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Design and Analysis of Smart Shoe

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Abstract: *The purpose of this report is to provide a new product to make life much and a lot simpler, and we as engineer this is one of our responsibilities, a smart shoe that would comfort the user. Our task would the generation of reliable amount of power by using the conversion of mechanical energy into electrical energy using piezoelectric materials and stored it, to use many purposes such as (Mobile charging, lighting, etc.). A model for a shoe that enabled with the obstacle sensors which are help to walking of blind people and Lighting arrangement for its better and advanced applications for differently able and rural users. The shoe will be also could pair location and navigation which identifies the location of place and Listen to the sounds & audio nearby device anytime secretly without making any sound. It has also, with help of SOS Panic button feature. Press Panic/SOS button will call to relative/family number and alert them for help. so, it provides safety for the people.*

Keywords: Piezoelectric Sensor, Full-wave bridge rectifier, Lithium Polymer Battery, LED, USB Port, Arduino Nano, Obstacle sensor, GPS with live Audio.

I. INTRODUCTION

Now a day's energy is one of the most important issues around the world. Especially in Rural area, energy crisis is a bigger problem. Renewable energy sources can be a great resource to solve this energy crisis problem in rural area. In this project we propose a smart wearable shoe which is integrated with sensors such as piezoelectric sensor, ultrasonic sensor, GPS, and Arduino Nano device.

- The aim is to find a suitable and efficient source of electrical energy by using our surrounding, I have used the mechanical energy produced from our footsteps in order to produce sufficient and reliable amount of energy.
- 285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision, about 90% of the world's visually impaired live in low□income settings where 82% of people living with blindness are aged 50 and above. (World Health Organization, 2017) (Parentcenterhub.org, 2017). In this paper discusses how to help such type of person to walk safely.[1]
- At the present scenario women are competing with men in every prospect of society. Women contribute to fifty percent of the development of our nation. Many unfortunate incidents have been taking place in woman's case. Problems may come from any direction such as women walking on the road after the work, going to super market or many other reasons for which they go alone. [2]

People at home are not sure of their return safely. This paper also discusses on a security system that is designed solely to serve the purpose of providing security and safety to women so that they never feel helpless while facing such social challenges.

II. DETAILS OF THE PROJECT

2.1 Description

It is a device that uses the piezoelectric effect, to measure changes in pressure, strain or force by converting them into an electric charge. Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. We arranged these piezoelectric sensors in series parallel combination for harvesting the energy. The produced output voltage is in the form of AC. Then it can be converted to DC by passing it through Rectifier circuit. The converted DC voltage can be fed into DC-DC Booster circuit. Here, we have used LIPO battery to store charge. Further, we interface LEDs, GPS module and obstacle sensor are used further for the application. Then

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through USB port, USB cable is put in then the phone starts getting charge. Arduino Nano is used for the controlling and management of charge for its optimum utilization.

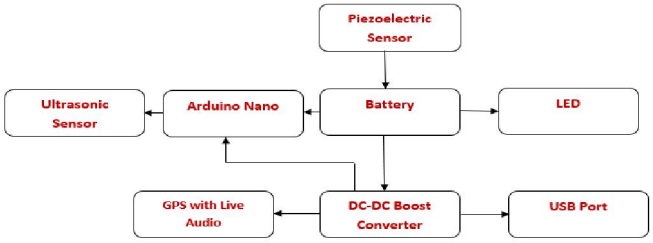

Figure 1. Block Diagram of Smart Shoe

- *Piezoelectric Device* - This day most of the research in the energy field is to develop sources of energy for future. It is time to find renewable surceases of energy for the future. Piezoelectric materials are being more and more studied as they turn out to be very unusual materials with very specific and interesting properties. In fact, there materials have the ability to produce electrical energy from mechanical energy for example they can convert mechanical behavior like vibrations in to electricity. Such devices are commonly referred to as energy harvesters and can be used in applications where outside power is unavailable and batteries are not a feasible option. While recent experiments have shown that these materials could be used as power generators, the amount of energy produced is still very low, hence the necessity to optimize them. Piezoelectric materials have two properties that are define as direct and converse effect. Direct effect is the property of some materials to develop electric change on their surface when mechanical stress is exerted on them, while Converse effect is the property of some materials to develop mechanical stress when an electric charge is induced.
- *Full Wave Rectification* - Piezoelectric materials are used for producing AC voltage. From this perception, the importance of transforming this AC voltage into DC voltage is a must because DC voltage can be stored and used later in various applications. This process is called rectification; we use an element called a diode, which is made using silicon or germanium. The rectification process is divided into two main types: (a) full wave & (b) half wave. We will use the full wave bridge rectifier because of its ease of implementation, cheaper cost & high efficiency. The working principle of a full wave rectifier is simple; The output waves of the rectifier contain considered amounts of ripples, which will affect the storing ability of the battery. So, we must use a suitable filter in order to eliminate these ripples from the output wave to get a pure DC wave. Simple filters such as the RC filter can be used.
- *Capacitor* - In this prototype the capacitor receives the energy from piezoelectric plate and charges the battery. The features of the capacitor used are 50v. Here a non-conductive area separates two non-conducive regions. The non-conductive region is coined as dielectric which may be either vacuum or electrical insulator. They can be plastic, paper and ceramic.
- *Lithium Polymer Battery* - Battery an array of electrochemical cells for electricity storage, either individually linked or individually linked and housed in a single unit. An electrical battery is a combination of one or more electrochemical cells, used to convert stored chemical energy into electrical energy. Battery stand-by power applications
- *USB Charging Cable* - A special USB charging cable with one pin that can go into the charging port provide easy USB charging.
- *Arduino Nano* - Arduino is an open□source electronics platform based on easy□to□use hardware and software. Arduino boards are able to read inputs and tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.
- *Mini GPS Tracker with live Audio* - A GPS tracking unit is a navigation device normally carried by a moving person that uses the Global Positioning System (GPS) to track the device's movements and determine its location data can either be stored within the tracking unit or transmitted to an internet-connected device using the cellular (GPRS or SMS), or satellite modem embedded in the unit. This allows the location to be displayed

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against a map backdrop either in real time or when analyzing the track later, using GPS tracking software. In this module, auto call back to your number whenever there is any sound near GPS tracker. Listen to the sounds & audio nearby device anytime secretly without making any sound. It has also, with help of SOS Panic button feature. Press Panic/SOS button will call to relative/family number and alert them for help.

- Some other components are *Ultra sonic sensor, LED & buzzer.*

All our components are embedded inside a large size pair of shoes. The large size of shoe, its wide girth and its low cost made it really viable for our purpose.

III. STEP OF CONSTRUCTION

- Software Simulation **(**MATLAB**).**
- Energy harvesting through piezoelectric device.
- Realisation of battery charging through piezoelectric device.
- Testing of Mini GPS Tracker with live Audio.
- Combining all the projects elements to form the Prototype.
- Testing of the Prototype

IV. PROCEDURE

The approach used to overcome the problems of the energy extraction from the piezo elements is by using; proper smoothing capacitor in case of the standard circuit. In this case, the capacitor value is selected just before the electrical load such that the output is constant and has improved results in

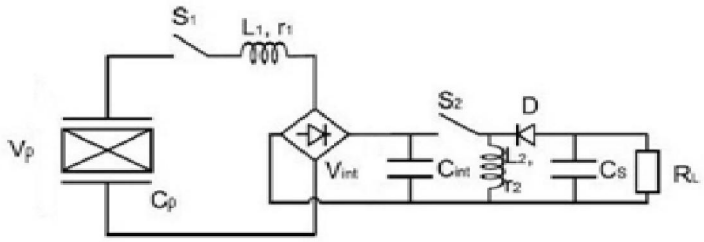

Figure 2. Single Switch Harvesting Model

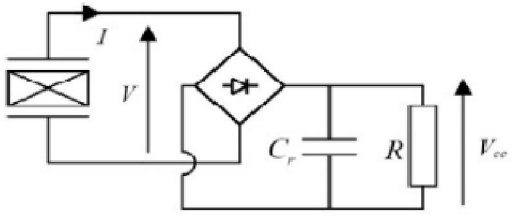

Figure 3. Standard Harvesting Device

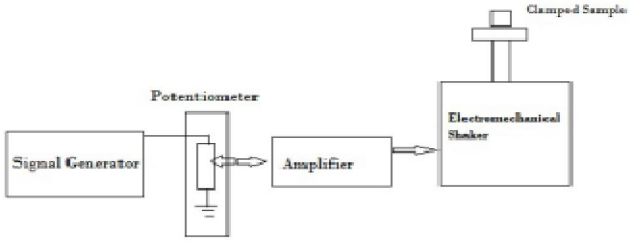

Figure 4. Experimental Setup of The Micro Generator

terms of voltage optimization.[1]. The basic circuit, having a piezo element, an uncontrolled bridge followed with a capacitor, is explained in the project. This issue has been rectified in the current work.

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The modelling of the mechanical structure in different way was tested and the best model under different situation was proposed. It also throws some light on the basic harvesting circuits.

V. RESULTS

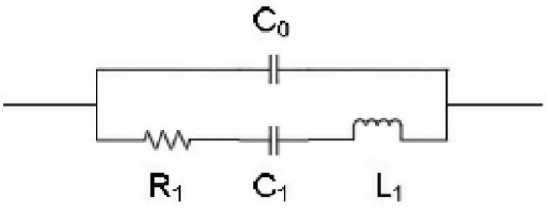

Figure 5. Electrical Equivalent Circuit

Result for Piezoelectric Transducer

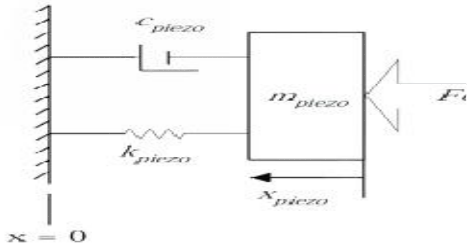

Figure 6. Mass Spring Model of Piezoelectric Generator

This section discusses the output of the piezoelectric transducerelectrical model.

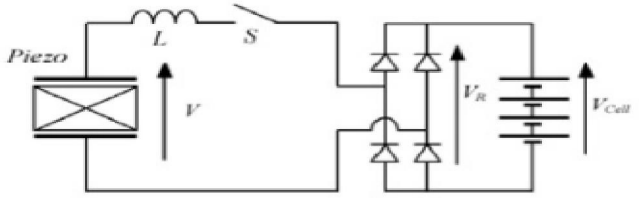

Figure 7. Synchronized Switch Harvesting Over Induction

The model taken up in this project consists of an A.C current source in parallel with a capacitor. The output voltage of the piezoelectric transducer is 50 volts and the output current is 1 milliampere. The current source is taken as 1milliampere and the capacitor value is taken as 30 Nano Farad.[3]

Figure8. Depicts the simulation model of the piezoelectric transducer and depicts the output voltage and current waveform of the piezoelectric transducer.[3]

Element	Value
Piezoelement Current Ip	1mA
Piezoelement Capacitor Cp	30nF
Output voltage Vp	50V
Output current I	1mA

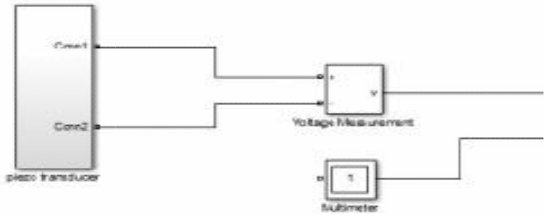

Figure 8. Piezoelectric Transducer

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Result for Standard Extraction Circuit

This section discusses about the standard extraction circuit and its waveform. The standard extraction circuit consists of a piezoelectric transducer model which is connected to the uncontrolled bridge followed by a smoothing capacitor and a resistive load.

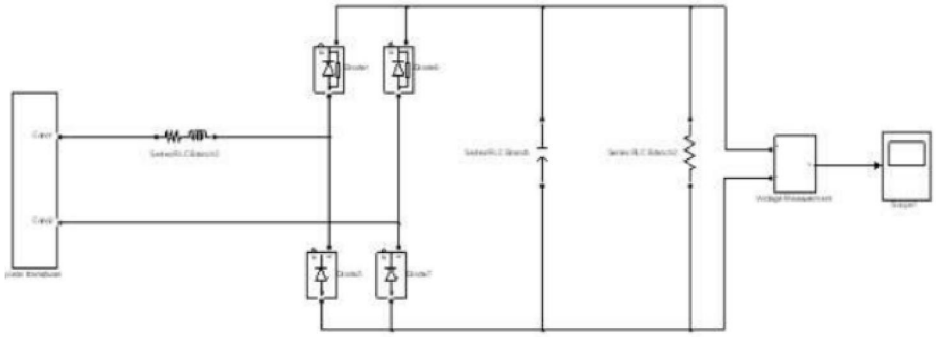

Figure 9. Simulation circuit of Synchronized Switch Harvesting Over Inductor

The issue with this extraction circuit is that it is not continuous i.e., there is a lot of dead zone area present in the output voltage waveform. Also, the output is dependent on the load connected to the circuit.

Result for Synchronized Switch Harvesting Over Inductor Extraction Circuit

In this section, a further modification of the standard circuit isdone by adding an inductor in series with the piezoelectric element. The addition of the inductor boosts the output voltage at the load. But a drawback of the inductor is suffered. The inductor makes the waveform to pulsate which further bring in the requirement of a battery where the energy can be stored before being used in any application. Figure 9 shows the simulation circuit of synchronized switch harvesting over inductor and Figure 10 shows the waveform of the simulation circuit.[3]

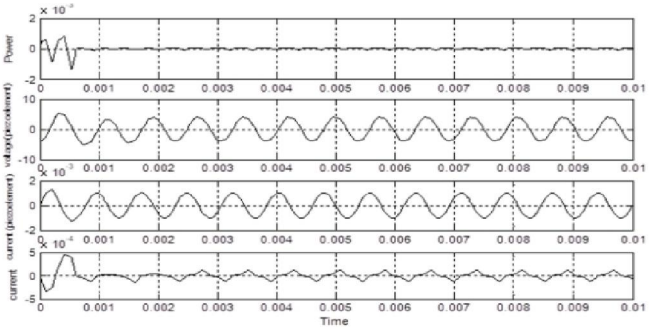

Figure 10. Waveform of SSHI Circuit

Figure 11. Voltage obtained through piezoelectric device

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Combining Results

We will design the circuits and embed in shoe with the various indicators and instruments for the layout a Smart Shoe. Smart Shoe will provide a reliable and unique way for indoor and outdoor navigation. Our design will also integrate detailed pressure sensing to give accurate information about a person's feet movements and feet pressure distribution while walking, jogging or running. With support for USB charging, help to walk the visually impaired & old age person & provide safety for woman and children. This product would be a complete and marketable final product. We believe that our product will cater to the vast number of people who use their Smart phones for navigation, athletes and the common people.

Figure 12. Front & Side Views of Prototype

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VI. ADVANTAGES

- In rural area, it provides electrical energy for changing the mobile phones.
- It helps to walk the visually impaired & old age person.
- In this shoes LED is also provide for lighting purpose which helps to walk in dark night.
- It also provides safety for the woman & children.

VII.CONCLUSION

7.1 Accomplishments

We had several accomplishments through the semester. After getting our idea approved, we started working on getting a proof of concept. We created a design for each circuit in the project. In addition to make each circuit work perfectly we read every component datasheet so we can make them work in optimum operation as much as we can.

Our biggest achievement for this project was how to get everything assembled inside the shoe. We spent a lot of time trying to add user comfort and how to make the product look nice. We added in charging socket on the side so that the product looked completer and more finished.

7.2 Uncertainties

Although our design is extremely light weight and compact, we are not sure if the users will become used to the added weight if these components are added to the shoe. We did several tests with the shoe which we added a weight exactly the same of our circuit's weight. We found out that, initially, the added weight is very evident but after some time the user tends to forget about it and become accustomed to it. However, these results could be different for different people and we will have to perform further tests to ensure the device is not causing any distraction or discomfort.

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VIII. FUTURE WORK

- Our bigger challenge will to make the design more modular so that it can placed inside any shoe. And protect from water so that it can wear in rainy season. Also, implement this project into reality by making a prototype for the shoe with all the components inside it, and work perfectly.
- We also intend to make the design more compact and light weight, so that it causes minimal distraction to the user.
- Wireless induction charging could be added to provide a convenient way of charging the device without having to hook up any wire to it.

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