Solar/Motion Powered Shoe Heater

Project Proposal

ECE 445

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1 Introduction

1.1 Project Overview

Title: *Solar/Motion Powered Shoe Heater*

There is a high demand for portable power production in the market today. Piezoelectric materials and solar cells are viewed as potential alternative power sources. Piezoelectric materials produce electric charge through deformation and solar cells produce transform light energy into electricity. By using these sources as a built-in battery charger, there would be less need to carry extra batteries or battery chargers around. In addition to that, these two sources are safer for the environment and help minimize battery waste. For this project, we will be using human motion and light as the main energy sources for an automatic shoe-heating device.

Commercial foot heaters, such as pads and insoles, require charging from an electric outlet and have limited battery life. Another issue with these products is that they tend to either inadequately heat the feet, or overheat them. We are excited to see if it is possible to design a shoe-heating device that is powered by motion and light and can maintain a relatively constant temperature in the shoe, which can be set by the user.

1.2 Objectives

1.2.1 Goals

The overall goal of this project is to design a shoe-heating device that is safe, convenient to use and maintenance-free. We intend to accomplish this by combining and storing solar/motion power (generated through kinetic energy) in a think film lithium battery, and using the energy stored to heat and track steps taken through the shoe with information being transmitted though Bluetooth to a android application.

1.2.1 Benefits

- No need to carry chargers or extra batteries
- Longer battery life
- Easy control over temperature settings with android app
- Environmentally-friendly
- No maintenance required

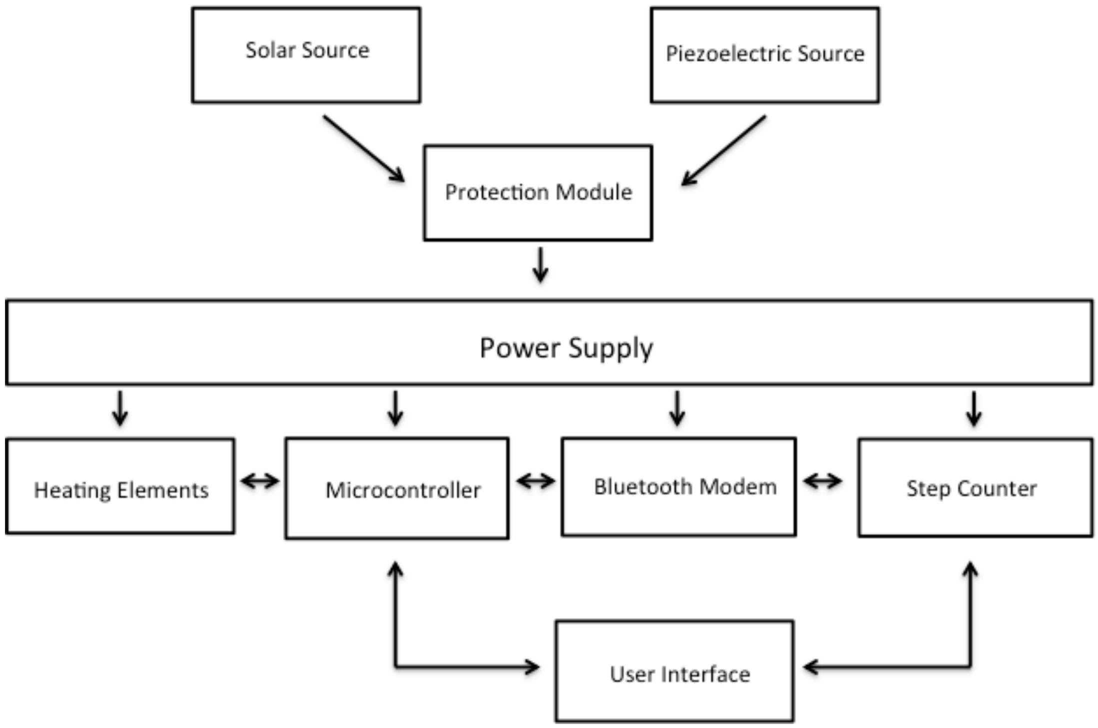
The battery stores the charge produced by the piezoelectric material and the solar cells, eliminating the need for a battery charger. The user can set the temperature inside the shoe using an android app that communicates with the heating device through Bluetooth. Heating is done using insulated heating strips.

1.2.2 Features

- User-friendly android app interface
- Temperature range from 80^{o}F - 110^{o}F
- Bluetooth range up to 300ft
- Automatic heating to within 2^{o}F of desired temperature
- Weatherproof

2 Design

2.1 Block Diagrams



2.2 Block Description

<u>Solar Source</u>

The solar source consists of twelve 2.5cm by 5cm solar cell strips connected in series on the outer surface of the running shoe. The power generated by the solar cell strips will be used to recharge the power supply, both when stationary and while the piezoelectric source is active.

<u>Piezoelectric Source</u>

The piezoelectric source consists of eighteen 6mm by 41mm piezoelectric film strips. The strips will be connected in series and mounted in the inside of the shoe. The power produced from deforming the piezoelectric film strips will be used in conjunction with the solar source to recharge the power supply.

Power Supply

The power supply consists of lithium batteries and a circuit implementing step-down dc to dc conversion that will supply at least 2W of power and the appropriate voltage to the heating elements, microcontroller, Bluetooth modem, and step counter. The batteries will be charged by the power generated from the piezoelectric and solar sources.

Protection Module

The protection module is a circuit that will be designed or purchased to protect the power supply. This circuit will provide the battery with over-charge voltage protection as well over-discharge voltage protection in order to preserve the life of the lithium batteries.

Heating Elements

The heating elements consists of flexible silicone rubber fiberglass insulated heaters that will be placed in the bottom of the inside of the shoe. These are powered by the power supply and are used in combination with the microcontroller to maintain the temperature set by the user within the user interface.

Microcontroller

The microcontroller is the TI MSP430. The microcontroller will be programmed in the user interface via the Bluetooth modem. It will be mounted on the exterior of the shoe and will be used to monitor the internal temperature of the shoe and control the power supplied to the heating element. When the temperature of the shoe falls below the threshold (set using the user interface), the microcontroller will activate the heating element and warm the shoe back to the desired temperature. The microcontroller will also be used to interface the step counter with the Bluetooth modem.

Bluetooth Modem

The Bluetooth modem is the BlueSMiRF Gold Bluetooth modem. It will be mounted on the shoe externally and connected to the microcontroller. The Bluetooth modem will be used to wirelessly transmit temperature settings to the microcontroller from the user interface. Additionally, the modem will transmit step count data to the user interface.

Step Counter

The step counter consists of a circuit that will be designed using parts from a standard pedometer. It will be used to count the steps taken by the wearer of the shoe. The step count data will then be transmitted through the Bluetooth modem via the microcontroller to the user interface.

User Interface

The user interface consists of an application for Android phones. The user interface is used to set the desired temperature and program the appropriate microcontroller settings wirelessly using Bluetooth. In addition to programming the temperature settings, the user interface will also display the step count information provided by the step counter circuit.

3 Requirements and Verifications

3.1 Requirements

1. The power supply (Lithium-ion battery) should generate at least 2 W for all the load circuits to operate.
2. The battery should not be charged higher than 8V.
3. The heating circuit should automatically start when the temperature goes below the desired temperature by at most 2^{o}F and automatically stop when the temperature goes above the desired temperature by at most 2^{o}F.
4. The power sources should be flexible enough to not interfere with movement and should be tough enough to withstand stresses on the foot due to walking. They should also be waterproof to ensure their functionality in any outdoor condition.
5. The heating system should respond to updates in temperature settings through the app up to 300ft away. The step counter should also update in real-time as long as the device is within the 300ft range of the Bluetooth capable device.
6. The electronic circuits should be enclosed within a waterproof casing for safety of operation.

3.2 Verification

1. We will test the piezoelectric and solar sources separately using capacitors. We will be calculating the energy in these capacitors, and using the time it took to charge them, we will calculate the power. For the solar circuit, we will do the testing in various light conditions. For the piezoelectric material, we will try to do the testing in different types of stress due to motion. This will give us the different

combinations so we will be able to check what the minimum conditions are to achieve the 2-Watt requirements.

2. We will measure the output voltage of the protection module using a DMM to ensure that the voltage is not higher than the rated voltage of the Li-ion battery.
3. We will set a sample temperature manually and check if the microcontroller switches the heating circuit on or off whenever the temperature sensor detects a change in the ambient temperature in the shoe. This is done with a fully charged battery to ensure that the circuit has enough power.
4. We will test the voltage output of each source in wet and dry conditions to evaluate their performance. We will also try to put them in a shoe to test their flexibility and if they hinder any movement.
5. We will check the Bluetooth connection first by sending hardcoded data to the android phone at 300 ft. If this functions properly, we will try to connect the Bluetooth chip with the microcontroller and the step counter and check if the data is transmitted successfully at a maximum of 300 ft.
6. We will test the prototype in both wet and dry conditions and check if there are any significant differences in the performance of the prototype.

3.3 Tolerance Analysis

The most important components of our design are the two power sources. The two sources are all that is used to maintain the charge of the battery, which supplies power to entire design. It is vital to our project that we have enough piezoelectric film and solar cells to produce the necessary power. Therefore, we will be performing extensive tests on the power sources to ensure that our estimated power production values are accurate in real world conditions and adjusting as necessary. We will be testing the solar cells in various lighting conditions to determine actual performance. We will also be testing the piezoelectric film power production with various levels of activity and environmental conditions.

4 Cost and Schedule

4.1 Cost Analysis

Labor:

Name	Hourly Rate	Total Hours Invested	Total = Hourly Rate x 2.5 x Total Hours Invested
Crystal Cardenas	$40.00	150	$15,000.00
Carlo Vendiola	$40.00	150	$15,000.00
Andrew Chavarria	$40.00	150	$15,000.00
Total		**450**	**$45,000.00**

Parts:

Item	Quantity	Unit Price	Total Cost
MSP430 Microcontroller	3	$4.30	$12.90
Bluetoooth Modem- BlueSMiRF Gold	3	$64.95	$194.85
Super Solar Cells 0.5V 25mA - 6 pack	6	$12.95	$77.70
Silicone rubber heater, 1in by 10in	2	$19.00	$38.00
Thin Film Linthium Ion Battery	6	$20.29	$121.74
Protection Ciruit Module for Li-Battery	3	$2.85	$8.55
Piezoelectric Film 6mm x 41mm x .2mm	18	$6.75	$121.50
Resistors	30	$0.05	$1.50
Capacitors	30	$0.10	$3.00
Inductors	30	$0.10	$3.00
PCB	3	$50.00	$150.00
Parts Total			**$732.74**

GRAND TOTAL = LABOR + PARTS = $45,000.00 + $732.74

GRAND TOTAL = $45,732.74

4.2 Schedule

Week	Task	Responsibility
9-Sep	Work on and submit RFA	Crystal
	Work on RFA	Carlo
	Work on RFA	Andrew
16-Sep	Project Proposal: Block Diamgram, Cost and Schedule, Research on solar panels and bluetooth	Crystal
	Project Proposal: Introduction, Requirements and Verifications, Research on rechargable battery and heating elements	Carlo
	Project Proposal: Block Descriptions, Research on piezo film and step counter circuit	Andrew
23-Sep	Design schematic for microcontroller and its interface to bluetooth modem	Crystal
	Design interface circuit for solar panels and piezo film and power supply circuit	Carlo
	Design schematic for step counter and flow for user interface android application	Andrew
30-Sep	Design review and start building circuits on breadboard	Crystal
	Prepare for testing and verification of circuit and wireless connections	Carlo

	Design review, finalize and begin ordering parts and familiarizing with andriod application software	Andrew
7-Oct	Work on getting bluetooth connection with microcontroller and test receiving and transmitting signals	Crystal
	Layout PCB and verify	Carlo
	Start creating android application	Andrew
14-Oct	Integrate all project components and began debugging	Crystal
	Integrate all project components and began debugging	Carlo
	Integrate all project components and began debugging	Andrew
21-Oct	Complete Indivial Progress Reports	Crystal
	Complete Indivial Progress Reports	Carlo
	Complete Indivial Progress Reports	Andrew
28-Oct	Integrate all project components and began debugging	Crystal
	Integrate all project components and began debugging	Carlo
	Integrate all project components and began debugging	Andrew
4-Nov	Prepare for Mock Demos	Crystal
	Prepare for Mock Demos	Carlo
	Prepare for Mock Demos	Andrew
11-Nov	Prepare Mock-upPresentation and finalize project design	Crystal

	Prepare Mock-upPresentation and finalize project design	Carlo
	Prepare Mock-upPresentation and finalize project design	Andrew
18-Nov	Thanksgiving Break	Crystal
	Thanksgiving Break	Carlo
	Thanksgiving Break	Andrew
25-Nov	Start working on/writing final report and	Crystal
	Start working on/writing final report	Carlo
	Start working on/writing final report	Andrew
2-Dec	Project Demo	Crystal
	Project Demo	Carlo
	Project Demo	Andrew
9-Dec	Final Design Presentations	Crystal
	Final Design Presentations	Carlo
	Final Design Presentations	Andrew