ENSC 305W/440W Grading Rubric for Functional Specification

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project.	**/05%**
Content	Document explains the functionality of the proposed product without excessive design content (i.e., outlines the "what" rather than the "how").	**/10%**
Technical Correctness	Ideas presented represent valid functional specifications that must be considered for a marketed product. Specifications are presented using tables, graphs, and figures where possible (rather than over-reliance upon text).	**/15%**
Process Details	Complete analysis of problem. Justification for chosen functionalities. Sources of ideas referenced. Specification distinguishes between functions for present project version and later stages of project (i.e., proof-of-concept, prototype, and production versions). Comprehensively details current constraints.	**/20%**
Engineering Standards	Outlines specific engineering standards that apply to the device or system and lists them in the references.	**/10%**
Sustainability/Safety	Issues related to sustainability issues and safety of the device are carefully analyzed. This analysis must cover the "cradle-to-cradle" cycle for the current version of the device and should outline major considerations for a device at the production stage.	**/10%**
Conclusion/References	Summarizes functionality. Includes references for information from other sources.	**/05%**
Presentation/Organization	Document looks like a professional specification. Ideas follow in a logical manner.	**/05%**
Format Issues	Includes letter of transmittal, title page, executive summary, table of contents, list of figures and tables, glossary, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted.	**/10%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear concise, and coherent. Uses passive voice judiciously.	**/10%**
Comments		

October 15, 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, *Functional Specification for Power-Generating Shoes*, describes the detailed functional specification for our product: e-Shoe. Our goal is to design a pair of shoes that can generate power by human's walking, and the generated power can be used to charge small portable electronics devices.

The functional specification provides detailed specifications for our product by breaking it down to three major components: a mechanical to electrical energy converter, an energy storage circuitry, and a charging circuit. The document will be used as a guideline and reference for our team members to effectively develop our product.

ePower Incorporated consist of 4 talented senior engineering students: Janine Li, Eric Yang, George Gu, and Edward Huang. If you have any questions about the project proposal or our company, please feel free to contact us by phone at 778-836-9730 or by email at jiayinl@sfu.ca.

Sincerely yours,

Janine Li

Janine Li
Chief Executive Officer
ePower Incorporated

Enclosure: Functional Specification for Power-Generating Shoes

Functional Specification 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: October 15, 2013

i. Executive Summary

Nowadays, people are using more and more portable electronics devices such as GPS, MP3 players, and cell phones. These devices have improved the quality of people's life; however, people do not always have access to power to charge the electronics devices when the batteries run out. Therefore, charging the devices as people walk will be a great improvement on people's life. The e-Shoe is designed to generate and accumulate electrical energy when people move and then to charge a rechargeable battery.

In the first phase of the project, we plan to approach the e-Shoe design, which consists three parts including mechanical to electrical energy converter system, energy storage system and charging system. The systems shall have the following functionalities:

-The system should be able to convert the mechanical pressure into electrical energy.

-The system should be able to store electrical energy.

-The system should be able to discharge itself if too much energy is stored into it

-The system should be able to convert the energy stored in the energy storage circuitry to a 5V DC power source.

-The system should be able to fully charge a rechargeable battery.

In the second phase of the project, the e-Shoe prototype will be tested using the system test plan and modified to improve the functionalities. Meanwhile, the prototype will be tested to satisfy all system requirements.

Table of Contents

List of Figures

Glossary

CSA Canadian Standards Association

GPS Global Positioning System

ISO International Organization for Standardization

PCB Printed Circuit Board

1. Introduction

It is indicated that in 2003 an American took 5,117 steps a day on average whereas the data collected in Western Australia is 9,695 steps a day. The data collected also includes Switzerland (9,650 steps) and Japan (7,168 steps) [1]. The e-Shoe is designed to generate and accumulate electrical energy when people walk or run. In each step person takes, the mechanical energy will be converted to electrical energy. A report states that an average person can produce 20 watts power when the person dances [2]. The requirements for the e-Shoe, as proposed by ePower Incorporated, are described in this functional specification.

1.1 Scope

This document states the list of functions which will be performed on our design of the e-Shoe. Users can generate and accumulate electrical energy when they move a step. The following information will be as a blueprint during the period of the e-Shoe design.

1.2 Intended Audience

This document is provided to ePower members and potential stakeholders of this project. The leaders of the project can operate and trace the progress with this document when the developers implement functions. Meanwhile the testers can view this document as a guideline to verify the design's confusion. Potential stakeholders can use this document as a reference to invest. When mechanical engineers and electronic engineers do further research, this document can be considered as great materials.

1.3 Classification

This document uses the following convention to number and prioritize the functional requirements:

[R#-P] A specific functional requirement.

where *R#* denotes the section number, and where *p* denotes the priority of the specification and can have one of the following values:

Priority **I** – Feature must be implemented into the testing and prototype.

Priority **II** –Feature is unnecessary but may be implemented.
Priority **III** – Feature is not important but if time permits, this feature will be implemented into the final product.

2 System Requirements

General requirements applicable to e-Shoe for a complete system are described in the following sections.

2.1 System Overview

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

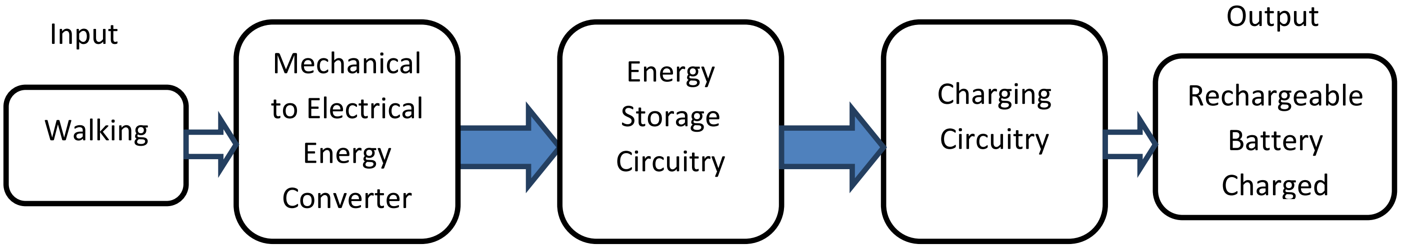

Figure 1: System Function Block Diagram

It is clear that our system has three major function 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, and the output is the rechargeable battery charged. 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. Users can easily take the rechargeable battery to charge their electronic devices.

2.2 General Requirements

[R1-I] The insole of the shoes must be easily set up and taken off.
[R2-I] The rechargeable battery can be fastened on belts that can be attached to users' legs.
[R3-II] The shoes shall have a maximum retail price of $150.
[R4-I] The users must step their feet to the ground in order to let the shoes generate power.
[R5-I] The rechargeable battery shall be connected to the shoes by using micro USB interface.
[R6-I] The shoes must charge a rechargeable battery when in operation.
[R7-I] The users can charge their devices from the rechargeable battery by using USB cable.
[R8-II] The shoes must not make users feel any big difference than normal walking or running with normal shoes.

[R9-I] The shoes must withstand all normal activities from the users.
[R10-I] The shoes must work both outdoors and indoors.

2.3 Electrical Requirements

[R11-I] The system must operate without external power supply.
[R12-I] The shoes must be insulated.

2.4 Environmental Requirements

[R13-I] The shoes must be waterproof.
[R14-II] The shoes shall be weather resistant.
[R15-II] The shoes must be working between 0°C to 60°C.

2.5 Standards

[R16-I] The shoes must conform to CSA standard Z32-04 "Electrical Safety in Health Care Facilities" [3].
[R17-II] The shoes must conform to CSA Standard Z195-09 "Protective Footwear" [4].
[R18-I] The shoes must conform to ISO 50001[5].

2.6 Performance Requirements

[R19-I] The shoes must charge a rechargeable battery at a power of at least 0.3 watts when in operation.
[R20-II] The shoes must not overcharge any rechargeable battery.

2.7 Usability Requirements

[R21-I] The shoes should clearly inform users of the status of the system (charging mode or discharging mode).

2.8 Luxury Functions

[R22-I] The shoes shall warn the users when the rechargeable battery is fully charged.
[R23-I] The shoes shall calculate how many steps the users have walked.

[R24-I] The shoes shall calculate the calorie consumed.

[R25-I] The shoes have a button to reset steps and calorie.

3 Hardware Packaging

The hardware packaging of our system is an insole with a mechanical to electrical energy converter, an energy storage circuitry, and a charging circuitry. The packaging must meet the following requirements:

3.1 Mechanical to Electrical Energy Converter

3.1.1 General Requirements

[R30-I] The converter must be rugged enough to stand people with different weight.

[R31-II] The converter must be usable for at least 6 months under normal daily usage.

3.1.2 Electrical Requirements

[R32-I] The converter must be insulated from the rest of the hardware packaging.

[R33-I] The converter outputs at least 0.3 watt energy when in operation.

[R34-I] The output of the converter must not destroy the energy storage circuitry or other electronics components.

3.2 Energy Storage Circuitry

3.2.1 General Requirements

[R35-II] The entire circuitry components must be soldered on a PCB in mass production.

3.2.2 Electrical Requirements

[R36-I] The circuitry must prevent the storage from being destroyed by the output of the mechanical to electrical energy converter.

[R37-I] The rated voltage for the storage capacitors must be below 25V for safety [6].

3.3 Charging Circuitry

3.3.1 General Requirements

[R38-II] The entire circuitry components must be soldered on a PCB in mass production.

3.3.2 Electrical Requirements

[R39-I] The circuitry will output a 5V DC voltage source to charge a rechargeable battery.

[R40-II] The charging temperature must be between 0°C to 60°C.

4. User Documentation

[R41-III] User documentation will be available online and can be easily printed.

[R42-III] User documentation shall be written for an audience with minimal knowledge of electrical devices.

[R43-III] User documentation shall be provided in English, French, Traditional Chinese, Simplified Chinese, and other languages as needed.

[R44-III] Technical support shall be provided by phone.

5. Sustainability and Safety

The engineers and the developers are not only responsible to have satisfied designs, but also are required to have safety systems are applied to avoid human error. The e-Shoe has numerous safety features to have steady converters, fixed storage. The following features include:

- The shoes must not generate any electrical shock to users.
- The shoes must not generate excess heat or present any danger of a burn.
- Other electromagnetic devices must not interfere with alert signal transmission.
- The shoes failure or broken must have no adverse consequence and be easily recognizable to user

5.1 Reliability and Durability

e-Power understands its responsibility that both characteristics of permanence and safety should be implement to the design. In the each step of developing progress of the e-Shoe, our engineers would consider any possible solutions and indispensable components to build up maintainable product. Meanwhile, our engineers would conduct any kinds of experiments to observe the product performance and report it. e-Power would consult standard safety regulations from other organizations, so that the product is considered to be thoughtful and reliable.

5.2 Sustainability

During the period of creating and utilizing the prototype and proof of concept of our product, we would use the breadboard and some specific electronic components which we have already to build up the circuit. By doing so, we hope we will not make much non-recyclable electronic components in building prototype. Also, before we make any decision of purchasing any suitable components which are required in our prototype, we would have some tests for other similar components such as spring and gear. Meanwhile, considering the environmental problem and the budget, we would make sure there is a return or refund policy on any purchased items, in case we find out those components are not suitable for our needs.

6. System Test Plan

In order to make sure the product functions properly and stably, ePower has proposed a system test plan. The system test plan is divided into two parts: individual module testing and integration testing. Individual testing is conducted in order to make sure the proper functionality of each module we use, and integration testing will be conducted after every individual component are tested to ensure that the whole system works as what we expected.

6.1 Individual Module Testing

The Individual module tests are performed once the modules are built or bought. The tests include but are not limited to the following:

6.1.1 Mechanical to Electrical Energy Converter

- Able to convert the mechanical pressure into electrical energy
- Able to be reused so that it produces energy at every step people make

6.1.2 Energy Storage Circuitry

- Able to store unstable electrical energy
- Able to discharge itself if too much energy is stored into it

6.1.3 Charging Circuitry

- Able to convert the energy stored in the energy storage circuitry to a stable 5V DC voltage power supply
- Able to fully charge a rechargeable battery
- Able to disable charging once the battery is fully charged or when battery is not attached

6.2 Integration Testing

After individual module testing has been completed, integration testing will be performed as follow:

- Integrate mechanical to electrical converter with energy storage circuitry to make sure the circuitry can store the energy produced by the converter
- Integrate the charging circuitry with above to make sure the energy stored in the storage circuitry can charge a rechargeable battery

6.3 Typical Usage Scenario

The e-Shoe prototype will be tested in many ways in order to simulate real world situations, and the tests include but are not limited to the following:

- 1 minute of walking without battery attached
- 30 minutes of walking with battery attached
- 30 minutes of running with battery attached

Note: every test above will be tested by two or more people with different weight.

7. Conclusion

The functional specification clearly defines the capabilities and requirements of our product: e-Shoe, which generates power by human's walking. Development of our product will be divided into two phases: a proof-of concept model and the final product. The proof-of-concept model will satisfy the requirements outlined above, and the final product is expected to be deliverable by December 15th, 2013.

8. References

[1] *T.Parker-Pope*, “The Pedometer Test: Americans Take Fewer Steps,” [Online] 2003, http://well.blogs.nytimes.com/2010/10/19/the-pedometer-test-americans-take-fewer-steps/?_r=0 (Accessed: September 28, 2013)

[2] *E.Rosenthal,* “Partying Helps Power a Dutch Nightclub,” [Online] 2008, http://www.nytimes.com/2008/10/24/world/europe/24rotterdam.html?pagewanted=all&_r=0 (Accessed: September 28, 2013)

[3] *CSA*, “Electrical Safety in Health Care Facilities”

[4] *CSA*, “Z195-09 – Protective footwear”

[5] *ISO*, “Energy management systems – Requirements with guidance for use,” [Online] 2011, https://www.iso.org/obp/ui/#iso:std:iso:50001:ed-1:v1:en (Accessed: October 15, 2013)

[6] *M. Voigtsberger*, “Small Contact Voltage Exposures Not Lethal to Human,” [online] 2012, http://ecmweb.com/shock-amp-electrocution/small-contact-voltage-exposures-not-lethal-human (Accessed: October 15, 2013)