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RESEARCH ARTICLE OPEN ACCESS

Design of an Advanced Piezoelectric Footstep Power Generation System.A Case Study of Must – Basement Room

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***Abstract*:**

Advanced piezoelectric footstep power generation system is a system concerned with generation of electric power using piezoelectric sensors through footsteps. The designed system involved staircases of Administration area at Mbeya University of Science and Technology (MUST) where workers and students pass. When there is no supply power from TANESCO, some of the rooms especially basement Rooms which are the main venue for some of the classes become out of use because of total darkness during a day time. The purpose of the designed system was to change the mechanical energy produced by personnel through movement into electrical energy that can be used to power the basement rooms at MUST. The number of peoples who pass through the staircase per day was observed and the minimum number was taken for analysis and design purpose. After design, the circuit was simulated in order to observe results. The circuit was built and then tested where up to 12 Volts was produced. The output voltage can be stored using bank of batteries. The designed circuit system will act as backup power for basement Rooms at Mbeya University of Science and Technology when supply power from TANESCO is cut off.

***Keywords*: Footsteps, Piezoelectric, Energy conversion, Microcontroller, Battery Bank**

I. INTRODUCTION

Electricity is most commonly used energy source. Electricity can be generated from difference resources like water, wind, solar, geothermal, tidal, natural gas etc. To generate the electricity from these resources, development of big plants are needed having high maintenance cost and some cause high pollution. Most of the buildings at MUST are having the Basements Rooms which are used as class rooms and some as staff offices. There has been several power outage from the supply authority during the working hours which lead to total darkness on the basement rooms and hence stoppage of all activities. MUST as an academic institution, at its main campus is having 5,482 students and around 500 staff [1]. At the stair cases of Administration area the average steps of 13000 up to 15000 steps was observed per day during the period of study by counting number of peoples go and return through the stair cases. While walking energy is wasted in the form of vibration to the surface. This wasted energy can be converted into electricity using the principle called piezoelectric effect.

Piezoelectric effect is the effect in which mechanical vibrations; pressure or strain applied to piezoelectric material is converted into electrical form by using Piezo-electric materials such as quartz, Lead Zirconate Titanate (PZT), Polyvinylidene fluoride (PVDF), Rochelle salt, Mica etc. From literature survey it is evident that, piezoelectric material (PZT) is superior in characteristics and series-parallel combination is found to be more suitable. .

The efficiency of the system can also be increased by using Prieto battery (rechargeable battery made of nanotechnology) and voltage can be effectively increased by using boost converter. By using

synthesized piezoelectric crystals and better selection of place of installation more electricity can be generated. Utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated places like the roads, railway stations; bus stands, colleges, universities, temples, etc. are all over crowded of people move around the clock.

The main objective of this research paper is to design and develop the model of advanced piezo-electric footsteps power generation system. In order to accomplish the main objective the following are the specific objectives:

- To study the existing system for advanced piezo-electric footsteps power generation system.
- To design the proposed circuit for advanced piezo-electric footsteps power generation system

II. LITERATURE REVIEW

Piezoelectric crystal is the way of generating electricity by using human footsteps. Key concept of working of this system is capturing the mechanical energy produced by human being through movements and converting it into electrical energy. The piezoelectric placed under insulating material like hard rubber and pressure created by foot step will produce electrical energy which can be stored and used to power the basement rooms devices like lamps, computers etc.

A. Array Sensor (Piezo Electric Plate)

Piezoelectric Material has a crystalline structure; it has ability to convert mechanical strain to electrical energy. It belongs to the group of ferroelectric material. The most available piezoelectric materials are PVDF and PZT. For getting better output voltage for various pressure it is important to select the best piezoelectric material. As we apply various pressure applied to the piezoelectric material the different voltage readings corresponding to the force is displayed.

The array sensor is as shown in figure 1

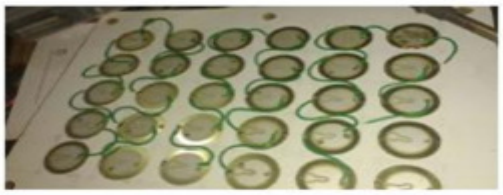

Figure 1: Array Sensors

B. Liquid Crystal Display (LCD)

A Liquid Crystal Display (LCD) is an electronically-modulated optical device shaped into a thin flat panel made up of any number of color or monochrome pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector [2]. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. LCD has material which combines the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped [3]. Figure 2 indicate the LCD used together with piezoelectric plate.

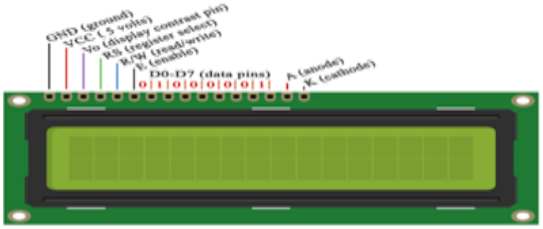

Figure 2: Liquid crystal Display

C. Arduino UNO Microcontroller

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on the computer, used to write and upload computer code to the physical

board [4]. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program [5]. Figure 3: shows

Arduino UNO Microcontroller

Figure 3: Arduino UNO Microcontroller

D. Microcontroller Applications

Microcontrollers are intended for embedded devices, in comparison to the micro-processors which are used in PCs or other all-purpose devices. Microcontrollers are employed in automatically managed inventions and appliances like- power tools, implantable medical devices, automobile engine control systems, office machines, remote controls appliances, toys and many more embedded systems. By dipping the size and expenditure in comparison to a design that make use of a different micro-processor, I/O devices and memory, micro-controllers formulate it inexpensive to digitally control more & more appliances and operations. Mixed signal micro-controllers are general; putting together analog constituents required controlling non-digital electronic structures.

E. Step Down Transformer

Step down transformer is used to step down ac voltage from main supply into 12V voltage [6] to the value that is suitable to be fed to the rectifier for the further process. The ideal transformer is shown in figure 4

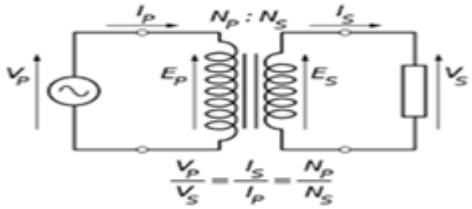

Figure 4: Transformer

F. Filter Capacitor

It is a passive two-terminal electrical component used to store energy electro statically in an electric field [7]. It used to removes ripples from pulsating DC voltage by shorting to the ground AC signals and allowing DC signals to flow to the regulator for further process. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e. insulator). The conductors can be thin films, foils or conductive electrolyte, etc. A dielectric can be glass, ceramic, plastic film, air, vacuums, paper, and mica. The non-conducting dielectric acts to increase the capacitor's charge capacity. An ideal capacitor does not dissipate energy but stores in the form of an electrostatic field between its plates

The capacitor used for filter is shown in figure 5

Figure 5: Capacitor

G. Inverter

An inverter is an electronic device that converts the direct current (DC) into alternating current (AC). Operation of inverter depends on the power provided by the battery during the runtime. The inverter of 1500 W was proposed to carry the estimated load at the Basement Room.

III. METHODOLOGY

For successful completion of this research, various of methods were adopted, these methods includes data collection, data analysis

A. Data Collection

This concerned with gathering data which facilitated the accomplishment of the project. The data collected are very important as far as designing and implementation of the system is concerned.

B. Data Analysis

The data collected are mathematically analyzed in order to obtain the useful behaviors that are helpful for the design.

C. Designing Circuit and Simulation

After the designing the system, proteus software was used to simulate the circuit.

IV. DATA PRESENTATION, ANALYSIS AND DISSCUSSION OF THE RESULTS

Data were collected from the pilot Basement Room on its estimated electrical power consumption, population of MUST population (staff and students) and physical counting of personnel's who pass through the proposed area of administration block

The data was collected from MUST Basement Room used as class room for teaching purpose. The aim was to know the power consumption of Basement's used equipments and devices together with the lightings. The collected data are as recorded in table 1.

Table 1Power consumptions of Basement's equipments

S/No	Equipment	Model	Quantity	Power(W)	Total power(W)
01	Laptop	Hp ProBook 430	1	45	45
02	Projector	EB-W05 Epson	1	282	282
03	Lamps	LED	31	16	496
		Tube light	11	36	396
		Energy saver	4	11	44
Grand Total					1263

Source; Must 2019

The population of MUST staff and students were obtained from human Resource and Admission offices respectively as shown on Table 2.

Table 2 Admission and Human Resource Office Data

S/No	Category	Sub-total
01	Employed staff	504
02	Students	5482
Total		5986

Source; Must 2019

Data was also collected through counting the physical population of people who pass in average through the stairs at MUST Administration area are as shown in Table 3

Table 3 Average Counted Population at Administration Area

Duration	Number of people
Morning	2026
Afternoon	1205

Evening	987
Night	754
Average total number of people/day	4972

Source; Must 2019

A. Power Generated

The maximum voltage is generated when maximum force or weight is applied to piezoelectric materials [8]. Pressure provided to piezoelectric materials is directly proportional to amount of power generated. According to [9] piezo sensor can generate 1 V (minimum) and 10 V (maximum) per step. Considering the minimum value, 9600 steps are required to increase 12 V in a battery. According to the data collected as shown on table 3, during the morning in the area proposed which has six stairs there are about 12,156 steps which are enough to produce the required voltage.

B. Circuit Diagram

The circuit diagram for generation of Electricity using piezo electrical materials was designed. The circuit diagram is as shown in figure 6 and the designed prototype is also shown in figure 7.

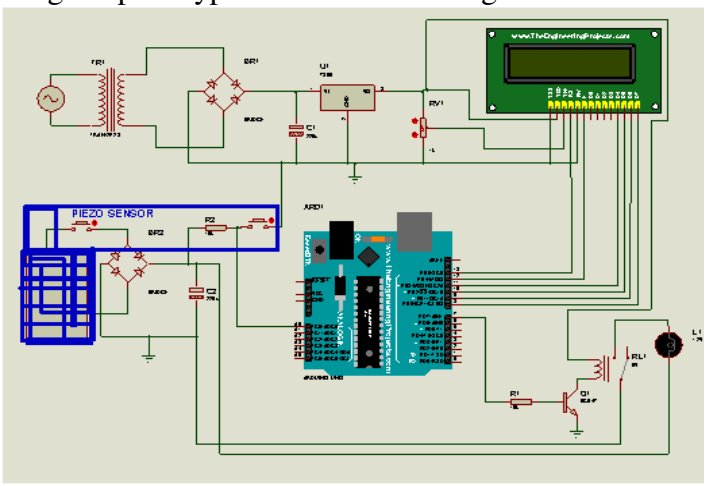

Figure 6: Designed circuit diagram

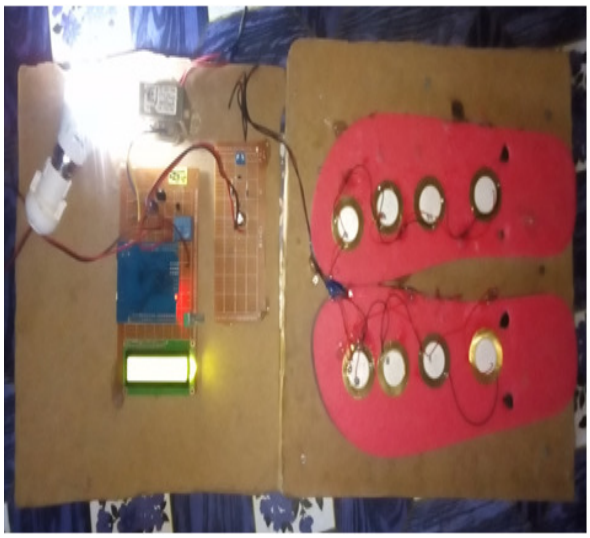

Figure 7: Prototype of Piezoelectric Footstep Power Generation

C. Circuit Operation

When force applied to piezoelectric transducer it is converted into electrical energy. A rectifier controls the fluctuation in generated voltages and unidirectional current controller controls the battery charging current with the help of microcontroller. The voltage generated by series of sensors is stored in Lead Acid batteries. This voltage can be used to drive either DC or AC loads. For AC loads, pure sine wave inverter circuit is used. Inverter converts dc voltages stored in lead acid batteries into 220 Volt AC. AC voltages can be used to drive AC loads. Rating of battery charger depends on amount of power generation from foot step. The generated voltage from the footsteps is displayed on the LCD.

D. Conclusion

Advanced piezoelectric footsteps power generation system is a system designed for the purpose of generating power through the use of footsteps of people at Mbeya University of Science and Technology. The researcher aimed to solve the problem of electric power supply at University Basement Rooms when the supply from TANESCO is cut off. The designed system can be used to other different places having crowd movement.

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List of Abbreviations

MUST	Mbeya University of Science and Technology
LCD	Liquid Crystal Display
TANESCO	Tanzania Electric Supply Company
SIMS	Students Information Management System

