جامعة الأمير محمد بن فهد الأهلية
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

SHOES DESIGN FOR ENERGY HARVESTING

College of Engineering

Department of Mechanical Engineering

Senior Design Project Report

Presented by

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Abstract

The demand for clean renewable energy has increased due to the facts that the traditional sources of energy are the main cause of pollution, global warming and inherently non-renewable. Therefore, engineers start harvesting power from sun, wind, geothermal and many other mechanical or heat sources. In this project shoes are designed that yield the kinetic energy of the movement of the human body to generate electricity that can be used to power sensors, small appliances and even to charge a mobile phone battery.

Acknowledgment

We at first bow our head before Allah Almighty who bestowed his countless blessings upon us, guided us towards the way of success and blessed us with courage of facing problems and obstacles that enabled us to accomplish this senior design project report.

Secondly, from inducting into this university until our final year project, our sincere appreciation and innumerable thanks goes to our Chair of Mechanical Engineering Department, Dr. Faramarz Djavan Roodi and whose guidance, constructive comments, support and advice has enabled us to gain profound understanding throughout the whole process of this learning.

We would like to thank and express our utmost gratitude to our project advisor Dr. Mohamed Elmehdi Saleh who not only helped us in achieving our goal but also showed his expertise and experience which made our life a whole lot easier. Without the guide and help of our respected teachers and support of our family we would not have accomplish this achievement of completing this project successfully.

LIST OF ACRONYMS

P_{APP}	*Pressure applied*
T_P	*Thickness of piezo*
C	*Piezo rating*
Rf	*Resistance in parallel*
Ri	*Resistance in series*

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Chapter 1: Introduction

The aim of the project is to construct a gadget that will use piezoelectric strips and energy from strolling that will be storedenergy into one AAA battery-powered batteries. Structuring such a gadget necessitates that the shoe stay as ordinary as possible under the circumstances while just picking up the points of interest from putting away energyin the batteries or charge the phone directly without batteries.The framework will be lightweight; notwithstanding, it will not be as adaptable as the piezoelectric strips will be inside the shoe underneath the insole. The target crowd is runners, climbers andwild life adventurers who are usually in need of electrical power to charge gadgets, for example, chargeable fans, chargeable torch, laptops and mobile phones. The underlying model should be a framework structured after a MIT energyscavenging shoe gadget that utilized a bimorph in the impact point of the shoe.

1.1 Project Definition

The working principle of the proposed device is to change dynamic energy into electrical energy and store it until transferred to another gadget through and an outlet provided. To do this we will structure an item that achieves this undertaking, while meeting other indicated prerequisites. Our key business technique is to use piezoelectric innovation and execute this into a shoe, so that as the wearer strolls, their active energy is stored as latent energy and later on transferred as electrical energy. The final device will comprise of a shoe and energy gathering gadget half-breed that is proficient and does not impede the wearer's comfort and health. The framework will change mechanical energy, produced in the result of the activity of the wearer of device, into electrical energy by utilizing piezoelectric strips placed and attached under the insole of the shoe.

The gadget ought to have the option to give a full charge after an individual wears the gadget and strolls for some miles. The interfaces will include however are not restricted to: a shoe, a sole, the ground, piezoelectric strips, wires, a capacitor, more wires, lastly a USB yield. The USB port will make it possible to transfer the electrical energy, which converts from mechanical energy, to any device attached.

1.2Project Objectives

This said project strives to attain some objectives that are mentioned bellow:

- Advances in low configuration open the likelihood to collect energy from nature to control electronic circuits. The objective of the present theory undertaking is to examine energy sources to control wearable gadgets from physical human action that holds latent energy or heat.

- Electrical energy harvested from the human motion will be endorsing different transducers: piezoelectric materials, variable capacitors, and inductive generators.

- Thermoelectric generators will be the best approach to separate electrical energy from the temperature contrast between the human body and the earth. Different conceivable outcomes in this exploration zone like removing electrical energy from the temperature contrast between the wearable gadget and the earth or the human body will be likewise object of concentrate for the postulation.

1.3Project Specifications

We have developed a very simple design that may also be easy to made and have certain specifications that prove to be a cost effective.

Table # 1.1: Project Specifications

Characteristics	Details
Power output (per one shoe)	1.8 Wh (nominal)
Voltage	9 V
Current	Up to 0.15 A
Temperature	-20 degree to 65 degree centigrade
Embedded electronics	USB

Figure # 1.1; Piezo Discs Arrangement

1.4Project Applications:

Here are some of the following key applications with detail:

- Vibrations caused from machines in the gym.
- At workplaces, piezoelectric crystal in the rotating chairs for storing energy.
- Utilizing the vibrations in the vehicle like clutches gears etc.
- Series of crystals underneath the floor mats, tiles and carpets.

Chapter 2: Literature Review

2.1 Project Background

Eventually each individual needs to discover a wellspring of intensity. For our gatherings venture, we are hoping to make a power source that can give explorers access to batteries if necessary. This gathering will probably take care of this issue by utilizing piezoelectric innovation to change over mechanical energy into electrical energy, which can be stored in a battery and used to charge one AAA battery-powered batteries. This will help the adventurers and explorers would have the option to charge any gadget that employs AAA battery, for example, chargeable fans and electric lamps. This device will make the lives of people who have less or no access of direct electricity power source progressively proficient, and their gadgets will be more averse to die on them because of this energy-collecting supplement. It would be an enormous achievement if the gadget could consolidate changing over motor energy to electrical energy sufficiently utilizing piezoelectric innovation while additionally being lightweight, broadly open, and easy to use.

2.2 Previous Work

I. Patel, (2010), has discussed the capacity of piezoelectric in energy harvesting. He mentioned a previous modelling study by Starner, (1996) showed 5 Watt of electrical power generated by 52 kg person at a brisk walking pace using a PVDF (polyvinylidene fluoride) power harvesting device integrated in a shoe.The findings of this experiment have paved the way for energy storage using a bridge rectifier and a capacitor.

Energy harvested by piezoelectric material through the impact of raindrops has also been proposed and proven in principle (R. Guigon, 2008). According to him, our system forages the vibration energy from piezoelectric flexible structure impacted by a water drop.

The duo from MIT whom introduced the concept of "Crowd Farming" carried out an experiment to demonstrate their hypothesis by using block slippage against one another that performs as the power generator based on the principle of a dynamo (Wright, 2007). They found out that a single human step is able to power two 60 Watt light bulbs for about one flickering second; hence a crowd motion of 28 257 steps (per say) may generate enough power to move a train for one second.

2.3`Comparative Study

Some projects are developed in the past and the present with the different key concepts one of these is energy harvesting shoes for secure and intelligent geo localization and the other one is quitepertinent in the past is piezoelectric based energy harvesting and the third one which we found is named as walk and charge. These are the certain undergraduate projects done previously.

We have increases the efficiency so that the human motion would be able to convert it into the more useful energy. Therefore battery would be get comparatively more charge in less time. Our project aims to produce such a device proves to be an advancement in the study and application of energy. We look forward to present a device that will be able to store the mechanical energy efficiently and effectively without wasting any latent energy in result providing ample electrical power source to charge mobile completely in lesser time as compared to previous researches and models of the past.

Chapter 3:System Design

3.1 Design Constraints and Design Methodology

3.1.1 Geometrical Constraints

Energy harvesting using piezoelectric disc in the shoes is a very creative and interesting project. Major concern regarding project is that shoe must not get heavier than a usual shoe to keep it comfortable and wearable gadget. Keeping in consideration the weight of the shoe we have to keep the setup simple and light. To achieve this task we will use the materials like piezo discs and battery that lightest in weight. Setup should perfectly fixed and attached so that nothing should disturb or poke the feet of the wearer. The design of framework is in such a way that all the constraints related to size and weight are taken care.

3.1.2 Sustainability

An energy harvester to perform up to the mark, it is essential that piezoelectric setup prove to be sustainable at all times. Our goal is to make the project cost effective and long lasting. Once the installed setup is functional, it should last forever if the energy harvester is in continuous use. One aspect of sustainability is that system should fall apart due to jogging or running. Framework soldered finely and waterproof glue used to attach the base avoids any dis-connectivity.

3.1.3 Environmental Concern

The Energy-Harvesting concept within a shoe due to human motion is an incredible work of engineering. Now a day's technology has taken all the exercise and activity based tasks from the human beings and in result becoming a major reason of laziness and lethargy. Whereas on the other hand the piezoelectric shoes are endorsing active and healthy life style by adding walk and brisk activities in our daily routine to generate low cost electrical energy to charge our mobile phones and emergency lights. This project is not just a fun creativity rather it will help in long run to save electricity generated either from hydropower or from fossil fuels.

3.1.4 Social impact

Our project will have a very positive impact on our society. It will help people to get out of their homes and go to parks for running or walking. This will not only help people to have a healthy style it will also endorse and enhance the likelihood of more human interaction. This project provides the wearer with the facility of charging their gadgets anywhere anytime without regular electricity power. This make the piezoelectric shoes very useful for mountain climbers, travellers and adventurers.

3.1.5 Economic

The financial constraints attached with formation of the project are the biggest limitation on the project. The material and tools cost of the said project is very minimal that makes this project quite cost effective. Although it is also true that charging speed from the piezoelectric shoes is very less and it takes long hours to charge the mobile phone, still piezoelectric shoes will work in any area even where there is no electricity or generators and at no cost at all. Energy Harvester in Piezoelectric shoe may not be efficient like regular power but it operates at no cost at all.

3.1.6 Safety

The piezoelectric energy harvester is very easy and safe to use. There are no risks involved in the framework. Piezoelectric shoe is consists of brass and ceramic piezo discs and a battery along with a capacitor and diodes. Our project is also been planned to be maintain and sustain safety all the time the gadget is in use. For this purpose, we will try to make the piezoelectric shoe waterproof and shockproof as well.

3.1.7 Ethic

Energy harvester in piezoelectric shoes is not new concept it is an existing technology. There are many designs and models of the use of piezoelectric material as an energy harvester even in the shoe. We intend to present this project as the hour of the need to uplift the quality and living style of our lives. This project should implemented in all those areas where mechanical energy is wasted. Aim of the project is to design a model of piezoelectric shoe, which proves to be beneficial, sustainable, durable and effective.

3.2 Engineering Design Standards

The components used for harvesting the energy through piezoelectric shoe are quite simple yet we have made effort to select only high quality material so that we can assure the efficiency and effectiveness of the piezoelectric shoe in harvesting the electrical energy. High quality components require less energy, as they have high sensitivity level, and in return generated energy is stored with less or no loss. To make sure our project stands out we have followed the following engineering standards.

Table # 3.2 Engineering Standards

Components	Engineering standards
Solder	ASTM: B828
Diode	ASTM: 1n4001
Polystyrene	ASTM: C578

3.3Product Subsystems and selection of Components

In the following table, the list of the components of the piezoelectric shoe is along with their quantity and brief detail.

Table # 3.3 Components and Details

Components	Quantity	Details
Shoes	1 pair	Skechers
Piezoelectric discs	5	Brass and ceramics
Battery	1	9V

Solder	Multiple	ASTM: B828
Diodes	4	ASTM: 1n4001
Capacitor	1	25V
Polystyrene	5 sheets	ASTM C578
Multi-meter	1	Digital
Cardboard	1 sheet	Carved into the size and shape of shoe used

- **Shoes**

The whole system will setup in the sole of the shoe with an attached USB port inside the shoe where it ends around the ankle. For this purpose, we are using a relaxed fit pair of Skechers brand. We need our final shoe to be comfortable enough so that wearer can walk or run comfortably for as long he desires. The shoe we chose is very lightweight and flexible that piezoelectric system placed in the sole of the show will cause neither any discomfort nor unease.

Fig # 3.3: Skechers Relaxed fit

- **Piezoelectric discs**

Table # 3.3 (a) Specifications of piezoelectric discs

Characteristics	Specifications
Quality	Temperature resistant, stable, durable and long service life
Material	Brass and ceramics
Dimensions	27mm diameter 0.4mm thickness
High performance	Resonant frequency 4.6 +/-0.5 KHz Low power consumption High sensitivity

- **Battery**

We will be using 9V battery with the dimensions of 48 x 26 x 16 mm. The 9V battery has built in low self-discharge technology that prevents it from losing its power after long storage periods. Once charged, it can be stored for 12-24 months with a high capacity percentage left. It is very light in weight and small. The following table presents the specifications of the battery.

Table # 3.3 (b): Specifications of Battery

Characteristics	Details
Type	NIMH
Voltage	9 volt
Capacity	200 mAh
Dimensions	48x26x16 mm
Weight	0.08Lbs

- **Diodes**

Table #3.3 (c): Specifications of Diode

Characteristics	Specifications
Diode type	1n4001
Repetitive reverse voltage vrrm max	50V
Forward current IF(AV)	1A
Forward voltage VF Max	1.1V
Operating temperature range	-55°C To +150°C

Diode case style	DO-41
No of pins	2 per diode

Figure # 3.3 (a): Diode

- **Capacitor**

Table # 3.3 (d) Specification of Capacitor

Characteristics	Specifications
Capacitance	1 F
Voltage rating	25 VDC
Tolerance	20%
Operating temp	+10°C to +85°C
Dimensions	8mm x 12mm (diameter x height)
Lead spacing	5mm

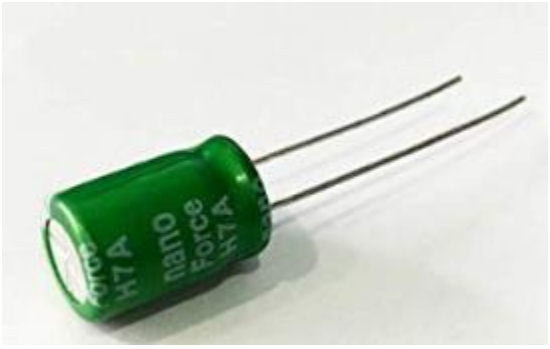


Figure # 3.3 (b): Capacitor

Tools required

- Soldering iron
- Hot glue gun

3.4 Theory and theoretical calculations

3.4.1 Working Principle

The basic principle on which this gadget is going to work is the transformation of human mechanical power into electrical signals. The mechanical power generated is due to the brisk and constant m movement of the ankle. A running or walking person possess a certain amount of kinetic energy and along with this the amount of pressure applied on the ground wearing shoe is our target and we will utilize this pressure in our product development.

Piezoelectric disc transducer fed by the mechanical energy in form of vibrations, which in result vibrates the piezo-crystals. This excitation in the piezo crystals generates a voltage. Figure shows the piezoelectric plate where golden layer is the base plate and crystals embedded is the center of the disc.

The application of the said project completely depends on human pressure and foot movement. Mechanical stress and voltages generate power via piezoelectric transducers placed in the sole of the shoe. Transducer helps to covert the vibrational energy into electrical energy.For a 70 kg man walking the piezoelectric disc will produce a voltage of 1.5V- 2V. This voltage will enhance to 8V if we use a suitable resistance management 20 ohm and 5 ohm. However, we will keep it optional.

3.4.2 Voltage developed

To calculate the voltage developed by the system once operative we will be going to use the following formula:

$$\textbf{Voltage} = P_{app} * T_p * C$$

3.4.3 Amplification Model

The voltage gain depends on the impedances connected across the pnp transistor.

$$\textbf{Gain} = rf/ri_{+}\ 1$$

We are assumingthe following conditions remain unchanged; we will receive the results as mentioned in the table below:

- The piezo electric disc is used for the experiment had the same piezoelectric constant C
- The thickness of the disc is 2mm and the diameter is 20mm assuming best quality
- The same person is stepping on the piezo all the time.

Table #3.4: Voltage generated while walking

Step. No	Voltage generated
1	0.540 V
4	0.750 V
8	1.308 V
12	1.456 V
16	1.529 V
20	1.603 V

Table # 3.4 (a): Voltage generated while running

Step. No	Voltage generated
1	0.550 V
4	0.835 V
8	1.355 V
12	1.653 V
16	1.842 V
20	2.011 V

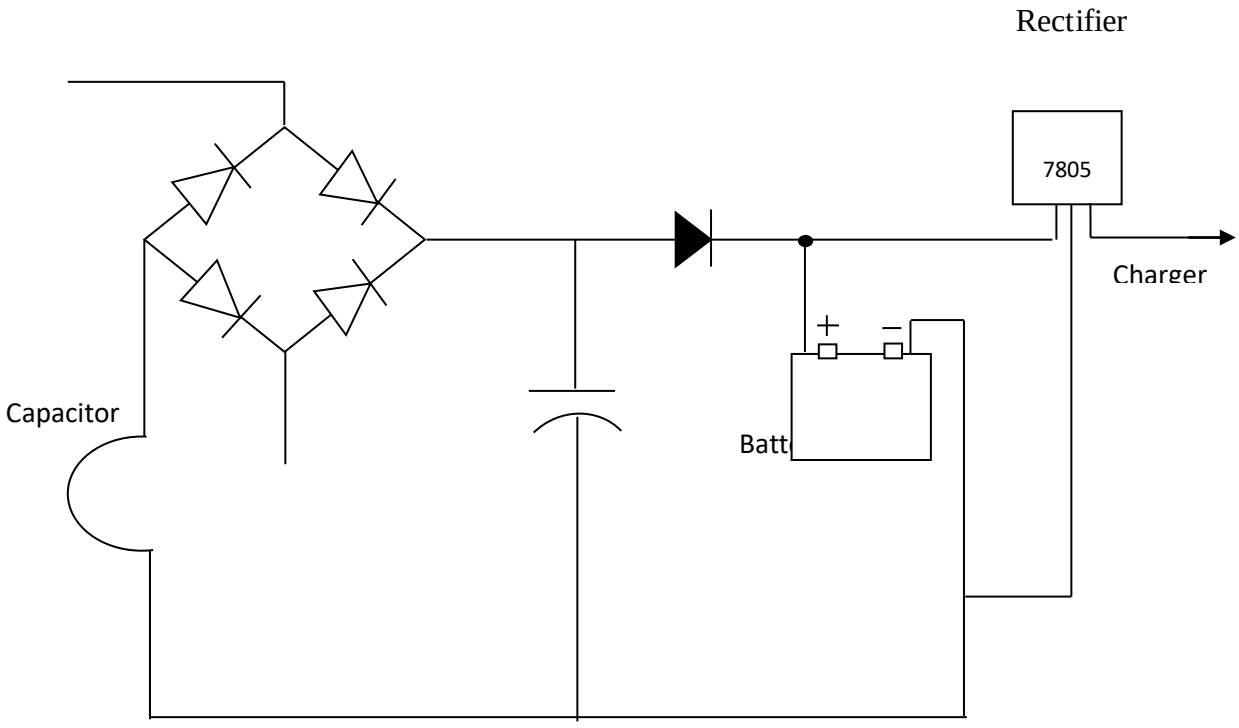


Figure # 3.4: Circuit Diagram

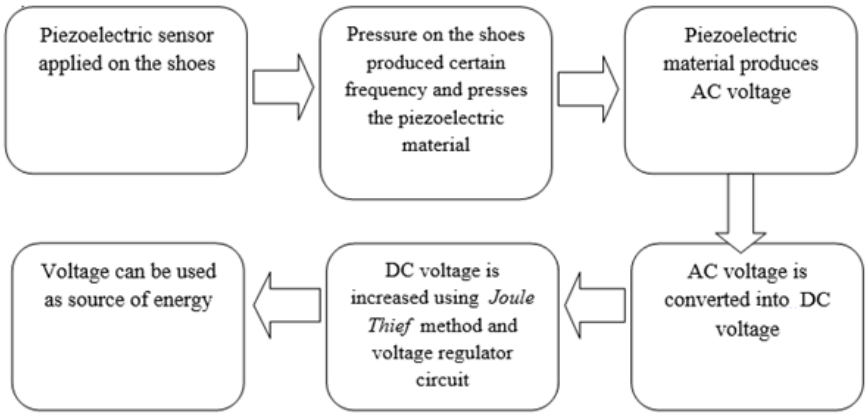


Figure # 3.4 (a) Block Diagram

3.5Manufacturing and Assembling

To generate sustainable electric energy in the shoe by harvesting mechanical energy from human motion is very appealing approach. This is not only generating energy but also endorsing healthy lifestyle. This is a very simple project yet it holds the power to uplift the society if adopted widely. For this project, we have used the piezoelectric discs to act as energy magnet or in other words, it will harvest mechanical energy in shoes generated from the motion and pressure of the wearer. This harvester is sandwiched beneath the removable sole of the shoe. This sandwiched structure have a very thin thickness which makes is compatible with the shoe.

First, we will take cardboard and polystyrene and cut them exactly the same size of the inner removable of the shoe. Then we will design the placement of the piezoelectric discs and other elements we need to attach to the polystyrene base glued above cardboard to give a firm support. Secondly, attached piezoelectric disc and the base with the help of hot glue gun according to the design diagram. Thirdly solder the discs with each other with the help of soldering gun. To generate ample amps along with the voltages we will solder the piezo discs in parallel as positives soldered with positive and negative soldered with negative. We can use multi-meter to ensure the piezo discs work by setting the multi-meter to AC volts and pressing on the piezo or we can add a led bulb in the circuit that will indicate open or close circuit.

Chapter 4: System Testing and Analysis

4.1Experimental Setup, Sensors and Data Acquisition System

4.1.1 Multimeter

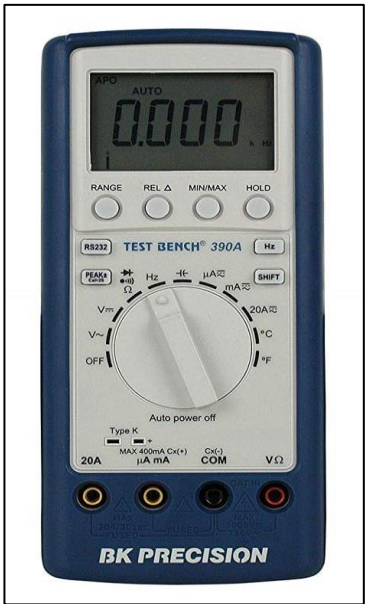
In order to test and analyse the performance and outcome of energy harvesting piezoelectric shoes we were required to calculate and evaluate all the parameters important to gauge the performance of our energy-harvesting shoe. For this experimental setup, we collected the data with the guidance of our lab technician. In our project, the data that was required to be collected was the voltages generated by the shoe at two different situation one while running and second while running. At first we noted the voltage produced by the piezo disc at resting then we noted the readings of voltage generated while running at different time intervals and we noticed new reading at every interval. Same process of noting down the voltages done while wearer of shoe was running and a completely different set of readings recorded.

The Multimeter used to measure the voltages generated by the piezo electric discs possess the specification mentioned in the table below:

Table # 4.1: Specifications of Multimeter

Manufacturer	B & K Precision
Category	Digital Multimeter
Type	Handheld
Accuracy:	3%
Number of Digits:	3 ¾ Digit LCD
Voltage Range:	66 mVDC to 1000 VDC, 660 mVAC to 750 VAC.
Resistance Range:	660 mohms to 66 mOhms.
Capacitance Range:	6.6 nF to 66 mF
Display Count:	6600
Frequency:	660 Hz to 66 MHz

Ranging: Auto,	Manual
True RMS:	Yes
Data Hold:	Yes
Package Weight:	285 g
Package Size:	165 mm x 42.5 mm x 78 mm



Fig# 4.1:Multimeter

4.2 Results, Analysis and Discussion

Data recorded from running the tests in order to determine the performance of energy harvesting piezoelectric shoes, following tables have been compiled which states the voltage generated and steps taken wearing piezo shoe. With the help of these tables, we were able to find out the exact number of step required to charge battery completely while both running and walking. The equation we used to calculate the energy/steps to charge the battery is as below:

$$E = \frac{1}{2} V^2 C$$

Where,

E = Steps to charge the battery

V^2 = Voltage

C = Capacitance

Calculating energy to charge the battery while walking

The following table shows the data gathered by observing and recording the voltage generated at different steps with the help of voltmeter.

Table #4.1 (a): Voltage generated while walking

Step. No	Voltage generated
1	0.540 V
4	0.750 V
8	1.308 V
12	1.456 V
16	1.529 V
20	1.603 V

Now putting the values in the equation where we already know that capacitance of capacitor used is 10 J.

$$\mathbf{E = 0.5 * (1.603)^2 * 1}$$

$$\mathbf{E = 1.2848045}$$

Now dividing the capacity of battery 6480 J with the energy calculated above

Steps to charge the battery = 6480 J/1.2848045

= 5043.5 steps

According to this calculation if at steps piezoelectric shoe is generating 1.603 V then it will need 5043.5 steps to charge the battery completely.

Table # 4.1(b): Energy to charge battery while walking

No of steps	Voltage generated	Steps to charge battery
20	1.603	5045

Calculating energy to charge the battery while running

The following table shows the data gathered and recorded for the voltages generated at different steps with the help of voltmeter.

Table # 4.1 (c): Voltage generated while running

Step. No	Voltage generated
1	0.550 V
4	0.835 V
8	1.355 V
12	1.653 V
16	1.842 V
20	2.011 V

Now with the help of above table we calculated energy required to charge the battery completely. As we know from the table that 2.011V is generated at 20^{th} while running now to find out that how much energy or steps are required to charge the battery of a mobile with the battery capacitance of 6480 J we used the same equation $E = ½ V^2C$

Now putting the values in the equation mentioned above

$$E = 0.5 * (2.011)^2 * 1$$

$$E = 2.022 \text{ J}$$

Now the capacitance of battery divides with above calculated 2.022 J

E = 6480/2.022

Steps to charge the battery = 3205

These calculations show that with 2.011 V while running, 3205 steps will charge the battery completely.

The following table contains the values of energy to charge the battery calculated by using the above equation and voltage generated and steps taken.

Table# 4.1 (d): Steps to charge battery while running

No of steps	Voltage generated	Steps to charge battery
20	2.011	3205

From all the data collected and testing and calculations done, we can confidently proof that energy harvesting piezo electric shoe can charge a mobile phone battery without any help of external electric power. As we can also notice change in the electric voltage generated at different steps, this change is manageable. Tables above clearly shows that by just walking or running one can charge his/her phone completely and properly where needed. The calculations show that while running one needs to take 3205 steps to generate enough voltage to charge the battery. Although these steps may sound hectic or too much to someone but still running is a good and healthy and if 4-4.5 km run can give you a fully charged mobile phone then it is worth a try.

Chapter 5: Project Management

5.1 Project Plan

In order to execute our project efficiently and effectively on time successfully we designed a good project plan. This project just like others had lots and many different tasks, which needed to breakdown into smaller and achievable task. We also allocated ample to each task in which the task achieved. Each group member assigned the task and was required to fulfil all the requirements of the assigned task within the given deadline to achieve a successful project and attain best results. The following table shows our project plan.

Table # 5.1: project plan

S.No.	Tasks		Start	End	Duration
1	Chapter # 1: Introduction		09/09/19	19/09/19	10
2	Chapter # 2: Literature Review	Project Background	20/09/19	30/09/19	10
		Previous work			
		Comparative Study			
3	Chapter # 3: System Design	Design Constraints and Design Methodology	01/10/19	10/10/19	10
		Engineering Design Standards			
		Theory & Theoretical Calculations			
		Product Subsystems &Selection of			

		Components			
		Manufacturing & Assembly			
4	Chapter # 4: System Testing & Analysis	Experimental Setup, Sensors and Data	02/11/19	12/10/19	10
		Results, Analysis & Discussions			
5	Chapter # 5: Project Management	Contribution of team Members	15/11/19	20/11/19	5
		Project Execution Monitoring			
		Challenges and Decision Making			
		Project Bill of Materials and Budget			
6	Chapter # 6: Project Analysis	Impact of Engineering Solution	26/11/19	28/11/19	2
		Contemporary Issues Addressed.			
7	Chapter # 7: Conclusion & Recommendation	Conclusion	28/11/19	29/11/19	1
		Future Recommendation			
8	Design of Prototype		05/11/19	11/11/19	6
9	Parts Purchase		20/09/19	05/10/19	15

10	Manufacturing	05/10/19	19/10/19	14
11	Testing	20/10/19	22/10/19	2

Table # 5.1 (a): Assigned Members for Tasks

S. No.	Task	Assigned Members
1.	Chapter # 1: Introduction	Mohammad Aludaib
2.	Chapter # 2: Literature Review	Abdulaziz & Abdullah Alhammad
3.	Chapter # 3: System Design	Zyad , Musad & Muhammad
4.	Chapter # 4: System Testing & Analysis	Zyad & Abdulaziz
5.	Chapter # 5: Project Management	Abdullah & Musad
6.	Chapter # 6: Project Analysis	Musad Al Abdulhadi
7.	Chapter # 7: Conclusion & Recommendation	Abdullah
8.	Design of Prototype	Zyad & Mohammad
9.	Parts Purchased	Abdulaziz & Musad
10.	Manufacturing	Everyone
11.	Testing	Everyone

5.2 Contribution of Team Members

Successful execution of Group Projects absolutely depends on the teamwork. Our team has put in its complete efforts and energy to achieve the desired outcomes. All the members of the group has worked very hard in order to fulfil the project requirements. Everyone has contributed his valued time and energy. The table below shows the contributions made by each group member.

Table # 5.2: Contribution of Members

S. No.	Tasks		Assigned Member	Contribution
1.	Chapter # 1: Introduction		Mohammad	100 %
2.	Chapter # 2: Literature Review	Project Background	Abdulaziz	50 %
		Previous work	Abdullah	50 %
3.	Chapter # 3: System Design	Design Constraints and Design Methodology	Zyad	20 %
		Engineering Design Standards	Musad	20%
		Theory & Theoretical Calculations	Mohammad	20 %
		Product Subsystems & Selection of Components	Zyad	20 %
		Manufacturing & Assembly	Musad	20 %
4.	Chapter # 4: System Testing & Analysis	Experimental Setup, Sensors and Data	Abdulaziz	100%
		Results, Analysis & Discussions	Zyad	
5.	Chapter # 5: Project Management	Contribution of team Members	Abdullah	100%
		Project Execution Monitoring		

		Challenges and Decision Making	Musad	
		Project Bill of Materials and Budget		
6.	Chapter # 6: Project Analysis	Impact of Engineering Solution	Musad	100%
		Contemporary Issues Addressed.		
7.	Chapter # 7: Conclusion & Recommendation	Conclusion	Abdullah	100%
		Future Recommendation		
8.	Design of Prototype		Zyad & Mohammad	100%
9.	Parts Purchase		Abdullah & Musad	100%
10.	Manufacturing		Everyone	100%
11.	Testing		Everyone	100%

5.3 Project Execution Monitoring

Once tasks assigned to each group member, it was very important for us to keep track of completion of the tasks. For this purpose we had team meetings regularly on weekly basis, not only this we had meetings with our advisors and instructors to keep them updated regarding our status and they were very kind to guide us and point us in right direction. Since it was our first experience and we were in learning and developmental stage feedbacks on our designs, reports and presentation were very important. Table below shows the details of our meetings and important events in project.

Table # 5.3: Dates of Activities & Events

Time/Date	Activities/Events
Once in week	Assessment Class
Bi-Weekly	Meeting with the group members
Bi-Weekly	Meeting with the Advisor
20th September, 2019	Ordering parts
14thNovember, 2019	Midterm Presentation
20thOctober, 2019	First Test of System
21st November, 2019	Finishing Final Prototype
4thDecember, 2019	Test of the System
5thDecember, 2019	Final Submission of Report
15th December, 2019	Final Presentation

5.4 Challenges and Decision Making

Throughout the execution of the project, we faced a lot of challenges and issues, and solved and rectifiedthem in order to deliver a complete successful project. While we were working on the design of our prototype, we had to take major decisions that were in the developing stage. The biggest problem we faced was as the assembling of the shoe so that it stays comfortable even after layering the complete energy harvesting setup underneath the inner soul of shoe. This issue took quite a long time to resolve however, we were able to rectify this problem efficiently and did all the tasks up to the mark. The problems, which we faced, are as follows.

5.4.1 Equipment and Device Problems

Wiring and connectivity

Energy harvesting piezo electric shoe is such a device in which the whole set up was to be embed and once connected and fixed the inner soul is glued back and shoe is closed. We faced problems while wiring and connecting piezo electric disks, capacitor, and USB port

as these were to fix so perfectly that even after running or throwing shoe should not damage the connection and piezo electric disc should keep working as planned or designed.

Piezo electric discs

To resolve the problem of low voltage generation we had to find good quality piezo electric discs, which should work perfectly fine underneath the inner soul of shoe and should feel the thrust/push of walking or running completely. The more energy is stored by piezo the more voltage will be generated. For this, we chose relax fit shoe that absorbs all the vibrations caused while running/walking without dispersing the effect. Along with this selection, we used high quality piezo electric discs and the problem solved.

5.4.2 Testing and Safety Issues

Our setup would have been successful only if it was tested and proved to be safe at all conditions. Having an energy harvester embed in ones shoe raise concerns regarding the safety of the wearer. Setup should not cause any electric shocks to the wearer for this problem we made sure to make setup waterproof and properly covered and secured the energy harvester setup underneath the inner sole with non-conductor materials such as cardboard. We tested the shoe by causing damage to shoe by throwing it hard and operating the shoe in water and in both test this shoe proved to be successful.

5.5 Project Bill of Materials and Budget

The table show the parts purchased/ordered and fabricated from the market. It includes the total amount spent on our project in Saudi Riyals SAR.

Table # 5.5: Project Bill of Materials

Material	Cast (SAR)
Shoes	270
Solder iron kit device	83
Diode (5pc)	5
Capacitor	1

Piezoelectric generator (5pc)	68
Rechargeable battery	53
Battery clip connector (20pc)	50
Solder	10
Rectifier	5
Charger wire	10
Multimeter	95
Total sum	**650**

Following table shows the true cost for one shoe excluding the cost of the extra materials.

Table # 5.5(a): cost of one shoe

Materials	**Cost (SAR)**
Shoes	270
Diode (5pc)	5
Piezoelectric generator (5pc)	1
Rechargeable battery	68
Battery clip connector	26
Rectifier	2.5
Charger wire	5
Total cost	**377.5**

CHAPTER 6: Project Analysis

6.1 Life-Long Learning

Working on project that requires a real life implementation as well teaches you a lot more than what we learn in classrooms. Although we have learned all these concepts of engineering in university but when it came to real life execution we came across life-long learnings. We learnt how to design a prototype and how we should be wise enough to make modification in the design according to the requirements and need of the situation. We learnt we should not be rigid and keep in mind that we may have to bring changes either in our design or concept as we proceed further into execution. We tried to be open minded and worked on trial and error basis and learned from our mistakes.

6.1.1 Software Skills

We are students of mechanical engineering but this does not mean that we should know nothing about software technologies. It is very important to use technological advances and learn new skills in order to accomplish our objectives in a professional manner. Our project is mainly and purely mechanical and electrical but it did require software skills at beginning when we had to design our prototype. We referred to online websites to understand and familiarize ourselves with the best designs in the market and learn how we can improve it. Not only designing the prototype involved software skills, but report writing, power point presentations, table, diagrams and Gantt chart preparation all required software skills of some level.

6.1.2 Hardwar Skills

The hardware skills involved in our project were quite simple and straightforward. We just need to assemble all the parts properly and perfectly. We selected the best suitable materials in accordance with our engineering standards. Apart from assembling and embedding the energy harvester setup underneath the inner shoe sole the calculations and testing of system performance, we used multi meter, which gave us the values of the voltage generated.

6.1.3 Time Management

Time allotted to us to complete our project was 3 months, which seemed quite enough but once we started the execution we find it essential to manage our time well so that we can deliver the project on time. Our project is very simple although it is unique but required no late nights to complete the project. It took us three weeks to assemble the shoe once the purchase of material completed.Assembling of the setup gave us some tough time as in the beginning we were unable to achieve the comfort of the shoe; the energy harvesting setup was bringing discomfort to the wearer. After doing more research, seeking help, and guide from the experts, we were able to produce a comfortable fully functioning piezoelectric shoe.

6.1.4: Project Management

To accomplish a project successfully on time is an art, this just not happens one have to make efforts to do so. For this purpose, we managed our project beforehand by developing a Gantt chart, which acted as project management plan. In Gantt chart everything was specified in advance for example all the tasks, their due dates, and who was responsible for doing particular tasks. Each group member assigned with number of different tasks had the responsibility of their completion on time. Tasks among all group member were equally distributed. Along with this, we were all available to each other if any help required. We had regular biweekly meetings and we discussed issues and problems with our advisor and instructor for guidelines. This effective and efficient teamwork led us to successful completion of our project on time.

6.2 Impact of Engineering Solutions

6.2.1 Society

Natural resources i.e. fossil fuel is decreasing day by day and soon will become extinct if counteractive measures not taken. Use of solar energy promoted to save the natural resources is not the only way to save the in vain use of electricity. The idea we are promoting is very cheap and beneficial to our health. Piezoelectric shoes will not only help to charge our daily use small appliances but will also affect our health positively by keeping us active and smart. As piezoelectric shoe can be used anywhere in the world even if there is no electricity or any technology. One just have to wear it and walk or run as per your choice and charge mobile. Its cheap life long and healthy device to use.

6.2.2 Economy

Cost of the project is not too high so it was never our concern. We used best and high quality materials and parts to achieve best results. It is a low or no maintenance device. One setup is installed it is functional for longer period. A simple system has less chances of failure or breaking down leading to low maintenance cost.

6.2.3 Environment

Any future investment in energy harvester piezo electric device can result in functional substitute of electricity on smaller scale. If factories and industries adopt this idea where there are continuous vibrations formed on daily basis they can harvest good amount of energy and produce large-scale electricity. This can bring a positive and healthy change in the environment. This can help to decrease the damage caused to the natural resources to produce electricity.

6.3 Contemporary Issues Addressed

With the increase in the use of technologies and ease of life we see that dangerously growing issue in our youth is the obesity. This issue needs addressed via technology as technology has caused it. The idea of piezoelectric shoe will help eliminate the obesity and promote running and walking at 3-4 kilometres to charge a mobile once. Along with health benefits this technology is very useful for bikers, hikers and adventurers as they can use this anywhere in the world to charge their torches, mobile phone, laptops etc.

Chapter 7: Conclusion and Future Recommendations

7.1 Conclusion

The idea of charging a mobile phone without electricity and completely with help of piezoelectric shoe seemed very naïve at beginning but once we started the research we get know that there already is quite a work done on it. Engineers around the world are working on it. Our priority was to make the project at the lowest cost possible. We successfully utilized our engineering knowledge using trial and error method to achieve our objective. This project of time span of three months helped us in expanding our learning perspectives and learned how to stay motivated and determined. Moreover, we were successful in achieving our goals by designing low cost energy harvester piezoelectric shoes.

7.2 Future Recommendations

Due to time limits and limitations of knowledge and experience, we could not make an energy harvester of bigger scale. Although the current design works exceptionally but still there is some room for improvement. This setup in gyms where there are heavy cardio appliances/equipment producing continuous vibrations and this ample potential energy can be harvested and converted into electrical energy will be very successful. Bikers who travel the world must have these shoes with them to avoid any scenario like mobile battery down and nearby there is no electricity to charge it to avoid any inconvenience. This idea can be of great attraction and success as this promotes environment friendly and healthy technology.

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