IOT-BASED SMART STREET LIGHT CONTROL INCLUDING PIEZOELECTRIC ENERGY SOURCE

An Undergraduate CAPSTONE Project
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Under the Supervision of

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Faculty of Engineering
American International University - Bangladesh

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A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in their mentioned respective programs.

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DECLARATION

This is to certify that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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APPROVAL

The CAPSTONE Project titled **IOT-BASED SMART STREET LIGHT CONTROL INCLUDING PIEZOELECTRIC ENERGY SOURCE** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **May 2022** by the following students and has been accepted as satisfactory.

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ABSTRACT

The creation of new energy sources is the main issue in this period of technological growth. Appliances that are able to transform ambient energy in electrical energy are one of the areas of great interest. Our project is aimed at developing such an instrument that the piezoelectrical element can convert pressure to electrical energy. This research will also illustrate that some data may be utilized for the existence of waste vibration energy. The system of this project comprises the conversion to electrical power of continuous floor compression using piezoelectric materials.

The major objective of this project is to tackle the worldwide power problem, while it is not enough to satisfy an excessive demand for electricity but can alter and reduce dependence on traditional electric energy generation methods. This project emphasizes on a never-ending loop for the best outcome of efficiency and minimum rate of cost-cutting. First step of the project is to generate power by human footsteps with the help of PiezoElectric and then store that power in a battery cell. Then we monitor and control the power generation by an IOT device to avoid wastage of time and resources. But the IOT device is needed to be charged for continuous monitoring. It will be an extra cost if we take an outside source to charge the IOT device. So, we use the charges from that storage battery to charge the IOT device with the help of a RFID device. But the efficiency of this method cannot be high. So, we should also follow an alternative method by connecting the IOT device to the storage battery to charge.

This project can assist terminating power shortage in the city area as well as in the rural area. The worldwide generation of energy from each new technique is encouraged by the necessity for daily living. And this project attends the main motto of that theme.

Chapter 1

INTRODUCTION

1.1. Overture

The production of electric power from human foot step movement can be the next major popular solution as a renewable energy system. The implementation of various clean energy systems is a critical method for achieving environmental sustainability. The majority of individuals spend the most of their lives walking. Walking is also known as ambulation, and it is a fundamental and common mode of mobility for humans in everyday life. Walking creates touch between the human foot and the ground surface. The pressures experienced by human feet when they fall on the ground can provide kinetic energy which is a sustainable energy source. A footstep power generator can transform this energy into electricity. There are various types of footstep power generators on the market, and the majority of these devices generate power using a piezoelectric transducer. This power generation is not a constant process that is dependent on the people who utilize the matching footfall. As a result, regular monitoring of this power generation wastes both time and resources. This problem identification can be resolved with the assistance of an IOT (Internet of Things) control arrangement on it. The corresponding system linked with IOT leads to the avoidance of continuous monitoring and separate resources to regulate power generation, as well as maintenances for the exact time of demand from wherever and whenever. In this human stride power generating system, we generate electricity with the use of a human stride, which is also utilized to charge a battery. The power stored in the battery is used to charge the IOT device via RFID card. The goal of this project is to build a loop system for continuous power generating, which will be monitored by an IOT device with help of a RFID card to charge the IOT device.

1.2. Significance of the Project / Research Work

The major theme of this paper is the generation of electric power from people's footstep movement and the pressure produced when walking, which is frittered away. This thesis paper is basically based on the previous research work on various types of power generation methods using human footsteps. Some of the research papers only emphasize on the generating part. So, there are some limitations for that part of power generation. If we study the previous literature work, we will come to notice that they mostly worked on how to generate the power by human footsteps using PiezoElectric. So, there were no monitoring for the power generation. For that reason, there could be some wastages of power. As we are working on a closed-loop system of power generation, we may observe some improvements and changes in power variation. The more substantial our literature review is, the more we may learn about the benefits and drawbacks of power generation using PiezoElectric without controlling and monitoring it. It allows us to add certain changes, enhancements, and improvisations to our case. If we discover any flaws or shortcomings when doing a literature review, we can provide our best contribution to help fix the situation. As a result, this study project is unquestionably important.

1.3. Engineering Problem Statement

In this research work, we are establishing a closed loop-based continuous power generating system with some useful sensors to control and monitor the flow of produced power. The power generation system by human footstep using PieazoElectric will be one of the best alternative solutions for producing power for over populated countries like Bangladesh, India and China etc. Because it is a loop system that does not require any extra steps from outside to maintain, the project being built will assist cut costs to virtually nil (apart from installation costs). This idea can help to eliminate electricity shortages in both urban and rural areas. It is both a low-cost and an appealing project. It is a long-term solution for generating and optimizing electricity energy. It will enhance electricity's basic necessities. Power, current, and voltage are the three. The suggested model in this solution employs an Arduino Uno as a microprocessor, PiezoElectric sensors, RFID sensor I2c protocol, and a battery outfitted with a PiezoElectric Transducer. The transducer will try to assemble maximum kinetic energy. The power producing floor generates power, which is essentially the generation of electrical energy from kinetic energy with the help of that transducer [1]. Then an IOT device is being used to regulate and control the power generation flow, it is also used to control the generated power distribution. It helps to prevent waste of time and resources. Then a RFID sensor is added to charge the IOT device from the storage battery to keep it functioning. So, it will not be required to take power or charge from outside to charge the IOT device. Thus, it makes a closed-loop system. This system is required to provide safe regulation for the PiezoElectric transducer. So, it can be long lasting. Different types of Power Generating system can be already noticed on several literature surveys. The focus of this paper is to improve the efficiency of the power generation and also to improve the performance of the transducers by making it a closed-loop system. This project will make use of a variety of mathematical formulae. As a result, it may identify gaps in existing works and provide an engineering-based remedy that will be a valuable asset to a country.

1.4. Objective of This Work

This study aims to provide a brief knowledge of research-based power generation system by PiezoElectric tiles based on a closed-loop system. Because it is a loop system that does not require any extra steps from outside to maintain, the project being built will assist cut costs to virtually nil (apart from installation costs). This idea can help to eliminate electricity shortages in both urban and rural areas. This paper will illustrate the design methodologies of Piezo-Electric Power Generation pertaining to IOT device, RFID sensors, stepper drivers, motors, voltage regulation, physical implementation and software construction. We split our efforts into two objectives. They are –

1.4.1. Primary Objectives

- To design IOT based closed-loop continuous power generation system.
- To create a working demonstration of a closed loop power production system.
- To compare the old conventional power generation by footsteps with the new closed-loop system.

1.4.2. Secondary Objectives

- To integrate several sensors to ensure the safety and effectiveness of the suggested solution.
- To implement various types of source codes to prevent hacking and data stealing.

1.5. Comparison with Traditional Method

Piezoelectric materials are used to convert pressure into electrical energy. The amount of pressure applied on the material might range from the weight of a car to individuals walking across it. Despite the fact that the electrical energy generated by this pressure is not continuous, every electrical device demands steady electrical input. As a consequence, Piezo ceramics, as well as a Full-Bridge rectifier and an AC ripple filter, are required, and the Piezo materials are layered in a series-parallel configuration. It is possible to collect enough power (DC Power) to store the obtained electrical energy [2].

According to survey results, people are more likely to embrace our renewable technology than the technique. It is relatively simple to cause significant environmental damage with this way. Nuclear power facilities and thermal power plants, for example, are far more detrimental to the environment. Keeping the environment in mind, such an environmentally friendly electrical project is essential. This project will initially be expensive to replace, but once completed, it will generate a significant amount of long-term electricity. We discovered that IOT (internet of things)-based Piezo-electric power generation is considerably superior to traditional piezo-electric power generation in the approach. We employed a variety of sensors and codes to safeguard our system from any undesired external or internal dangers that are not present in traditional method. We have implemented different types of coding in Arduino to program the system as our needs safely. If a nuclear power plant is one of the techniques, it becomes a threat to that country and nation, as well as the region, if it explodes. This IOT-based piezo-electric power production technology has no such danger. The need for energy is always rising, and companies are attempting to supply this demand in a variety of ways. However, natural resources such as oil, gas, coal, and others are used to create energy. However, these natural resources will run out at some point, but if we become used to generating power using piezo-electricity, we will not have to worry about future generations since this energy will never run out.

1.6. Innovation / Scope of the Project

The power generation by human footsteps can become a great choice of power generation nowadays. Because of the notion of a green environment, renewable energy sources are becoming the preferred choice for power generation. The flooring is designed using piezo electric technology, the electrical energy created by pressure is caught by floor sensors and transformed to an electrical charge by piezo transducers, which is then stored and utilized as a power source. Then, to reduce the wasting time and money, we monitor and manage the power generation using an IOT device. We then use the charges from the storage battery to charge the IOT device using an RFID device. Then the system acts as a never-ending loop system. This type of system can be long-lasting and inexpensive. Without a doubt, this idea has the potential to help end the electricity shortages in both urban and rural areas and have a bright future in the field of power generation.

1.7. Impact of Project on Society

1. Do you think this automated Power Production or Generation system can be useful to solve the current power shortage problems?

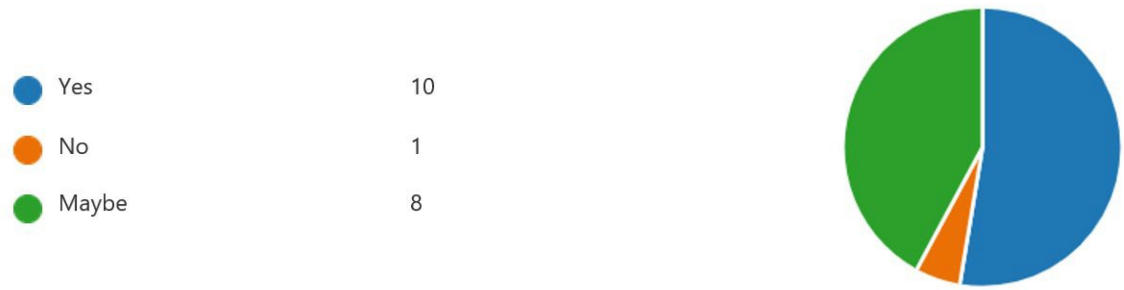

Figure 1.1 Obtained results from question 1

Figure 1.1 illustrates that automated Power Generation has sustainability for our country's power shortage problems because 10 (53%) of the total voters in this questionnaire survey are agreed with this decision by providing their answers in a positive indication. And (42%) 8 of them agreed in conceivable.

2. Do you think we need to replace the current power generation system with a newer advanced automated power production system?

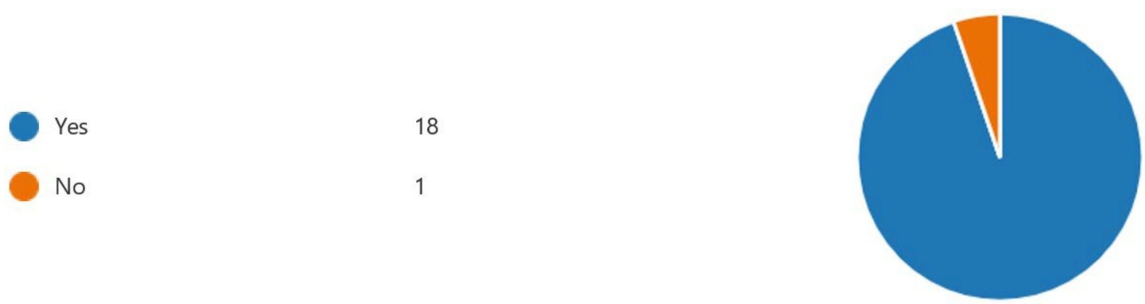

Figure 1.2 Obtained results from question 2

Figure 1.2_indicates that the current power generation system needs to be replaced with a more advance automated power production system according to the votes of the survey.

3. Do you think this automated power generation system can be helpful to make the best use of the city or rural areas?

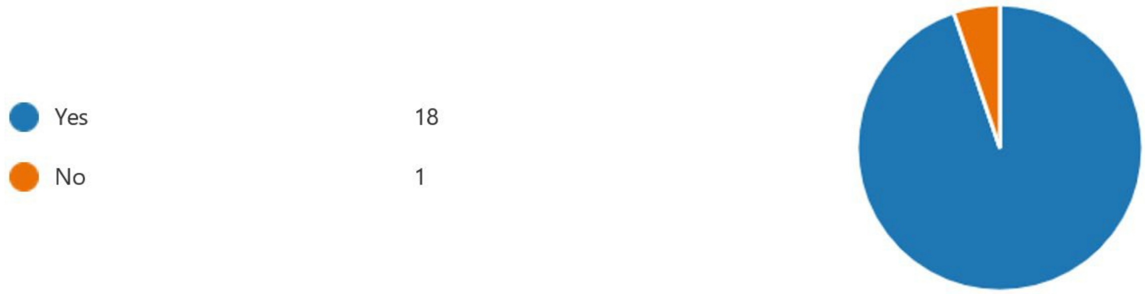

Figure 1.3 Obtained results from question 3

Figure 1.3 Before presenting the proposed solution, we anticipated that it would be more efficient in rural regions than the usual mode of energy generation. Figure 1.3 shows that our expectations were met because 18 (95 percent) of the persons agreed with our conclusion.

4. Do you think this automated power generation system will resolve the related power shortage issues in our country?

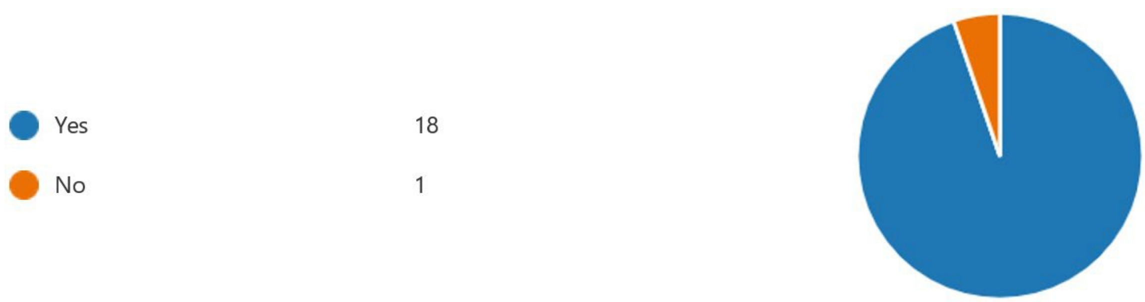

Figure 1.4 Obtained results from question 4

Figure 1.4 represents that almost 95% (18 out of 19) people think that automated power generation system will resolve the related power shortage.

5. Do you think that this automated power generation system will be environment friendly?

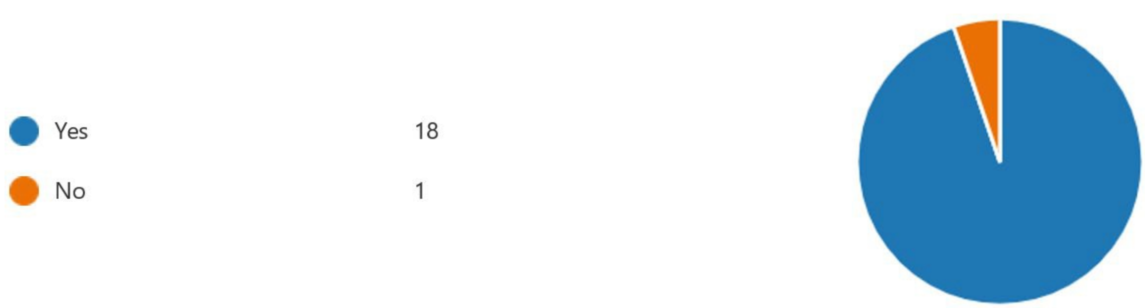

Figure 1.5 Obtained results from question 5

Figure 1.5 indicates that almost everybody thinks that this proposed system will be environment friendly.

So, in conclusion, after the questionnaire survey, according to the majority voters, this proposed system of automated power generation system or “Power Generation by Human Footsteps” will have a great impact on the society.

1.8. Organization of Book Chapters

This section discusses the structure of book chapters. This chapter provided a quick overview of the project. Furthermore, older and more current research were addressed in the historical context section. The current use of technology, as well as the major and secondary purposes, were also discussed. This section also includes some survey report analysis leading to the project's influence on society.

Chapter-2: Literature Review with in-depth investigation:

This chapter provides an overview of the entire project. In addition, historical context, previous research, and a background study on social impairment have been explored, with a focus on mobility impairment and a traditional and smart solution to mobility impairment.

Chapter-3: Project Management:

This section will highlight how to do a S.W.O.T analysis, schedule management, cost analysis, and P.E.S.T analysis, as well as individual accountability and interdisciplinary component management

Chapter-4: Methodology and Modeling:

The technique and modeling plans for the automated power generating system are discussed in this chapter. This section displays a block diagram of the planned project's work, followed by a flow chart.

Chapter-5: Implementation of Project:

This chapter will go through project implementation. The mechanical implementation will be explained initially. After discussing mechanical implementation, we will move on to electrical implementation.

Chapter-6: Results Analysis & Critical Design Review:

The findings are analyzed here, including running times, power rate, and efficiency under various conditions.

Chapter-7: Conclusion:

The project, as well as its contribution and assistance to patients, will be discussed in this chapter. The project summary will be emphasized, spanning the complete debate on the project and its effects, as well as the prospects for future task deeds.

Chapter 2

LITERATURE REVIEW WITH IN-DEPTH INVESTIGATION

2.1. Introduction

In no time, our nonrenewable resources will be exhausted. In 100-150 years, there is a high chance that we will have depleted most of our nonrenewable resources. As a result, developing sustainable solutions is vital for our prosperity. Hence, various renewable techniques, such as hydroelectric power generation, solar power generation, and so on, have been found. However, it must be highlighted that they are either expensive or inefficient, or both at once. On the other hand, using Piezo to generate energy might be a game-changer in terms of power generation. Using Piezo and combination of various other devices, it is possible to transform kinetic energy spent by people into electrical energy.

We transform potential energy (or storage energy) into kinetic energy as we travel from one location to another. Now, while part of this energy is utilized, some of it is debauched. The goal of employing the Piezo technique of energy generation is to use it to power many street lights and other commercial systems. Yes, these approaches will not be able to power a metropolis. However, street lighting and many other electric gadgets on the roadways and elsewhere require a significant amount of energy. As a result, implementing this type of technology will alleviate the burden on power generation businesses.

In this paper, the possibility, functionality, and capabilities of using such methods are going to be address in-depth.

2.2. Background Studies

Because piezoelectric technology is a relatively new idea, any application of piezoelectric technology for power generation is unique. It was created by two French sibling scientists in the 1800s, Pierre Currie and Jacques Currie [3]. Mr. Pierre, by the way, was the spouse of the legendary Marie Currie. In any event, since the Piezoelectric was introduced, the ability to capture kinetic energy and convert it to electrical energy grew dramatically. Humans may make use of the energy they squander when they take a step, drive from one location to another, and accomplish a variety of other tasks.

2.2.1. Backstory of Piezoelectric

Ferroelectrics are a specific class of electrical elements or components, include the focus of this writing, piezoelectric devices. The phrase "spontaneous electric polarization" describes this group of elements called Ferroelectrics. External electric fields may be utilized to reverse the polarization of this characteristic, which is crucial in the conversion of pressure to electrical energy.
The Currie brothers suggested the Piezoelectric activity of tourmaline idea in the 1880s.
Since then, the Piezoelectric effect has been explored and implemented in a variety of fields. Woldemar Voigt, a German scientist, developed a more exact counterpart for Piezo in 1894. Despite this, the Curries' heir and successor, the Langevin, was able to carry out the plan. Langevin designed a supersonic underwater detector [3]. Figure 2.1 illustrates a Piezoelectric Ceramic with Sensor.

Figure 2.1 Piezoelectric Ceramic with Sensor [4]

2.2.2. Backstory on IOT

The Internet of Things, or IoT, refers to a wide range of devices that may be used to monitor and control power output. With the help of IoT, it is possible to discover and convert data, as well as build smoother and more efficient processing or analysis, as well as precise decision-making. In short, with the help of IoT, it is likely to achieve a more integrated, distributed, and smarter energy system [5]. Figure 2.2 shows an IoT sensor module.

Figure 2.2 IOT Sensors [6]

Because IoT is a component of the internet, there is no one or independent inventor. Rather, it grew into what it is presently through time. During the Cold War, the United States of America advocated the internet as a way of sharing and processing information more quickly [7]. The Soviet Union launched the Sputnik satellite into orbit on October 4, 1957. For the Americans, this was a horrifying event that prompted the creation of special agencies like as NASA and ARPA. In 1962, an M.I.T. scientist and ARPA's J.C.R. Licklider suggested the notion of a Galactic Network, in which computers might interact with one another. As a consequence, the 'Galactic Network' developed into what it is now [7]. Figure 2.3 illustrates the entire branches of IoT.

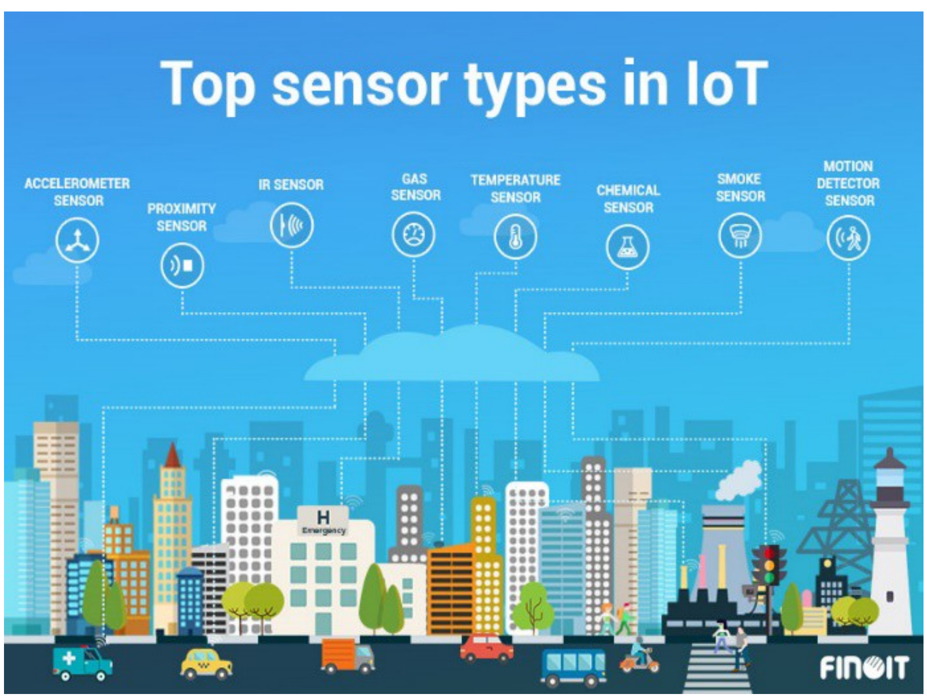

Figure 2.3 The Entire IOT Branches [8]

2.2.3. Backstory on Arduino

The first Arduino board was created in the classrooms of the Interactive Design Institute in Ivrea, Italy, in 2005. An Arduino is an open-source microcontroller-based development board that has allowed a new generation of designers and engineers to explore the world of electronics [9]. Figure 2.4 shows an Arduino Uno microcontroller board [10].

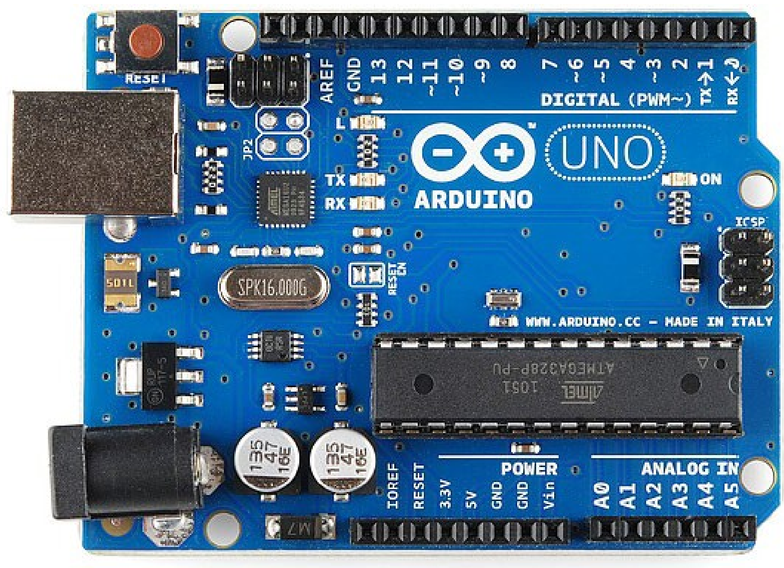

Figure 2.4 Arduino Uno [10]

Arduino is an open-source platform that may be used to create electrical creations. Arduino is made up of a hardware programmable circuit board (also known as a microcontroller) and software, known as an IDE (Integrated Development Environment), that runs on your computer and is used to create and upload computer code to the physical board. The Arduino platform has grown in popularity among those who are just getting started with electronics, and for good cause. Unlike most prior programmable circuit boards, the Arduino does not require a separate piece of hardware (known as a programmer) to load new code into the board; instead, a USB cable is all that is required. Furthermore, the Arduino IDE makes programming easier by using a simplified form of C++. Finally, Arduino offers a standard form factor that separates the microcontroller's tasks into a more manageable packaging.

2.3. Related Research Works

2.3.1 Earlier Research

2.3.1.1. Footstep Power Generation Using Piezo Electric Transducers

The basic method of transferring pressure into electrical energy is to employ Piezoelectric materials. The amount of pressure exerted to the material might range from the weight of a car to people strolling across it. Despite the fact that the electrical energy created by this pressure is not constant, every electrical device requires consistent electrical input. Piezo ceramics, as well as a Full-Bridge rectifier and an AC ripple filter, are required as a result, and the Piezo materials are stacked in a series-parallel pattern. It is feasible to obtain enough power (DC Power) to be able to store the gained electrical energy [2].

The output of a single Piezo would be much less. As a result, the number of Piezo ceramics that are linked to the tile in a series-parallel configuration to improve performance. It is feasible to create around 40V with a high current density by doing so. Later, an inverter is used to link this to a battery. In addition, with the aid of a microcontroller, the voltage provided is shown on an LCD [2].

2.3.2. Recent Research

In this section, a detailed analogy of all the references and previous publishes will be addressed in depth. By doing so, it should provide you with the necessary knowledge and purpose of the entire writeup.

2.3.2.1. Arduino Power Generating Using Human Foot Step

The Arduino, often known as the Arduino Uno Board, is a well-known programmable board. Anyone who isn't a seasoned programmer may use this to get their work done and complete a variety of complicated tasks. It also aids in the utilization of the system's large number of sensors and allows users to set the board in the best possible position for optimal performance [9]. Figure 2.5 represents a flow diagram of Power Generation with human step using piezo electric sensor and Arduino.

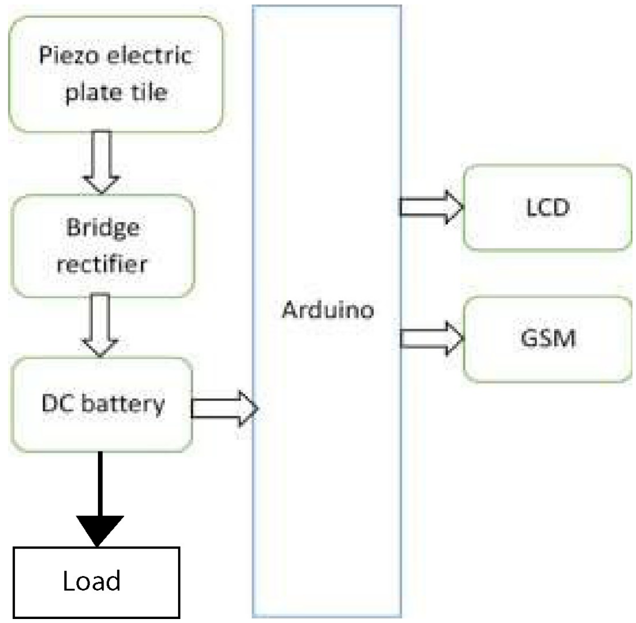

Figure 2.5 Power Generation with human step using piezo electric sensor and Arduino

We can give the stored energy a purpose by connecting Arduino to a Piezo board. A platform is initially pressed upon. The mechanical energy delivered to the Piezo sensors below is converted to electrical energy. As a result, it's known as the "Foot Step Power Generation System [9]. After going via a Full Bridge Rectifier, this is sent to a battery. Then after, the data is delivered to a GSM modem, which is then processed by a microcontroller and sent to a specific individual's mobile phone to tell them of the battery voltage condition [9].

2.3.2.2. An effective approach to charge IOT devices using footsteps

We can change the energy we waste when traveling, whether by vehicle or by walking steps, using a Piezoelectric Transducer, an Arduino Uno Microcontroller, and RFID technology. The goal of this form of energy generation is to store the converted energy in an IoT device that can subsequently be used to charge phones. Regardless, this sort of technology may be utilized to power a wide range of devices. A dozen Piezo materials will be attached to a plate or platform in a parallel arrangement. Electricity is generated and stored in a battery when pressure is applied to the tile or platform [11].

Now, the entire contraption is powered by a series of other components [11]:

i. At mega 328 microcontroller

ii. Arduino IDE

iii. RFID sensor

iv. LCD

v. USB Link

Here is how the entire contraption works:

Step-1 When a foot is kept on the plate, it will activate the Piezo underneath. Then, upon walking on the platform, the Piezo will keep charging the system. The power generated will be stored in a battery.

Step-2 Once the charging is done, the contraption depends on a RFID model to charge a phone. Due to this, an individual can charge for a specific amount of time.

Step-3 A microcontroller along with several other components help give the contraption full functionality

Step-4 .RFID controllers and tags are used to determine how much charge is allocate for a specific individual. Cards will be charged, which the sensors will detect and determine the amount of charge an individual receives.

2.3.2.3. An IOT used piezoelectric sensor used power generation through footsteps

The entire mechanism operates on a few steps. It is essential to state that there are several figures that provides a gist of how the entire contraption works. The following steps is deduced from those figures [12]:

Step-1 Upon applying on the platform containing Piezo, the pressure is going to be converted into Electrical Energy.

Step-2 After that, the energy is passed on through a unidirectional diode. The diode makes sure that the AC power gained from the Piezo is converted into DC, which is further boosted using DC boosters.

Step-3 Once the DC boosters release the final electrical energy, it is stored in a super capacitor as potential energy.

Step-4 Before, using the stored energy is again converted into AC via inverter and is connected to an appliance for further work.

2.3.2.4. Power Generation from Piezoelectric Footstep Technique

The major focus of this study is on generating power or electricity through footstep. There are various approaches do this, including employing gear wheels or fly wheels. Additionally, Piezo is installed beneath the platforms, which create energy when someone walks across them. The piezo is oscillated by a spring mechanism, and this is how energy is generated [13].

After receiving the electrical energy, it is transferred to a 12-volt acid battery, which stores the electrical energy as potential energy. The battery is then linked to an inverter, which converts the DC to AC and powers an energy-saving light [13].

2.4. Validity and Accuracy of Existing Solution

Since the invention of electricity, humans have been rapidly depleting our nonrenewable resources. As a result, we must ensure that we can develop new methods of energy production. We have now employed solar panels to collect energy from the sun in order to do this [11]. Then there are hydroelectric power plants, wind turbines, and other renewable energy sources. We're even experimenting with nuclear power generating. However, these solutions are either inefficient (such as solar panels) or cost a lot of money to set up and maintain (hydrogenerations or nuclear power plants). We came up with a terrific option after multiple trials and implementations: turning our own kinetic energy to electrical energy.

We utilized a platform and attached 8 piezo ceramics below it in this suggested system. The platform is attached to a spring system that ensures that the weight of those who step on it is dispersed evenly. We will be able to attain the best results if we do so. Anyway, the following 8 Piezo are joined to the bottom; three on top, three in the middle, and three at the bottom. It is feasible to ensure that we obtain the maximum power output by doing so.

The power generated is stored in a battery. A complete bridge configuration is also utilized to guarantee that the current and voltage remain steady. The stored energy is then connected to a rectifier, which allows the power to be converted into DC from AC. The electricity will then be connected to a street light. We expect to minimize the load on the mains power supply plants as a result of this. Thus, the power can also be controlled by an Arduino device for the IOT based purposes.

2.5. Wide Range or Conflicting Research Works

The research of the piezoelectric effect and, in particular, the quest for novel application areas for piezoelectric materials continue to be the focus of great interest, as indicated by the enormous number of papers in the journal Ferroelectrics. In piezoelectric materials research as a whole and in the study of specific families of materials, such as piezoelectric oxides, the situation is radically different. Figure 2.6 shows a graph of achievements expected growth in designing new piezoelectric materials.

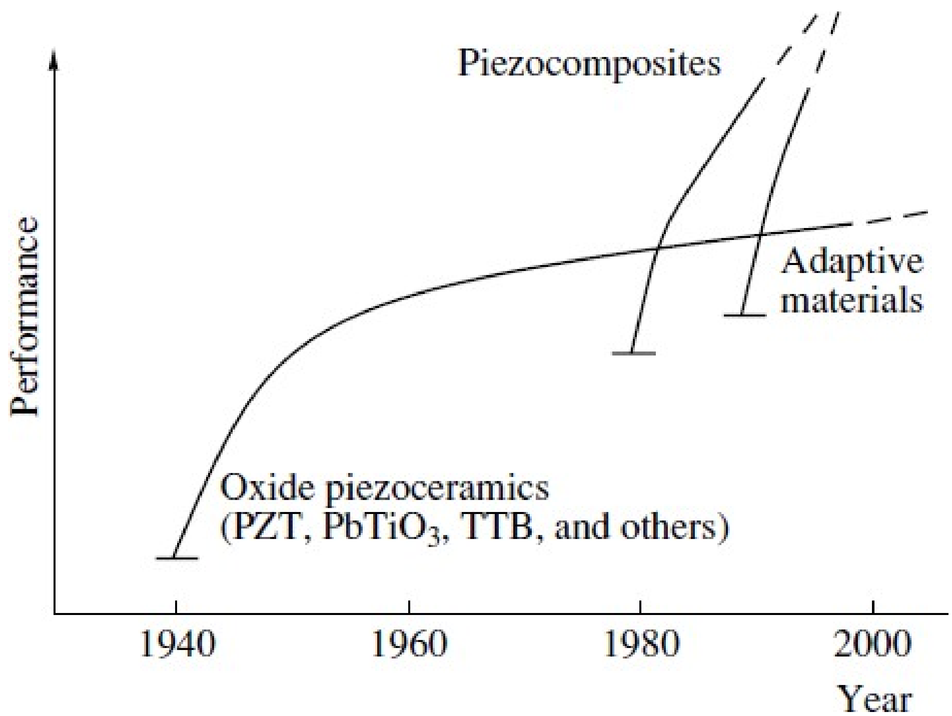

Figure 2.6 Achievements expected growth in designing new piezoelectric materials [14]

The discovery of piezoelectric characteristics in barium titanate in the 1940s led extensive study into a variety of piezoelectric oxides. In the 1950s and 1970s, comprehensive research of such oxides allowed for the selection of the most appealing materials for practical use, including materials based on lead zirconate titanate (PZT), lead titanate, lead meta-niobate, bismuth titanate, and alkali niobates. The best performance materials in each of these classes were created in the 1970s and 1980s, and the basic property–structure–composition correlations were established. PZT-based ceramics, for example, proven to be the best materials for general-purpose piezoelectric transducers, outperforming other types of oxide piezoceramics in terms of electromechanical coupling coefficient (0.7) and piezoelectric moduli. With the exception of antimony sulfoxide, such ceramics' longitudinal piezoelectric charge coefficient may surpass 800 pC/N, and their longitudinal electromechanical coupling coefficient is equivalent to that of single crystals of known piezo-electrics.

2.6. Critical Engineering Expert Information

Numerous tests on the subject have been conducted in the past. Regardless, we're attempting to use Piezoelectric to power street lighting in this setup. The suggested system's primary principle is to use Footstep to power an appliance.

To begin, there will be a number of tiles with 8 Piezo ceramics connected below each one. When the Piezos are engaged, the pressure or kinetic energy is converted into electrical energy. There are a few steps that must be performed to guarantee that the electrical energy generated is sufficient.

2.6.1. Full Bridge Rectifier

The amount of electrical energy received from the Piezo will vary. Actually, it will be unstable since each person's weight will vary, and the power generated will be proportional to that. As a result, a Full Bridge Rectifier is used to smooth out the generated electrical current and guarantee that it is stable and constant. The true purpose is to covert AC to DC [15].

2.6.2. Piezo Arrangement

The performance of the contraption will be determined by the placement of the Piezo beneath each tile. When they are connected in series, they provide a different result. In addition, the result varies in tandem. As a result, in order to ensure that we get the best of both worlds, the Piezo is coupled in a series-parallel configuration to achieve optimal circumstances.

2.6.3. Type of Piezo

We are referring to the dimensions of the ceramic by the kind of Piezo. In general, there are two types:

a. **Square**

b. **Circular**

It is preferable to use circular ones. This is because it is considerably easier to place them, and it ensures that each Piezo is activated whenever someone walks across the tiles.

2.7. Stakeholders from Research Literatures

The availability of resources and the cooperative and willing attitude of the parties involved will determine whether the use of piezoelectric sensors in this project meets local social interests and requirements. The project is only possible because of the resources. Examining how the implementation of piezosensors in this project will satisfy the interests and demands of various stakeholders is done by looking at what these interests and needs are in terms of product, process, and usage phases. The project's overall evaluation of the future possibilities and attractiveness of piezosensors on a macroscale appears to have promising future prospects. Between 2016 and 2022, the piezoelectric device market is estimated to reach USD 31.33 billion, increasing at a CAGR of 4.88 percent. The piezoelectric device market is expected to be driven by increasing demand for piezopolymer and composite materials, emerging applications of piezoelectric devices such as low-power and portable energy sources in healthcare, structural health monitoring, computer disk drives, robotics, accelerometers in mobile phones, and notebooks in the consumer (stakeholder) sector, increased funding from investors and government, and emerging applications of piezoelectric energy harvesting devices [16]. The overall market for piezoelectric generators is estimated to grow at the highest rate during the forecast period. The piezoelectric generators market would be mainly driven by portable electronic devices such as smartphones, smartwatches, laptops, and so on. All stakeholders are enthusiastic about this initiative and study on this issue since it is novel, green, and long-term. It is recommended to concentrate on piezosensor applications that provide visibility to users. As the poll findings in Chapter 1 illustrate, this should not infringe on users' or the environment's privacy, but rather focus on increasing safety and guaranteeing constant public lighting. The participants in this study stated that they are prepared to work together to create a well-designed environment in which piezosensors may be used [17].

2.8. Summary

Our major goal is to develop new ways to generate electricity. And the energy generated will not be used to power cities or anything else significant. We're looking for a solution to power additional modest commercial appliances, such as street lighting, etc. If we can do this, we will be able to limit the amount of energy utilized and, as a result, the impact on our natural resources, and what better way to do so than by utilizing our own energy? We can finally transform the energy we lose when we move from one location to another using Piezo, and use it for the advancement of humanity. We've employed Arduino, IoTs, RFIDs, and a variety of other components in addition to Piezo. However, they are simple to use and are commonly available on the market. As a result, incorporating this principle into our daily life is cost-effective, simple, and excellent.

Chapter 3

PROJECT MANAGEMENT

3.1. Introduction

As the need for power grows over time, it is critical to develop more efficient and readily available fuel sources. If not, there is a high probability that humans will exhaust all accessible fossil fuel resources on Earth in a short period of time. As a result, it was critical to devise a strategy that would allow humans to create power without relying on these fossil fuels (as well as conserving them), which is the goal of this project. This project began with the creation of a prototype design, which was then used to construct the final product. Extensive study and component searches were conducted in order to construct the design. The prototype steadily took shape as the required components were figured out, and voila, continuous power generation utilizing Piezo electricity and footfall was established.

3.2. S.W.O.T. Analysis of the Project

It is imperative to make good and well-considered decisions in order to establish a plan. As a result of the S.W.O.T. study, we may create a well-organized strategy and double-check any unfavorable consequences. The acronym S.W.O.T. stands for strength, weakness, opportunity, and threat analysis. Thus, individuals will be able to assess all of the benefits and drawbacks of a project or experiment and offer an unbiased parallel. [18]

3.2.1. Strengths

- Utilizes Kinetic Energy generated by human beings and converts that into Electrical Energy.
- Reduces the dependency on fossil fuel, and thus, conserves the fossil fuel, which allows the conservation of non-renewable resources like oil, gas, etc.

- Does not require high-financial backing to establish and can be stationed anywhere required. The method has no negative impact on the environment.

3.2.2. Weaknesses

- Will not be able to power mega-level electronics or electrical components.
- Each of the tiles will have to be installed individually, which may be a time-consuming and exhausting job because any error during the installation would output inefficient and incomplete power generation from the entire system.
- Maintaining a stable and consistent power production may be problematic due to the fact that each human being produces a varied amount of electricity throughout the conversion.

3.2.3. Opportunities

- Incorporating more complex elements, it is possible to enhance the functionality of the system.
- In addition to footsteps, the complete system may be upgraded to function with automobiles and a variety of other methods with little adjustments

3.2.4. Threats

- If the tiles get damaged, the tiles will not be able to activate the Piezo ceramics properly, which will reduce the power output.
- The tiles may not be waterproof, which means that if there is a terrible climate, such as rain, the entire system might collapse

3.3. Schedule Management

The approach of establishing a project, managing a project, and human action project schedules for time and a few resources is referred to as schedule management. Schedule management refers to the technique of generating project policies, methods for implementation, and documentation for planning, managing, executing, developing, and dominating the project management schedule. This project's schedule meeting database is shown in **Table 3.1.**

Table 3.1. Schedule Management

Date / Tasks	Aug 29	Aug 31-Sept 9	Sept 16	Dec 3	Dec 26	Dec 30	Jan 02	Jan 06	May 08	May 10	May 15	May 22	May 26
Topic selection & literature view													
Orientation													
Proposal submission													
Submission of Draft Chapter 1 & 2													
Supervisor for review													
Upload Chapter 1 & 2 (approved from the supervisor)													
Upload Video Presentation													
Online Progress Defense (in MS Teams)													
Submission of Draft Project Book to Supervisor for review													
Submission of Peer review survey form Link													
Submission of Poster, Summary & Revised Project Book to Supervisor													
Submission of Project Book to													

External for review												
Submission of Final version of Book, Poster, Summary and Plagiarism Report to Supervisor												
Final Defense												

3.4. Cost Analysis

A cost of materials is a list of components used in Project's assembly. The bill of materials is used chiefly for cost estimates. Table 3.2 shows the comparison between Estimated Cost and Actual Cost of the Components

Table 3.2. Comparison between Estimated Cost and Actual Cost of the Components

NO	Components	Quantity	Estimated Cost	Actual Cost
1	Piezo Element 35 mm	8	440	640
2	KVPC3510 Rectifier	1	60	50
3	Breadboard	2	220	190
4	Jumper Wire	2 Set	200	180
5	Pin Header	2 Set	50	35
6	Voltage Sensor	1	150	90
7	Current Sensor	1	150	215
8	Buck Converter	1	100	110
9	Wi-Fi Module	1	600	430
10	Wi-Fi Relay	1	250	300
11	Potentiometer	1	8	6
12	Rated Resistor	3	15	9
13	12V Rechargeable Battery	1	700	630
14	Arduino Uno R3 SMD	1	600	550
15	Cork Sheet Board	2	160	200

16	16*2 LCD Display	1	250	200
17	Normal Wire	3 Set	120	150
18	Tiles Board	2	1000	1200
19	Screw & Nut	4 Set	60	40
20	Small LED	3	30	15
21	DC Bulb (LED)	1	400	465
	Total		5563	5705

Table 3.3 illustrates the standard Deviation for the Previous Cost.

Table 3.3. Standard Deviation for the Previous Cost

Previous Cost (X_i)	Mean (X)	X_i-X	$(Xi-X)^2$	$s^2 = (X_i-X)^2/(n-1)$	s
440	264.905	175.095	30658.342	70461.190	265.445
60	264.905	-204.905	41985.961		
220	264.905	-44.905	2016.438		
200	264.905	-64.905	4212.628		
50	264.905	-214.905	46184.057		
150	264.905	-114.905	13203.104		
150	264.905	-114.905	13203.104		
100	264.905	-164.905	27193.580		
600	264.905	335.095	112288.819		
250	264.905	-14.905	222.152		
8	264.905	-256.905	66000.057		
15	264.905	-249.905	62452.390		
700	264.905	435.095	189307.866		
600	264.905	335.095	112288.819		
160	264.905	-104.905	11005.009		
250	264.905	-14.905	222.152		
120	264.905	-144.905	20997.390		
1000	264.905	735.095	540365.009		
60	264.905	-204.905	41985.961		
30	264.905	-234.905	55180.247		
400	264.905	135.095	18250.723		

Table 3.4 shows the Standard Deviation for the Actual Cost.

Table 3.4. Standard Deviation for the Actual Cost

Previous Cost (X_i)	Mean (X)	X_i-X	$(Xi-X)^2$	$s^2 = (X_i-X)^2/(n-1)$	s
640	271.667	368.333	135669.444		
50	271.667	-221.667	49136.111		
190	271.667	-81.667	6669.444		
180	271.667	-91.667	8402.778		
35	271.667	-236.667	56011.111		
90	271.667	-181.667	33002.778		
215	271.667	-56.667	3211.111		
110	271.667	-161.667	26136.111		
430	271.667	158.333	25069.444		
300	271.667	28.333	802.778		
6	271.667	-265.667	70578.778	86667.933	294.394
9	271.667	-262.667	68993.778		
630	271.667	358.333	128402.778		
550	271.667	278.333	77469.444		
200	271.667	-71.667	5136.111		
200	271.667	-71.667	5136.111		
150	271.667	-121.667	14802.778		
1200	271.667	928.333	861802.778		
40	271.667	-231.667	53669.444		
15	271.667	-256.667	65877.778		
465	271.667	193.333	37377.778		

3.5. P.E.S.T. Analysis

P.E.S.T., like S.W.O.T., is a means of calculating particular factors that the system will affect. The acronym P.E.S.T. refers for political, economic, social, and technical analysis, and it allows researchers to determine how the system will affect all other variables in society, among other things. [19]

3.5.1. Political Analysis

The responsibility of maintaining and protecting a country's resources is entrusted to its governments. With the use of this system, a country may lower the demand on its main power plants, and as the dependency is reduced, more fossil fuel can be preserved, resulting in total fossil fuel conservation. As a result, by choosing this type of power production system, the government will be reducing the weight on the traditional power generation plants.

3.5.2. Economic Analysis

The country's economic position will improve further if the system of continuous electricity generation via footfall is implemented. Electricity rates will be lower when demand from traditional power plants and other generating groups is lowered. As a result, people will be able to focus on other elements of their lives while also contributing to the improvement of the economy.

3.5.3. Social Analysis

The system's deployment will have a favorable influence on society's thinking. People's perceptions of the system will improve since they will be able to assist in power generation (the Kinetic Energy from their footsteps will be transformed to electrical energy). A new feeling of duty and commitment to society may assist the people in having a more positive outlook and being satisfied with the results, and the development in the economy will also considerably enhance the general positivity and circumstances of the society.

3.5.4. Technological Analysis

Piezoelectricity generation is a relatively recent concept. There are nations that use this technology in some form or another, but fully using it as a power generating option might be a game changer. The system is simple to set up, even in a large-scale project, and it is simple to maintain due to the extensive code and database development that had to be considered, and several other things. In brief, technologically, it is simple, cost-effective, and efficient to use, and it requires minimal weekly maintenance.

3.6. Professional Responsibilities

3.6.1. Norms of Engineering Practice

Design standards are moral rules in the field of design. Normative design aims to strike a balance between technological and ethical limitations when it comes to design trade-offs. When designing to such standards, the engineer is forced to evaluate the design's overall influence on the society in which it will be implemented. Engineers' services must be based on honesty, impartiality, justice, and equity, as well as a commitment to the public's health, safety, and welfare. Engineers must adhere to a professional code of conduct that compels them to follow the highest ethical standards.

The IEEE Code of Ethics for Engineers was strictly followed during the project's duration [20]. The first and second codes of ethics were largely observed during project work, out of the ten. The first code of ethics states that “to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment”. The suggested system generally adheres to the first code of ethics since it is concerned with public welfare, and it also adheres to the second code of ethics, which stipulates that “to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems”. The suggested approach is clearly comprehensible for everyone, according to the second code of ethics. The solution also safeguards customers' privacy by combining IoT with a well-established and secure Thingspeak platform, which ensures data privacy. In this project, none of the components or the entire procedure are hazardous to the environment or will cause any environmental harm.

3.6.2. Individual Responsibilities

Different duties or accountabilities are required for a project's overall success. We aim to separate our jobs effectively in our specific project and then blend them in a decorative manner. Individual Responsibilities and roles of our members are listed here:

Mobarak, Bhuiyan Saad Bin

- Investigate and plan the entire project.
- Prepared progress report.
- Chapters 1 and 2 of the thesis book have been completed.
- Prepared a power point presentation slide.

Wasei, S.M.A.

- Hardware implementation and simulation.
- Prepared thesis book chapter 4.

- Accuracy is measured by comparing it to the references.
- Rearranged the contents of the book.

Atif, Rafid Ahnaf

- Chapters 3 of the thesis book are being prepared.
- Research articles and publications have been analyzed.
- The project was propagated by making a survey questionnaire.
- Poster creation.

Haque, T.M. Ehasanul

- Equipment was purchased.
- Prepared a power point presentation slide.
- Chapters 3 of the thesis book are being prepared.
- Prepared summary

3.7. Management Principles and Economic Models

Any large-scale project will necessitate a wide range of form components from a variety of disciplines. As a result, there are various crucial components that must be covered in order to create a great system. S.W.O.T. and P.E.S.T. are two analytical approaches that can help with specific elements, but there are still some points that need to be discussed. In this part, those aspects will be addressed and discussed. Figure 3.1 illustrates the Multidisciplinary Component Management of Piezoelectric Transducers.

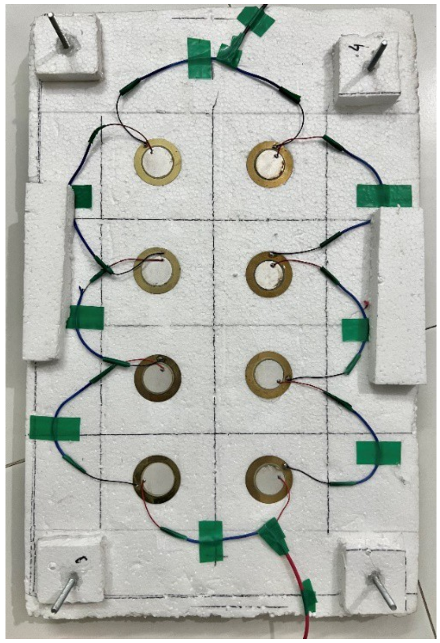

Figure 3.1 Multidisciplinary Component Management of Piezoelectric Transducers

3.7.1. Research on Monitoring

- Arduino UNO, Voltage sensor, Current Sensor installation.
- IOT based monitoring/control approach.

3.7.2. Engineering

- Electrical Design.
- Mechanical Design.

3.7.3. Logistic and Purchasing

- Purchasing of mechanical and electrical component.
- Transportation of power supplies and connection components.

3.7.4. Operational Commissioning

- Commissioning in real time.
- Commissioning of the electrical system.

3.8. Project Cycle

To provide a superior and more understandable overview, the provided cycle should be of great help. Visual representation of Project Life Cycle is shown in Figure 3.2.

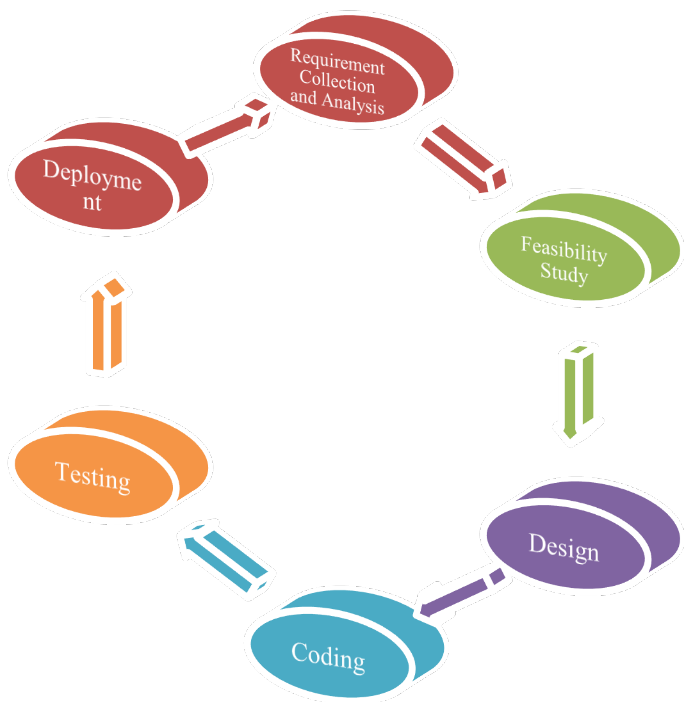

Figure 3.2 Visual Representation of Project Life Cycle

3.8.1. Requirement Study and Design

In this section, a number of further study publications and other literatures will be employed as the foundation for this system. These papers may be used to compare and contrast functionality, operation, and, most importantly, design.

3.8.2. Feasibility Study

After the operation is completed, the entire system's viability must be determined. By doing so, experimenters and investigators will be able to determine if the system is excellent or bad in the long run, as well as estimate the system's cost.

3.8.3. Design

Now that the system seems feasible, the focus shifts to the designing part. In that part, a fully operational and efficient system will be formulated

3.8.4. Coding

After the design part, in order to improve the functionality and keep records of the data, many coding systems will be implemented.

3.8.5. Testing

When the designing and testing procedures are over, it's time to verify and see if the system is performing as it should. In other words, during the testing phase, it will be determined whether the system is capable of producing the desired outcomes and functionality.

3.8.6. Deployment

In this phase, we will setup or deploy our suggested project to our different spots to test how our offered solution performs in practice.

3.9. Summary

Under this chapter, we offered the numerous management schedules for the project life cycle in a variety of formats. That section also provides us with a detailed description of the pricing of our solution, which will allow us to readily distinguish our project from standard gadgets. As a result, it is an excellent moment to replace the old system and launch a user-friendly utility service. We also demonstrate numerous implementation viewpoints of our proposal, such as political, economic, social, and technological aspects. And the life cycle of our proposed solution will assist us in properly implementing our project.

Chapter 4

METHODOLOGY AND MODELING

4.1. Introduction

In this chapter, the whole methodology of designing and building model of power generation using piezoelectric with the help of IOT is discussed. The mechanism of the system of this footstep power production is described in this chapter using a theoretical equation and a block diagram. Modeling is the process through which the project system has physical form and is rendered in 3D.

4.2. Block Diagram and Working Principle

4.2.1. Block Diagram

The proposed systems' block diagram is discussed here as well as the current systems' block diagram is explained. The block diagram of proposed system is like a closed-loop system. It does not take any outside assistance. Once implemented, the system will be running without any help from outside. So, it can be called as a never-ending process. Figure 4.1 shows the proposed systems' block diagram.

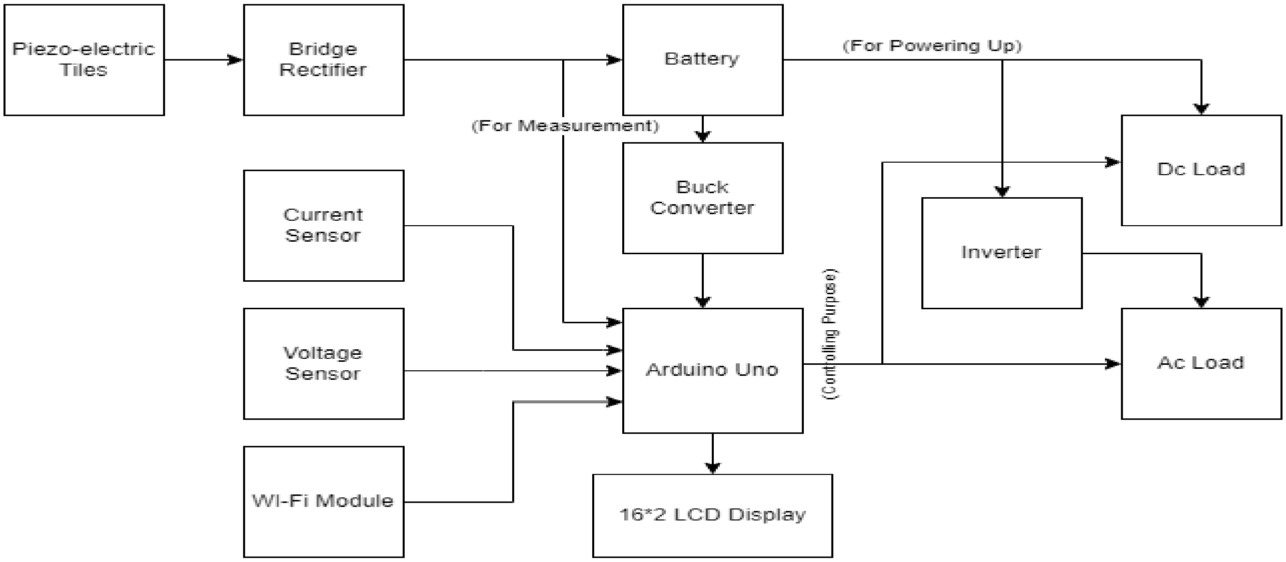

Figure 4.1 Block Diagram of Proposed System

As a prototype system is being made, so the complete proposed systems' idea could not be followed due to some limitations like feasibility, efficiency and financial issues. In the prototype system a current sensor could not be implemented for some major issues. Following the Arduino Micro-controller has a limited load usage. When connecting the current sensor to the micro-controller board it was not able to read any current data from the micro controller, as the Piezo-electric Power Generating system is not a static power generation system. Current will be only produced when pressure is being applied above the piezo-electric tiles. So, this kind of variation in current generation could not be read by the current sensor while being connected to a constant load. Again, in this prototype, the micro controller is being power by an external power source like Power-bank or another Battery or from desktop, as the used storage battery for storing the chargers that are being produced from the piezo-electric transducers, has an input voltage capacity of 12 voltages. In future, these kinds of drawbacks can be terminated by using a more efficient, rich and sustainable system. Block diagram of actual prototype designed system is shown in Figure 4.2.

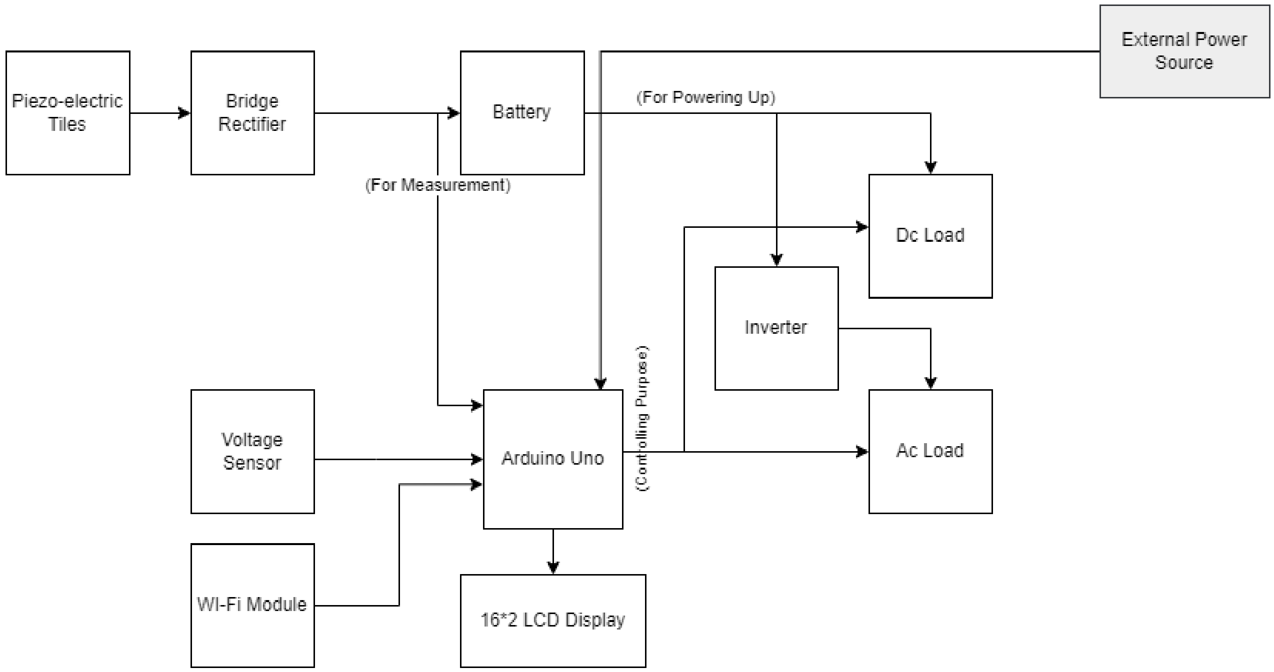

Figure 4.2 Block Diagram of Actual Prototype System

4.2.2. Working Procedure

The project's goal is to create a low-cost, environmentally friendly power production system that is smarter than a traditional system module. The piezoelectric is the primary power source in this case, which may be established by applying external pressure (Footstep). When we walk on the piezoelectric, the kinetic energy of that individual is turned into electrical energy, which is used to generate alternating current (AC). A battery is required because we must store energy. A battery, on the other hand, can only be charged by a direct current source (12V rechargeable battery) (constant power). As a result, a complete bridge rectifier (KBPC3510) is employed to convert alternating current (AC) to direct current (DC). The 12V rechargeable battery is used to power up the Arduino Uno, and the power created by the piezo-electric (Footstep) may be kept in this battery, allowing us to use the power whenever it is required to power on any load. Because the Arduino Uno requires a continuous 5V (DC), we utilized a buck converter to reduce the output voltage from 12V to 5V. (over power consumption harmful for Arduino Uno). Figure 4.3 shows the actual graphical representation of the proposed designed system.

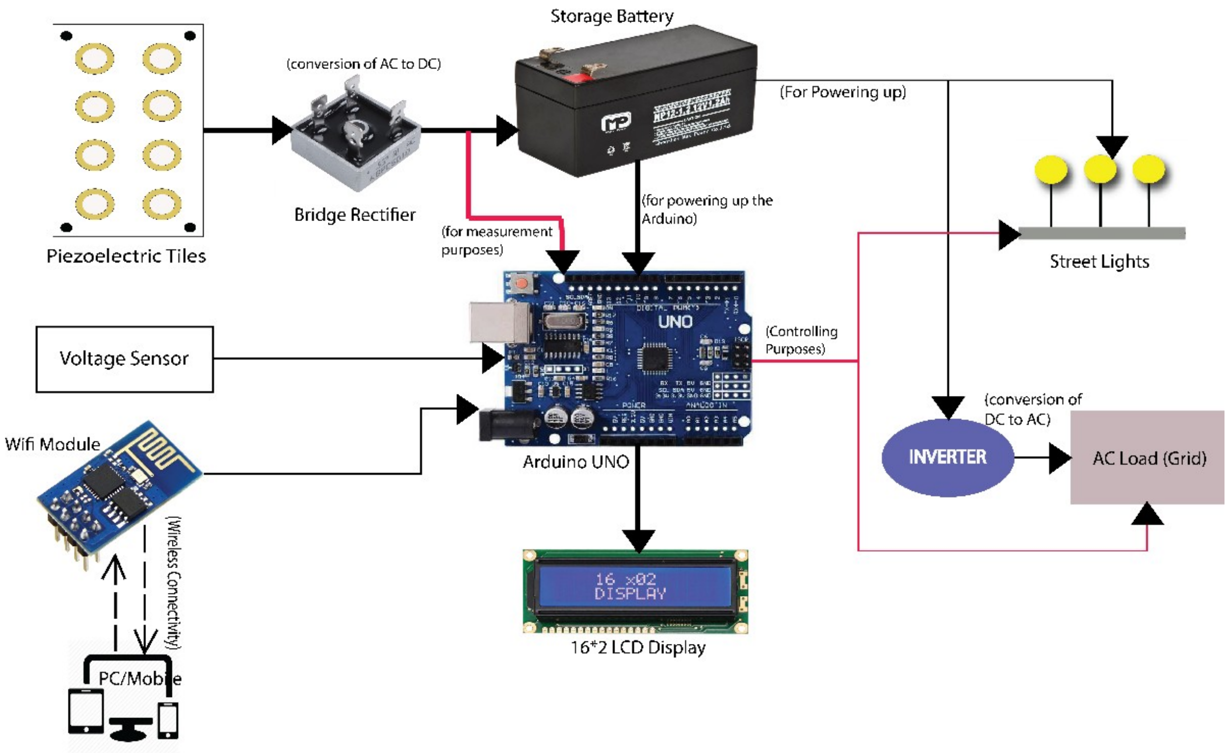

Figure 4.3 Graphical Representation of the Proposed System

The Arduino Uno is utilized as a switch to control the other components in this example. Different types of sensors, such as a voltage sensor and a current sensor, are linked to an Arduino Uno to measure power. We utilized a 16*2 LCD panel to acquire information including what electricity is generated or used, as well as other information. Because the project is IoT-based, we also required a Wi-Fi module that is linked to the Arduino Uno. To powering on the load at the ending of a battery, two options are provided: DC load or AC load. As a result, an inverter is utilized to convert dc electricity to alternating current power. As a result, this sustainable, low-cost power generating system may be utilized to power any sort of load.

4.2.3. Project Work Flowchart

The flow chart depicts the project's whole workflow. To build the suggested IoT-Based Smart Street Light Control with Piezoelectric Energy Source, the project's needs will be carefully studied first. The specifications of the essential hardware and software components will be finalized based on it. The circuit's schematic diagram will be constructed next. For this, Proteus software will be utilized.

Arduino will be used to process the data. Proteus software will then be used to model the circuit. Following that, the circuit will be built and tested in the lab.

Firstly, the power generation part will be analyzed through a simple flow chart. Here, how the data from the achieved power by the Piezo-electric transducers is simply processed to the micro-controller is shown. Lastly, the correct data in real time in shown in the Display, processed by the microcontroller. Figure 4.4 illustrates the flow chart of the Piezo-electric power generation system.

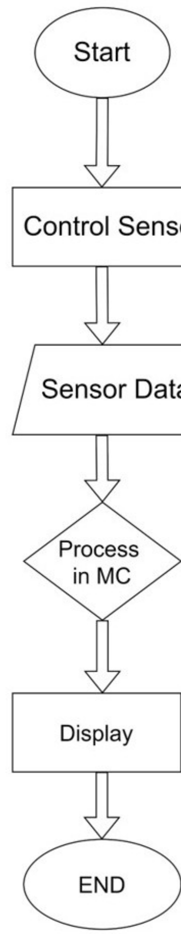

Figure 4.4 Flow Chart for the Piezo-electric power generation system

Secondly, the data processing in the IoT purposes will be studied via a data flow diagram. In this data flow diagram, how the data from the system can be sent via internet and how the data can be seen from anywhere, is given. Figure 4.5 shows the data flow diagram of the designed system.

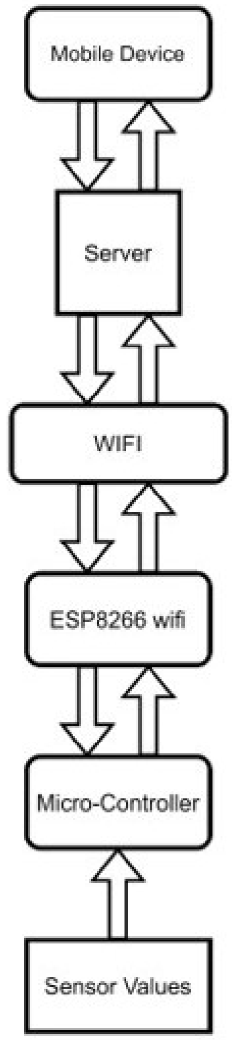

Figure 4.5 Data Flow Diagram

Finally, the complete system is shown below through a complete flow diagram. The following Figure 4.6 shows the overall methodological module of our IoT based Piezo-electric power generation.

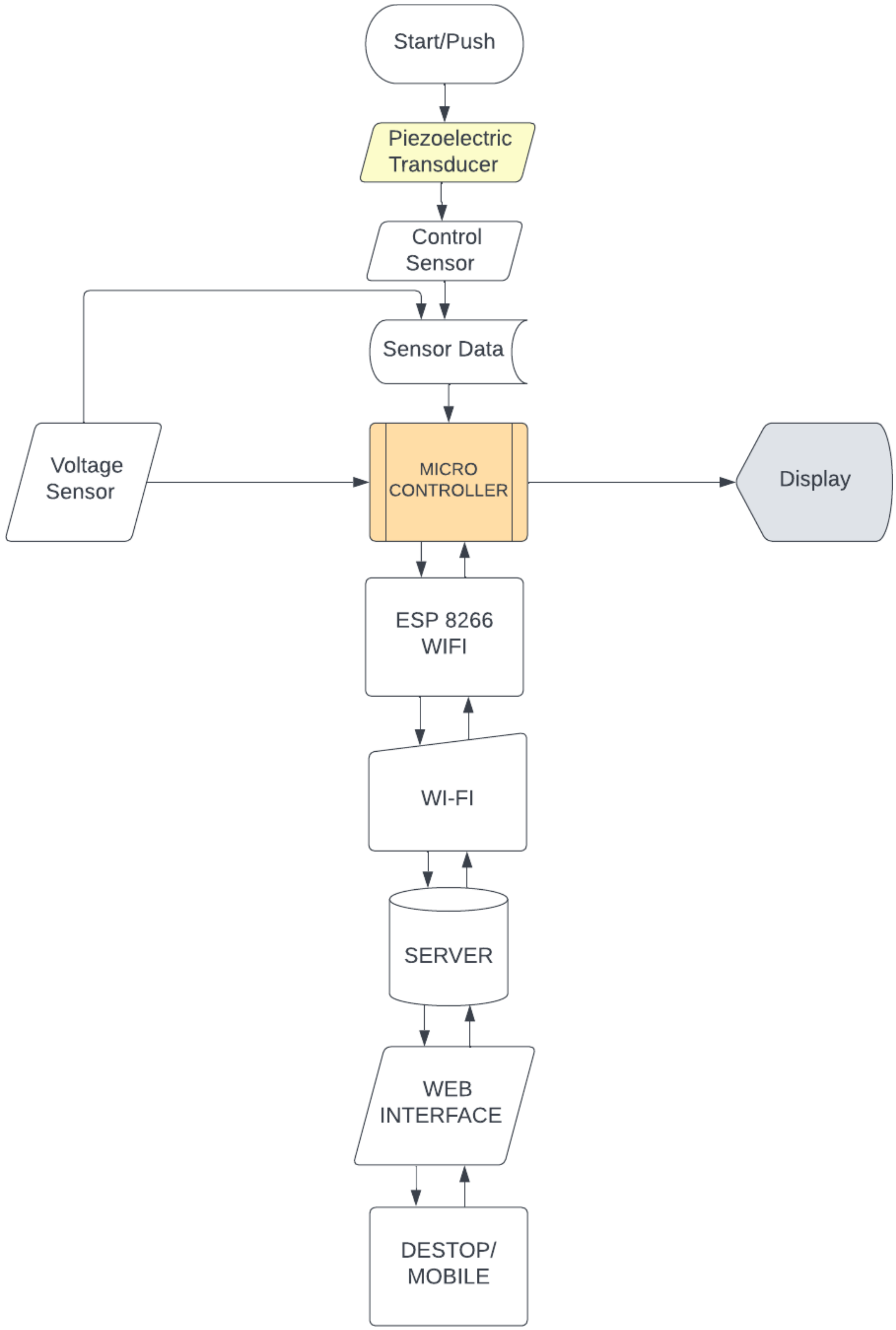

Figure 4.6 Flowchart of the Project

4.3. Modeling

The section gives a comprehensive overview and analysis of how Piezo electronics and human footfall can be utilized to create energy consistently. This chapter will contain all pertinent material, such as equations, flowcharts, and theories, to ensure a thorough grasp of the complete system. Later on, a model component will be included to create a more accurate picture of the system, allowing for a better understanding of how it functions.

4.3.1. Piezoelectric Power Generator

The Piezo turns the pressure of human footsteps into electrical energy. Piezoelectricity is the formation of an electric potential in some materials as a result of mechanical stress, such as bending, stretching, or compressing. The materials that display these properties are known as piezoelectric materials. When the electric charge domains in a piezoelectric material are moved by stress, the piezoelectric effect occurs. Due to the weight of the human, the platform is pushed to compress the Piezo material, causing a negative and positive charge imbalance inside the structure. Because of the charge imbalance, an electric field is generated as a result of the transmitted pressure, causing a current to flow. Figure 4.7 illustrates a 2-D Architecture Map of Piezoelectric Power Generator Model.

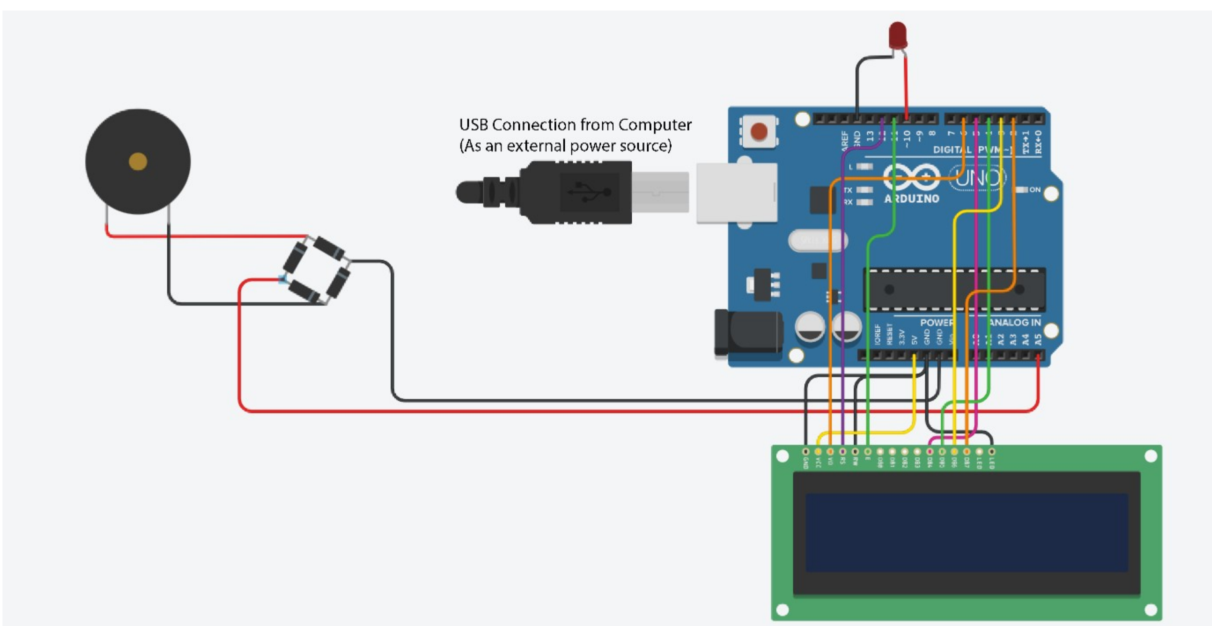

Figure 4.7 2-D Architecture Map of Piezoelectric Power Generator Model

This model mainly emphasizes on how truly power is being generated by piezoelectric transducers. Here a bridge rectifier is used to convert the generated AC voltage to DC. Then it is connected to Arduino Uno for further measurements and controlling of the load.

4.3.2. IoT Based Smart Load Control

In the modern era, almost everything is integrated with Internet. To make the project more reliable and convenient, the Internet of Things (IoT) was used to aid. For analyzing real time data and controlling the load in real time and from anywhere IoT is surely a great aspect. To make the use of IoT, a nodemcu is used. Here NodeMCU ESP8266 Lua V2 is implemented for the wireless connection purposes. Then the Wi-Fi module is connected to the Arduino Uno for synchronizing data via wirelessly and controlling the load (in this case: streetlamp) via internet. For this purpose, a subjective interface was built [21].

4.4. Software Module

In order to run the entire system, few other components where needed. These components did not deal with the hardware, rather they dealt with the software portion of the entire project.

4.4.1. Arduino IDE

Various software-related programs were loaded in the Arduino, which was connected to a Wi-Fi module and other system components. The code for various functions was examined in the Arduino UNO provided by the Arduino Company in order to assess the system's accuracy, guaranteeing that the system provides the best and most efficient functioning.

4.4.2. Thingspeak

ThingSpeak is a cloud-based IoT analytics tool for aggregating, visualizing, and analyzing real-time data streams. It allows users to issue alarms, submit data from devices, and view real-time statistics.

In this project, information is collected from our device and the data is pushed to cloud like how many voltages is generated per step or per day. As well as the device can be controlled; it can be switched on or switched off.

4.5. Summary

The development curves of humans and technology are becoming increasingly parallel as time passes. Humans invent new ways, laws, scientific discoveries, and technological advancements every day. So, with all of the equipment and information at our disposal, we can build a system that will assist us in becoming self-sufficient. Using this strategy, the requirement for additional renewable and non-renewable resources may be decreased, allowing for the conservation of various energy sources. The chapter provides the readers with expert information and specifics about the technique, experimentation, and how the overall project turned out in the end.

Chapter 5

PROJECT IMPLEMENTATION

5.1. Introduction

The current global crisis for major energy supplies has resulted in a significant increase in the expense of intangible energy sources. As a result, there is an increasing desire to find cleaner solutions to power the globe and reduce greenhouse gas emissions. There is no better way to deal with the current difficult situation than to search for renewable energy options.

The economy is growing per annum that's means the energy demand is increasing. "IoT-Based Smart Street Light Control incorporating Piezoelectric Energy Source" will play a critical role in supplying power without interruption, without causing harm to the overall system, and in reducing surplus electricity wastage. We're going to talk about the System in this chapter. Hardware implementation is far more difficult than project design and creation. Implementation is an important part of presenting a desired outcome for the entire project. Implementing the project for the Covid-19 pandemic scenario has grown more difficult than previously. We, on the other hand, have a tendency to do it. Let's have a discussion about it.

5.2. Required Tools and Components

- Piezo Element 35mm
- Arduino UNO R3
- KBPC Bridge Rectifier
- Buck Converter LM2596 Step Down
- Current Sensor ACS712 30A
- Voltage Sensor Module DC 0-25V
- NodeMCU Lua V2 ESP8266 Wi-Fi
- 16 x 2 LCD Display
- 12V Rechargeable Battery

- Potentiometer

5.2.1. Piezo Element 35mm

Ferroelectric materials include piezoelectric ceramics. Without the application of an electric field, ferroelectric materials are polar crystals. Piezoceramics such as PbTiO3, PbZrO3, PVDF, and PZT are known to have a piezoelectric effect. The piezoelectric material is the most important component of the project. It is critical to select the right piezo material. To accomplish so, an examination of the two most widely accessible piezoelectric materials - PZT and PVDF - was performed to establish which was the most suited. Better output voltage at varied pressures applied was the criterion for selection. The V-I characteristics of each material, namely PZT and PVDF, were plotted in order to comprehend the output corresponding to the various applied forces. The material under test for the Piezo transducer is put on a Piezo force sensor for this. When someone wants to detect vibration or a knock, piezo components come in helpful. By monitoring the voltage on the output, they may be rapidly used as tap or knock sensors. They can also be used to power a small acoustic transducer like a buzzer. Piezo components will be required to sense vibration or a knock. By monitoring the voltage on the output, they may simply be used as tap or knock sensors. They can also be used to power a small acoustic transducer like a buzzer. This pivotal Piezo Element has a diameter of 35mm and works well as a vibration sensor. Measuring the voltage throughout the two wires by attaching the round disc to the item that will be banged on, such as a door. When a voltage is put across a piezo element, it can create sound. Figure 5.1 shows a Piezo Element Ceramic.

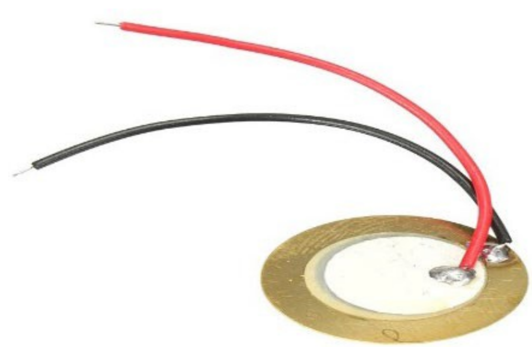

Figure 5.1 Piezo Element 35mm [22]

5.2.2. Arduino UNO R3

Arduino is an open-source computer hardware and software company, project, and user community that designs single-board embedded systems and micro - controller kits for building digital devices and interactive objects that can sense and control objects in both the physical and the digital. This same program's hardware and software are available as open-source hardware and software under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), allowing anybody to make Arduino boards and distribute software. Commercially available Arduino boards are either preassembled or sold as DIY kits. A wide range of microprocessors and controllers are used in Arduino board designs. The boards provide digital and analogue input/output (I/O) pins that may be used to connect to expansion boards, breadboards (shields), and other circuits. Serial communications ports, including Universal Serial Bus (USB) on some variants, are also included on the boards, which are used to load applications from personal computers. Microcontrollers are often programmed using a dialect of C and C++ programming features. The Arduino project includes an integrated development environment (IDE) based on the Processing language project, in addition to standard compiler technology in the context. The Arduino project started in 2003 as a class for students at the Interaction Design Institute Ivrea in Ivrea, Italy, with the goal of providing a low-cost and simple solution for beginners and experts to design devices that interact with their surroundings using sensors and actuators. Simple robots, thermostats, and motion detectors are all common examples of such gadgets aimed at beginning enthusiasts. 11 Arduino is named after a pub in Ivrea, Italy, where some of the project's founders used to gather. Arduino of Ivrea, the margrave of the March of Ivrea and King of Italy from 1002 to 1014, was honored with a bar named after him. The Arduino UNO is a microcontroller board that uses the ATmega328P microprocessor. There are 14 digital input/output pins (six of which may be used as PWM outputs), six analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power connector, an ICSP header, and a reset button on this board. It comes with everything you'll need to get started with the microcontroller; simply connect it to a computer by USB or power it with an AC-to-DC converter or battery. Someone can dabble with UNO without being concerned about making a mistake. In the worst-case situation, the chip can be replaced for a few bucks and the game can be restarted. For electronics and coding, the Arduino UNO is the ideal board. The UNO is the sturdiest board to start with if this is someone's first time working with the platform. Furthermore, among the whole Arduino family, the UNO is the most widely used and documented board. An Arduino UNO R3 board is shown in Figure 5.2.

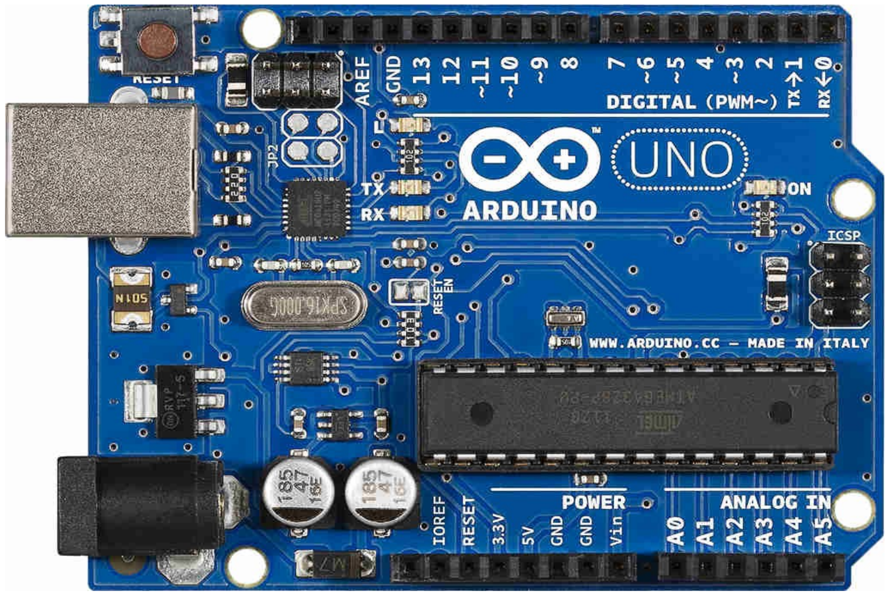

Figure 5.2 Arduino UNO R3 [23]

5.2.3. KBPC Bridge Rectifier

KBPC5010 is a 50A 1000V rectifier bridge. It is a single-phase silicon bridge rectifier with a reverse voltage of 50 to 1000V, 50.0A. A bridge rectifier, or KBPC5010, is a set of electrical components used in most voltage sources. The bridge is made up of four diodes coupled in a certain pattern, and its purpose is to convert alternating current to direct current.

The KBPC5010 bridge rectifier has the following features:

- Housing made of metal

- Diode type: bridge rectifier

- Bridge type: a phase

- 1000 V maximum driving voltage

- 50 A maximum driving current

- Inverse voltage peak: 1 kV

- Vf (direct voltage) (max.) If: 1.1 volts @ 25 amps

- Voltage converter (AC/DC)

- Operating temperature range: -55 to 150 degrees Celsius

- KBPC square metallic encapsulating

- There are four pins in all.

- Pin size: 6.35 mm Faston

- Dimensions: 2.8x2.8x1.1 cm

Figure 5.3 shows a KBPC bridge rectifier.

Figure 5.3 KBPC Bridge Rectifier [24]

5.2.4. Buck Converter LM2596 Step Down

The LM2596 Power Supply is a DC-DC Buck Converter Step Down Module with outstanding line and load control capable of driving a 3-A load. Fixed output voltages of 3.3 V, 5 V, and 12 V, as well as an adjustable output version, are available for these devices. Furthermore, because the LM2596 series operates at a switching frequency of 150kHz, it is possible to use smaller filter components than with lower frequency switching regulators. Specifications for the LM2596 Power Supply DC-DC Buck Converter Step Down Module:

- Conversion efficiency: 92 percent (highest)

- Switching frequency: 150 kHz

- Maximum output ripple: 30 mA9

- Load Regulation: ± 0.5 percent

- Voltage Regulation: ± 0.5 percent

A buck converter model is shown in Figure 5.4.

Figure 5.4 Buck Converter LM2596 Step Down [25]

5.2.5. Current Sensor ACS712 30A

The ACS712 is a hall effect-based linear current sensor with 2.1kVRMS voltage isolation and an integrated low-resistance current conductor that is fully integrated. It is described as a current sensor that calculates and measures the applied current using its conductor. An accurate, low-offset linear Hall circuit with a copper conduction route near the die's surface makes up the ACS712 Current Sensor Module with a 30A range. The Hall IC turns a proportional voltage into a magnetic field created by applied current flowing through this copper conduction route.

The features:

- 80kHz bandwidth
- 66 to 185 mV/A output sensitivity
- Low-noise analog signal path
- Device bandwidth is set via the new FILTER pin
- 1.2 mΩ internal conductor resistance

- Total output error of 1.5% at TA = 25°C
- Stable output offset voltage.
- Near zero magnetic hysteresis

Figure 5.5 shows a current sensor.

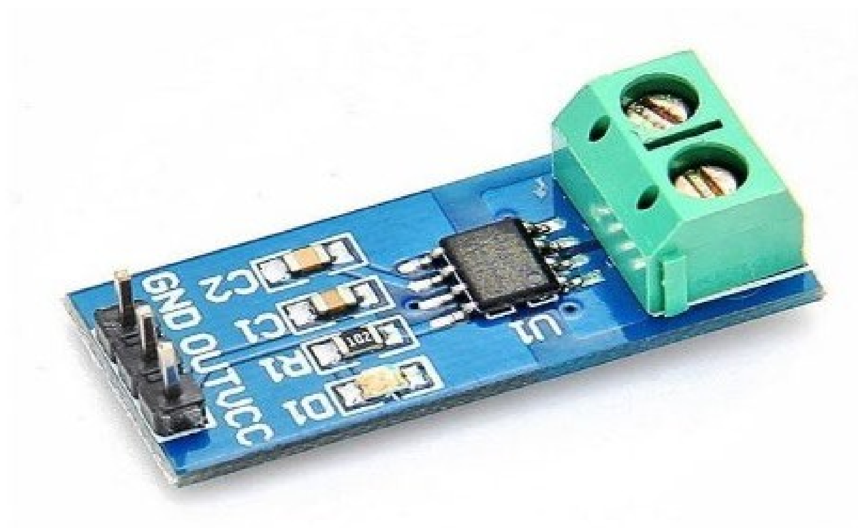

Figure 5.5 Current Sensor ACS712 30A [26]

5.2.6. Voltage Sensor Module DC 0-25V

The voltage sensor module is a resistive voltage divider circuit-based 0-25 DC voltage sensing device. It creates a matching analog output voltage by reducing the input voltage signal by a factor of 5. The Voltage Detection Sensor Module 25V is based on the principle of resistive voltage divider construction, and it can reduce the input voltage to the red terminal connection by 5 times. Analog input voltages of up to 5 volts on the Arduino. The voltage detector module must have an input voltage of no more than 5V x 5 = 25V (or 3.3V x 5 = 16.5V if utilizing 3.3V systems).

It is limited to Arduino analog inputs with a maximum voltage of 5 VDC. So, it is wanted to detect larger voltages, it will have to use a different method. A voltage divider is one option. A 30k and 1 7.5k ohm resistor are used to create a 5:1 voltage divider. Figure 5.6 shows a voltage sensor.

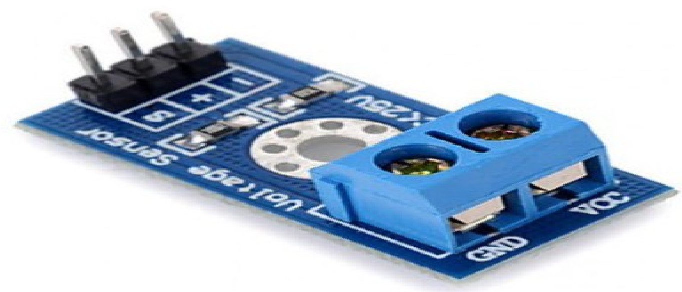

Figure 5.6 Voltage Sensor Module DC 0-25V [27]

5.2.7. NodeMCU Lua V2 ESP826 Wifi

IoT applications are on the increase these days, and linking items is becoming increasingly vital. Objects can be connected in a variety of ways, including using the Wi-Fi protocol. NodeMCU is an open-source firmware and development board that allows users to prototype an IoT device with just a few lines of Lua script. The board is built on the ESP8266 Wi-Fi chip, which has 10 GPIO and 1 ADC input. As a result, the process of designing IoT applications is sped significantly. NodeMCU is an open-source platform based on the ESP8266 that uses the Wi-Fi protocol to link things and send data. Furthermore, giving some of the most important microcontroller capabilities, such as GPIO, PWM, ADC, and so on. It is capable of meeting many of the project's requirements on its own.

The general features of this board are as follows:

- Simple to use
- Programmable with the Arduino IDE or IUA languages
- Can be used as an access point or station
- Can be used in Event-driven API applications
- The presence of an internal antenna
- Features 13 GPIO pins, 10 PWM channels, I2C, SPI, ADC, UART, and 1-Wire communication.

An IoT module NodeMCU is shown in Figure 5.7.

Figure 5.7 NodeMCU Lua V2 ESP826 Wi-Fi [28]

5.2.8. 16 x 2 LCD Display

The term LCD stands for liquid crystal display. It is a type of electronic display module that is utilized in a wide range of circuits and devices such as mobile phones, calculators, computers, television sets, and so on. Multi-segment light-emitting diodes and seven segments are the most common applications for these displays. The primary advantages of utilizing this module are its low cost, ease of programming, animations, and the fact that there are no restrictions on displaying unique characters, special and even animations, and so on. A 16x2 LCD display is a basic module that may be found in a variety of devices and circuits. A 16x2 LCD can display 16 characters per line, and there are two lines in total. The 224 distinct letters and symbols may be shown on the 16 x 2 intelligent alphanumeric dot matrix display. LCD 162 stands for Liquid Crystal Display, which is a flat panel display technology used in computer monitors and televisions, smartphones, tablets, and other mobile devices. Both LCD and CRT screens have the same appearance, yet they operate differently. A liquid crystal display features a backlight that gives light to each pixel in a rectangular network instead of electron diffraction at a glass panel. A 16*2 LCD display can be shown in Figure 5.8.

Figure 5.8 16*2 LCD Display [29]

5.2.9. 12V Rechargeable Battery

A rechargeable battery, accumulator, or electric cell (or archaically accumulator) is a type of electrical battery that can be charged, discharged into a load, and recharged several times, as opposed to a disposable or main battery, which is charged once and then discarded. It's made up of one or more chemical science cells. Because it gathers and stores energy through a reversible chemical chemistry process, the word "accumulator" is used. From button cells to power unit systems coupled to stabilize an electrical distribution network, reversible batteries are available in a variety of forms and sizes. Lead-acid, zinc-air, nickel-cadmium (NiCd), nickel-metal binary compound (NiMH), lithium-ion (Li-ion), atomic number 3 Iron Phosphate (LiFePO4), and lithium-ion compound are only a few of the many combinations of conductor materials and electrolytes employed (Li-ion polymer). Figure 5.9 shows a rechargeable battery.

Figure 5.9 12V Rechargeable Battery [30]

5.2.10. Potentiometer

A potentiometer is a voltage divider that consists of a three-terminal resistor with a sliding or revolving contact. Potentiometers are often used to operate electrical devices, such as audio equipment volume controls. The potentiometer has three terminals, two of which are fixed and one of which is changeable. The potentiometer's two fixed terminals are attached to both ends of the track resistive element, while the third terminal is connected to the sliding wiper. The resistance of the potentiometer is varied by a wiper that slides along the resistive element. When the wiper is moved across the resistive path, the resistance of the potentiometer changes. Figure 5.10 shows a potentiometer

Figure 5.10 Potentiometer [31]

5.3. Implemented Models

The main objective of the planned project is to implement the hardware system as well as for the simulation.

5.3.1. Simulation Model

Figure 5.11 demonstrates the primary circuit diagram for the prototype system. Here, the circuit was designed in Proteus 8 software. For the circuit design, 8 Piezo-electric transducers were used. They were connected to a bridge rectifier (made of 4 diodes) for conversion from AC to DC. Then a connection is being made to the Arduino Uno for reading data (step count, voltage readings). Then a 16*2 display is used to show that data in real time. For IoT purposes NodeMCU ESP8266 module is being connected to the Arduino Uno. For reading the actual voltage, a generic voltage sensor was developed using some basic components like resistors, capacitor and diode. In voltage sensors, the measurement is based on a voltage divider.

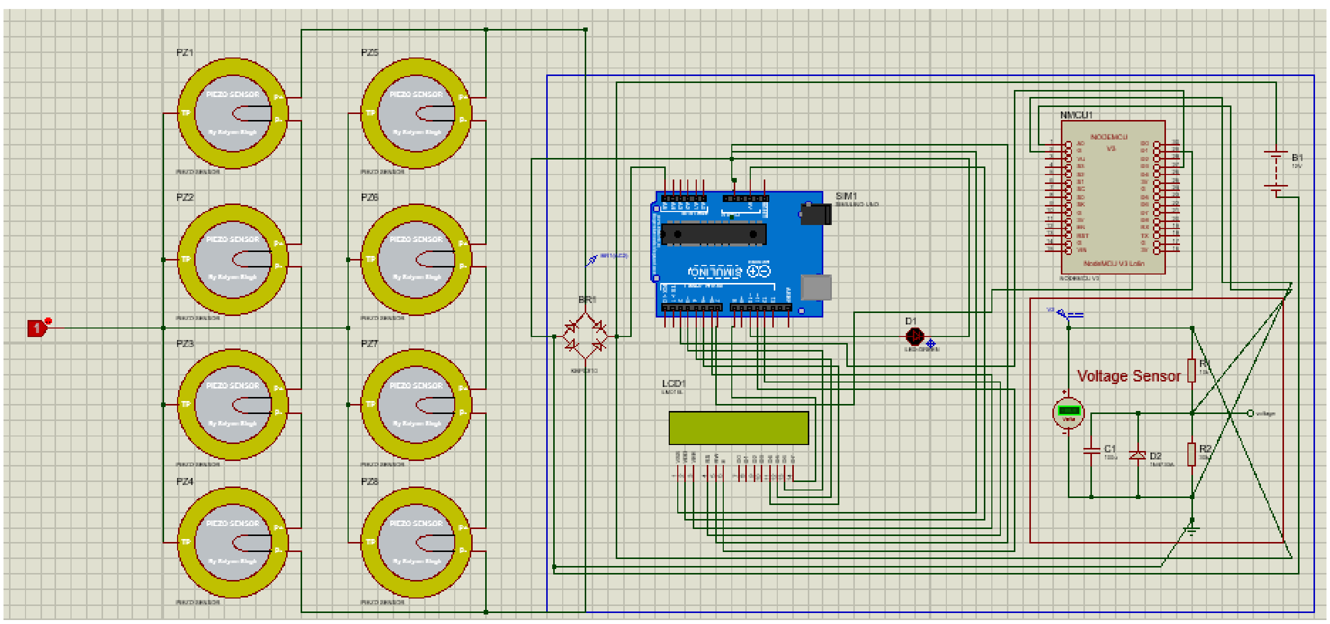

Figure 5.11 Circuit Diagram for the Prototype System

5.3.2. Hardware Model

Figure 5.12 illustrates how the project prototype looks like after hardware implementation. Here a voltage sensor is connected to the Arduino, and the bridge-rectifier is connected to the Piezo-electric Tiles. This voltage sensor communicates with the Arduino Uno. A 16*2 LCD Display is connected to the Arduino Uno for seeing the data in real time. Then battery is kept alongside the piezo-electric tiles for storing the power from Piezo-electric transducers. Then from the Tx and Rx of microcontrollers to the Node MCU. The outcome is sent to Thingspeak, where the data may be seen via a web interface on a mobile or desktop device.

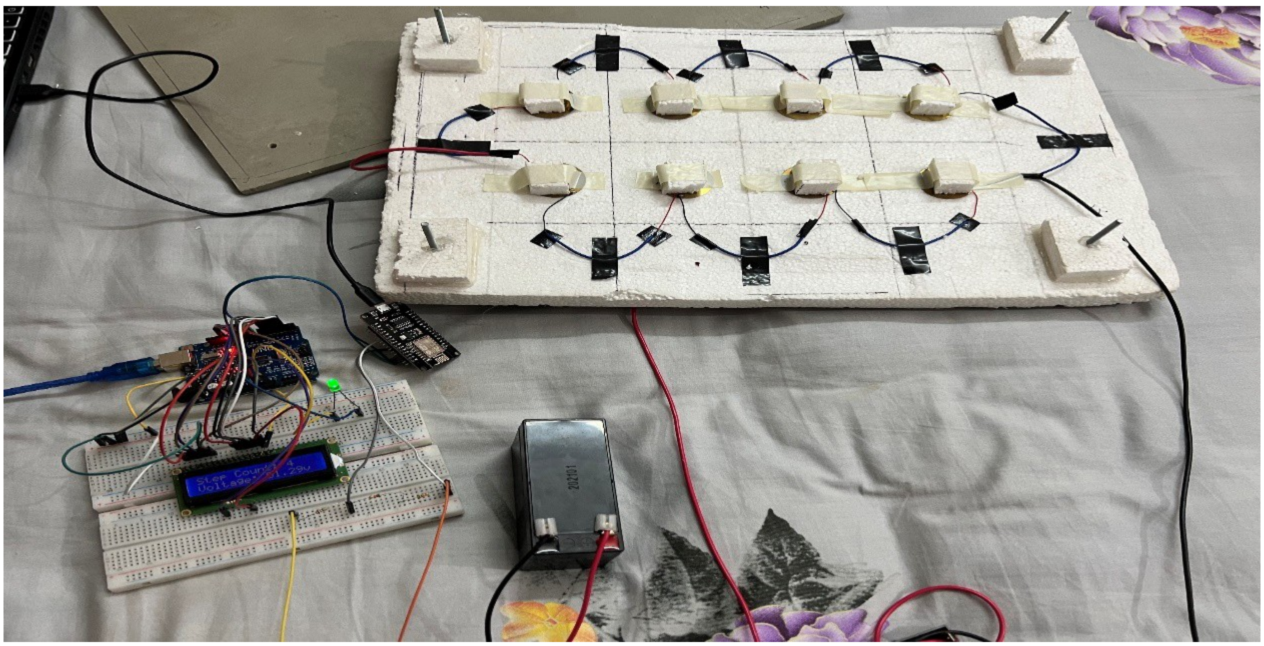

Figure 5.12 Hardware Implementation of Prototype

For arranging the Piezo-transducers, we used 8 piezo elements. 2 parallel connections were made between 4 series connected Piezo-elements. The arrangement of the Piezo-electric transducers in a tiles is demonstrated below as graphical representations.

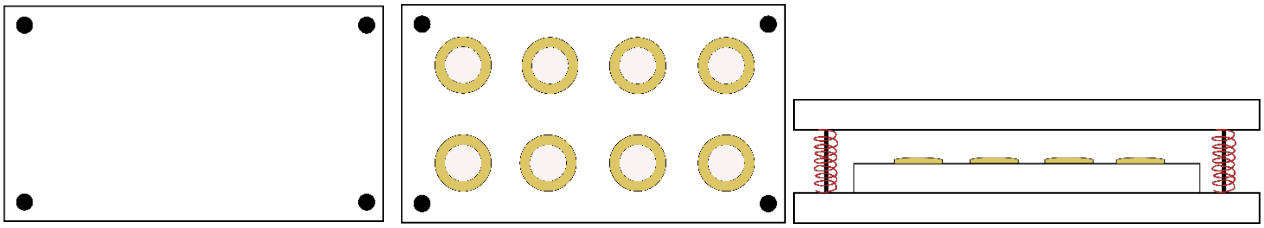

Figure 5.13 Piezo-Electric Transducers arrangement in a tile; following Front, Inside and Side View

5.4. Summary

This chapter explains the overall system as well as the hardware implementation of the major system components of the IOT-controlled footstep power generating system. This chapter has outlined all of the rules pertaining to equipment and their connections in a concise manner. The rule that is linked to footage aids in the appropriate execution of the project. So, in some way, this effort accomplished the stated purpose.

Chapter 6

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

6.1. Introduction

The completion of a project necessitates the completion of a result analysis. The success or failure of a project is frequently determined by the project's outcomes. The outcomes of our experiment are presented and assessed in this chapter. "IoT-Based Smart Street Light Control with Piezoelectric Energy Source" is what we usually do. Various parameters such as efficiency, gain, and all the other important parameters that must be analyzed are represented in this chapter. Case studies are also being prepared in order to better understand the initiative in practice. In a word, this chapter has covered the key summary.

6.2. Result Analysis

Some necessary calculations are shown briefly below to understand how the project works. Simulation and Hardware implementation results are also analyzed. Some case studies will also be studied to understand the actual working functionality of the project.

6.2.1. Power Calculation

People whose weight varied from 70 to 90 kg were made to walk on the piezo tile to test the voltage generation capacity of the Piezo tile. The adjoining observations were made.

A graph of Power generation at different weights is shown in Figure 6.1

Figure 6.1 Power Graph based on different weights

Statistically, maximum voltage of 14V is generated across the tile, when a weight of 80 kg is applied on the tile. And the current was measured maximum 0.025 A.

Thus, Power, P = V * I

= 14V * 0.0025 A

= 0.035 Watts

6.2.2. Battery Charging Calculation

Here, a 12V 1.3Ah Universal Sealed Rechargeable Lead Acid Battery was used.

*** It should be kept in knowledge that; the below calculation is only based on a single piezo-electric tile consists of 8 piezo-electric transducers. Basically, how much time is required to charge a 12V 1.3Ah rechargeable battery from a single piezo-electric tile (from a single foot-step); is shown below ***

Here is the formula of charging time of a lead acid battery.

Charging time of battery = Battery Ah / Charging Current

T = Ah / A

Where,

T = Time (in hours)

Ah = Ampere Hour rating of battery
A = Current (in Ampere)

Charging time for 1.3Ah battery = 1.3 ÷ (0.0025) = 520 Hrs.

But this was an idea case…

Practically, it has been noted that 40% of losses occurs in case of battery charging.

Then 1.3 x (40 ÷ 100) = 0.52 …… (1.3Ah x 40% of losses)

Therefore, 1.3 + 0.52 = 1.82 Ah (1.3 Ah + Losses)

Now Charging Time of battery = Ah ÷ Charging Current

Putting the values;

1.82 ÷ 0.0025 = 728 (in real case)

So, in real life total 728 hours are required to charge a battery if **a single footstep** is applied on **a single piezo-electric tile**.

*** If we consider **10 piezo-electric tiles**, and **average footstep counts 10** on per tile ***

[728 / (10*10)]

= 7.28 hours required to charge a 12V 1.3Ah rechargeable lead-acid battery

6.2.3. Results from Simulation

The simulation was done in Proteus 8 software. For the simulation 8 piezo-electric transducers were taken and they were connected in series-parallel connection. From the simulation, it can be seen that, a 16*2 LCD display is connected to the Arduino Uno board. From the display, total step count, voltage, current and power generation amount can be seen in real time. Whenever there is a pressure applied above those transducers, a Green LED will be turned on and display will show the above-mentioned parameters. Figure 6.2 and 6.3 illustrates the Simulation for the Power generation part from Piezo-electricity.

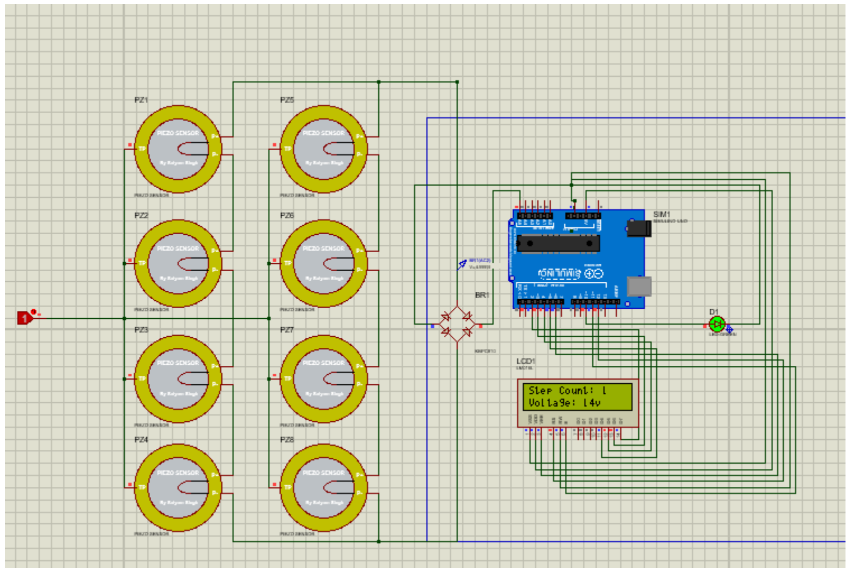

Figure 6.2 Simulation for the Power generation part from Piezo-electricity (a)

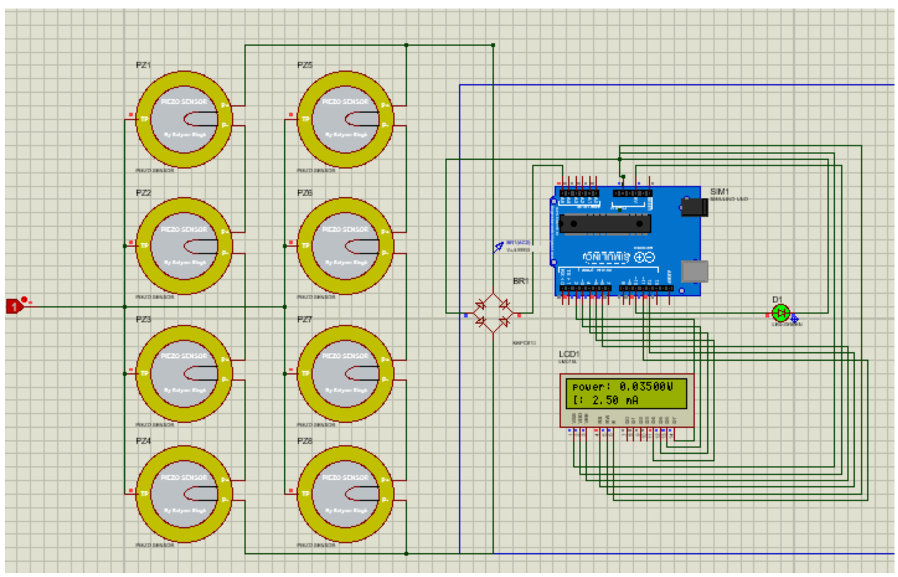

Figure 6.3 Simulation for the Power generation part from Piezo-electricity (b)

From the above simulation, pictures it can be seen that, whenever there is a pressure, the display will show the step count and voltage generated; and in figure 6.2 from the display, **STEP COUNT: 1** and **Voltage: 14V**.

In figure 6.3, it can be seen from the display that; **Power: 0.035 Watts and Current I: 2.5miliA.**

6.2.4. Results from Hardware

Here is the result after implementing the hardware part for just Piezo-Electricity Power Generation. After pressure being applied above the piezo-electric tiles, the 16*2 display will show the step count, and the amount of voltage generated as well as the current and power generation amount. It basically shows the data with the help of Arduino UNO. Here Arduino Uno reads the data and send it to the display. Again, whenever a step is being put on the tile, the green LED will be turned on as an indication that, the power generation part really works. Figure 6.4 shows the Hardware implementation results for Piezo-Electric Power Generation part.

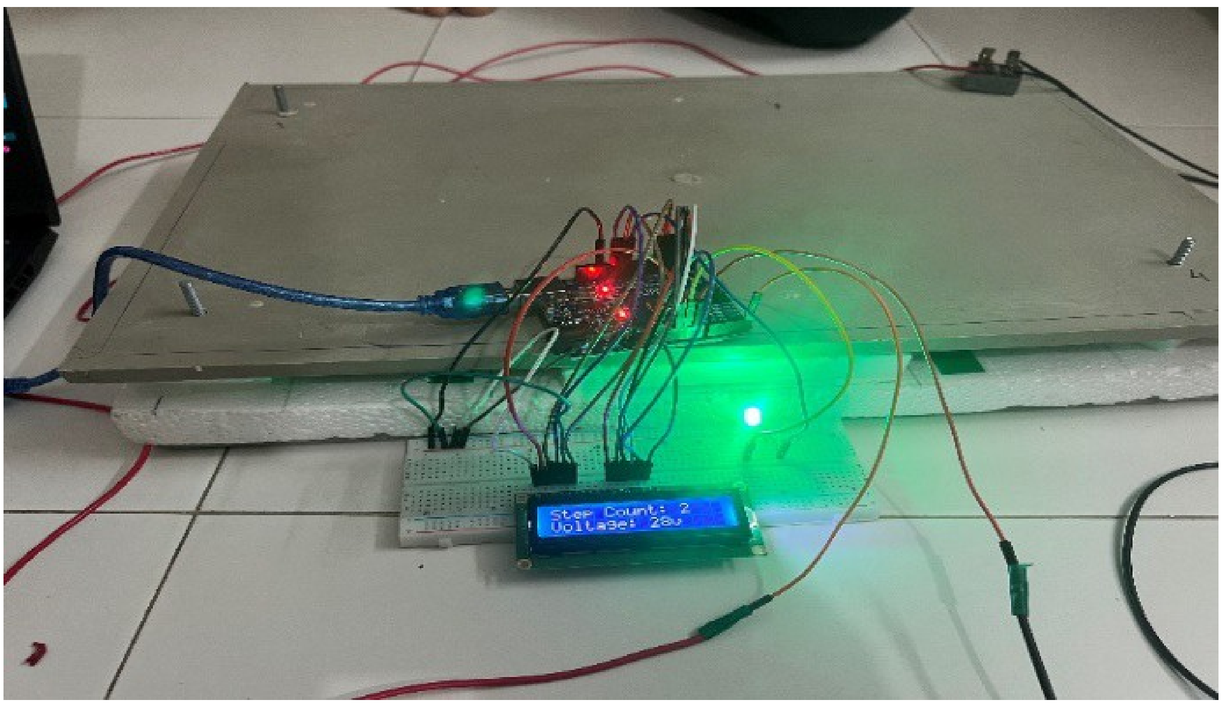

Figure 6.4 Hardware implementation results for Piezo-Electric Power Generation part. After putting 2 step, step count: 2 and voltage: 28V

The Power and Current generation after putting 1 step on the Piezo-electric tiles is shown in Figure 6.5.

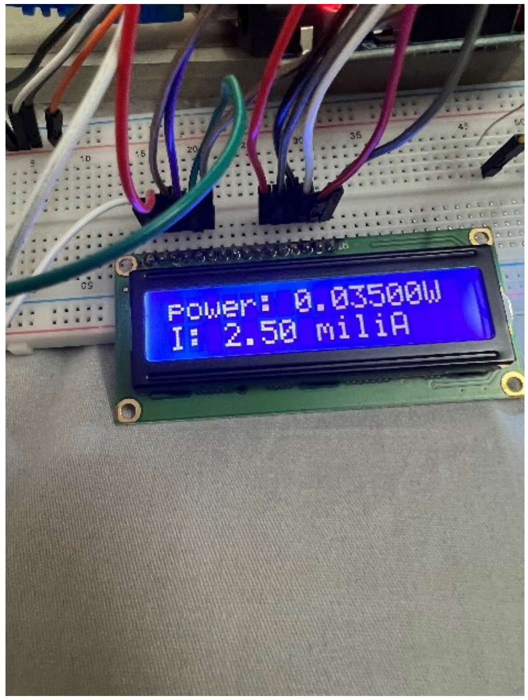

Figure 6.5 After putting 1 step, Power: 0.035W and Current: 2.5 mA

Here, also the full result after hardware implementation of full prototype system is shown in Figure 6.6.

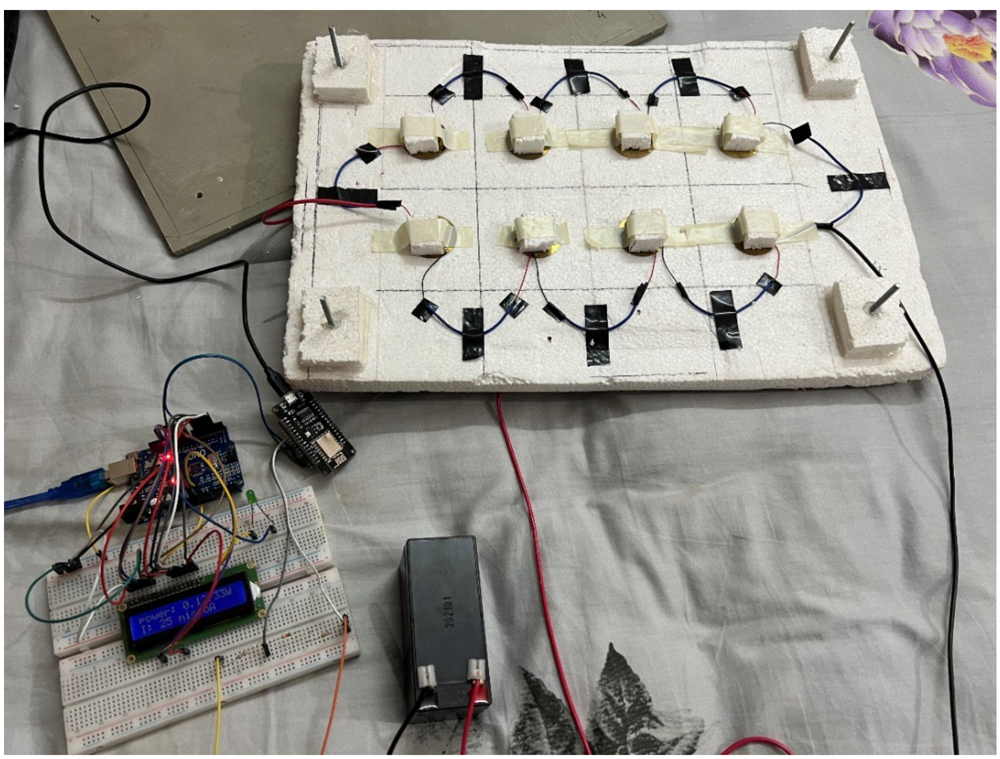

Figure 6.6 Full Hardware Implementation of the Prototype

6.2.5. Results from Web Interface

This prototype project is based on IoT. So, the data will be transferred to a server, where they can be accessed from anywhere in the world via internet. Again, through the web interface, the output load (in this project, a green LED) can be turned on and off. For the project, 'ThinkSpeak' analytic platform was used. This was used as a data streaming host server for our web-interface. When step in applied on the piezo-electric tile, the data will be sent to this 'ThingSpeak' server. Then those data will be fetched from that server into our web interface through the API and Channel keys. Figure 6.7 illustrates the results from Web Interface.

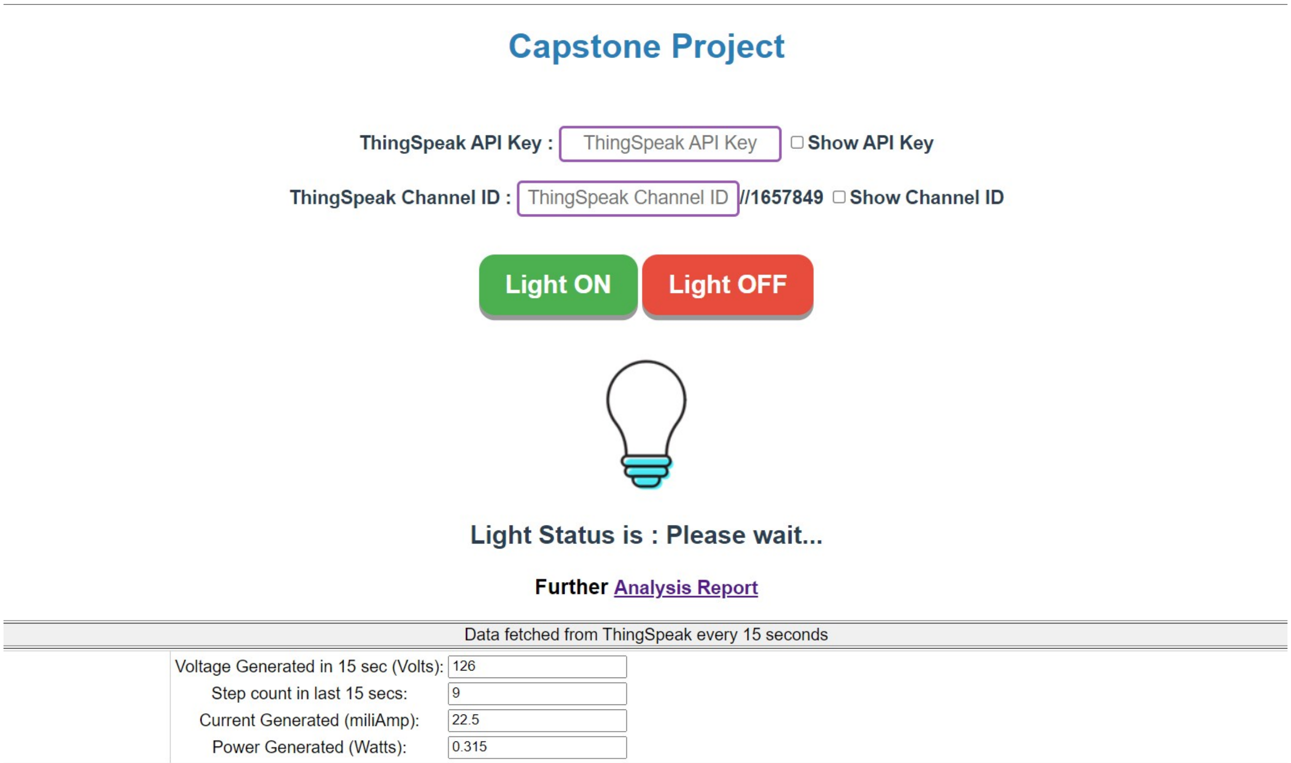

Figure 6.7 Web-Interface Result

ThingSpeak is a free data hosting server. As this is a free server, it has some limitations. One crucial limitation is that, this server stores the data every 15 seconds. Basically, it does not constantly keep storing data, rather its' storing duration gap time is 15 seconds. So, from the figure 6.7, it can be seen that: total step count in 15 seconds were 9 and voltage was 126V in last 15 seconds. Current was 22.5 mA where power was 0.315 watts in 15 seconds.

6.2.6. Case Study 1 based on how much Power Consumption can be saved in a particular area.

Here for the calculation, we selected the crowdy place- New Market which is of around 140000 m^2

If the area considered $250m^2$(as the one tile size)

Average Footfall – 35000 people (counted by the device)

Effective Footfall – 24500(Around 70% of the people step on the piezo tiles)

If an average person walks 250 steps in an area of $250m^2$, then-

Total Steps = 24500 x 250

= 6125000 steps

One Step can produce 0.035W

So,

Total Power = 0.035 x6125000

= 214375 W

= 214.375 KW

The energy produced = 214.375KWh

As stated, efficiency of tiles is 70%

So, the output energy = 150.063KWh

Cost of electricity/unit= 7.35 TK

Now,

Cost of electricity produced by titles = 214.375 x 7.35

= 1575.657 TK (Electricity saved in one day)

For 30 days / 1month = 47,269.71 TK

For 12 month/ 1 year = 567,236 TK

For 5 years = 2,836,182.6 TK

If the area considered 140000 m^2

Cost of electricity produced by titles = 560 x 1575.657

= 882,367.92 TK (Electricity saved in one day)

For 30 days / 1month = 882,367.92 TK

For 12 month/ 1 year = 317,652,451 TK

For 5 years = 1588262260 TK

6.2.7. Case Study 2 based on how much Installation Cost is needed in a particular area.

We took the area of Dhaka New Market as the projected area for our case study which area is 140000 m^2

And the size of a single piezoelectric tile is 1 m^2 and cost of the upper tile is approximately 250 TK

We need (140000/1) = 140000 tiles to cover that area. So total cost of tiles (250 x 140000) = 35,000,000TK

Additional tiles installation cost (miscellaneous): 2500000 TK (approximately)

For each tile we need 4 spring dampers and some screw and nuts. Their cost approximately per tiles: 70 TK

(70 x 140000) = 9,800,000 TK

A single tile consists of Piezoelectric Transducers. So cost of Piezoelectric Transducers cost per tiles:

(40 x 25) = 1000TK. So cost of total Piezoelectric Transducers: (1000 x 140000) = 140,000,000TK

For storing the charges from the tiles, we need batteries. *A single battery to cover for 50 Piezo Tiles*

So total Batteries needed, (140000/35) = 4000

Total Batteries Cost: (4000 x 1250) = 5,000,000TK

<u>GRAND TOTAL COST:</u> (35,000,000 + 2500000 + 9,800,000 + 140,000,000 + 5,000,000)

= 192300000 Tk (approximately)

So, total installation cost is 192300000 TK for an area of 140000 m^2

6.2.8. Case Study 3 based on Piezo-Electric requirement in a general House-holding.

Let's consider an apartment which has following:

3 fans	= 75 x 3 (A typical 48-inch ceiling fan will use 75 watts.)
	= 225 Watt
5 lights	= 30 x 5 (Considered of 30-Watt LED light)
	= 150 Watt
1(1.5 ton) AC	= 1500 Watt (1.5 ton of cooling = 1,500 watts.)
1 refrigerator	= 350 Watt (Home refrigerator uses 350 watts-small refrigerator)
1 television	= 58.6 Watt (Modern TVs use, on average, 58.6 watts when in on mode)
2 (15 Watt) mobile charger	= 2 x 15
	= 30 Watt
1 desktop	= 200 (A complete desktop uses an average of 200 Watt)
1 micro-oven	= 1200 Watt (1200 watts is the average power level of the regular kitchen microwave oven)

Device's usage time is following:

Fan = 16 hours; Light = 9 hours; AC = 5 hours; Refrigerator = 24 hours

Television = 3 hours; Mobile charger = 2 hours; Desktop = 5hours;

micro-oven = 1 hour.

So, power consumption for each device will be following:

Fan = 225 x 16 W-h

= 3600 W-h/ 3.6 KW-h

Lights = 150 x 9 W-h

= 1350 W-h/ 1.35 KW-h

Ac = 1500 x 5 W-h

= 7500 W-h/ 7.5 KW-h

Refrigerator = 350 x 24 W-h

= 8400 W-h/ 8.4 KW-h

Television = 58.6 x 3 W-h

= 175.8 W-h/ 0.1758 KW-h

Charger = 30 x 2 W-h

= 60 W-h/ 0.06 KW-h

Desktop = 200 x 5 W-h

= 1000 W-h/ 1 KW-h

Micro-oven = 1200 x 1W-h

= 1200 W-h/ 1.2 KW-h

Total power consumption for one day in a general house holding = (3.6 + 1.35 + 7.5 + 8.4 + 0.1758 + 0.06 + 1 + 1.2) KW-h

= 23.2858 KW-h

If a Piezo-electric tiles can generate 0.035W(per single step), then

Piezo tiles needed = 23285.8 ÷ 0.035

≈ 665,309 tiles.

If we consider 50 footsteps in a tile, then

Piezo tiles needed = 23285.8 ÷ (0.035 x 50)

≈ 13,307 tiles. [Each tile can consist of 6-8 piezo-electric transduces]

6.3. Comparison of Results

From the simulation which was done in Proteus 8, the certain parameters was achieved. Following, voltage generation was 14V, current was 0.0025 A and Power generation was 0.035W when the step count was 1.

From the hardware implementation, in figure 6.4; after putting 2 step, step count: 2 and voltage: 28V. So, voltage generated per step was (28/2) = 14V. In figure 6.5; after putting 1 step, Power: 0.035W and Current: 2.5 mA.

From the Data Processing from Web Interface, following parameters were achieved: Step Count in last 15 seconds: 9, Voltage in last 15 seconds: 126, Current in last 15 secs: 22.5 mA and last Power Generated in last 15 seconds: 0.315 Watts. So, voltage per step (126/9) = 14V; Current per step (22.5/9) = 2.5 mA and Power generated per step (0.315/9) = 0.035 Watts.

So, from the above results, it can be stated that, the result differences between simulation, hardware and web interface are almost none. Some marginal errors can be expected and occurred due to the design of the prototype model.

The majority of the criticalities in our project were eliminated as much as feasible through simulation, calculation, and hardware implementation. Nonetheless, due to several key variables that could not be ignored, some vital criticalities were highlighted. Following:

- Due to Covid-19, it was difficult to obtain the appropriate electrical and mechanical component from an online or local store since the supply chain was completely disrupted during the pandemic period.
- This project's construction is difficult and expensive in Bangladesh. To make this as realistic as possible, we must pay any additional fees. Though it is impossible to guarantee 100 percent feasibility and efficiency.
- There were some severe issues with the hardware implementation. Because the Piezo-electric Power Generating system is not a static power generating system, it was not possible to read any current data from the microcontroller board when connecting the current sensor to it. Only when pressure is applied above the piezoelectric tiles will current be generated. As a result, when the current sensor was attached to a constant load, this type of change in current production could not be detected.
- The microcontroller in this prototype is powered by an external power source such as a power bank or another battery, or from the desktop, since the employed storage battery for storing the charges created by the piezo-electric transducers has a 12-volt input voltage capacity. These kinds of

disadvantages can be eliminated in the future by implementing a more efficient, rich, and long-lasting system.

6.4. Summary

This chapter includes a detailed examination of our project work outcomes, as well as calculations, output knowledge, graphical representations, and calculations. The outcome analysis produced a precise strategy for the output results of our project's many alternatives. Also included is the data from the software application, which we can see. Finally, the critical style critique is summarized, as well as the project's challenges.

Chapter 7

CONCLUSION

7.1. Summary of Findings

It is essential to minimize man's power while boosting the use of a unique renewable energy source in this age of science and technology. It is a basic requirement to understand every aspect of the project in order to achieve the end aim. During the first part of the project, we tend to decide on the project's goal. The main goal is to address the global power crisis, which requires not only meeting an excessive demand for electricity but also modifying and reducing reliance on old electric energy producing technologies. This project focuses on a never-ending loop to achieve the optimum efficiency and lowest cost-cutting rate. Based on the data and comparisons, this piezo-electric power generation appears to be cost-effective. A few sensors and electronic gadgets are included for this operation's purpose. Some components are employed that are beneficial to the environment.

7.2. Novelty of the Work

Any work's novelty refers to anything that has never been done before. Each study's focus should be on novelty. The project's uniqueness stems from its novelty. That originality is also present in our project. The extraordinary issue of this project is, it is closed-loop never ending system of power generation. Previously many researchers worked on only how to generate power from piezo-electricity. In their research works, they had to bring outer assistance to run those generation systems [1] [2]. But in our project, a system was developed such that it does not require any extra steps from outside of the system to maintain. Another novelty of this project can be addressed. Which is implementing IoT system to the project. This project is the first one to be ever implemented with IoT to get data from the power generation system.

7.3. Cultural and Societal Factors and Impacts

7.3.1. Cultural and Societal Factors Considered in Design

The main purpose of this method was to improve social life. The electricity production from footfall was devised and proposed in light of Bangladesh's existing situation. Bangladesh, as previously said, is a densely populated country. Many individuals, particularly in rural areas, still do not have access to power. With features like an IoT-based power monitoring system, this system was supposed to be a cost-effective alternative to commercially accessible renewable energy sources. The system also contains a power storage component that may be used in the event of a power outage. This suggested system can be managed via IoT, allowing it to be simply switched off in the event of a threat. This renewable energy source may be used in both the home and the workplace. It has the potential to minimize electricity scarcity in areas where people want power.

7.3.2. Cultural and Societal Impacts of the Proposed Design

The created system performed as planned. This step-by-step power generating mechanism can help to lessen the requirement for extra electricity. In today's world, power is required in every area, yet generating it is both difficult and expensive. This project is based on the footsteps of individuals. When the number of footfalls in a tile increase, it can create greater power. In a highly populated location, it may be assumed that more footfall equals greater power, as previously stated. It can also be controlled through IoT, where all information such as how many volts have been made and how many steps have been supplied may be communicated to the user. An internet-connected mobile device may also be used to operate the entire system.

7.4. Proposed Professional Engineering Solution

The suggested system satisfies the standards of a professional engineering solution since it aims to tackle an existing problem while drawing inspiration from previous work and incorporating some new ideas. A block diagram, simulation model creation and testing, and real hardware model implementation were all part of the prototype implementation process. To ensure that the system was operating properly, the results were compared between the hardware and simulation model. The total system's implementation necessitates expertise in a variety of engineering domains, including as electronics, microcontrollers, and programming. The installed IoT functionality is also done on a well-known IoT platform called ThingSpeak, which manages all server and data connectivity, resulting in more dependable IoT communication. ThingSpeak, as a well-known platform, offers more privacy and communication than a DIY-designed app. The IoT integration also allows the user to manage the machine remotely using only an internet connection. The technology is more dependable and cost-effective than other renewable energy sources on the market.

7.5. Limitations of the Work

As each system has its own set of constraints, our project has some as well. Despite the fact that a basic output from the project was achieved, there are significant limitations to this project that are listed below:

- As the project is a combination different types of sensors, modules, microcontroller and numbers of piezo-electric transducers, it takes lots of time to implement.
- It was unable to complete the body of the design owing to the Coronavirus outbreak and a lack of time.
- The load capacity of the Arduino Microcontroller is restricted. Since the Piezo-electric Power Generating system is not a static power generating system, it was not possible to read any current data from the microcontroller board when connecting the current sensor to it. Only when pressure is applied above the piezoelectric tiles will current be generated. As a result, when the current sensor was attached to a constant load, this type of change in current production could not be detected.
- The microcontroller in this prototype is powered by an external power source such as a power bank or another battery, or from the desktop, since the employed storage battery for storing the charges created by the piezo-electric transducers has a 12-volt input voltage capacity.

As, the system was built as a prototype, durability and legibility of the prototype might not get up to expectation.

7.6. Future Scopes

The process of identifying and recording a list of specified project goals, deliverables and future activities is known as project scope. A scope statement, also known as terms of reference, is a document that documents the scope of a project. Some of the scopes of this project can be determined. Following:

- This project has the ability to provide several services at the same time. As a result, this initiative will undoubtedly benefit the renewable energy sector.

- The instrumentation and, as a result, the sensors we've employed for diverse systems are of extremely high quality. As a result, it will last for a long period.
- Because no fuel was used, it is not damaging to the environment, and our system does not release greenhouse gases. There is no risk to the atmosphere and this project can never have disastrous consequences for the environment.

This project emphasizes on a never-ending loop for the best outcome of efficiency and minimum rate of cost-cutting. The project which is being designed will help reduce cost to almost zero (other than installation cost) as it is a loop system and it does not take any extra steps from outside to maintain.

7.7. Standard Requirements and Ethical Concerns

7.7.1. Related Code of Ethics and Standard Requirements

All norms of ethics were strictly observed when creating the system. Several organizations are in charge of establishing ethical codes and standard requirements. To begin, there is the IEEE, which has ten codes of ethics that engineers should follow, the NSPE, or National Society of Professional Engineers, which has 14 codes of ethics divided into two categories, and the ACA, or American Counseling Association, which has 14 codes of ethics divided into two categories. The majority of the ethical codes in different organizations are largely the same.

7.7.2. Health and Safety

The first rule of ethics, according to the majority of organizations, is the public's and individuals' health and safety. First code of ethics declares- “to hold paramount, the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment”. The fundamental goal of this system was to improve public welfare by boosting power output and decreasing reliance on natural resources like as coal, gas, and oil, so that future generations would not suffer from a shortage of energy. Natural resources should be conserved as they were because if the ecosystem is harmed, humans would not be able to survive for long.

7.7.3. Economy, Environment and Sustainability

The proposed method is financially feasible since it offers advanced functionality at a reasonable price when compared to the alternatives. There is no negative damage to the environment as a result of this system. Because none of the components in this mechanism have an expiration date, nothing eventually becomes e-waste. Because the system is modular, if one of the sensors fails, the portion may be readily replaced without impacting the overall performance of the system.

7.8. Conclusion

Technology has altered our environment and everyday lives throughout the years. Technology has given birth to marvels. Technology has given us amazing tools and resources, allowing us to have access to a wealth of information at our fingertips. Technology has made our life simpler, faster, and better as a result of all of these changes. Medical advancements have increased people's lifespans and enhanced their quality of life all across the world. The energy industry has undergone a massive and welcome transformation as a result of technological advancements.

The main goal of this project is to address the global power crisis, which requires not only meeting an excessive demand for electricity but also modifying and reducing reliance on old electric energy producing technologies. This project focuses on a never-ending loop to achieve the optimum efficiency and lowest cost-cutting rate. The project's first phase is to use PiezoElectric to create electricity from human footfall, which will subsequently be stored in a battery cell. The electricity generation is then monitored and controlled by an IoT device to avoid wasting time and resources. However, the IoT gadget must be charged in order to be monitored continuously. Using an external source to charge the IoT gadget will incur an additional fee. So, with the aid of an RFID device, we use the charges from that storage battery to charge the IOT device. However, the efficiency of this strategy is unlikely to be great. Furthermore, the possibility of charging an IoT device through RFID cannot be assured. As a result, an alternate technique was used to charge the IOT device: connecting it to the storage battery.

Since it is a loop system that does not require any extra steps from the outside to maintain, the project being built will assist cut costs to practically nil (other than installation costs). This idea can help end electricity shortages in both urban and rural areas. The requirement for everyday existence encourages the worldwide creation of energy from each new approach. And this project adheres to that theme's fundamental slogan.

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Appendix A

Datasheet of the Codes used

Codes of Arduino IDE for Serial Communication:

```
#include <SoftwareSerial.h>
#include<ArduinoJson.h>
SoftwareSerial s(8,11);

#include <LiquidCrystal.h>
int Contrast=75;
LiquidCrystal lcd(12, 9, 5, 4, 3, 2);

int step_count = 0;
float total_voltage = 0;
float total_power =0;
float current =0;

#define NUM_SAMPLES 10

int sum = 0;                    // sum of samples taken
unsigned char sample_count = 0; // current sample number
double voltage = 0.00;          // calculated voltage

void setup() {
  // put your setup code here, to run once:
s.begin(9600);
```

```
Serial.begin(9600);
  analogWrite(6,Contrast);
  lcd.begin(16, 2);
  lcd.setCursor(0, 0);
  lcd.print("Step Count: ");
  lcd.print(0)
}

void loop() {

   if (s.available()>0){

float val = s.parseFloat();

if (s.read()=='\n')
{
  float voltage = val;

Serial.println(voltage);
//
if (voltage> 2.5)
{
  Serial.println(voltage);
//  s.write(voltage);

       // to make the LED visible
   step_count+=1;
   digitalWrite(10, HIGH);
   lcd.setCursor(0, 0);
```

```
  lcd.clear();

   lcd.print("Step Count: ");
   lcd.print(step_count);
   lcd.setCursor(0, 1);
   lcd.print("Voltage: ");
   lcd.print(voltage);
   lcd.print("v");
// t1 = millis();
   delay(1500);

   lcd.clear();
   lcd.setCursor(0, 0);
   lcd.print("power: ");
   total_power =+ (voltage * .0025);
   lcd.print(total_power,5);
   lcd.print("W");
   lcd.setCursor(0, 1);
   lcd.print("I: ");
   lcd.print(25);
   current+=25;
   lcd.print(" microA");
   delay(1500);
   digitalWrite(10, LOW);
  // String x;
   }
}
}
}
```

Codes of Arduino IDE for Thingspeak Data fetching and other conditions:

```
#include <SoftwareSerial.h>
SoftwareSerial s(D7,D8);
#include <ArduinoJson.h>

#include <ESP8266WiFi.h>

long long milsec = 0;
int count = 0;
int c =0;
bool fl =0;
float voltage =0;
float comp=0;
float h;
String apiKey = "RTU39LD3PVO33LBG";     // Enter your Write API key from ThingSpeak

const char *ssid =  "poxER";     // replace with your wifi ssid and wpa2 key
const char *pass =  "mexiCana551";
const char* server = "api.thingspeak.com";

WiFiClient client;

void setup()
{
  Serial.begin (9600);
  s.begin(9600);
  while (!Serial)
  { Serial.println("not Connecting ");
```

```
    continue;
  }


      delay(10);


      Serial.println("Connecting to ");
      Serial.println(ssid);


      WiFi.begin(ssid, pass);


     while (WiFi.status() != WL_CONNECTED)
     {
          delay(500);
          Serial.print(".");
     }
     Serial.println("");
     Serial.println("WiFi connected");
}
void loop()
{
  if (millis()<(14000*c))
      {
       if (Serial.available() > 0) {
          h = Serial.write(Serial.read());
          voltage += h;
          count++;
       }
//    if (comp!=h)
//    {
```



```
    // comp = h;
//    }
          float t =getSensorData() ;
//      Serial.println(voltage);
     Serial.println(voltage);
     }
  else{
     Serial.println(millis());
   c++
                    if (client.connect(server,80)) // "184.106.153.149" or api.thingspeak.com
                  {
                     String postStr = apiKey;
                     postStr +="&field2=";
                     postStr += String(voltage);
                     postStr +="&field3=";
                     postStr += String(count);
                     postStr += "\r\n\r\n";
                     client.print("POST /update HTTP/1.1\n");
                     client.print("Host: api.thingspeak.com\n");
                     client.print("Connection: close\n");
                     client.print("X-THINGSPEAKAPIKEY: "+apiKey+"\n");
                     client.print("Content-Type: application/x-www-form-urlencoded\n");
                     client.print("Content-Length: ");
                     client.print(postStr.length());
                     client.print("\n\n");
                     client.print(postStr);
                     Serial.print("step count: ");
                     Serial.println(count);
                     Serial.print("Voltage Per Step: ");
```

```
            Serial.println(voltage);
             Serial.println("%. Send to Thingspeak.");
          }
    client.stop();
    Serial.println("Waiting...");
  voltage = 0;
  count = 0;
 // thingspeak needs minimum 15 sec delay between updates
 }
}
int getSensorData(){
 return random(1000); // Replace with your own sensor code
}
```

Appendix B

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ORIGINALITY REPORT

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SIMILARITY INDEX

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