ADICHUNCHANAGIRI UNIVERSITY

BG NAGARA, Nagamangala Taluk, Mandya District – 571448,
Karnataka, India

A DISSERTATION ON

On

"FOOTSTEP POWER GENERATION USING PIEZOELECTRIC MATERIAL"

Submitted in partial fulfillment of the requirements for the award of the degree

BACHELOR OF ENGINEERING
IN
ELECTRONICS AND COMMUNICATION ENGINEERING

For The Academic Year 2023-2024

Submitted By

NAME	USN
AMRUTHA K	20ECE005
ANANYA H M	20ECE007
DIVYA H S	20ECE028
LIKHITH K N	20ECE050

Under the guidance of:

Dr. M B ANANDARAJU, ME, Ph.D.
Director-HR, ACU
Proffessor, Dept. of ECE
BGSIT, BG Nagara

FACULTY OF ENGINEERING, MANAGEMENT & TECHNOLOGY

(BGS INSTITUTE OF TECHNOLOGY)

B G Nagara, Nagamangala Taluk, Mandya District– 571448

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that the project report entitled **"Footstep Power Generation Using Piezoelectric Material"** work is a bonafide work carried out by **AMRUTHA K (20ECE005), ANANYA H M (20ECE007), DIVYA H S (20ECE028), LIKHITH K N (20ECE050)** of **Faculty of Engineering, Management & Technology** (**B.G.S Institute of Technology**), **B.G Nagara** in partial fulfillment of the award Bachelor of Engineering in **Electronics and Communication Engineering**.Under **Adichunchanagiri University**, B G Nagara during the year 2023-2024. It is certified that all corrections/suggestions indicated for the internal assessment have been incorporated in the report deposited in the department library.The project report has been approved as it satisfies the academic requirements in respect of the project work prescribed for the said degree.

INTERNAL GUIDE

Dr. M B ANANDARAJU
Director-HR,ACU
Professor, Dept. of ECE
BGSIT, B G Nagara

PROJECT CO-ORDINATOR

Dr. MANOJ KUMAR S B
Assoc. Professor, Dept. of ECE
BGSIT, B G Nagara

HOD

Dr. P S PUTTASWAMY
Professor & HOD
Dept. of ECE, BGSIT, B G Nagara

PRINCIPAL

Dr. B N SHOBHA
Dean & Principal
BGSIT, B G Nagara

External Viva

Name of Examiners	**Signature of Examiners**
1. …………………………	………………………………
2. …………………………	………………………………

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(BGS INSTITUTE OF TECHNOLOGY)

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

DECLARATION

We **AMRUTHA K (20ECE005)**, **ANANYA H M (20ECE007)**, **DIVYA H S (20ECE028)**, **LIKHITH K N (20ECE050)** students of 8th semester BE in Electronics and Communication Engineering**, B.G.S Institute of Technology (BGSIT)**, **B.G Nagara.** hereby declare that the project work entitled **"FOOTSTEP POWER GENERATION USING PIEZO ELECTRIC MATERIAL"** submitted to the **ADICHUNCHANAGIRI UNIVERSITY,** during the academic year **2023- 2024**, is a record of an original work done by us under the guidance of **Dr. M B ANADARAJU,** Director-HR,ACU, Professor, Dept. of ECE, Faculty of Engineering, Management & Technology (B.G.S Institute of Technology). This project work is submitted in partial fulfillment of the requirements for the award of the degree of **BACHELOR OF ENGINEERING IN ELECTRONICS AND COMMUNICATION ENGINEERING,** we further declare that the work embodied in this project report has not been submitted to any other university or institute for the award of any degree.

DATE:
PLACE: B G Nagara,

AMRUTHA K	**20ECE005**
ANANYA H M	**20ECE005**
DIVYA H S	**20ECE028**
LIKHITH K N	**20ECE050**

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AMRUTHA K	20ECE005
ANANYA H M	20ECE007
DIVYA H S	20ECE028
LIKHITH K N	20ECE050

ABSTRACT

The population of the country increased and the requirement of the power is also increased. At the same time the wastage of energy also increased in many ways. So reforming this energy back to usable form is the major solution. As technology is developed and the use of gadgets, electronic devices also increased Power generation using conservative methods becoming deficient. There is a necessity arises for a different power generation method. At the same time the energy is wasted due to human locomotion and many ways. To overcome this problem, the energy wastage can be converted to usable form using the piezoelectric sensor. This sensor converts the pressure on it to a voltage. So by using this energy saving method, that is the footstep power generation system we are generating power.

In this project we are using the generated power to charge the mobile phones in the public places like bus stops, metro stations and also in railway station. In metro stations, the power generated from footsteps can be used for several purposes. One common application is to power low- energy devices and systems within the station. This could include LED lighting, digital displays, or small electronic devices. By incorporating footstep power generation in areas with high foot traffic, metro stations can harness the energy produced by commuters to contribute to the station's overall power needs, potentially reducing reliance on conventional energy sources and promoting sustainability.

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INTRODUCTION

Now a day’s energy is one of the most important issues around the world. Especially in India energy crisis is a big problem. Renewable energy sources can be a great media to solve this energy crisis problem in India. As we know natural resources will finish one day. That’s why researchers are trying to introduce substitute energy sources from nature that must be green and not harmful for the environment. Energy harvesting is defined as capturing minute amounts of energy from one or more of the surrounding energy sources. Human beings have already started to use energy harvesting technology in the form of windmill, geothermal and solar energy. The energy came from natural sources, termed as renewable energy.

A piezoelectric sensor is a sensor that generates a mechanical strain when an external force is applied or a deformation occurs when a voltage is applied to the sensor. The piezoelectric sensor is applied in various purposes in many industries and used widely such as medical industries, automobile industries, and information communication industry. This piezoelectric sensor determines the energy level from the external force condition, and it is expected to collect high energy in the ocean where the main external force is expected to be collected. In particular, the coastal structure protects the harbor facilities from the high waves.

Thus, to convert such wave energy into electric energy, this study proposes a new wave power generation system which derives the wave energy by the pressure applied to the front part by attaching the piezoelectric sensor device to the outside of the existing coastal structure. When the irregular waves impact the piezoelectric panel, the change of pressure caused by the wave power is outputted as the voltage through the measuring meter and converted into the amount of energy, and the maximum amount of generated energy is predicted by the power generation time.

Piezoelectric energy is a technology which converts mechanical energy into electrical energy. When an external force is applied to the piezoelectric system, electric charge is generated by drawing the charge generator in the system [4, 5]. Using this principle, it is being applied in various fields such as ecofriendly energy like sun, wind, wave, and vibration. The unimorph piezoelectric device applied to this experiment has a circular thin piezoelectric ceramic plate attached on the metal diaphragm, although there are various types of piezoelectric devices with various applications.

Energy harvesting refers to the technique of harvesting unused energy around us, such as light, temperature difference, and vibration energy, into useful electric energy [7]. The piezoelectric energy collection system applied to this study was designed to examine the energy generation efficiency and applicability to coastal structures in areas with wide wave energy width. It also includes the characteristics of wave power generation system in which the pressure is transmitted to the center of the system to generate a voltage when the main external force wave is applied to the device.

Since the piezoelectric effect generated by the MLCC (multilayer ceramic capacitor) differs from that of the widely used polarized PZT, it is necessary to carefully examine what results are obtained depending on the state of the input signal and the MLCC [8]. However, in this study, since unimorph-type PZT is installed in duplicate, energy collection and trend analysis are easier. As the coastal structures used in the experiment, caisson-type breakwater was applied to perform the normal function of the port facility since it effectively reduces the high waves in deep water depth. Particularly, it is possible to produce energy by wave by attaching the device to the upper part of the front side of the breakwater where high wave, the main external force, intensively influences.

Renewable energy harvesting plants generate KW or MW level power; it is called macro energy harvesting technology. Moreover, micro energy also can produce from those natural sources that are called micro energy harvesting. Micro energy harvesting technology is based on mechanical vibration, mechanical stress and strain, thermal energy from furnace, heaters and friction sources, sun light or room light, human body, chemical or biological sources, which can generate mW or μW level power. Micro power supply needs is increasing greatly with time as our technology is moving to the micro and Nano fabrication levels. It is essential to generate micro energy from vibration and pressure using piezoelectric material. Waking is the most common activity in day to day life. When the person walks he loses his energy in form of impact, vibration, sound etc. This mechanical energy can be tapped and convert into electrical energy.

Piezo electric sensor

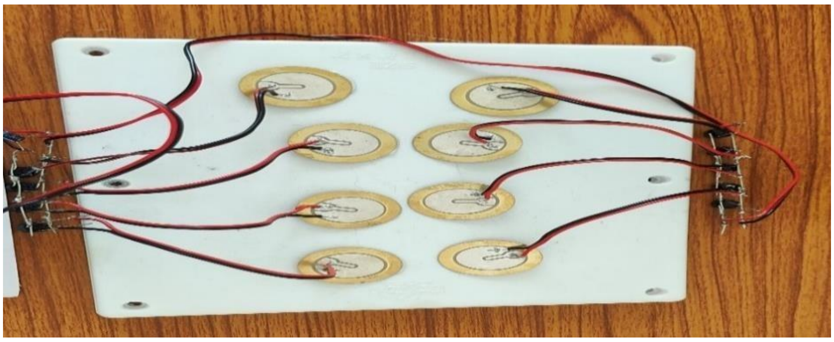

Fig.1.1 Piezo electric sensor

A piezoelectric sensor is a sensor that generates a mechanical strain when an external force is applied or a deformation occurs when a voltage is applied to the sensor. The piezoelectric sensor is applied in various purposes in many industries and used widely such as medical industries, automobile industries, and information communication industry. This piezoelectric sensor determines the energy level from the external force condition, and it is expected to collect high energy in the ocean where the main external force is expected to be collected. In particular, the coastal structure protects the harbor facilities from the high waves.

To convert such wave energy into electric energy, this study proposes a new wave power generation system which derives the wave energy by the pressure applied to the front part by attaching the piezoelectric sensor device to the outside of the existing coastal structure. When the irregular waves impact the piezoelectric panel, the change of pressure caused by the wave power is outputted as the voltage through the measuring meter and converted into the amount of energy, and the maximum amount of generated energy is predicted by the power generation time.

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Fig.1.2 Footstep power generation.

Fig.2 shows footstep power generation using piezo electric sensors, Energy harvesting refers to the technique of harvesting unused energy around us, such as light, temperature difference, and vibration energy, into useful electric energy [7]. The piezoelectric energy collection system applied to this study was designed to examine the energy generation efficiency and applicability to coastal structures in areas with wide wave energy width. It also includes the characteristics of wave power generation system in which the pressure is transmitted to the center of the system to generate a voltage when the main external force wave is applied to the device.

Foot step power generation using piezoelectric materials represents a cutting-edge approach to harnessing renewable energy from human movement. This technology captures the mechanical energy generated by walking and converts it into electrical energy through the piezoelectric effect. This model is particularly relevant as it aligns with sustainable energy goals and the quest for innovative ways to utilize everyday activities for power generation, thereby contributing to energy efficiency and environmental sustainability.

Piezoelectric materials, such as lead zirconate titanate (PZT), barium titanate, and certain polymers, have the unique ability to generate an electric charge in response to applied mechanical stress. This phenomenon, known as the piezoelectric effect, occurs because these materials have a crystalline structure that becomes polarized under pressure. When a person steps on a surface embedded with piezoelectric materials, the stress from the footstep induces a voltage across the material, converting kinetic energy into electrical energy.

The footstep power generation system typically integrates piezoelectric transducers into flooring tiles or mats. These transducers are strategically arranged in arrays to maximize the energy harvested from each step. When a foot applies pressure, the piezoelectric material deforms, generating an alternating current (AC) signal. This AC signal is then rectified to direct current (DC) and can be stored in batteries or capacitors. The design also includes an electronic circuit to regulate and store the generated energy, making it available for various applications such as powering LED lights or charging small electronic devices.

This technology offers numerous applications and benefits, particularly in high-traffic areas such as airports, shopping malls, and public transport stations. The energy harvested from footsteps can be used to power lighting systems, display screens, or wireless sensors. It can also serve as a supplementary power source for buildings, contributing to the reduction of conventional energy consumption. Additionally, footstep power generation can be employed in remote or off-grid areas to provide a reliable source of power without relying on external energy supplies, thus enhancing energy security and sustainability.

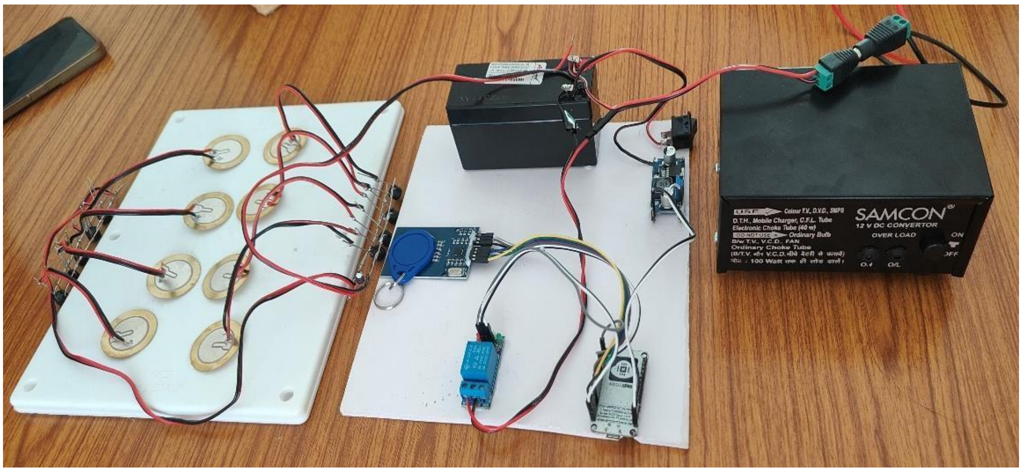

Fig 1.3 The Experiment Setup of the Piezoelectric Material.

Despite its potential, footstep power generation faces several challenges. The amount of energy generated per step is relatively small, which necessitates the aggregation of energy from many footsteps to achieve a significant power output. The efficiency of the system is highly dependent on the properties of the piezoelectric materials used and their integration into the flooring design. Durability under continuous mechanical stress and the cost of implementation are additional concerns. The technology also requires efficient energy storage and management systems to handle the intermittent nature of the power generated.

Future research and development in footstep power generation aim to improve the efficiency and practicality of these systems. Advances in materials science are focusing on developing new piezoelectric compounds with higher energy conversion efficiencies and greater durability. Innovations in system design seek to optimize the placement and configuration of piezoelectric elements to maximize energy capture. Furthermore, integration with smart grids and the Internet of Things (IoT) could enhance the management and utilization of the generated energy. As these technologies evolve, footstep power generation could become a significant component of sustainable urban energy systems, contributing to the reduction of carbon footprints and the advancement of smart cities.

1.1 MOTIVATION

Every step taken on surfaces embedded with piezoelectric materials can generate electricity. Given the high foot traffic in urban areas, public spaces, and commercial buildings, this untapped kinetic energy can be converted into a valuable power source. Piezoelectric power generation is an eco-friendly solution that produces no emissions or pollutants. By capturing energy from footsteps, it contributes to reducing the reliance on fossil fuels and helps in mitigating climate change. Integrating piezoelectric systems into floors, sidewalks, and staircases allows for continuous and decentralized power generation. This can significantly enhance the energy efficiency of buildings and public infrastructure by supplementing traditional energy sources. Adopting piezoelectric technology for power generation demonstrates a commitment to innovation. It showcases the potential of smart materials in creating intelligent, responsive environments that can adapt to human activity. Although the initial installation costs might be high, the long-term benefits include reduced energy bills and lower maintenance costs compared to other renewable energy systems. Additionally, it creates opportunities for new industries and job creation in the renewable energy sector. Visible implementations of footsteps power generation can raise public awareness about renewable energy and sustainability. It engages communities and individuals in the energy generation process, fostering a sense of responsibility and participation in environmental conservation. This technology can be applied in various settings, from busy metropolitan areas to remote locations, providing a versatile solution to energy generation challenges. It can be particularly beneficial in places where traditional power infrastructure is lacking or unreliable. Implementing piezoelectric systems in schools and universities can serve as a live demonstration of renewable energy principles, enriching the educational experience for students and inspiring future innovations in sustainable technology.

1.2 PROBLEM STATEMENT

To develop and implement a viable footsteps power generation system using piezoelectric materials that maximizes energy capture and conversion efficiency, ensures durability and reliability under high foot traffic, integrates seamlessly with existing infrastructure, and provides a cost-effective solution for renewable energy generation and distribution.

This project aims to harness the untapped kinetic energy from human footsteps, contributing to the overall energy mix and promoting sustainable and eco-friendly energy practices in urban environments.

Now a day's energy is one of the most important issues around the world. Especially in India energy crisis is a big problem. Renewable energy sources can be a great media to solve this energy crisis problem in India. As we know natural resources will finish one day. That's why researchers are trying to introduce substitute energy sources from nature that must be green and not harmful for the environment

1.3 OBJECTIVES

This project aims to design, implement, and evaluate a footstep electricity generation system using piezoelectric disks. The primary objectives are:

- Energy Harvesting: To harness mechanical energy from footsteps using piezoelectric disks and convert it into electrical energy.
- Energy Storage: To store the generated electrical energy in a 12V battery, ensuring a stable and usable power supply.

- Smart Control System: To integrate a NodeMCU microcontroller and an RFID reader for automated control of an inverter, allowing authorized users to access the stored energy for charging devices.
- Feasibility Demonstration: To demonstrate the practical application of the system in providing renewable energy for small-scale electronic devices.

1.4 ORGANIZATION OF THESIS

The thesis on footsteps power generation using piezoelectric material is organized to systematically explore and address the challenges and opportunities of this innovative energy solution.

Chapter 1: INTRODUCTION

The Introduction chapter sets the stage by presenting the global energy demand and sustainability challenges, emphasizing the necessity for renewable energy sources. It provides an overview of piezoelectric materials and their potential for energy generation, leading to a detailed problem statement. This chapter also outlines the key research questions, hypotheses, scope, limitations, and the structure of the thesis.

Chapter 2: LITERTURE SURVEY

The Literature Review chapter delves into the existing body of knowledge on renewable energy technologies, comparing them with traditional sources. It explores the properties and types of piezoelectric materials, their energy conversion mechanisms, and various applications. A focused review on footsteps power generation highlights previous research, case studies, and identifies gaps that this thesis aims to fill.

Chapter 3: DESIGN METHODOLOGY

In the Methodology chapter, the research design and approach are elaborated, justifying the methods chosen for this study. It describes the criteria for selecting piezoelectric materials, the characterization techniques used, and the design and integration of the power generation system into existing infrastructure. The chapter details the experimental setup, data collection methods, and the techniques for analyzing and evaluating the system's performance.

Chapter 4: RESULTS AND DISCUSSION

The Results chapter presents the findings of the material characterization, system performance evaluation, durability and reliability tests, and practical implementation. It includes detailed analyses of the piezoelectric properties, energy conversion efficiency, and the system's robustness under simulated foot traffic conditions. This chapter also discusses the challenges faced during integration and provides insights from a case study on practical implementation.

Chapter 5: THE CONCLUSION

The Conclusion and Future Work chapter summarizes the key findings, confirming or refuting the initial hypotheses. It highlights the contributions to the field of renewable energy and piezoelectric research, and suggests areas for further research and improvements in piezoelectric system design and efficiency. The chapter concludes with final remarks on the research's broader significance.

The thesis is complemented by a comprehensive list of References citing all sources used, and Appendices containing additional data, charts, diagrams, and supplementary materials that support the research. This structured approach ensures a thorough investigation and clear presentation of the potential of footsteps power generation using piezoelectric materials.

Chapter 2

LITERATURE SURVEY

[1]. Mohamed Yousuf. S and Mohammed Ghusn Yahya Al Hinaey, "Application of Piezoelectric Sensor in Energy Harvesting Technology for Pathway Sustainability", International Journal of Engineering Research & Technology (IJERT), vol. 11, no. 02, February 2022.

The literature highlights the increasing importance of alternative energy sources in addressing power demands. The paper focuses on energy harvesting through piezoelectric sensors from human footsteps, converting wasted mechanical energy into electricity. To enhance power output, the study suggests connecting Piezo sensors in series/ parallel combinations. The proposed technology finds applications in various settings, offering a sustainable solution for mobile charging, LED lighting, and more. The integration of a microcontroller (ATMega328P) monitors and displays real-time voltage status, making this approach practical for diverse purposes in the evolving power sector. The power sector is giving many changes in order to maintain an effective power flow. Even though renewable or non-renewable energy sources are present in the power market, some countries could not overcome the power demand due to an increase in the human population. In order to avoid such issues, power can be generated using alternating techniques

[2]. Anis Maisarah, Mohd Asry, Farahiyah Mustafa, Sy Yi Sim, Maizul Ishak and Aznizam Mohammad, "Study on footstep power generation using piezoelectric tile", Indonesian Journal of Electrical Engineering and Computer Science ,vol.15,no.2,August 2019.

The literature discusses an innovative concept: generating electricity from human footsteps using piezoelectric transducers. These devices convert mechanical energy from walking into electrical energy. Implemented in a series-parallel configuration, the transducers are applied to wooden tiles resembling walking surfaces. This approach holds potential for practical deployment in high-traffic areas, pedestrian pathways, or fitness equipment, providing a sustainable means to power low-consumption devices. Electrical energy is important and had been demand increasingly. A lot of energy resources have been wasted and exhausted. An alternative way to generate electricity by using a population of human had been discovered

When walking, the vibration that generates between the surface and the footstep is wasted. By utilizing this wasted energy, the electrical energy can be generated and fulfill the demand. The piezoelectric transducer is connected in series-parallel coonection. Then, it is placed on the tile that been made from wood as a model for footstep tile to give pressure to the piezoelectric transducers. This tile can be placed in the crowded area, walking pavement or exercise instruments. The electric energy that generates from this piezoelectric tile can be power up low power appliances.

[3]. Mazwin Mazlan and Mohamad Hazlami Abd Manan, "Modelling and Analysis Road Energy Harvester Using Piezoelectric Transducer", International Journal of Engineering & Technology, vol. 8, no. 1.7, pp. 94-100, 2019.

This paper explores designing a road energy harvester using piezoelectric transducers, aiming for an eco-friendly energy source without disrupting ecosystems. Utilizing Proteus Software, it compares circuit configurations, highlighting a 4 Series 2 Parallel connection for a voltage doubler as the most effective, generating 6.634 V. This paper describes the design of energy harvester from the road using piezoelectric transducer for creating a clean energy source with out disturbing any existing ecosystemIn this paper, the piezoelectric sensors are used as a key elemem in generating electricity. Piezoelectric sensors that conduct for converting kinetic energy to electricity have placed vibrations from the movement of vehicles and humans as the main focus of the project. Simulation by Proteus Software is used to determine the circuit connection for converting an alternative current (AC) to direct current (DC).

[4]. Amitha V Menon, K M Anjana, Anjana S Ravindran and S Divya, "Piezoelectric Wireless Mobile Charger", IOSR Journal of Engineering (IOSRJEN), pp. 31-35,2018.

Electricity usage is expanding at an exponential rate. This research recommends making use of human locomotion energy, which, despite being extractable, is largely wasted. This research presents an energy storage concept that employs human movement, skipping, and running as energy. The piezoelectric sensors are used in this innovative footstep power production system. The piezo sensors are positioned below the platform. to generate a voltage from footstep. The sensors are arranged in such a way that maximum output voltage is generated, which is then sent to our monitoring circuitry. This energy is then stored in the batteries and can be used whenever it is convenient. A model like this is near suitable for India, which has a large pedestrian people. This method of generating charge and storing it for later use encourages an approach to energy creation and the development of clean green energy. Keywords: Piezoelectricity, Plates, Footsteps, Power Generation, Electricity. This research addresses the escalating demand for electricity by proposing the utilization of human locomotion energy, often wasted. The innovative footstep power production system employs piezoelectric sensors beneath a platform, converting footstep pressure into voltage. The strategically arranged sensors maximize output voltage, feeding into monitoring circuitry and subsequently storing the energy in batteries for convenient use. Tailored for densely populated pedestrian areas like India, this approach promotes environmentally responsible energy creation, contributing to the development of clean and sustainable energy solutions.

[5].Mervyn Fernandes, Minal Patil, Vedant Desai and Asawari Dudwadkar, "Implementation of Piezoelectric Sensors for Generation of Power", International Journal of Innovative Research in Science Engineering and Technology, vol. 6, no. 4, April 2017.

The electrical power consumption is increasing exponentially. Therefore, the need of a fool-proof and economically viable power generation and distribution system demands a certain interest. This paper proposes utilization of human locomotion energy which, although extractable goes mainly to waste. This paper proposes a model that uses human walking, jumping and running as a source of energy and store it for essential use. Such a model is opt in a demography that of a country like India which has such a huge pedestrian population. This paper illustrates a method for harvesting this human locomotion energy with the use of piezoelectric sensor and demonstrates an application with the stored energy Le to charge a mobile phone securely using RFID. The ground reaction force (GRF) exerted from the foot, when converted to voltage by piezoelectric sensors is capable enough to power up a device. Successive exertion leads to aperiodic voltage build up which with proper circuitry can be used to charge a storage battery. The power produced by this technique can also be employed in basic application such as street lighting, notice boards, gyms and other areas of public domain. It also promotes green energy and environment friendly approach towards energy generation. In this paper we have provided the basic concept and design details of this model and a basic implementation of the same.

[6].D Marshiana, M Elizabeth Sherine, N Sunitha and C Vinothkumar, "Footstep Power production using Piezoelectric Sensors", Research Journal of Pharmacy and Technology, July 2016.

In day today life the utilization of power turns to be necessary for each work. The power delivered in this paper will not contaminate the surroundings and it is also will not to rely upon the climate conditions. The paper proposes a novel technique for the creation of power utilizing piezoelectric sensors kept along the footpaths which can ready to charge the battery and ready to supply the force at whatever time of our prerequisite. The footstep power generation technique through piezoelectric sensors produces electrical force by changing mechanical energy of the development of individuals on the floor to electrical energy. The benefits of piezoelectric force generation framework is that it is sheltered and secure to utilize, it doesn't make any issue ordistress for the general population strolling through footpath, and it is absolutely chance free strategy. Footstep power generation technique has mechanical part and in addition electrical part, however the electrical and mechanical losses are negligible. This framework additionally has the ability to store the electrical force away battery. The power produced by this technique can be utilized for helping up the road lights, additionally for activity reason, sign boards of streets.

Chapter 3

DESIGN METHODOLOGY

When the person walks on the steps he transfers his energy in a form of impact, vibration, sound etc. Piezoelectric sensors which will be connected in series and parallel combination tap this mechanical energy and convert into electrical energy. The polarity of charge depends upon whether element is under compression or tension as a result of applied force. If the element is subjected to an applied compressive force its polarity will be positive and due to applied tensile force it will be negative. This element generates the electrical charge. The produced output is in the variable form so bridge rectifier is used to convert AC into DC. The remaining AC will be converted and neutralised by capacitor. Capacitor will be grounded if AC is present it will grounded and we will obtained pure DC. This is fed to IN4148 diode which makes current to flow in one direction and it will fed into microcontroller arduino. The voltage produce across the time can be displayed on LCD. Capacitors store the power which is connected to loads. The process charges the battery ,an inverter ups is connected to the battery which gives 220v ac output to which computers ,lights, tv can be connected. But in this project we are connecting mobile charger to charge the mobile phones and we will content the light bulb for the conformation.

3.1 HARDWARE AND SOFTWARE REQUIREMENTS:

3.1.1 Hardware Requirements:

NodeMCU: The ESP8266 NodeMCU CP2102 board has ESP8266 which is a highly integrated chip designed for the needs of a new connected world. It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.

ESP8266 has powerful on-board processing and storage capabilities that allow it to be integrated with the sensors and other application-specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, and the entire solution, including the front-end module, is designed to occupy minimal PCB area.

The ESP8266 NodeMCU development board – a true plug-and-play solution for inexpensive projects using WiFi. The module arrives pre-flashed with NodeMCU firmware so they're ready to go – just install your USB driver (below). ESP-12 Lua Nodemcu WIFI Dev Board Internet Of Things board contains a full ESP8266 WiFi module with all the GPIO broken out, a full USB-serial interface, and a power supply all on the one breadboard-friendly package.

Fig.3.1 NodeMCU

Piezo Electric Sensor: Piezoelectric materials possess a distinctive property where they produce an electric charge in response to mechanical stress and, conversely, deform under an applied electric field. This effect, known as the piezoelectric effect, is due to their asymmetric crystal structures, which create internal electric dipoles when mechanically deformed. Common examples include natural crystals like quartz and synthetic ceramics such as lead zirconate titanate (PZT), which are widely utilized for their strong piezoelectric responses. These materials can convert mechanical energy into electrical energy and vice versa, making them crucial in various technologies.

The practical applications of piezoelectric materials are vast and diverse. They play a key role in sensors for measuring pressure, acceleration, and force in devices like accelerometers, microphones, and ultrasound transducers. In actuators, piezoelectric materials enable precise movements in applications such as precision positioning systems and inkjet printers. Additionally, they are used in energy harvesting to convert mechanical vibrations into electrical energy, providing power for small devices in remote locations. Their high sensitivity and broad frequency response make piezoelectric materials essential in both industrial and consumer technologies, where precise control and efficient energy conversion are required.

Fig.3.2 Piezo Electric Sensor

UPS Inverter: In footstep power generation using piezoelectric materials, piezoelectric sensors are embedded in surfaces where footsteps are frequent, such as floors or staircases. When someone walks over these sensors, mechanical stress is applied, causing the piezoelectric materials to generate electrical charge. This generated energy, although relatively small and inconsistent due to the irregular nature of foot traffic, can be harnessed and accumulated in a storage system. However, the electricity produced is typically in an alternating current (AC) form, with variable voltage and frequency.

To make this power useful for typical household or industrial applications, an Uninterruptible Power Supply (UPS) inverter is employed. The UPS inverter converts the irregular AC power generated by the piezoelectric sensors into stable direct current (DC). This DC is then either used directly to charge batteries or further inverted back to a steady AC form compatible with electrical grids or appliances. This ensures that the intermittent power from footsteps is transformed into a reliable and usable energy source, thereby integrating piezoelectric generation into practical energy systems.

Fig.3.3 UPS Inverter

Bridge Rectifier: In a footstep power generation system using piezoelectric materials, a bridge rectifier is crucial for converting the AC (alternating current) output from the piezoelectric elements into DC (direct current). Piezoelectric materials generate electricity when subjected to mechanical stress, such as from footsteps. This electricity is in the form of an AC signal because the mechanical pressure is variable. A bridge rectifier, typically consisting of four diodes arranged in a bridge configuration, allows current to pass through in only one direction, effectively converting the AC signal into a pulsed DC output.

This conversion is necessary because many electronic devices and batteries require DC for charging and operation. The bridge rectifier works by allowing the positive half-cycles of the AC signal to pass through one pair of diodes while the negative half-cycles pass through the other pair. This arrangement ensures that the output voltage remains positive, regardless of the input signal polarity. After rectification, a capacitor can be used to smooth the pulsed DC, reducing the ripple and providing a more stable DC voltage. This stabilized DC output can then be used to charge batteries or power small electronic devices, making the system efficient for harvesting energy from piezoelectric materials embedded in floors or other surfaces subjected to human foot traffic.

Fig.3.4 Bridge Rectifier

Relay: This 1-channel 5V control Single-Pole Double-Throw (SPDT) High-level trigger AC power relay board can be controlled directly via a microcontroller and switch up to 10A at 250 VAC. The inputs of 1 Channel 5V Relay Module are isolated to protect any delicate control circuitry.The default state of the relay when the power is off for COM (Power) to be connected to NC (Normally Closed). This is the equivalent of setting the relay board IN pin to HIGH (has +5V sent to it).

In a footstep power generation system utilizing piezoelectric materials, a relay serves as a crucial component for managing and distributing the generated electricity. Piezoelectric materials produce small bursts of electricity when subjected to pressure from footsteps. Since the generated power is intermittent and variable, a relay can act as an automatic switch that directs the flow of this electricity to a storage system, such as a battery or capacitor, or directly to a load. When the piezoelectric sensors generate enough voltage, the relay closes its contacts, allowing the current to flow to the desired circuit. Once the pressure is removed and the voltage drops below a threshold, the relay opens its contacts, disconnecting the circuit and preventing reverse flow or potential damage to the components. This controlled switching mechanism ensures efficient energy capture and prevents wastage or overload in the power generation system.

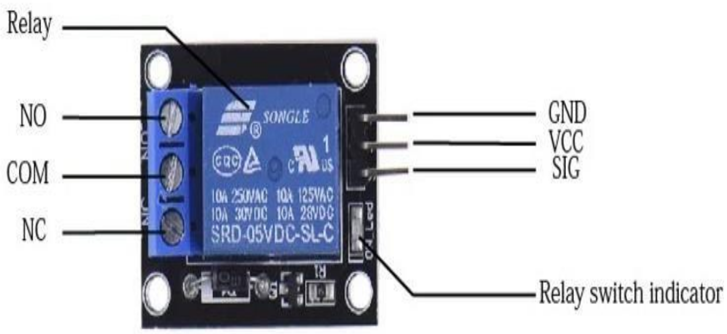

Fig.3.5 Relay

Battery: Batteries may be used once and discarded, or recharged for years as in standby power applications. Miniature cells are used to power devices such as hearing aids and wristwatches; larger batteries provide standby power for telephone exchanges or computer data centers.

Lead-acid batteries are the most common in PV systems because their initial cost is lower and because they are readily available nearly everywhere in the world. There are many different sizes and designs of lead-acid batteries, but the most important designation is that they are deep cycle batteries. Lead-acid batteries are available in both wet-cell (requires maintenance) and sealed no-maintenance versions. Lead acid batteries are reliable and cost effective with an exceptionally long life. The Lead acid batteries have high reliability because of their ability to withstand overcharge, over discharge vibration and shock.

The use of special sealing techniques ensures that our batteries are leak proof and non-spoilable. The batteries have exceptional charge acceptance, large electrolyte volume and low self-discharge, Which make them ideal zero- maintenance batteries lead acid batteries Are manufactured/ tested using CAD (Computer Aided Design). These batteries are used in Inverter & UPS Systems and have the proven ability to perform under extreme conditions. The batteries have electrolyte volume, use PE Separators and are sealed in sturdy containers, which give them excellent protection against leakage and corrosion.

Fig.3.6 Battery

RFID Reader: Do you want to know the work of RFID Reader/Writer RC522 SPI S50 CARD AND KEYCHAIN, then this Product is best for you . With this Product, you can detect radio waves produced by a reader to detect the presence of (then read the data stored on) an RFID tag.

This is RFID Reader/Writer RC522 SPI S50 CARD AND KEYCHAIN which works on non-contact 13.56mhz communication, is designed by NXP as low power consumption, low cost, and compact size read and write chip, is the best choice in the development of smart meters and portable hand-held devices.

It uses an advanced modulation system, fully integrated at 13.56MHz with all kinds of positive non-contact communication protocols. Support 14443A compatible answer signal. DSP deals with ISO14443A frames and error correction.

This module can fit directly in handheld devices for mass production. The module uses the 3.3V power supply and can communicate directly with any CPU board by connecting through the SPI protocol, which ensures reliable work, good reading distance.

Fig.3.7 RIFID Reader

3.1.2 Software Requirements:

Arduino IDE: Arduino ide is the software used to write-compile-upload program to arduino. Arduino code is written in C++ with an addition of special methods and functions. C++ is a human-readable programming language. When we create a sketch (the name given to Arduino code files), it is processed and compiled to machine language.

Code Structure:

The basic concepts which one should know to write a program on Arduino IDE are discussed.

Libraries:

In Arduino, much like other leading programming platforms, there are built-in libraries that provide basic functionality. In addition, its possible to import other libraries and expand the Arduino board capabilities and features. These libraries are roughly divided into libraries that interact with a specific component or those that implement new functions.

3.2 BLOCK DIAGRAM

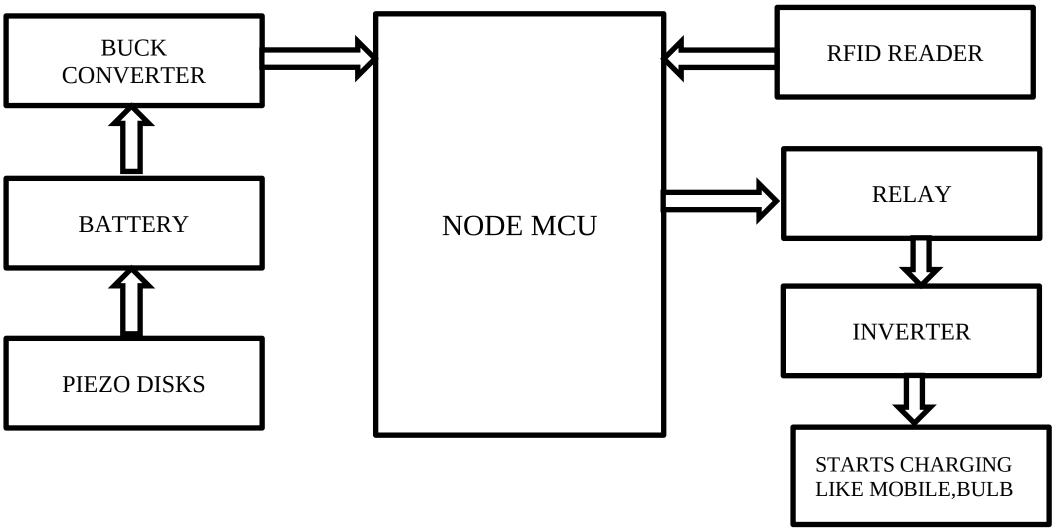

Fig.3.8 Block diagram of proposed methodology.

The footstep electricity generation system consists of several key components, each playing a crucial role in the overall functionality:

1. Piezoelectric Disks:

- **Configuration:** Ten piezoelectric disks connected in series to maximize voltage output.
- **Operation:** The disks generate electricity when subjected to pressure from footsteps.

2. Bridge Rectifier:

- **Function:** Converts the AC voltage generated by the piezoelectric disks into DC voltage.
- **Components:** Typically consists of four diodes arranged in a bridge configuration.

3. Voltage Regulation:

- **DC-DC Converter:** Adjusts the rectified voltage to match the requirements for charging a 12V battery.
- **Charge Controller:** Manages the charging process, ensuring battery safety and longevity.

4. Energy Storage:

12V Battery: Stores the generated electrical energy for later use.

5. NodeMCU and RFID Reader:

- **NodeMCU:** A microcontroller that manages the RFID reader and controls the inverter.
- **RFID Reader:** Detects RFID cards and sends signals to the NodeMCU for verification and control.

6. Inverter:

- **Function:** Converts the stored DC voltage in the battery to AC voltage, suitable for powering electronic devices.
- **Control:** Activated by the NodeMCU upon detection of an authorized RFID card.

3.3 WORK FLOW

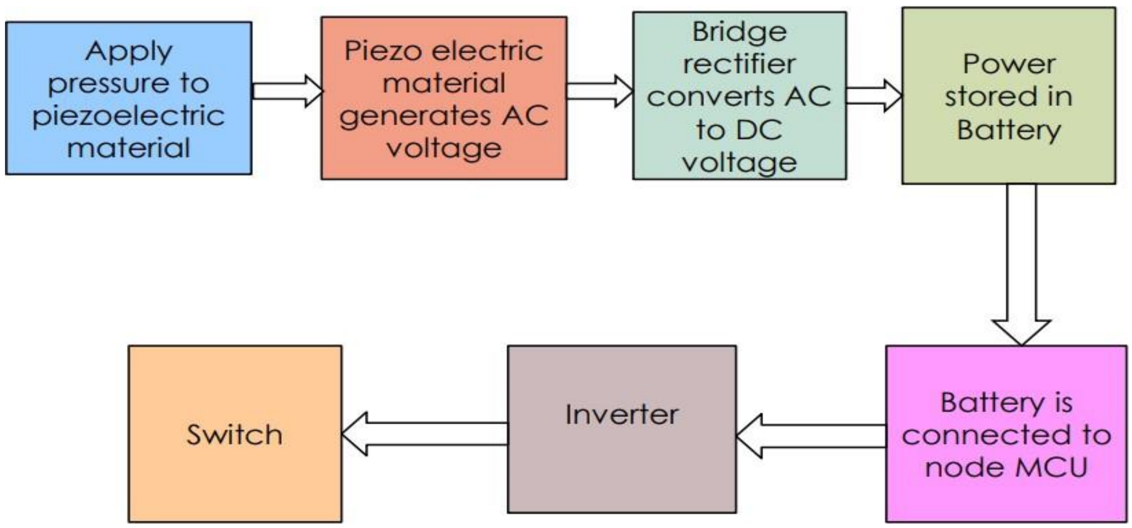

Fig.3.9 Workflow Diagram.

1. Piezoelectric Disk Array Configuration:

The ten piezoelectric disks are connected in series to increase the overall voltage output. Each disk is placed in a protective housing to ensure durability and efficient energy transfer. The series configuration ensures that the voltage produced by each disk is added together, resulting in a higher combined voltage output.

2. Bridge Rectifier and Voltage Regulation:

The output from the piezoelectric disks is directed to the bridge rectifier, which converts the AC voltage to DC. A capacitor is connected to the rectifier's output to smooth the voltage, eliminating fluctuations and providing a steady DC voltage. This voltage is then fed into a DC-DC converter, which adjusts it to the appropriate level for charging the 12V battery.

3. Charge Controller and Battery Connection:

The DC-DC converter's output is connected to the charge controller, which manages the charging process. The charge controller is then connected to the 12V battery, ensuring that the energy is stored efficiently and safely. The charge controller monitors the battery's voltage and current levels, preventing overcharging and deep discharging.

4. NodeMCU and RFID Integration:

The RFID reader is connected to the NodeMCU microcontroller, which is programmed to read RFID cards and control the relay connected to the inverter. The NodeMCU continuously checks for RFID card presence and verifies the card's UID. Upon detecting an authorized card, the NodeMCU activates the relay, allowing the inverter to convert the stored DC voltage to AC.

5. Inverter and Output Connection:

The inverter is connected to the 12V battery and converts the stored DC voltage to AC. The AC output is then made available for users to plug in their devices. The system ensures that the inverter is only activated when an authorized RFID card is detected, providing secure and controlled access to the stored energy.

Chapter 4

RESULTS AND DISCUSSIONS

The footstep electricity generation system successfully demonstrates the feasibility of using piezoelectric disks to harness mechanical energy from footsteps. The generated energy is effectively stored in a 12V battery and can be used to power electronic devices through an inverter. The integration of a NodeMCU and RFID reader provides a smart control system, ensuring that only authorized users can access the stored energy.

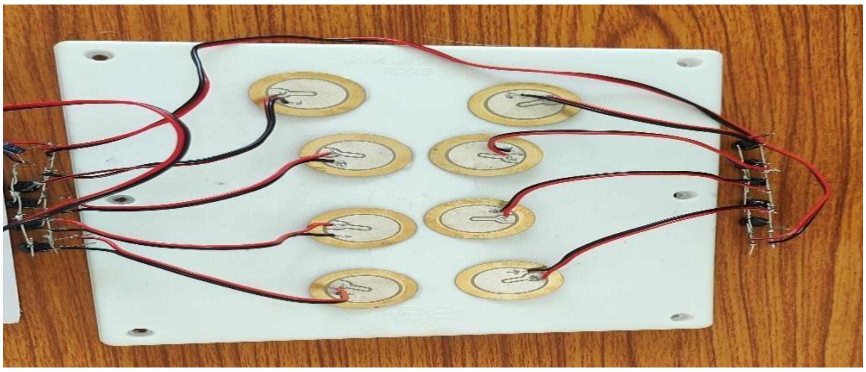

Fig.4.1 Piezo Electric Sensors.

The system's performance depends on several factors, including the number and sensitivity of piezoelectric disks, the efficiency of the bridge rectifier and voltage regulation components, and the capacity of the battery. Future improvements could focus on optimizing these components, increasing the energy harvesting efficiency, and expanding the system's scalability for larger applications.

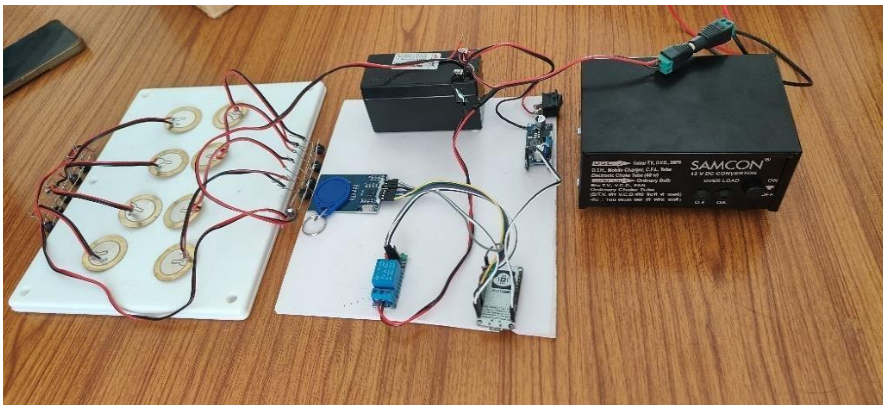

Fig.4.2 The Experiment Setup of the Piezoelectric Material.

The piezoelectric transducer output is in AC waveform. The output of the transducer needs to be rectify and filtered before being used to the storage or to the DC loads. Figure 3 shows the output of the piezoelectric transducer before being inserted to the full bridge rectifier

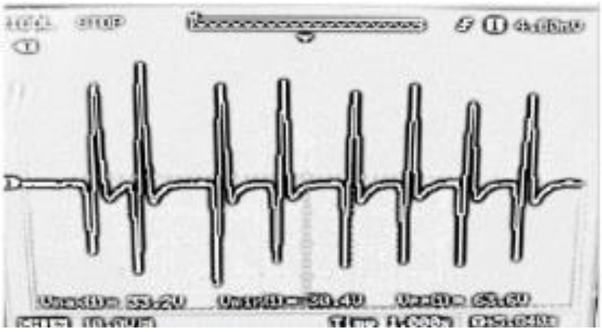

Fig.4.3 The output of the piezoelectric transducer before being rectifiy.

Connection of Piezoelectric

The piezoelectric transducer was connected in series and parallel connection. Before using the piezoelectric transducer to generate electric energy, the connection needs to be determined to choose the better output from the piezoelectric transducer. Figure 4 shows three piezoelectric transducers were connected in series. Figure 5 shows, three piezoelectric transducers are connected in parallel connection. Two sets of three piezoelectrics that connected in series were attached in parallel for series-parallel connection as shown in Figure 6. The multimeter was connected to the piezoelectric transducers to measure the voltage and current across the connection. A double-sided tape 3mm is placed on the top and the bottom of the piezoelectric transducer to maximize the output of this transducer. Figure 7 and Figure 8 shows the output of the piezoelectric based on the connection that being done.

Fig.4.4 The series connection of piezoelectric material

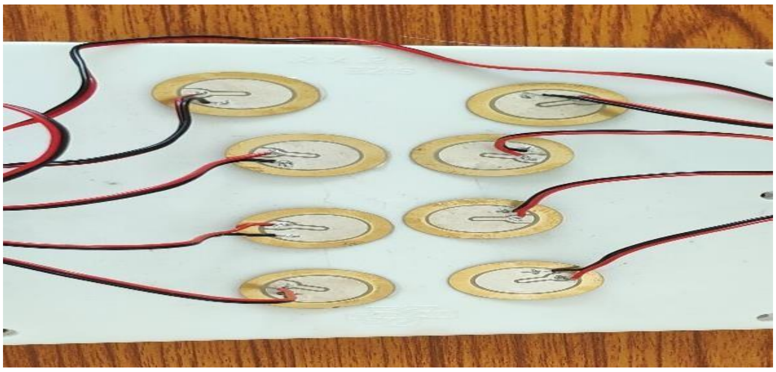

Fig.4.5 The parallel connection of piezoelectric material

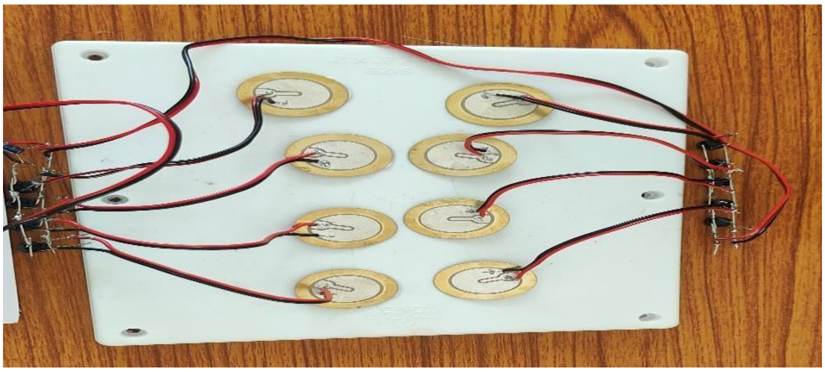

Fig.4.6 The series-parallel connection of piezoelectric material

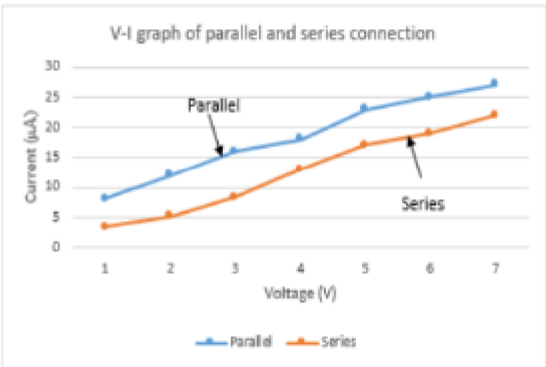

Fig.4.7 Voltage – Current graph of parallel and series connection of piezoelectric

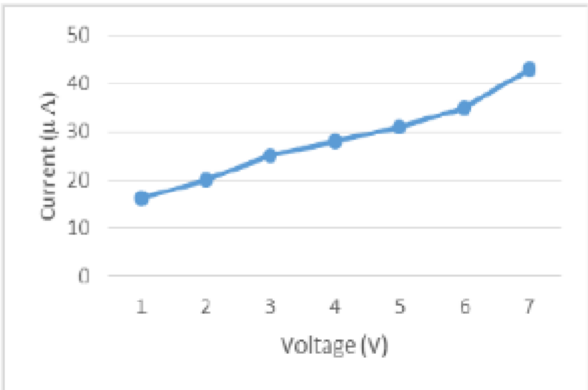

Fig.4.8 Voltage – Current graph of parallel and series connection of piezoelectric

Figure 19 shows that when the piezoelectric are connected in series the output voltage is high but the output current is low. However, vice versa happened for the parallel connection of the piezoelectric transducer. It give high current but low output voltage. In order to solve this problem, the combination of this connection needs to carry out. Two set of three piezoelectric transducers that connected in series was attached together in parallel to form series-parallel connection. The value of voltage as well as current output are both satisfactory.

Analysis on the Piezoelectric Material

The piezoelectric tile that show on the Figure 4.9 is used for foot press or pumping activites in order to collect the voltage. The 6 cell of piezoelectric transducers is placed between the upper and lower of this piezoelectric material. This piezoelectric tile is design in a square shape with wood block. This tile are screw at its four edge and combine with the spring to make the upper tile bounce back after the person step on it. The piezoelectric transducer is placed between the gaps of the two tiles. The subjects are asked to do the foot press or pumping activities on this piezoelectric tile to collect the voltage produced by the 6 cell piezoelectric transducers during that activities. Figure 4.10 show the model of the piezoelectric tile from front, side and inside view

Fig.4.9 The piezoelectric tile that used for foot press activities

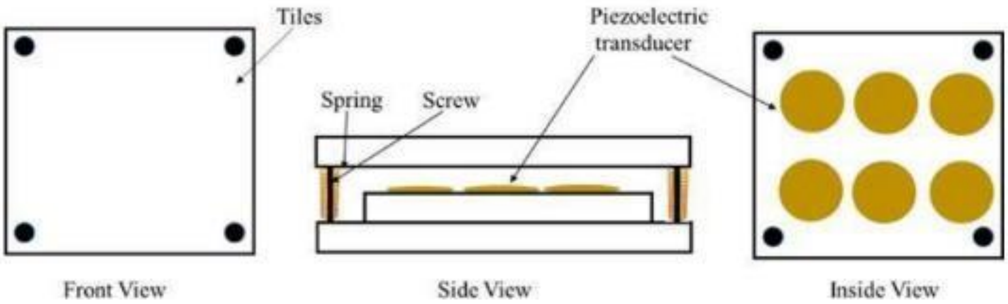

Fig.4.10 Model of piezoelectric tile with 8 cell of piezoelectric material

Table 1. The Weight and the Voltage Taken based on the Jump on the Piezoelectric

Subject	**Weight(kg)**	**Time(sec)**			
		5 sec	**10 sec**	**15 sec**	**20 sec**
Subject 1	45	1.98 V	2.15 V	2.80 V	3.78 V
Subject 2	50	0.83 V	1.23 V	2.38 V	3.12 V
Subject 3	55	1.76 V	2.73 V	4.66 V	5.65 V
Subject 4	60	2.75 V	4.59 V	5.31 V	6.06 V

Study using foot press or pumping is conducted to determine the voltage output of a 8 cell of the piezoelectric transducer that connected in series-parallel connection. Table 1 shows subject with 45 kg, 50 kg, 55 kg and 60 kg body weight are used to test the piezoelectric tile. They are asked to step on the tiles to do the foot press or pumping activities to test the voltage generating capacity of the piezoelectric tile. The voltage generated is based on the time recorded which are 5 sec, 10 sec, 15 sec, and 20 sec.The relation between the time taken and the voltage being generated is plotted in the graph for each weight. From Figure 11, it can be seen that maximum voltage is generated when the person pumps about 20 seconds on the piezoelectric tile. The voltage generated depends on the force that being applied to the piezoelectric tile. In theory when a bigger person pump on this piezoelectric tile, the voltage that is generated is higher compared to the smaller person. There are a linear relation between the force and the voltage generated. Figure 4.11 shows that the theory is proved. The weight of subject 4 is bigger than other subjects so it the voltage that generates by this subject is the highest when the subject pump on the material.

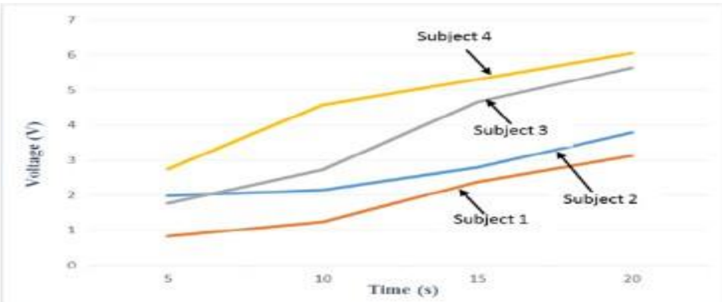

Fig.4.11 Voltage against time measured during subject press on the piezo material

- **Energy Harvesting Efficiency:**

  The efficiency of energy harvesting is influenced by the sensitivity of the piezoelectric disks and the amount of mechanical energy applied.

frequent and forceful, the system can generate a substantial amount of energy. However, in low-traffic areas, the energy output may be lower, necessitating additional strategies to enhance energy capture.

- **Storage and Utilization:**

The 12V battery provides a reliable means of storing the harvested energy, ensuring that it is available for use even when foot traffic is minimal. The battery's capacity and the charge controller's efficiency are critical factors in determining the overall system performance. Ensuring optimal charging conditions and preventing energy loss during storage are essential for maximizing the system's effectiveness.

- **Smart Control System:**

The NodeMCU and RFID reader integration adds a layer of intelligence to the system, allowing for automated and secure access to the stored energy. By enabling only authorized users to activate the inverter, the system ensures efficient use of the harvested energy and prevents unauthorized usage. This smart control mechanism can be further enhanced with additional features, such as data logging and remote monitoring, to provide comprehensive management of the energy harvesting system.

- **Scalability and Future Applications:**

The footstep electricity generation system can be scaled up for larger applications by increasing the number of piezoelectric disks and optimizing the energy storage and control components. Potential applications include powering streetlights, public charging stations, and other urban infrastructure. By integrating renewable energy harvesting with smart technology, the system can contribute to sustainable urban development and reduce reliance on conventional energy sources.

Chapter 5

ADVANTAGES, DISADVANTAGES AND APPLICATIONS

5.1 Advantages:

- **Sustainable Energy Source:**

  Utilizes renewable mechanical energy from footsteps, reducing dependence on fossil fuels and contributing to environmental sustainability.

- **High Efficiency:**

  Series connection of piezoelectric disks maximizes voltage output, improving energy harvesting efficiency compared to individual piezoelectric components.

- **Smart Control System:**

  Integration of NodeMCU microcontroller and RFID reader provides automated and secure access to the stored energy, enhancing user experience and energy management.

- **Energy Storage:**

  Efficient storage of harvested energy in a 12V battery with a charge controller ensures a stable and reliable power supply, preventing overcharging and deep discharging.

- **User-Friendly Interface:**

  RFID technology allows authorized users to easily access the stored energy, providing a seamless and secure user experience.

- **Scalability:**

  Designed to be scalable for various applications, from small-scale installations in high-foot-traffic areas to larger systems in urban environments.

- ### Cost-Effective:

  Efficient energy conversion and smart control mechanisms reduce overall costs, making the system a viable option for widespread adoption.

- ### Durability and Reliability:

  Protective housing for piezoelectric disks and robust control systems ensure long-term durability and reduced maintenance requirements.

- ### Versatile Applications:

  Capable of powering a variety of devices, from mobile chargers to small electrical appliances, making it versatile in different contexts.

- ### Environmental Impact:

  Reduces carbon footprint by harnessing ambient mechanical energy, promoting cleaner and greener energy solutions.

5.2 Disadvantages:

- It is not suitable for measurement in static condition.
- Since the device operates with the small electric charge, they need high impedance cable for electrical interface.
- The output may vary according to the temperature variation of the crystal.

5.3 Applications

1. Public Walkways and Sidewalks

Application: Piezoelectric tiles installed in busy public walkways.

Usage: Generate electricity to power streetlights, public information displays, or charging stations.

Fig.5.1 Pedestrians walking on piezoelectric tiles can generate electricity for public utilities.

2. Stadiums and Arenas

Application: Piezoelectric flooring in high-traffic areas of stadiums.

Usage: Harvest energy from foot traffic to power lighting, screens, or other facilities.

Fig.5.2 Crowds in stadiums can generate substantial power through piezoelectric floors.

3. Smart Floors in Buildings

Application: Embedded piezoelectric sensors in commercial or residential buildings.

Usage: Power sensors for occupancy monitoring, lighting control, and HVAC systems.

Fig.5.3 Smart floors can use footstep-generated power for building automation systems.

4. Interactive Flooring for Exhibitions

Application: Piezoelectric tiles in museums or commercial spaces.

Usage: Generate power for interactive displays, dynamic lighting, or information panels.

Fig.5.4 Visitors interacting with displays powered by their footsteps.

5. Wearable Technology in Shoes

Application: Piezoelectric materials integrated into shoes.

Usage: Generate power for health monitoring devices or mobile devices.

Fig.5.5 Smart shoes can power health trackers or GPS units using footstep energy.

6. Roadways and Highways

Application: Piezoelectric devices embedded in roads.

Usage: Generate electricity from vehicle vibrations for road lighting or sensor networks.

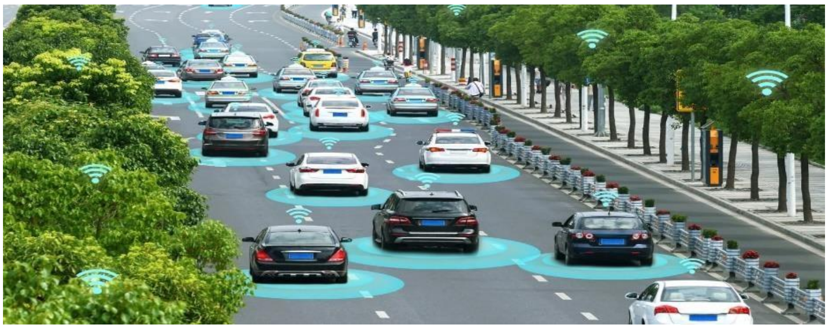

Fig.5.6 Roads equipped with piezoelectric materials can harvest energy from passing vehicles.

7. Bridges with Integrated Sensors

Application: Piezoelectric materials integrated into bridge surfaces.

Usage: Generate electricity from vibrations to power structural health monitoring systems.

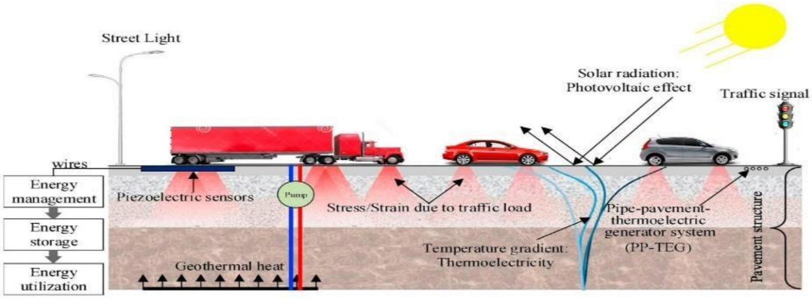

Fig.5.7 Bridges can use piezoelectric-generated energy for self-monitoring.

8. Interactive Gaming Floors

Application: Piezoelectric tiles in gaming or entertainment centers.

Usage: Power interactive gaming experiences or virtual reality environments.

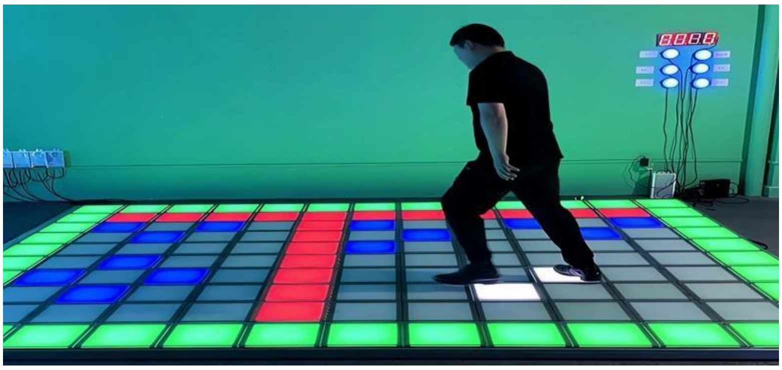

Fig.5.8 Interactive gaming floors can enhance player experiences with piezoelectric technology.

These applications show the versatility of piezoelectric materials in harnessing energy from footsteps for various practical uses.

CONCLUSION

In conclusion, footstep power generation utilizing piezoelectric discs presents a promising and sustainable solution for harvesting energy from human motion. The innovative technology leverages the piezoelectric effect to convert mechanical pressure from footsteps into electrical energy, offering a clean and renewable power source. As demonstrated by various research and prototypes, this approach holds great potential for applications in urban environments, public spaces, and high-traffic areas, contributing to the development of green energy solutions.

Further advancements in materials, design, and scalability could enhance the efficiency and feasibility of footstep power generation, making it an increasingly viable option for powering low-energy devices and potentially contributing to broader efforts in sustainable energy systems. Embracing this technology not only addresses the growing demand for alternative energy sources but also underscores the importance of harnessing the energy potential inherent in everyday human activities.

FUTURE SCOPE

Footstep power generation using piezoelectric materials is a burgeoning technology that converts mechanical energy from walking into electrical power. By embedding piezoelectric elements into surfaces like floors, pavements, and walkways, the energy from footfalls can be harnessed and converted into usable electricity. This innovation holds significant potential for sustainable energy applications, particularly in urban environments, where high foot traffic can be leveraged to power streetlights, sensors, or small electronic devices, contributing to the energy efficiency of smart cities. Moreover, integrating piezoelectric materials into wearable technology, such as smart shoes or clothing, can enable self-powered health monitoring systems and personal gadgets, reducing dependency on traditional battery sources. The application extends to public spaces, railways, airports, and even remote or off-grid locations, providing supplementary power and enhancing the sustainability of infrastructure. Despite challenges like efficiency, durability, and cost, ongoing advancements in piezoelectric technology promise to enhance its viability, making footstep power generation a compelling component of future renewable energy solutions.

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Footsteps Power Generation Using Piezo Electric Material

M. B. Anandaraju[1], Aruna B[2], Amrutha K[3], Ananya H M[4], Divya H S[5], Likhith K N[6]

HR-Manager, Department of ECE, BGS Institute of Technology, Adichunchanagiri University, B.G Nagara, Karnataka, India[1]

Assistant Professor, Department of ECE, BGS Institute of Technology, Adichunchanagiri University, B.G Nagara, Karnataka, India[2]

U.G. Students, Department of ECE, BGS Institute of Technology, Adichunchanagiri University, B.G Nagara, Karnataka, India[3 4 5 6]

ABSTRACT: Electricity usage is expanding at an exponential rate. This research introduces an energy storage concept that utilizes human movements like skipping and running. It recommends harnessing human locomotion energy, which, despite being extractable, is largely wasted. This innovative footstep power production system employs piezoelectric sensors placed beneath a platform to generate voltage from footsteps. The sensors are arranged to maximize output voltage, which is then directed to a monitoring circuit. The generated energy is stored in batteries for convenient later use. This model is especially suitable for India, which has a large pedestrian population. This method of generating and storing energy promotes an environmentally responsible approach to energy production and the development of clean, green energy.

KEYWORDS: Piezoelectric sensors, Electricity, Footsteps power Generation.

I. INTRODUCTION

Now a day's energy is one of the most important issues around the world. Especially in India energy crisis is a big problem. Renewable energy sources can be a great media to solve this energy crisis problem in India. As we know natural resources will finish one day. That's why researchers are trying to introduce substitute energy sources from nature that must be green and not harmful for the environment. Energy harvesting is defined as capturing minute amounts of energy from one or more of the surrounding energy sources. Human beings have already started to use energy harvesting technology in the form of windmill, geothermal and solar energy. The energy came from natural sources, termed as renewable energy.

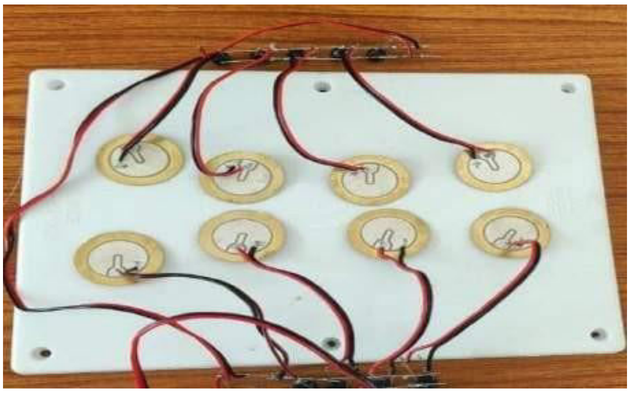

Fig.1: Piezoelectric Sensors

A piezoelectric sensor is a sensor that generates a mechanical strain when an external force is applied or a deformation

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occurs when a voltage is applied to the sensor. The piezoelectric sensor is applied in various purposes in many industriesand used widely such as medical industries, automobile industries, and information communication industry. This piezoelectric sensor determines the energy level from the external force condition, and it is expected to collect high energy in the ocean where the main external force is expected to be collected.

Since the piezoelectric effect generated by the MLCC (multilayer ceramic capacitor) differs from that of the widely used polarized PZT, it is necessary to carefully examine what results are obtained depending on the state of the input signal and the MLCC . However, in this study, since unimorph-type PZT is installed in duplicate, energy collection and trend analysis are easier. As the coastal structures used in the experiment, caisson-type breakwater was applied to perform the normal function of the port facility since it effectively reduces the high waves in deep water depth. Particularly, it is possible to produce energy by wave by attaching the device to the upper part of the front side of the breakwater where high wave, the main external force, intensively influences. A device and a panel attached to the structure.

II. PROBLEM STATEMENT

Now a day's energy is one of the most important issues around the world. Especially in India energy crisis is a big problem. Renewable energy sources can be a great media to solve this energy crisis problem in India. As we know natural resources will finish one day. That's why researchers are trying to introduce substitute energy sources from nature that must be green and not harmful for the environment.

III. LITERATURE SURVEY

The study conducted in [1] discusses the literature highlights the increasing importance of alternative energy sources in addressing power demands. The paper focuses on energy harvesting through piezoelectric sensors from human footsteps, converting wasted mechanical energy into electricity. To enhance power output, the study suggests connecting Piezo sensors in series/ parallel combinations. The proposed technology finds applications in various settings, offering a sustainable solution for mobile charging, LED lighting, and more. The integration of a microcontroller (ATMega328P) monitors and displays real-time voltage status, making this approach practical for diverse purposes in the evolving power sector. The power sector is giving many changes in order to maintain an effective power flow. Even though renewable or non-renewable energy sources are present in the power market, some countries could not overcome the power demand due to an increase in the human population. In order to avoid such issues, power can be generated using alternating techniques

The study conducted in [2] utilizes the literature discusses an innovative concept: generating electricity from human footsteps using piezoelectric transducers. These devices convert mechanical energy from walking into electrical energy. Implemented in a series-parallel configuration, the transducers are applied to wooden tiles resembling walking surfaces. This approach holds potential for practical deployment in high-traffic areas, pedestrian pathways, or fitness equipment, providing a sustainable means to power low-consumption devices. Electrical energy is important and had been demand increasingly. A lot of energy resources have been wasted and exhausted. An alternative way to generate electricityby using a population of human had been discovered when walking, the vibration that generates between the surface and the footstep is wasted. By utilizing this wasted energy, the electrical energy can be generated and fullfill the demand. The piezoelectric transducer is connected in series-parallel connection. Then, it is placed on the tile that been made from wood as a model for footstep tile to give pressure to the piezoelectric transducers. This tile can be placed in the crowded area, walking pavement or exercise instruments. The electric energy that generates from this piezoelectric tile can be power up low power appliances.

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This study [3] presents the review utilizes this paper explores designing a road energy harvester using piezoelectric transducers, aiming for an eco-friendly energy source without disrupting ecosystems. Utilizing Proteus Software, it comparescircuit configurations, highlighting a 4 Series 2 Parallel connection for a voltage doubler as the most effective, generating 6.634 V. This paper describes the design of energy harvester from the road using piezoelectric transducer for creating a clean energy source without disturbing any existing ecosystem .In this paper, the piezoelectric sensors are used as a key element in generating electricity. Piezoelectric sensors that conduct for converting kinetic energy to electricity have placed vibrations from the movement of vehicles and humans as the main focus of the project. Simulation by Proteus Software is used to determine the circuit connection for converting an alternative current (AC) to direct current (DC).

This study [4] Electricity usage is expanding at an exponential rate. This research recommends making use of human locomotion energy, which, despite being extractable, is largely wasted. This research presents an energy storage concept that employs human movement, skipping, and running as energy. The piezoelectric sensors are used in this innovative footstep power production system. The piezo sensors are positioned below the platform to generate a voltage from footstep. The sensors are arranged in such a way that maximum output voltage is generated, which is then sent to our monitoring circuitry. This energy is then stored in the batteries and can be used whenever it is convenient. A model like this is near suitable for India, which has a large pedestrian people. This method of generating charge and storing it for later use encourages an approach to energy creation and the development of clean green energy. Keywords: Piezoelectricity, Plates, Footsteps, Power Generation, Electricity. This research addresses the escalating demand for electricity by proposing the utilization of human locomotion energy, often wasted. The innovative footstep power production system employs piezoelectric sensors beneath a platform, converting footstep pressure into voltage. The strategically arranged sensors maximize output voltage, feeding into monitoring circuitry and subsequently storing the energy in batteries for convenient use. Tailored for densely populated pedestrian areas like India, this approach promotes environmentally responsible energy creation, contributing to the development of clean and sustainable energy solutions.

This study [5] the electrical power consumption is increasing exponentially. Therefore, the need of a fool-proof and economically viable power generation and distribution system demands a certain interest. This paper proposes utilization of human locomotion energy which, although extractable goes mainly to waste. This paper proposes a model that uses human walking, jumping and running as a source of energy and store it for essential use. Such a model in a demography that of a country like India which has such a huge pedestrian population. This paper illustrates a method for harvesting this human locomotion energy with the use of piezoelectric sensor and demonstrates an application with the stored energy Le to charge a mobile phone securely using RFID. The ground reaction force (GRF) exerted from the foot, when converted to voltage by piezoelectric sensors is capable enough to power up a device. Successive exertion leads to aperiodic voltage build up which with proper circuitry can be used to charge a storage battery. The power produced by this technique can also be employed in basic application such as street lighting, notice boards, gyms and other areas of public domain. It also promotes green energy and environment friendly approach towards energy generation. In this paper we have provided the basic concept and design details of this model and a basic implementation of the same.

IV. MODEL DESCRIPTION AND WORKING

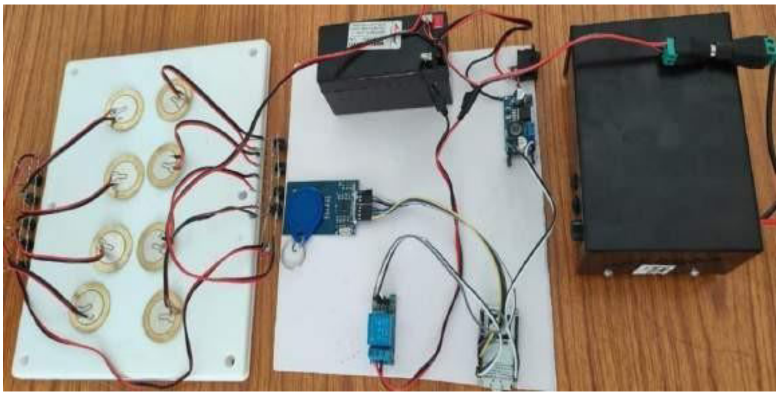

Fig.2 :Model setup of Footsteps power generator system using piezo electric material

When the person walks on the steps he transfers his energy in a form of impact, vibration, sound etc. Piezoelectric sensors which will be connected in series and parallel combination tap this mechanical energy and convert into electrical energy. The polarity of charge depends upon whether element is under compression or tension as a result of applied force. If the element is subjected to an applied compressive force its polarity will be positive and due to applied tensile force it will be negative. This element generates the electrical charge. The produced output is in the variable form so bridge rectifier is used to convert AC into DC.

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The piezoelectric disks form the core of the energy harvesting system. When a person steps on a disk, the pressure induces a mechanical stress that generates an electrical charge. By connecting ten piezoelectric disks in series, the system can produce a higher cumulative voltage, improving the overall efficiency of energy conversion. The series connection ensures that the voltage output from each disk adds up, resulting in a combined output sufficient to charge a 12V battery. The electrical energy generated by the piezoelectric disks is in the form of alternating current (AC) due to the nature of mechanical pressure variations. To store this energy in a battery, it needs to be converted to direct current (DC). A bridge rectifier, composed of four diodes, is used to rectify the AC voltage into DC voltage. The rectifier's output is then smoothed using a capacitor to eliminate voltage fluctuations, providing a steady DC voltage suitable for battery charging. The rectified voltage from the bridge rectifier may not be directly suitable for charging the 12V battery, depending on the output voltage of the piezoelectric disks. A DC-DC converter is employed to adjust the voltage to the appropriate level required by the battery. By maintaining optimal charging conditions, the charge controller ensures the longevity and reliability of the battery. The 12V battery serves as the storage unit for the harvested electrical energy. By storing the energy generated from footsteps, the system can provide a reliable power source for various applications, even when no immediate foot traffic is present. The stored energy can be used to power electronic devices through an inverter, making it a practical solution for renewable energy utilization.

The Node MCU microcontroller is a crucial component of the smart control system. It interfaces with the RFID reader, which detects RFID cards presented by users. When an authorized RFID card is detected, the Node MCU processes the signal and activates a relay connected to the inverter. This automation allows only authorized users to access the stored energy, enhancing the security and efficiency of the system. The Node MCU can be programmed using the Arduino IDE, enabling easy customization and expansion of the system's functionalities. The inverter converts the DC voltage stored in the 12V battery to AC voltage, which is required by most electronic devices. By providing a standard AC output, the inverter allows the harvested energy to be used for charging mobile devices, powering small appliances, and other applications. The inverter is controlled by the Node MCU, ensuring that it is only activated when an authorized user is detected by the RFID reader.

V. RESULT AND DISCUSSION

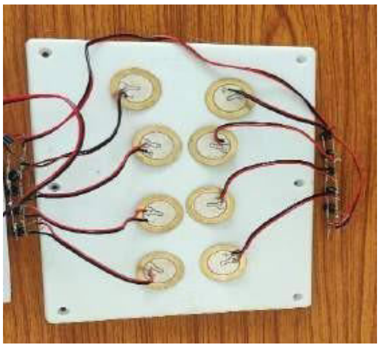

Fig.3: The series-parallel connectionof piezoelectric sensors

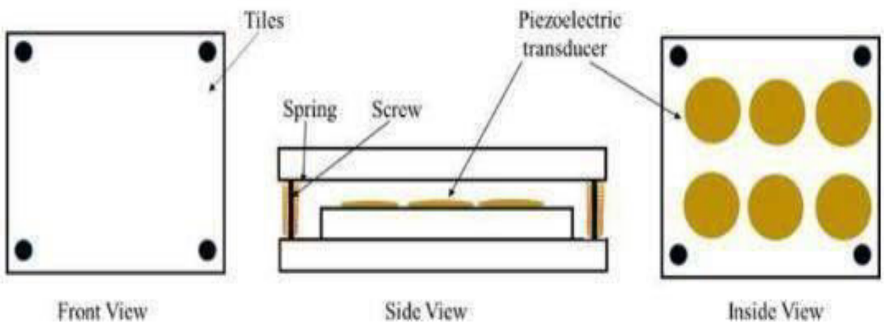

Fig. 4: Model of piezoelectric tile with 8 cell of piezoelectric material

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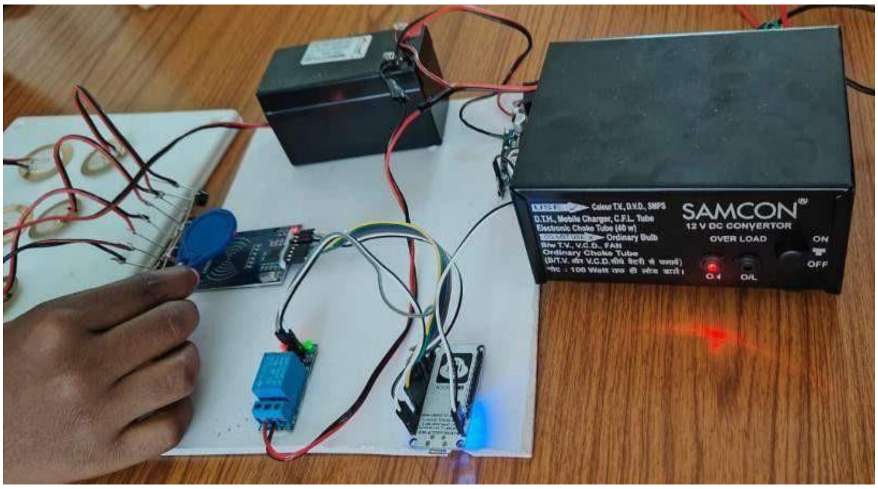

Fig.5: Developed model of footsteps power generation using piezoelectric material

The footstep electricity generation system successfully demonstrates the feasibility of using piezoelectric disks to harness mechanical energy from footsteps. The generated energy is effectively stored in a 12V battery and can be used to power electronic devices through an inverter. The integration of a Node MCU and RFID reader provides a smart control system, ensuring that only authorized users can access the stored energy. The system's performance depends on several factors, including the number and sensitivity of piezoelectric disks, the efficiency of the bridge rectifier and voltage regulation components, and the capacity of the battery. Future improvements could focus on optimizing these components, increasing the energy harvesting efficiency, and expanding the system's scalability for larger applications.

The efficiency of energy harvesting is influenced by the sensitivity of the piezoelectric disks and the amount of mechanical energy applied. In high-traffic areas, where footsteps are frequent and forceful, the system can generate a substantial amount of energy. However, in low-traffic areas, the energy output may be lower, necessitating additional strategies to enhance energy capture. The 12V battery provides a reliable means of storing the harvested energy, ensuring that it is available for use even when foot traffic isminimal. The battery's capacity and the charge controller's efficiency are critical factors indetermining the overall system performance. Ensuring optimal charging conditions and preventing energy loss during storage are essential for maximizing the system's effectiveness. The Node MCU and RFID reader integration adds a layer of intelligence to the system, allowing for automated and secure access to the stored energy. By enabling only authorized users to activate the inverter, the system ensures efficient use of the harvested energy and prevents unauthorized usage. This smart control mechanism can be further enhanced with additional features, such as data logging and remote monitoring, to provide comprehensive management of the energy harvesting system. The footstep electricity generation system can be scaled up for larger applications by Increasing the number of piezoelectric disks and optimizing the energy storage and control components. Potential applications include powering streetlights, public charging stations, and other urban infrastructure. By integrating renewable energy harvesting with smart technology, the system can contribute to sustainable urban development and reduce reliance on conventional energy sources.

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