contain information about the feasibility of the concept.

DESCRIPTION OF THE OVERALL DESIGN

OPPORTUNITIES:

Gaining sustainable power by creating a wearable product that can store energy without any noticeable effort of the user.

VALUES:

- Using human body heat to generate power;
- Using human movement to generate power;
- Using solar energy to generate power;
- Let people believe they are helping generating clean power;
- Self-satisfaction after activities that generated a lot of power.

STAKEHOLDERS:

- End-users;
- Engineers
- Tech-stores;
- Environmentalists;
- Governments (subsidy);
- Energy suppliers.

OWN POSITION:

We want to make people aware of the fact that they do not have to use traditional power dources to charge small mobile devices, but that they create the necessary energy themselves.

DESIGN SPECIFICATION

General requirements:

1. Aesthetics

   The design should be fashionable and make the consumer want to wear the device. To ensure we make use of the entire user-spectrum, we could use different designs and styles. The customer should be able to personalize his own wristband, in terms of added functionalities (see point 8) and custom styles.

2. Comfort

   The device should be made out of materials that feel comfortable and make it easy to wear. I.e. rubbers and leathers

   - Different weight
   - Stretchable
   - Avoid allergic Materials

3. Safe to Use

   The device should have no dangerous parts like sharp edges and loose electrical parts. Therefore the device should be made of non-conductive materials.

4. Natural or Environment-friendly materials

   The materials we use should have a minimal impact on the environment. Things like recycled plastics.

5. Durable materials

   The device should keep on working for a long time without degrading. This should be ensured by casing the electrical parts in a strong material.

6. Shock and water resistant

   The band should be able to handle some roughing up by usage. The point is that consumers wear it a lot and will probably bump the device, or get it wet at some point

7. Affordable

   The device should be made of low cost materials, and the production chain should minimize shipping costs. In case of repair the parts should be easy replaceable and the design as simple as possible.

8. Functionalities

   Customers should be able to choose between different functionalities like an indicator that shows how full the battery is charged, a clock and a stopwatch.

9. Profitable

   The costs for development should be minimal and the price/quality ratio for production needs to be greatly balanced

Technical requirements:

1. Produces enough energy

   For the device to be effective, it is important that it can store and produce and store enough energy to be useful.

2. Easy to connect to (e.g. Phone)

   For a good customer experience it is important that it is easy to connect the charged battery with a phone or other device.

THE DESIGN

OVERALL CONCEPT

In figure 1 a model of the Enycharge is shown. It first shows some of the components, for example the battery, wristband and the case. Also it shows that the Enycharge consist of a charger, which loads a battery. A charger could use different forms of energy to charge a device. Examples of different methods of charging are generalized into electromagnetic fields, solar energy, thermal power and electrical energy. Also in some of the classes are attributes mentioned. One dependency is given, namely between battery and case, because the indicator's task is to show its owner how far the battery in the Enycharge is loaded.

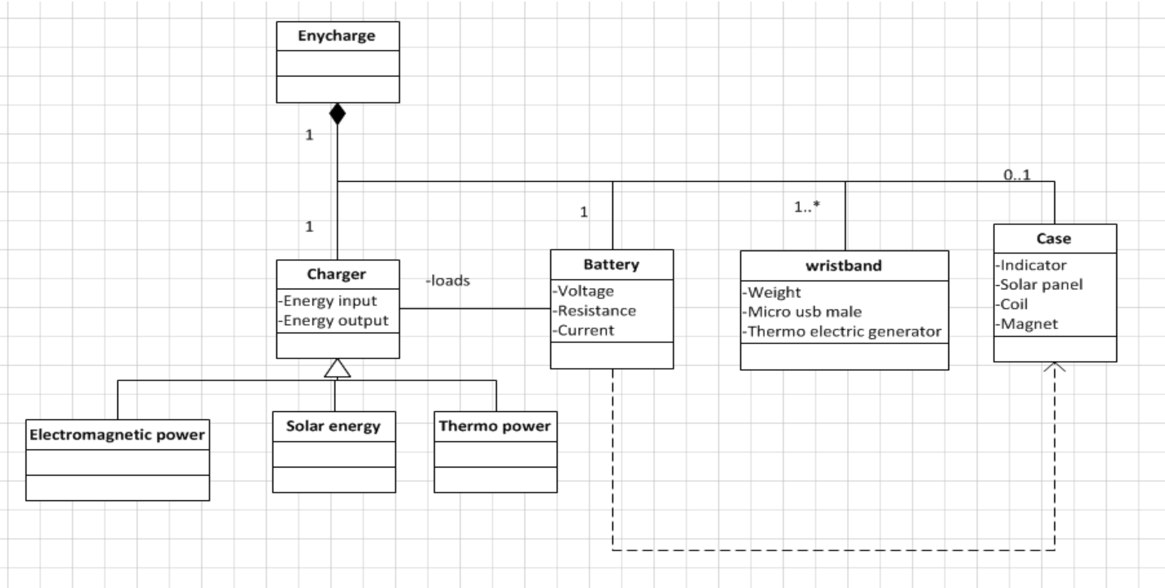


Figure 1: Block definition diagram of the Enycharge

In figure 2 is shown how a mobile device is charged with the Enycharge. Energy from the generated classes is converted to potential energy in the battery. When the Enycharge is connected to a mobile device the Enycharge charges it.

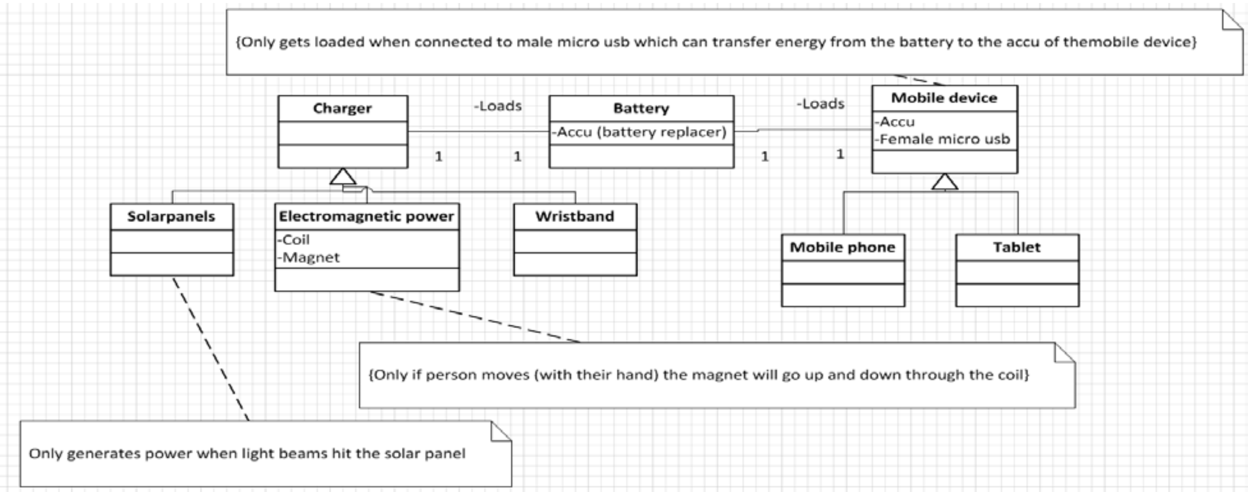


Figure 2**: Block definition diagram of how the Enycharge charges a mobile device**

IDEATION & VISUALISATION

After various brainstorms during our group meetings, in which we used the techniques covered in workshop A, we came up with various conceptual ideas. These ideas vary from visual appearance concepts to technical approaches to generating electricity.

THE WATCH-LIKE CONCEPT

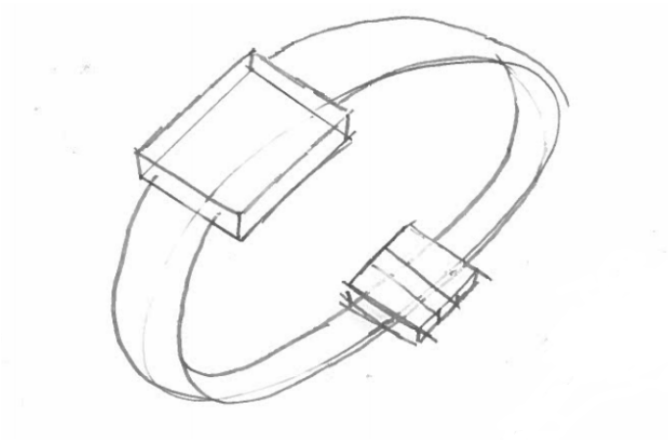


Figure 3a: Sketch of the watch-like design of the Enycharge

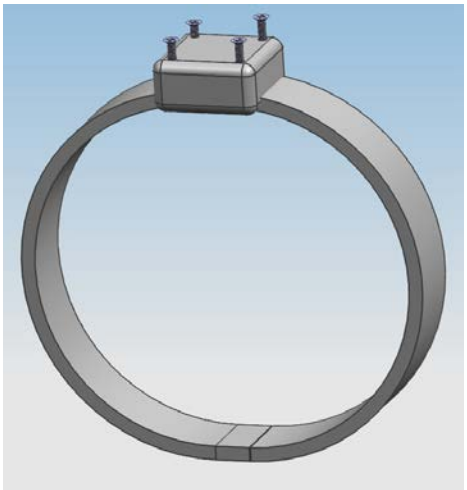


Figure 3b: 3D model of the watch-like concept of the Enycharge

The watch-like concept features a separate unit in which the electronic parts are integrated. This unit is strapped around a wrist or ankle with watch like bands.

This design provides a customizable set of materials for it is possible to choose different materials for the band and the electrical part. A sketch of this concept can be seen in figure 3a.

A 3D model also has been made, using the techniques learned in workshop D. In figure 3b you can see this 3D model of the Enycharge. As you can see, the three ways of gathering energy are shown in the figure. The block on top of the bracelet contains the mechanism which converts kinetic energy into electric current. On top of this block a solar panel is placed and the strap contains thermo-electric materials to convert body heat into electric current. More details of the way of gathering energy are explained in the 'Applicability' part of the report.

On top of the block screws are attached. The reason for this is to gain easy access to the coil and the magnet. So if something is broken in this part of the Enycharge, it can easily be fixed.

CONNECTION OF THE CHARGEABLE DEVICE

The entire point of generating and storing energy is to use this energy later on in e.g. a mobile phone. Therefore it is important to think about how to connect a device to the charger. We found 2 options. The first one is a rather straightforward solution, integrating a USB-port in the device. Secondly we thought of integrating a USB charger-cable in the band of the charger.

THE CABLE-INTEGRATED BAND

While an integrated USB-port may be convenient in its uniformity, it has its flaws. The –rather large- USB-port takes in a lot of space and it requires users to bring their own USB-cables. When implementing a charging cable in the band of the charger we make use of the space in the band and provide an easy way to charge a device. The concept is as follows: we implement a cable in the band, running from the charging electronics to the uniform charger in the band buckle. The buckle exists of a lock that keeps the bands together, a uniform charger and a device specific charger. The device could be a micro-USB, (apple's) lightning cable, or even a conventional USB-cable. A 3D model of this buckle is also shown in the figures 4a and 4b, both opened up and closed.

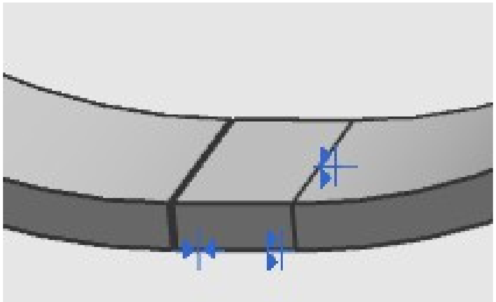


Figure 4a: Close-up of a closed buckle

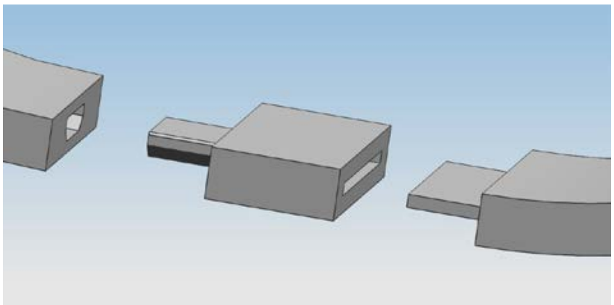


Figure 4b: Close-up of the buckle

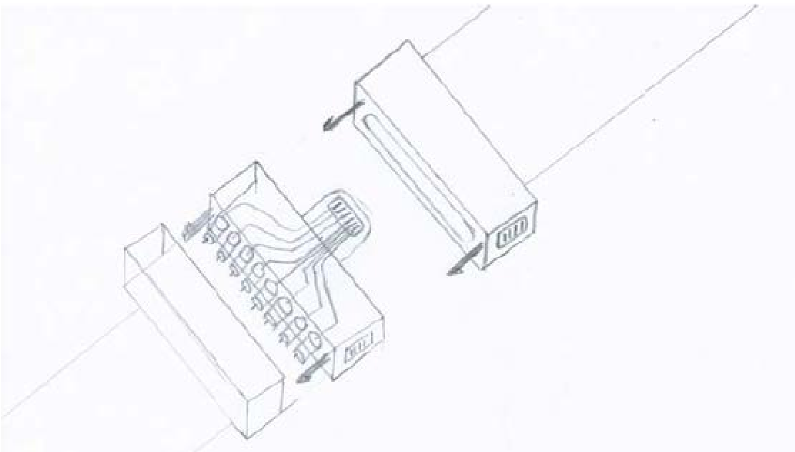


Figure 4c: Sketch of the buckle

This concept ensures the uniformity of the charger by using a device specific charger. Also it provides an innovative usage of space. This connection concept however is not compatible with the stretchable band of the stretchable visual appearance concept. A sketch of this cable-integrated band is shown in figure 4c.

ADDED FUNCTIONALITIES

The energy that is stored, could not only be used to charge a device, but could theoretically also be used as energy provider for a timer, charge-level indicator or even an mp3 player. Since things a timer and mp3 will likely decrease the effectivity of the charger, we thought not to use these. But the indicator provides a useful addition. A sketch of this indicator can be seen in figure 5.

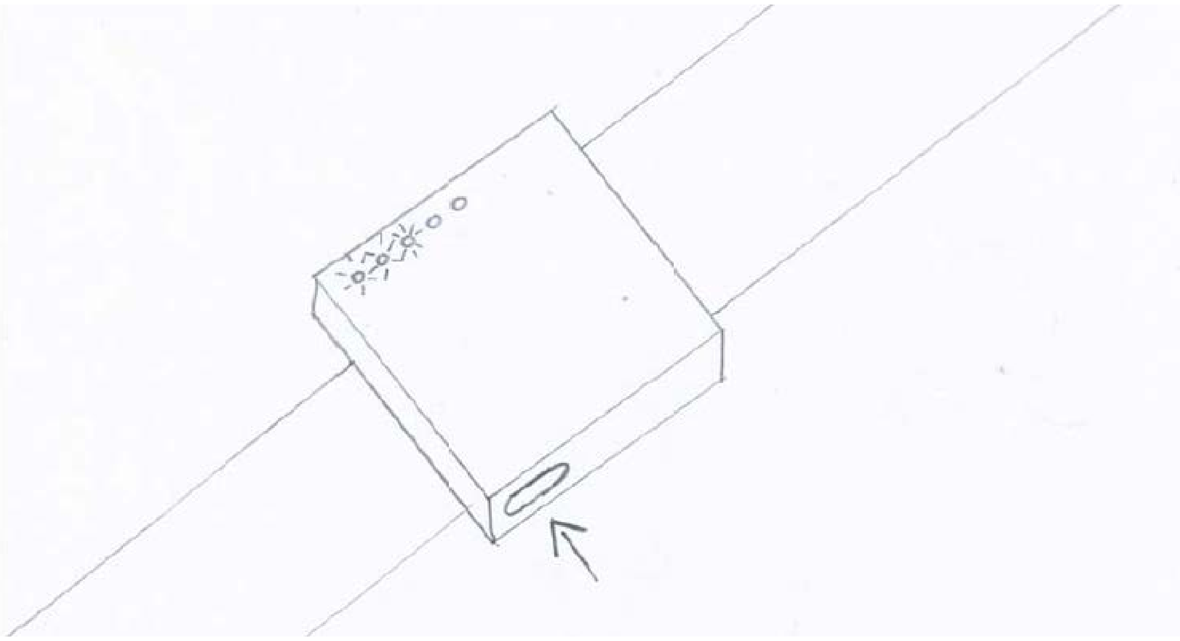


Figure 5: Sketch of the indicator

When pressing the button the LED's emit light, the more energy is stored, the more LED's will shine.

PROTOTYPE

A paper prototype has also been made. In the figures 6a and 6b you can see pictures of the prototype. This will give a small impression of what the Enycharge will look like. The Enycharge is customizable: The green strap for example can be changed in other colors of straps for example.
In the pictures the buckle can also be seen, with the micro-usb on the end of the buckle. This is the part you can use to charge your phone with. Also, in the pictures, you can see the small solar panel on top of the block. The lights of the energy-indicator can be seen on the left side of the block in figure 6a and on the bottom side of the block in figure 6b.

Figure 6a: Picture of the prototype of the Enycharge

Figure 6b: Picture of the prototype on a wrist

TECHNIQUES FOR ENERGY GATHERING

The techniques used for generating energy are thermo-electric energy, solar energy and a coil and magnet system.

ENERGY STORAGE

First the method of how energy is saved instead of how the energy is generated will be discussed. The energy is saved in a battery located in the main component. When an USB-port is connected to the circuit it will be used as an output. A solution is the circuit in figure 10:

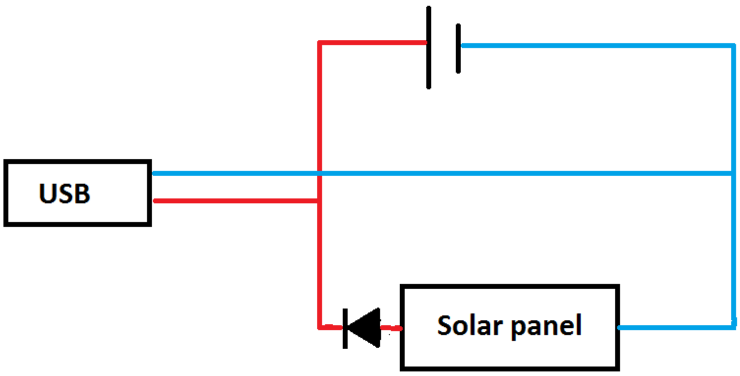


Figure 10: Circuit of the connection of the solar panel and USB to the battery

Note that when the USB is not connected to an external design, the energy generated by the solar panel is stored onto the battery. Also the red wire is the positive side and the blue wire is the negative side. Indicates a diode, the current only flows from right to left.

SOLAR ENERGY

Now that the way energy is stored is known, a deeper explanation of the different applications can be given. The first technique is solar energy; the sun as an energy source. When light hits a solar panel it is converted into an electrical current. This can be saved into our battery and when needed, a mobile device can be charged with it.

THERMO ELECTRIC ENERGY

The second concept is thermo-electric energy; thermoelectric generators (also called Seebeck generators) are generators that convert heat (temperature differences) directly into electrical energy. This effect is created because metals respond to temperature difference in different ways, creating a current loop and a magnetic field. See also figure 11.

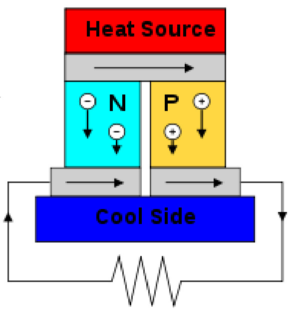


Figure 11: Schematic representation of a Seebeck generator

KINETIC ENERGY

The final concept is a coil and magnet system; the basic idea is to have the magnet move inside a coil. Since the magnet is moving the magnetic field also moves. It is known that a moving magnetic field generates a small electrical current in each turn of a coil. Therefore, if a coil has enough turns it can generate a lot of electrical current. Also see figure 12.

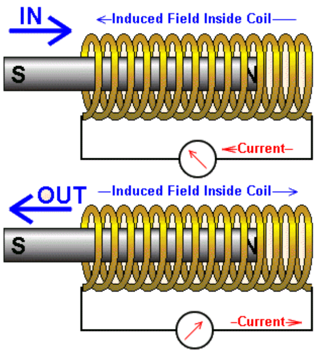


Figure 12: Schematic representation of the magnet and the coil

APPLICABILITY

MATERIALS

Figure 7: Aluminum case

There are several options to make the Enycharge more refined. For example:

- Firm case
- Water and weatherproof (materials, micro-USB)
- Flexible solar panels

A firm case should be resistant to bumps and needs to protect the insides of the case. Also it should be not too heavy and still good looking. A material which could be used is aluminum (figure 7); this is a, light, durable and erosion resistant material. One probable disadvantage is that aluminum is a conductor. When gathering electricity it must be done in a save way, so we should keep this fact in mind.

Figure 8: Waterproof micro-USB male

The transition between the aluminum case and solar panels should be made in a way that no dirt, water or other sustains are able to enter the case.

Also the materials of which the bracelet is made should be waterproof and of course the micro-USB. Making the whole Enycharge waterproof means that swimming with the Enycharge is possible and hereby the arms are moved a lot. This means that a lot of energy could be generated whilst swimming. It would also be a shame when the micro-USB gets wet while one is jogging outside and it starts raining and afterwards the micro-USB doesn't function anymore due to water damage.
This can be done on two ways:

- Develop/use a waterproof male micro-USB. When the bracelet is on and off it is resistant to water damage. (figure 8)
- Design a shutter that does not let water in, when using this, a waterproof male micro-USB is not needed.

Figure 9: Flexible solar panels

Flexible solar panels, shown in figure 9, are solar panels made of polymers with a high flexibility. Because of this, these solar panels can be bent. Also, the flexible panels are much thinner and lighter than regular solar panels; about an eighth of the weight. Another advantage of the flexible solar panel is that the production costs are lower and because of the flexibility, they are more broadly applicable.

However, a disadvantage of the flexible solar panel is that it has a lower efficiency compared to the glass version. The flexible solar panel has an efficiency of 2 to 5 percent less than the glass solar panel.

ENERGY GATHERING

Now the applicability of each of the concepts of energy generation is discussed. Again, some more information about the battery is given. In this part a lot of calculations will be shown to create a good view of our concept. Therefore the first calculation is of the battery.

CALCULATIONS FOR BATTERY

For calculation purposes a mobile device was picked, namely the HTC One m7, since that is the device of one of the team members. A picture of the battery can be seen in figure 13. First let's have a look at the formula that will be used:

Figure 13: Battery of mobile device

$E = \frac{Q \cdot V}{1000}$

E is the electrical energy in watt-hour.
Q is the electric charge in milliampere-hour.
V is volts.

More information is needed in order to apply this formula. The HTC One m7 has a battery of 2300 mAh and has an output of 5V(default for most mobile devices). Now the formula can be applied:

$$E = \frac{2300 \cdot 5}{1000} = 11.5\ Wh = 0.0115\ kWh$$

A phone is charging if input kWh is higher than devices kWh. Therefor the total of all concepts combined should produce more than 0.0115 kWh.

CALCULATIONS FOR SOLAR ENERGY

The solar panel used in our prototype has a surface of 15 cm^3. In Holland it is usually the case that that the efficiency is 85%. So 85% of the energy gets converted into usable energy. Solar energy cannot be express in watts, since solar energy is dependent on light. The more light the more watts, therefore a new unit is introduced, called watt peak (WP). This is the maximum watt generated by the solar panel. For calculation purposes a flexible solar panel with a WP of 20 has been used (this model has a price of 100 euro).

$$E = WP \cdot efficiency = 20 * 0.85 = 17\ Wh = 0.017\ kWh$$

Again this is the maximum therefore new assumptions have to be made. As a user you always wear your Enycharge, even when it is raining. It will not generate any electricity, since the Enycharge will be under your coat. The same argument can be held for being inside all day. The solar panel will not generate the maximum (WP). For calculation purposes the assumption that 50% of the WP is average is made. Therefore 0. 0095 kWh is the amount of energy used in the conclusion.

CALCULATIONS FOR THERMO-ELECTRIC ENERGY

Figure 14: thermoelectric generator

Recently a group of Korean scientist have invented a way to be able to transforms the heat escaping the body into energy. They developed a glass fabric-based thermoelectric generator to be light and flexible (see figure 14). They tested it on a small bracelet and it is said it can provide power in a stable and reliable way. So far only two types of thermal energy generators have been developed, these where always based on either organic or inorganic materials. Until now it wasn't possible to use the inorganic materials on the skin yet, because they were too bulky and the organic materials weren't able to generate enough power to be used. However the new concept uses a liquid like pastes of thermo electronic materials printed on a glass fabric. When using the generator, with a size of 10cm by 10 cm, for a wearable wrist band, it will produce around 40mW electric power based on the temperature difference of -0.55 degrees Celsius. This technology would be perfect to be integrated within the band of the wrist band. Because of this it will be integrated within our final concept.

CALCULATIONS FOR THE COIL AND MAGNET SYSTEM

The idea was simple but now calculations have to be made. First, assumptions on which type of coil will be used have to be made. The coil has to be placed under the solar panel and inside the block. Therefore the coil has to have a smaller area, let's assume that the area is not more than $7.8 \cdot 10^{-5}\ m^2$. A radius of 0.5 cm is used. The length of the coil is assumed to be 4 cm, since 5 cm is the length of the block that is used. In 4 cm of coil the amount of turns will be around 500 (by approach).

Research ha be done and from this can be concluded that this is only possible by doing tests with this specific coil. Therefore an assumption is needed to get an indication. Assume that 1 ampere is generated and that the time it takes on average to move the magnet up and down the coil is 1.2 s (by testing).

These information can now be filled in the formula (Faraday's Law). Figure 15 gives some explanation:

List of variables:

N = 500 turns

$$B = \mu_0 \cdot \frac{N}{l} \cdot I = 4\pi \cdot 10^{-7} \cdot \frac{500}{0.04} \cdot 1 = 0.016\ T$$

$$A = 7.8 \cdot 10^{-5}\ m^2$$

dt = 1,2 s

$$V_{gen} = -N \cdot \frac{d(B \cdot A)}{dt}$$

$$= -500 \cdot \frac{(0.016 \cdot 7.8 \cdot 10^{-5})}{1.2}$$

$$= -5.14 \cdot 10^{-4}\ V$$

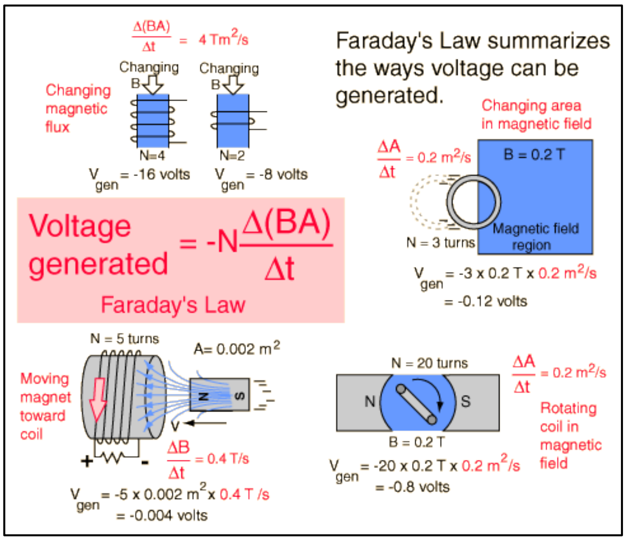


Figure 15: Explanation of the coil-magnet system

This is a negative number since it shows the direction. The up and down movement of the magnet gives negative and positive volts and therefore it doesn't matter which is picked in further calculations.

The next formula that is used is:

$$E = P \cdot 3600 = \frac{V \cdot I}{1000} * 3600\ kWh$$

$$E = P \cdot 3600 = 5.14 \cdot 10^{-4} \cdot \frac{1}{1000} \cdot 3600 = 0.0019\ kWh$$

APPLICABLE?

For each concept, there is a calculation given. As stated in the battery calculation for a new mobile phone like the HTC One m7 we need 0,.00115 kWh. The solar panel is perfect for integration in our wristband, since it is efficient enough.

For thermo-electric energy, the energy gained is constant, but is not high enough. With the current technology, this concept will not be efficient enough.

The coil and magnet system has other restraints. Space is the issue. In the main component there is a battery and the wires for the USB and solar panel which takes up space. If this system is integrated, the main component has to be made bigger, which is in contradiction with the design specifications.

All in all, the energy gained is not high enough to immediately charge your phone. However, by waiting long enough the battery will have enough power to charge the mobile device.

CONCLUSION

The challenge the Enycharge tries to solve is: Gaining sustainable power by creating a wearable product that can store energy without noticeable effort of the user. Within this challenge there is a underlying message, which is: making people aware of the fact that they don’t have to use traditional power sources to charge small mobile devices.

In this the Enycharge could be extremely successful, however for now the Enycharge won’t be feasible. This because the current technologies used within the Enycharge aren’t efficient enough to produce enough energy to replace traditional power sources. However the Enycharge could be used to lengthen the time you could use your mobile devices, which is could be useful for everyday use.

Besides being extremely useful for everyday use the Enycharge, also creates awareness for people. Awareness in regard to new ways of generating clean energy. Creating this awareness perfectly fits within the zero energy theme. A lot of people have the feeling the energy problem is a far away problem not regarding them, but it regards everyone.

With the Enycharge people will be able to generate energy with the sun, their body heat and their body movement. When people notice how easy it is for them to generate energy this way, they will start feeling more connected to saving energy and notice that all small changes can help. Also they will understand that saving energy can be useful to them, within this product there is energy for your mobile devices anywhere you go.

If the Enycharge would hit the shelves with the current technologies it wouldn’t be possible to replace traditional power sources, in regard to mobile device charging, but it could create some awareness in regard to Zero Energy. However in the coming years certain type of technologies will become more efficient. Solar energy already supplies enough energy to start charging the battery, but thermal and electromagnetic won’t (Proof for this can be found within the applicability chapter of this document). Seeing thermal energy is still a quite new technology there is a big chance that it will take major leaps in the current years thus making it more efficient. If this would happen the feasibility of the Enycharge would as well grow substaintly.

The conclusion on the future steps needed to be taken in regard to making it feasible is simply waiting, waiting for researchers to develop the technologies and becoming more efficient.