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A Design of Energy Harvesting Step Sole

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Abstract- **Now a day's Energy harvesting is a demanding area of research where the whole world is looking for regeneration of energy from various resources. Today the resources used to charge many electronic devices are the conventional portable batteries having a finite lifespan. The main problem for such batteries is their disposal. In order to solve this problem, we have designed and developed a Step Sole an alternative to charge the batteries of portable electronic devices such as Apple's i-pod, digital cameras, and mobiles. The energy is generated from piezoelectric transducer based energy harvesting sole while walking along the way. This could be an environment-friendly solution for minimizing the battery disposal issue in India.**

Keywords: AC, DC, Energy harvesting, Piezoelectricity

I. INTRODUCTION

Recently, the low-power electronic devices have become smaller in size and widely used. These devices are used to make our daily lives comfort. Due to this there is an increase in usage of portable electronic devices which implies the disposal of such battery units will be an upcoming issue in India where the concept of harvesting is much needed as an alternative to the renewable energy resources and hence there is a rise of piezoelectric energy harvesting as a new interest today for many researchers [1]. Decreasing size and power requirements of carrying electronics devices make it possible to replace portable batteries with systems that capture energy from human locomotion. Now day's cellphone users need to recharge their phone after some time of using it. If we increase the battery lifespan it also increases the size and weight along with battery capacity [2]. Such device's battery disposal is a major problem. This can be solved by the harvesting the energy from Step Soles. The step sole can be used as a substitute for portable batteries to power the electronic devices.

It is a time to discover alternative renewable sources of energy for the future. The Piezoelectric transducers are made up of ceramic. These materials are having the ability to produce electrical energy from mechanical energy (pressure applied on it) [3] for example they can convert mechanical behavior like vibrations into electricity; hence they are called as an energy harvester. While recent papers have shown that the piezoelectric materials are used to power the electronic devices where the amount of generation of energy is very low, hence there is a need of optimization.

This paper focuses how to extract energy from piezoelectric transducer to be stored in the energy storage device such as battery in order to charge the portable electronic devices. The remaining part of the paper is as follows: In section II Working principle of energy step sole is explained. Section III describes Simulation of energy harvesting circuit using Proteus Design Suite 8. In section IV Hardware Implementation of step, the sole is discussed. In the section, V results are discussed and Section VI concludes the paper.

II. WORKING PRINCIPLE

The block diagram of step sole for energy harvesting is as shown in figure 1 below. It consists of shoe sole tailored with a piezoelectric transducer with energy harvesting circuit designed by us.

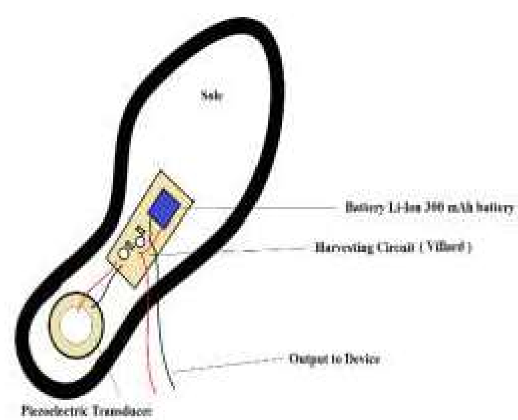

FIGURE 1: BLOCK DIAGRAM OF ENERGY GENERATION IN STEP SOLE

We used ceramic type piezoelectric transducer. Piezo transducer generates AC voltage when we apply pressure on a piezoelectric transducer. As AC voltage cannot be stored into battery, we have to convert AC voltage to DC voltage because DC voltage can be store. But in process of converting AC to DC, we may lose some energy if we use full wave Rectifier Bridge to convert AC to DC.

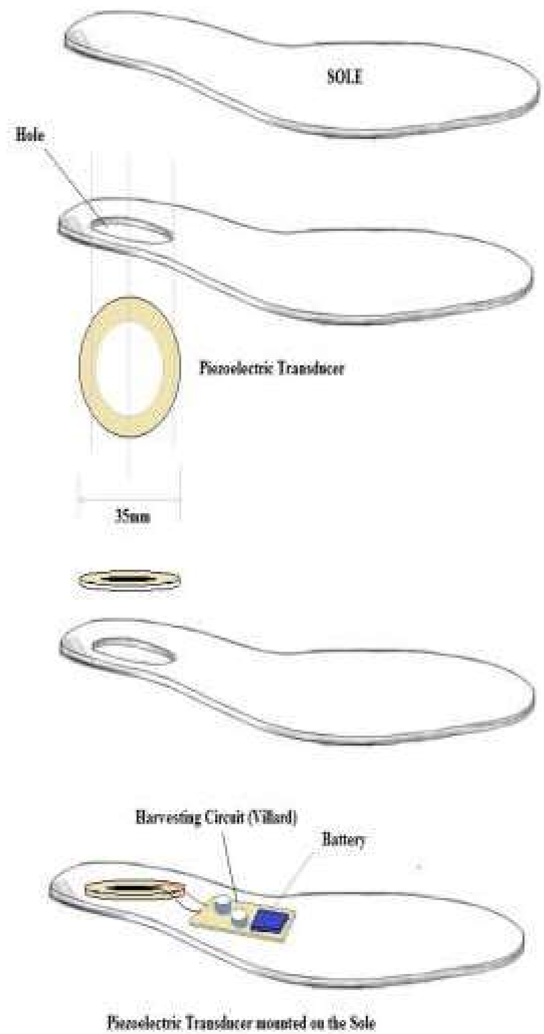

FIGURE 2: CONSTRUCTION OF SOLE EMBEDDED WITH PIEZOELECTRIC ENERGY HARVESTING CIRCUIT

We could be able to generate 80% energy generated by transducer but there will be an energy loss of 20 %. So it implies that if we connect each piezoelectric transducer with each full wave rectifier bridge and connect them in series we may lose a large amount of energy than released from the transducer, then we are unable to get the achievable output due to loss[4][5].

Therefore there is a need for amplification which can be done by cascade Villard with Piezo transducer. Now if we apply the pressure on the piezoelectric transducer, it generates the AC output. Such AC output connected to Villard cascade circuit to get boosted DC output. By using voltage multiplier we reduced rectifier bridge and voltage booster.

The 35mm diameter piezoelectric disc transducer is placed at heel position. This piezoelectric transducer produces AC voltage as per the pressure exerted on it. This voltage is rectified & then amplified by harvesting circuit. The produced voltage is stored in the storage battery. This stored energy will be further used for charging the batteries of camera, i-pods, smartwatch. The construction of sole embedded with piezoelectric energy harvesting circuit is as shown in figure 2 above.

III. SIMULATION

The requirement for powering apple i-pod Li-on battery model: EC001/EC807 is 3.7V. Now using our step sole with piezoelectric harvesting circuit we would be able to generate the 5V DC from 2V AC as shown in figure 3 below. This stored energy will be used for charging the battery of apple i-pods, smartwatch, Lenovo mobile Li-ion battery model BL243.The simulation output is as shown in figure 3 below. The simulation is done in Proteus Design Suite 8.

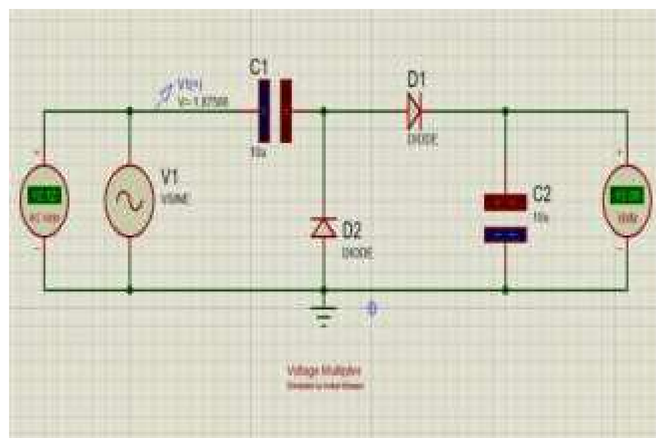

FIGURE 3: SIMULATION OUTPUT FOR GENERATION OF 5V DC FROM 2V AC

Normally many electronic portable devices are using Li-ion batteries as a source of power. By using our step soles one can power their own devices at any instance of time at any place by one go.

IV. HARDWARE IMPLEMENTATION

We have designed the circuit and implemented for generation of 3.7V for powering lithium-ion batteries [8][9][10]. These batteries were used in most of the digital cameras, smart watches, and Apple I-pods as listed in table 1 below. The figure 4, 5 below shows the hardware implementation of step sole for powering 3.7volt 250mAh

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Lithium Polymer battery pack of APPLE iPod SHUFFLE model.

TABLE 1: BATTERIES WITH THEIR SPECIFICATIONS CHARGED BY OUR STEP SOLE

TITLE	PRODUCT	SPECIFICATION
Digital Camera	Casio	3.7 V, 650 mAh
	Kodak	3.7 V, 600 mAh
	Fuji	3.7 V, 565 mAh
Apple I-Pod	1st & 2nd generation	3.7 V, 500 mAh
	I-Pod Shuffle	3.7 V, 250mAh
SmartWatch	Samsung Gear S	3.7 V, 300 mAh

FIGURE 4: 3.7VOLT 250MAH LITHIUM POLYMER BATTERY PACK OF APPLE I-POD SHUFFLE

FIGURE 5: HARDWARE IMPLEMENTATION

V. RESULTS

The designed circuit will be able to generate the DC voltage as per the specifications are shown below table 2. It means that by using our step sole one can power the 3.7 Volts battery by walking 4 miles. However from findings of a study by Stanford University researchers says that India is ranked at 39, with people averaging just 4,297 steps a day [7].It means one can charge their electronic portable devices using our steps soles in 2 days.

TABLE 2: READINGS FOR GENERATION OF 3.7V THROUGH STEP SOLE

BATTERY	PIEZO CURRENT	BATTERY CURRENT	APPROXIMATE NO OF STEPS	MILES TO COVER
For 250mA Battery	30uA	250mA	8334	4
For 300mA Battery	30uA	300mA	10000	5
For 565mA Battery	30uA	565mA	18833	9
For 650mA Battery	30uA	650mA	21666	11

VI. CONCLUSION

The design of piezoelectric energy harvesting step sole is implemented and observed the satisfactory performance and analysis of power generation of 3.7 V, 250 mA current is done to charge the I-POD SHUFFLE battery after covering 4 miles. The results were concluded by comparing the batteries of digital camera and smartwatch of 3.7V with a current rating of 300mA-650mA for 5, 9 and 11 miles respectively. Results can be improved by adopting different current boosting techniques to minimize the human locomotion and time to power the batteries in future.

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