ENSC 305W/440W Grading Rubric for Post-Mortem

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project. Includes clear background and motivation for the project.	**/05%**
Body of the Document	Provides a high-level description of main functions and project modules. Outlines materials, costs, and schedule (both estimated and actual).	**/15%**
Problems/Challenges	Outlines major technical challenges encountered. Explains how these were resolved. Details any major changes in scope and design.	**/05%**
Group Dynamics	Includes a discussion of how the team was organized, any problems that arose, and how they were resolved	**/05%**
Individual Learning/Work-load Distribution Chart	Includes a one-page, individually written reflection upon what was learned from the project, both technically and interpersonally (each team member writes a page about their learning experience). **The workload distribution chart outlines major technical, administrative, and support tasks and indicates who participated significantly in those tasks.**	**/25%**
Conclusion/References	Summarizes outcome and evaluates the project. Includes discussion of future plans, if any (or explains why project will be abandoned).	**/10%**
Meeting Agendas/Minutes	Includes an appendix that provides all the meeting agendas and minutes produced by the team over the course of the semester. (NB. Neatness does not count here.)	**/20%**
Presentation/Organization	Document looks like the work of a professional. Ideas follow in a logical manner. Layout and design is attractive.	**/05%**
Format Issues	Includes title page, table of contents, list of figures and tables, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted.	**/05%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear, concise, and coherent.	**/05%**
Comments		

December 2, 2013

Mr. Lakshman One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Functional Specification for Power-Generating Shoes

Dear Mr. One,

The attached document describes the post mortem for the eShoe designed by ePower. We have built up a pair of shoes that will generate electrical energy and transfer the energy to electronic devices by users' walking or running.

This post mortem summarizes our project, budget and timeline. It includes a list of some of challenges we have encountered during the period of designing eShoe. Meanwhile this document lists the description of each individual reflection and knowledge we have gained over the past months.

ePower consists of four talented and motivated engineering students: Edward Huang, Eric Yang, George Gu, and Janine Li. If you have any questions or concerns about our post mortem, please do not hesitate to contact me by phone at (778) 8369730 or by e-mail at jiayinl@sfu.ca.

Sincerely yours,

Janine Li
Chief Executive Officer
ePower Incorporated

Enclosure: Functional Specification for Power-Generating Shoes

Post Mortem for Power Generating Shoes

Janine Li
Chief Executive Officer

Eric Yang
Chief Technical Officer

George Gu
Chief Operating Officer

Edward Huang
Chief Financial Officer

Contact Person: Janine Li
Jiayinl@sfu.ca

Submitted to: Mr. Lakshman One – ENSC440
Mr. Michael Sjoerdsma – ENSC305
School of Engineering Science
Simon Fraser University

Issued Date: December 2, 2013

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Glossary

AC Alternating Current

DC Direct Current

PCB Printed Circuit Board

1. Introduction

Did you ever experience that your cell phone ran out of battery, but you needed to give your friend or family an emergence call? The motivation of our product *eShoe* is that to charge electronics devices by walking or running. The electrical power is generated each step people make and the energy can be transferred to the desired electronic devices, for instance, your cell phone. One report shows that each person can produce 20 watts of power when he/she dances [1]. Also, another report indicates that an average person takes about 7,500 steps a day [2].

In the past few months, four outstanding engineering students worked together because of the idea of eShoe. The post mortem report re-examines the process that took the concept to reality, and it reflects each member's responsibilities and group dynamics. The report also details our budget, timeline, market analysis and future improvement.

2. System Overview

The overview of e-shoe system is shown in Figure 1.

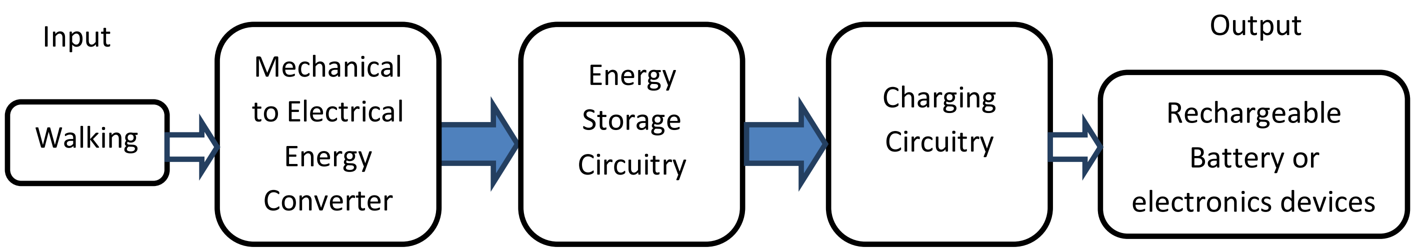

Figure 1: System Function Block Diagram

Our system has three major functional parties: a mechanical to electrical energy converter, an energy storage circuitry, and a charging circuitry. The input of the system is a person's walking or running, and the output is to charge rechargeable battery or electronics devices. As shown in Figure 1, the mechanical to electrical energy converter will get the energy from the input and convert it into electrical energy. Once completed, the energy will be stored into energy storage circuitry. After enough energy is stored, it will be charged into a rechargeable battery or electronics devices. Users can easily take the rechargeable battery to charge their electronics devices.

2.1 Mechanical Overview

Figure 2: Mechanical System Overview

Figure 2 provides the overview of the proposed mechanical design for the eShoe.

A problem we encountered at the beginning of using dynamos was how to convert linear motion to circular motion, since we are using small electrical generators which require circular motion in order to generate power. Therefore, we researched and found a converter in a power generating flashlight.

From Figure 2, we can see the bottom of the shoes is not even, and that is the linear to circular motion converter. The converter and other electrical circuitry are placed in the heel of the shoe, because every time people walk or run, their feet hit ground first, and the heel takes most of the weight of users.

2.2 Electrical Overview

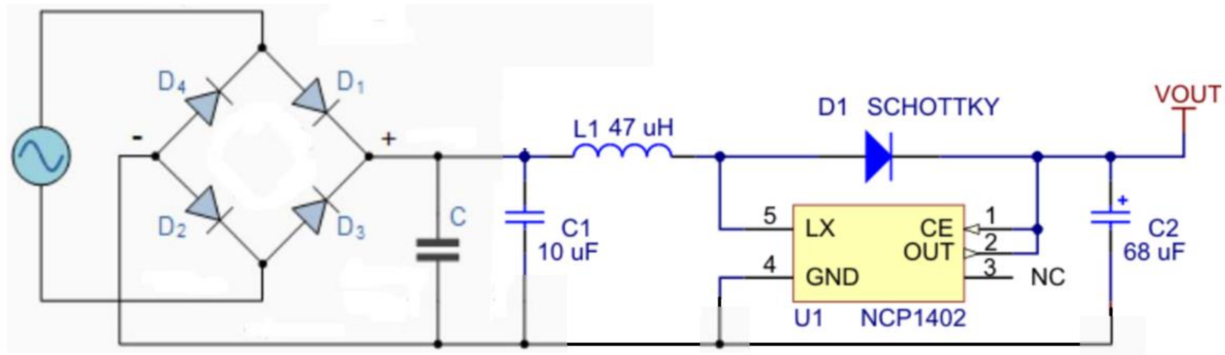

Figure 3: Electrical System Overview

Figure 3 shows our electrical overview, it contains 3 parts; dynamos as mechanical to electrical converters, diode bridge and the capacitor as energy storage circuitry, and the rest circuit is the charging circuitry.

First of all, dynamos can convert mechanical pressure to electrical energy, and then the energy is store into the capacitor. When the voltage in the capacitor meets the input requirement of NCP1402 which is a step-up voltage regulator, the stored energy in the capacitor can then be regulated to 5V DC voltage output which is the standard charging voltage for electronics devices. Lastly, the VOUT in the figure is connected to a rechargeable battery or electronics devices by micro USB interface cable.

All electronics components are soldered onto a small PCB so that we can fit them all into the shoes.

3. Finance

The following table – Table 1 illustrates the budget we calculated before we started the project and the actual budget during the projects:

Component	Budget	Actual Budget
Piezoelectric Transducer	$10x4	$3.81x6
Electric Components **(op-amps, capacitors, resistors)**	$25	$7.28
Rechargeable Battery	$20	N/A
Breadboard	$10	$10
Shoe Pad	$2.5x2	N/A
Belt	$5	N/A
Total	$105	$40.14

Table 1: Proposed Budget and Actual Budget for Original Solution

Since we changed the design solution for our project during the part testing stage, we did not reach the assembly stage; therefore we did not purchase a rechargeable battery, shoe pads and a belt. And we were able to use old electric components from previous undergraduate courses we took in the past four years; therefore, the budget is much lower than we expected.

The following table – Table 2 illustrates the budget we actually spent for our new design solution:

Component	Budget
Electrical Generator	$2.24x2
Shoes	Free
5V Step-Up Regulator (NCP1402)	$7.28
USB Cable	$1.00
Electric Components (capacitors, resistors)	Free
Total	$10.52

Table 2: Actual Budget for Adapted Solution

Some electric components are from our previous labs and Fred Heep, and an old pair of shoes is provided by Edward Huang; therefore, we did not spend money on those two sections. Overall, the budget for our adapted design solution is lower than we expected, and we are satisfied.

4. Timeline

The following figure illustrates the progress of our project over the past months:

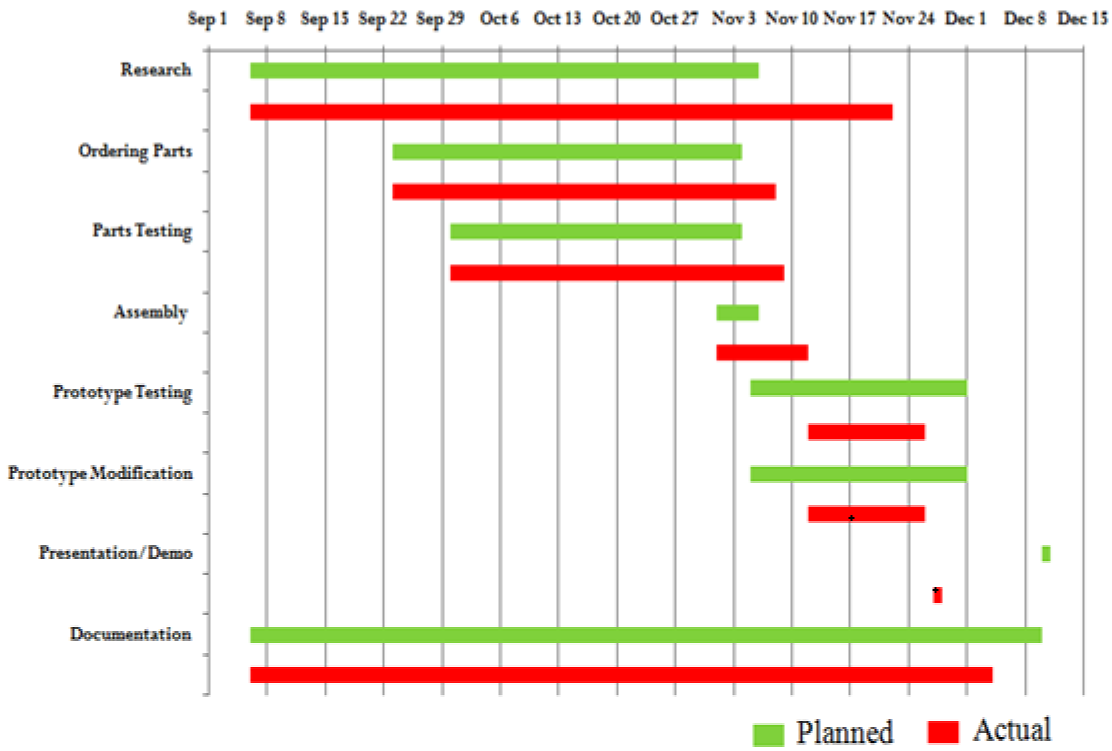

Figure 4: Planned Schedule and Actual Schedule

The Gantt Chart in Figure 4 illustrates the comparison between our predicted timeline indicated in green and our actual timeline indicated in red.

As shown in Figure 4, some of the deadline has be extend because we changed the design solution for our project; thus, we need more time to order, test and assembly. As a result, we delayed the starting date of prototype testing and modification. Moreover, the actual demonstration date was shifted to the end of November.

5. Future Plans

The main purpose of the eShoe is to generate electricity to charge a rechargeable battery or an electronic device. After testing the eShoe, we find that there are some more future achievable improvements to obtain a higher efficiency and at lower cost. The followings are our suggestions for future development.

- **Output**

  The maximum charging current of eShoe is 3 mA, while the charging current using USB cable is around 450 mA. There are several ways to increase the output from dynamo so that it can shorten the charging time. According to Faraday's Law of induction:

  $$Voltage\ Generated = -N\frac{\Delta(BA)}{\Delta t},$$

  where N is the number of turns of coils, B is the magnetic field, and A is the area of coil.

  1. Use more gears to increase the angular speed of the magnet so that the change of the magnetic field is strengthened.
  2. Increase the number of turns of coils.
  3. Increase the area of the coil of wires.

- **Size**

  Use multiple small gears to transfer the circular motion to replace the current large gear we are using.

- **Noise**

  Make the connection of gears smoother so that the friction between gears is reduced.

6. Lessons Learnt

Janine Li – Chief Executive Officer

In the past months, I believe that the ENSC305/440 are two most interesting and challenged courses in my university study life. I had to manage so much workload and to solve many practical problems with my group members, however I enjoyed conducting the project and the experience would be memorable in my study. Overall, ENSC305/440 course module differs from other engineering courses in some aspects. First of all, the method of gaining knowledge in these courses is not from the lectures which provided by professors, but from the self-search and varieties experiments. Secondly, the time table was made by us and we need to monitor by ourselves.

As ePower CEO, I was responsible for arrange meetings time and take notes during each meeting. I asked for each group member to attend each meeting regularly unless they worked for the project at that time. I believe that having regular meetings is vital for developing the project since everyone could know which part of the project process was in so that each member could stick on the planned schedule. Also, I was responsible for designing electrical system with other team members. We researched some published products in the market and investigated their working methods. During the electrical system design, I learnt that the piezoelectric transducer can generate huge voltage by stress, however, the transducer is a large resistor, so even a small resistor is applied in the circuitry, and the current is too small to achieve eShoe motivation. Also, I learnt that diode bridge circuit can be applied in the circuit so that the energy output efficiency can be improved from previous course.

Overall, I felt ENSC305/440 is valuable program for some reasons. First of all, during the period of conducting the project I would list self-reflection so that I can summarize that which aspects are my strength and my weakness as be an engineering student. Secondly, I realized that there are some determined factors including group cooperation, the project's time management and each member's responsibility, skills and professionalism to guide the project being successful. I admit that I am not a good technical problem solver. Therefore I need to study harder and keep learning more knowledge special in electrical aspect.

I highly appreciate everyone in ePower, and am really enjoy that I had this chance to work with my teammate. I also appreciate everyone, including professors and teaching assistants, who helped us a lot and gave us some important suggestions along the project. It was a tough mission but we have tried our best and succeed in what we can provide.

Eric Yang – Chief Technical Officer

Throughout the whole semester, I have worked hard with our team as a small start-up company. By completion of our power-generating shoes prototype, I have learnt and improved new skills such as communication skills, mechanical design skills and electrical design skills.

As a CTO in ePower Incorporated, I was responsible for designing the electrical circuit for our power-generating shoes: *eShoe*, and I was the technical consult for our team. Based on my previous knowledge on piezoelectricity, I first came up with the idea of using piezoelectric transducers as our power generator, which can convert our pressure to high voltage output. During the testing of our circuit while researching the scientific feasibility of piezoelectric transducers, even though the transducers can light up a small LED, the output power was too low to be considered as a power generator. Therefore, I researched another solution for our project which was to use several dynamos as the power source. Once our group bought a flashlight that contained a dynamo, our group members tested the output of the dynamo, and then I continued to design the circuit. Lastly I tested the output of our system which was a 5V DC voltage. Even though the charging voltage met our requirement and my cell phone showed the charging icon while connected to the shoe, the charging current was so low that it would take days to fully charge a cell phone. If we were able to continue with the project, we would definitely try to increase the charging current and might even implement more functionality besides charging electronics devices.

I really enjoyed working with the team in about only 3 months, and we finally built the functioning prototype. Applying the knowledge I learnt from SFU and my coop experience, I am proud of being able to convert an idea to a touchable prototype.

George Gu – Chief Operating Officer

For the past three months, I have worked hard with my co-workers in ePower Incorporated. During this time, we have completed our power-generating shoes prototype. Meanwhile, my teamwork skill has been improved when we were studying the electrical design and mechanical design process.

From a technical perspective, I have gained lots of knowledge of piezoelectric transducer and dynamo. At the beginning of project, I do not have much knowledge of piezoelectric transducer, so I started to research this material online. I tested a single piezoelectric transducer and a stack of four piezoelectric transducers with my co-workers. Also, we compared the difference between series connection and parallel connection. The best solution is to series all the piezoelectric transducers to create a larger output. However, after my calculation showed it would take almost 10 years to charge a 2000 mAh battery, we had to change to use dynamos as our solution. Then, I obtained a dynamo from a flashlight, and test the output current and output voltage. I also found that the output of the dynamo will increase when the angular speed of dynamo increases or the number of turns of coil increases.

On the other hand, I also learnt to be professional when working on a project. Planning is very important for the success of a project. Planning includes doing enough research and calculations to find the best solution. Especially before the topic is chosen, doing research can compare different possible solutions and find out which solution is the best which would save us time and effort. However, our group did not do enough research before we started our project. Then we spent almost half of the time working on piezoelectric transducer, and eventually we found out it did not work out. At the same time, writing a journal every time after meeting is a good way to record all the good idea.

I have also learnt that TA is one of the best recourses for us. Whenever you have any question regarding to the project, keep in mind that go talk with the TAs will provide you good ideas and suggestions. Do not afraid to bug them.

Edward Huang – Chief Financial Officer

Ensc305/440 capstone project course has been one of the most challenging projects though out my undergraduate studies. We had a clear idea to do for the project, but as Chief Financial Operator of ePower incorporation, I did not do a great job because of my mistake, we did not participate in the presentation for the funding; as result, we did not get any funding from the school. Hence we did not have any funding. We spent a lot of time on research before we purchase any components for the project because we do not have much budget.

In the beginning, Eric proposed the idea about the piezoelectric transducer as our main source for power generator then we started to do research about it and start with it, but it did not work quit well as we calculated before we start part testing; we decide to stack up the piezoelectric transducer to test if the output will be increase as it stacks up, but it fails again. There was once we tried to give up the original idea and change the theme of the project, but we found another component to replace the transducer which by dynamo. After many experiments and modifications, it finally worked and I am really glad we did not give up.

Through the process of the project, I learned how to use and understood the concept of the piezoelectric transducer; although, it is not work as power generator for our project, I see a lot more potential on it. And I hope we can work on it in the future and create something useful. I also learned 555 timer circuits as we planned to give up the original idea and move on to the new theme and lights many LEDs with different sequences. The most important thing I learned is communication, without proper communication nothing would be done.

Since the project is all about power generator, there is no any software designed for our proof of concept model and the power is not enough to charge the cell phone efficiency. Again, the task may sounds simple, all we need to create something that can generate power though any form of walking/running and small enough to install in the shoes, but it is really not that simple otherwise other people would already designed it; thus, we are pretty much all working together and participate every single small elements of the entire project.

Overall, I was satisfied with all of the group members' performance and dedication on this project. However, I do think if we could start the project earlier or had a much clear agenda, we would accomplish more and much earlier.

In the end, I am proud that we were able to demonstrate a working prototype of our project. I would like to thank all of my group members along with my instructors and the TA's who have supported us and have provided guidance and feedback on our documentation.

7. Conclusion

We would like to thank our professors, Mr. Lakshman One, Mr. Michael Sjoerdsma, and SFU's School of Engineering for giving us the resources and the opportunity to work on a meaningful, innovative project.

During the fall semester in 2013, ePower Incorporated has built a functioning prototype successfully. However, there are some small aspects that can be improved such as output efficiency, size of the device, and the connection of gears. This document has summarized the progress we made in developing this project and discussed the personal experiences of each group member.

Overall, we have achieved what we set out to do at the beginning of the semester. Everyone has gained much technical and non-technical experience.

8. References

[1] Elisabeth Rosenthal, “Partying Helps Power a Dutch Nightclub,” Internet: http://www.nytimes.com/2008/10/24/world/europe/24rotterdam.html?pagewanted=all&_r=0, Oct. 23, 2008 [Sept. 28, 2013]

[2] Tara Parker-Pope, “The Pedometer Test: Americans Take Fewer Steps,” Internet: http://well.blogs.nytimes.com/2010/10/19/the-pedometer-test-americans-take-fewer-steps/?_r=0, Oct. 19, 2010 [Sept. 28, 2013]

Appendix 1: Meeting Minutes

September 27, 2013

Length of meeting: 50 mins
Present: Eric, George, Janine, Edward

Discuss with Lucky
Problems from Lucky:

(1) Energy transfer system: to consider we want converter or storage container
Our decision: converter because we do not have a specific target for using our product

(2) Input and output of our system

(3) Do some research and calculate how much the energy is produced by each step?

(4) List the devices which would be benefit from our products

(5) Do some research ratchet, spring and kinetic watch design. Purpose: how do they work?

(6) How can we make sure when we wear that "shoes" would not affect our normal behavior?

(7) Open the topic on Canvas and discus the solutions and feasibility

October 1, 2013

Length of meeting: 60 mins

Present: Eric, George, Janine, Edward

Test a piezoelectric transducer's output. It has high output voltage but very low current.

Tested voltage can go up to 40V and down to -40V, and the current is up to 0.03mA.

Therefore, it confirms Lucky's suggestion; it might not work to charge a battery.

However, we think that if might produce higher current if we implement more transducers or even build the entire insole using piezoelectric materials.

October 11, 2013

Meeting length: 2hrs

Present: Eric, George, Janine, Edward

(1) Reported and shared research info with Lucky

(2) Did some quick experiments and confirmed that when a piezoelectric transducer was pressed, it would generate power with high positive voltage spike. No matter how long it was pressed, only displacement of the transducer could cause power being generated. Then as the piezoelectric transducer was released, it would generate power with high negative voltage spike.

(3) Linear motion could be converted into circular motion, therefore, we could also use a small generator with small power to achieve our goal

(4) However, only one was absolutely not going to produce enough power to charge any electronics devices; therefore, need to do some tests with a stack of piezoelectric transducers.

Next topic: how to make piezoelectric sandwich?

Do research: rechargeable battery data sheet to see how does it work?

October 18, 2013

Meeting length: 60 mins

Present: Eric, George, Janine, Edward

(1) Discussed what type of rechargeable battery we should order.

(2) Tried to build up the piezoelectric transducers in series and in parallel to test the output, and recorded data for our experiments

Next topic: what capacitors do we need for our energy storage circuit and what kind of circuit do we need in order to have a 5V DC voltage output

October 22, 2013

Length of Meeting: 1 hour

Present: Eric, George, Janine, Edward

- Made a stack of 2 piezoelectric transducers to compare series output and parallel output

- Separated the stack by washers, and it seemed like it didn't matter with the size of the washer

- Researched on voltage regulator, and found that LM7805 could be used in our circuit

October 31, 2013

Length of Meeting: 1 hour

Present: Eric, George, Janine, Edward

- Changed to use motor or electrical generator instead of piezoelectric transducers

- Linear motion -> circular motion -> motors

- Started to look for small electrical generator ~0.5W

November 8, 2013

Length of meeting: 1 hour

Present: Eric, George, Janine, Edward

1. Discussed how to increase the output and how to stable the output.

2. Finalized the shoe

3. Discussed the design specification.

a) George: Mechanical design

b) Janine & Eric: electronic design

c) Eric & Edward: summary, intro, conclusion

Everyone has to finish their part by Nov 11

4. Talked about using LED to notify users

November 15, 2013

Length of meeting: 1 hour

Present: Eric, George, Janine, Edward

1. Tried to add a LED into circuit to notify users

2. Finalized the shoe

3. Calculated the total cost of eshoe

4. Final presentation is on Nov 27. Discussed the actions and resources in the final presentation

5. Everyone should start to prepare for their own part for the final presentation

6. Will have a mock presentation on Nov 25