

Smart Step: Piezoelectric Energy for Uninterrupted Smart Board

A.Vamshidhar Reddy¹, G.R.Varsha², B.Navya Sri³, N.Siddartha Varma⁴, D.Raj Kumar⁵

^{1,2,3,4,5}Department of ECE, CMR Technical campus, Hyderabad, India.

Corresponding Author mail id: vamshidharreddy.ece@cmrtc.ac.in

Abstract:

In modern educational environments, uninterrupted power supply is essential for the effective use of smart boards and digital teaching tools. This project introduces an innovative solution by harnessing piezoelectric energy through strategically placed mats on the dais. Whenever mechanical pressure is applied such as footsteps or movement the piezoelectric mats generate electrical energy. This energy is collected, regulated, and stored in a rechargeable battery system. During power interruptions, the stored energy is automatically redirected to power the smart board, ensuring continuous teaching without disruption. The proposed system not only enhances reliability in classrooms but also demonstrates sustainable energy harvesting by converting everyday mechanical activity into useful electrical power. By integrating piezoelectric technology with energy storage and smart switching mechanisms, the project highlights a practical, eco-friendly approach to bridging gaps in conventional power supply.

I . INTRODUCTION

In recent years, the use of digital technologies in education has increased significantly. Modern classrooms are equipped with advanced teaching tools such as smart boards, digital projectors, computers, and other interactive devices. These technologies improve the learning experience by making lessons more engaging, visual, and interactive. However, the effective use of these digital tools depends on a continuous and reliable power supply. In many educational institutions, power interruptions are a common problem that disrupts teaching activities and affects the learning process. When electricity fails, devices such as smart boards stop functioning, which interrupts the flow of the lecture and reduces the efficiency of digital learning systems. Therefore, it is necessary to explore alternative and sustainable methods of generating and storing electrical energy to support these systems during power failures. Energy

amounts of energy from the surrounding environment into usable electrical power. One of the most promising energy harvesting techniques is the use of piezoelectric materials, which generate electrical energy when mechanical pressure or stress is applied to them. This property allows the conversion of everyday mechanical movements, such as footsteps, into electrical energy. The proposed project utilizes piezoelectric mats placed on the classroom dais, where teachers frequently move during lectures. The mechanical pressure created by footsteps on the piezoelectric sensors generates electrical energy. This generated energy is then collected, regulated, and stored in a rechargeable battery system. During power interruptions, the stored energy can be used to power the smart board, ensuring uninterrupted teaching. This project not only provides a backup power solution but also promotes the concept of sustainable energy utilization by converting otherwise wasted mechanical energy into useful electrical power. By integrating piezoelectric technology with energy storage and power management systems, the proposed model demonstrates an eco-friendly and innovative approach to supporting modern digital classrooms. Overall, the project highlights the potential of energy harvesting technologies in educational environments and encourages the adoption of renewable energy solutions for improving the reliability and efficiency of smart learning systems.

II . LITERATURE REVIEW

This paper presents the design and development of a piezoelectric energy harvesting system that generates electrical energy from mechanical pressure applied on piezoelectric mats placed on the classroom dais. The generated energy is collected, regulated, and stored in a rechargeable battery system, which can be used as a backup power source for smart boards during power interruptions. This system helps ensure uninterrupted teaching and supports the effective use of digital learning tools in modern classrooms. In this project, we have also proposed a simple and eco-friendly method of converting everyday human movement, such as footsteps, into useful electrical energy using piezoelectric technology. The system demonstrates a sustainable approach to energy

generation and highlights the potential of energy harvesting technologies in educational environments.

[1] The paper titled “Arduino-Based Footstep Power Generation using Piezo Electric Material” presents an innovative approach to harvesting electrical energy from human footsteps using piezoelectric sensors integrated with an Arduino-based system. This work is part of the broader research domain focused on renewable and sustainable energy generation through non-conventional sources. Recent studies in this field have extensively explored the application of piezoelectric transducers for converting mechanical energy into electrical energy. Piezoelectric materials generate an electric charge when subjected to mechanical stress, making them suitable for energy harvesting applications in high-footfall areas. Several researchers have investigated the deployment of such systems in public places such as railway stations, shopping malls, and pedestrian walkways. Prior research has demonstrated that arranging multiple piezoelectric sensors in series and parallel configurations can significantly enhance the overall power output. Experimental implementations, particularly in staircase-based energy generation systems, have shown that sufficient energy can be generated to power low-energy devices such as LEDs, sensors, and small electronic circuits. Furthermore, the integration of microcontroller platforms, especially Arduino, has improved system efficiency by enabling real-time data monitoring, control, and display functionalities. Some studies have also incorporated additional modules such as RFID systems and energy storage units to enhance automation and system performance. Despite these advancements, several challenges persist, including low energy conversion efficiency, high installation costs, and the mechanical durability of piezoelectric materials under continuous stress. Nevertheless, the existing literature indicates that footstep-based energy harvesting systems hold significant potential for micro-scale power generation in urban environments. Journal: E3S Web of Conferences (ICPGRES 2024) [2] The paper titled “Experimental Study on the Piezo-Based Energy Harvester Utilizing the Ambient Vibrations for Smart Applications” presents an efficient method for harvesting electrical energy from ambient vibrations using piezoelectric materials. Energy harvesting has gained importance for powering low-energy devices such as wireless sensor nodes, IoT systems, and biomedical implants, where battery replacement is difficult. Among various energy sources, mechanical vibrations are

considered highly suitable due to their availability and relatively higher power density. Piezoelectric materials are widely used in such systems because they can directly convert mechanical stress into electrical energy. Previous studies have mainly focused on piezoelectric vibration energy harvesters using cantilever beam structures and different materials such as PZT and PVDF. Research shows that modifying the geometry and structure of the harvester can significantly improve output performance. Analytical and simulation tools like COMSOL have been used to study parameters such as natural frequency, stress distribution, and power output. The proposed work introduces a novel truncated cone with rectangular beam (TCRB) structure, which enhances energy generation. Experimental results indicate that the proposed design produces higher voltage and operates efficiently at lower frequencies compared to conventional cantilever beam harvesters. Overall, the study concludes that piezoelectric energy harvesting is a promising solution for self-powered smart applications, although challenges such as efficiency and optimization still exist. Journal: *Automatika: Journal for Control, Measurement, Electronics, Computing and Communications* [3] The paper titled “Effective Piezoelectric Energy Harvesting for Self-Supplied IoT Gadgets” presents a comprehensive study on the application of piezoelectric energy harvesting (PE-EH) systems for powering Internet of Things (IoT) devices in smart environments. Energy harvesting has become essential for modern smart city applications, where continuous power supply to wireless sensors and embedded systems is required. Traditional batteries have limitations such as short lifespan and maintenance issues, making piezoelectric energy harvesting a viable alternative. Piezoelectric materials convert mechanical vibrations into electrical energy and can be effectively used in various environments. Previous studies have explored multiple energy sources such as human motion, wind, water flow, and structural vibrations for generating power. Researchers have also investigated wearable energy harvesters integrated into footwear, clothing, and accessories, as well as systems embedded in infrastructure like roads, bridges, and pavements. These approaches demonstrate the versatility of piezoelectric systems in harvesting energy from everyday activities. Furthermore, research has focused on improving the efficiency of piezoelectric harvesters by optimizing material selection, operating modes (31 and 33 modes), and structural design. It has been observed that proper tuning of frequency and system configuration significantly enhances power output. Overall, the literature indicates that piezoelectric energy harvesting is a promising solution for developing self-powered IoT

systems, especially in smart cities. However, challenges such as efficiency optimization and energy management remain important areas for further research. Journal: International Academic Journal of Science and Engineering (IAJSE) [4] The paper titled “Walking Watts: Footstep-Based Electricity Generator and Energy Harvesting System” presents an innovative approach to generating electrical energy from human footsteps using piezoelectric transducers integrated into flooring systems. With the increasing demand for sustainable and renewable energy sources, footstep power generation has emerged as an effective method of harvesting mechanical energy from daily human activities. Earlier research primarily focused on mechanical systems such as rack and pinion mechanisms, which convert linear motion into rotational motion to generate electricity. These systems are simple and cost-effective but suffer from issues such as mechanical wear and reduced long term efficiency. Recent advancements have shifted towards piezoelectric-based energy harvesting systems, which generate electrical energy directly from mechanical stress without moving parts. Studies show that piezoelectric tiles embedded in floors can efficiently generate power in high-traffic areas such as malls, railway stations, and public spaces. These systems offer better durability and compact design compared to traditional mechanical methods. Further research has explored the integration of smart technologies such as IoT for real-time monitoring and energy management. Innovations like wearable energy harvesting devices and gait recognition systems have expanded the scope of this technology into smart city and healthcare applications. The literature also highlights practical applications in urban environments, including street lighting, public displays, and charging systems. However, challenges such as low power output, efficiency optimization, and energy storage remain key concerns. Overall, footstep-based energy harvesting is identified as a promising solution for sustainable energy generation in smart infrastructure. Journal: International Journal of Creative Research Thoughts (IJCRT) [5] The paper titled “Design and Implementation of a Low-Cost Piezoelectric Footstep Energy Harvesting System for Portable Power Applications in Grid Unstable Regions” presents a practical and cost-effective approach to generating electrical energy from human footsteps using piezoelectric sensors. With the increasing demand for reliable energy and the challenges associated with unstable power grids,

especially in developing regions, alternative energy harvesting methods have gained significant importance. Previous studies have explored various renewable energy sources such as solar, wind, thermoelectric, and piezoelectric systems. Among these, piezoelectric energy harvesting has been widely recognized due to its ability to directly convert mechanical stress into electrical energy with minimal infrastructure. Earlier research has demonstrated the use of piezoelectric tiles and sensor arrays embedded in high-footfall areas such as public buildings, walkways, and transportation hubs. These systems capture mechanical energy from human motion and convert it into usable electrical power. Studies have also investigated different configurations of piezoelectric materials, including series and parallel arrangements, to improve voltage output and efficiency. Additionally, advancements in system design have incorporated rectification circuits, energy storage units, and microcontroller-based monitoring systems to enhance performance and usability. Despite these improvements, challenges such as low power output, dependency on foot traffic, and efficiency optimization remain key limitations. The proposed work builds upon existing research by developing a low-cost and efficient system capable of generating and storing energy for portable applications, particularly in regions with unreliable electricity supply. The study concludes that footstep-based piezoelectric energy harvesting systems offer a promising solution for decentralized and sustainable power generation. Journal: International Journal of Frontiers in Engineering and Technology Research (IJFETR), 2025 [6] The paper "Smart shoe based on piezo electric sensors for low power applications" explores energy harvesting from human footsteps using piezoelectric transducers embedded in shoe soles, addressing the global energy crisis through renewable sources from locomotion. It reviews prior works on piezoelectric energy harvesting, highlighting early efforts like Shenck and Paradiso's shoe-mounted piezo electrics that demonstrated initial scavenging from steps. Subsequent advancements include Kamboj et al.'s footstep power generator and Ishida et al.'s fully integrated footwear systems, which improved voltage output and integration. Pioneering studies from 2001 by Shenck and Paradiso laid the foundation for shoe-integrated piezoelectric, generating power from mechanical stress during walking. Mid-2000s to 2010s saw gait analysis systems by Bamberg et al. and energy harvesters by Li et al., focusing on biomechanical efficiency and sensor applications. Recent 2010s works, such as Meier and Almog's podiatric sensing shoes and Kamal et al.'s footstep harvesters, enhanced output to

practical levels like 1.2 V per step, as prototyped in the paper. Journal: AIP Conference Proceedings. [7] The paper titled “Footstep Power Generation using Piezoelectric Sensor and Distribution using RFID” presents an innovative and practical approach to generating electrical energy from human locomotion using piezoelectric sensors and managing its distribution through RFID-based authentication. With the rapid increase in global energy demand and the growing need for sustainable and ecofriendly energy sources, alternative methods of power generation have gained significant attention, particularly in densely populated regions. Previous studies have explored various renewable energy sources such as solar, wind, and kinetic energy harvesting systems. Among these, piezoelectric energy harvesting has emerged as a promising technique due to its ability to directly convert mechanical stress, such as human footsteps, into electrical energy without requiring complex infrastructure. Earlier research has demonstrated the implementation of piezoelectric materials in footstep energy harvesting systems installed in high pedestrian traffic areas such as railway stations, shopping malls, and public pathways. These systems utilize ground reaction forces generated during walking to produce electrical energy. Studies have also investigated different configurations of piezoelectric sensors, including series and parallel arrangements, to enhance voltage output and improve overall system efficiency. Furthermore, advancements in system design have incorporated power conditioning circuits such as bridge rectifiers and filters, along with energy storage devices like rechargeable batteries. Integration of microcontrollers has enabled monitoring and control of the generated power. In addition, the use of RFID technology for user authentication and controlled energy distribution represents a significant improvement in ensuring secure and efficient utilization of the harvested energy. Despite these developments, certain limitations persist, including low energy output per step, dependency on continuous human movement, and challenges in optimizing energy conversion efficiency. The proposed work builds upon existing research by developing a system that not only generates energy from footsteps but also incorporates secure distribution using RFID technology. The study concludes that such systems provide a feasible, eco-friendly, and user-oriented solution for decentralized power generation and can be effectively implemented in public spaces for small-scale energy applications.

Journal: International Research Journal of Engineering and Technology (IRJET) [8] The paper titled “Power in Every Step: A Piezoelectric Staircase Solution” presents an innovative and sustainable approach to generating electrical energy by utilizing human footsteps on staircases through piezoelectric sensors. With the increasing depletion of fossil fuels and the environmental concerns associated with their usage, the need for alternative and eco-friendly energy sources has become critical. This study emphasizes the importance of harnessing mechanical energy from human motion, particularly in high-footfall areas such as railway stations and public infrastructures. Previous research has explored various renewable energy sources including solar, wind, and hydropower systems. Among these, piezoelectric energy harvesting has gained considerable attention due to its capability to directly convert mechanical stress into electrical energy without dependence on environmental conditions. The reliability, compactness, and adaptability of piezoelectric systems make them suitable for integration into urban infrastructure. Earlier studies have demonstrated the use of piezoelectric materials such as lead zirconate titanate (PZT), zinc oxide (ZnO), and barium titanate (BaTiO_3) for energy harvesting applications. These materials exhibit varying levels of efficiency, with PZT providing higher voltage outputs due to its superior piezoelectric properties. Research has also focused on embedding piezoelectric sensors into walkways and staircases to capture energy from pedestrian movement, highlighting their potential for powering low-energy devices. Furthermore, advancements in system design have incorporated essential components such as bridge rectifiers for AC to DC conversion, voltage regulators for output stabilization, lithium-ion batteries for energy storage, and inverters for supplying usable AC power. These integrated systems enhance the practicality and usability of piezoelectric energy harvesting for real-world applications such as LED lighting, sensor systems, and mobile charging. Despite these advancements, several challenges remain, including low power output, dependency on consistent foot traffic, and limitations in scalability for high power applications. Efficiency optimization and material improvement continue to be key areas of research. The proposed work builds upon existing literature by introducing a piezoelectric staircase system designed for sustainable energy generation in public spaces. The study concludes that such systems offer a promising solution for decentralized, clean, and renewable energy production, particularly in smart city environments and densely populated regions. Journal:

International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT) **III. PROPOSED METHOD**

In this project, we are proposing a piezoelectric energy harvesting system that generates electrical energy from mechanical pressure produced by footsteps. Piezoelectric mats are placed on the classroom dais where teachers frequently move during lectures. When pressure is applied on the mats, the piezoelectric sensors convert the mechanical energy into electrical energy. The generated electrical energy is then collected, converted into DC using a rectifier circuit, and regulated to maintain a stable voltage. The regulated energy is stored in a rechargeable battery system. During power interruptions, the stored energy can be supplied to the smart board using an automatic switching mechanism. This system demonstrates a simple and eco-friendly method of generating electrical energy from everyday human movement. The proposed system can be effectively implemented in classrooms and educational institutions to support uninterrupted digital teaching and promote the use of renewable energy technologies.

IV . SIMULATION RESULTS

The output from piezoelectric sensors depends on applied pressure and number of discs used.

Observed Values:

Single piezo disc output: 0.04V – 0.08V (AC, peak)

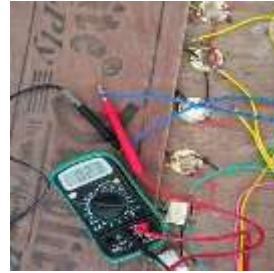


After rectification & boost: Stable 4V DC (Based on Foot Pressure)



Using multiple discs (array):

Voltage: 0.1V – 0.9V (combined AC before regulation)



when a person walks or applies pressure on the piezoelectric mat, the piezoelectric sensors generate electrical voltage due to the piezoelectric effect.



V. CONCLUSION

The Piezoelectric Energy Harvesting System for Smart Board Backup project successfully demonstrates an innovative approach to generating electrical energy from mechanical pressure. By using piezoelectric sensors placed on classroom mats, the system converts the mechanical energy produced from footsteps into electrical energy. The generated energy is processed through a rectifier and voltage regulator and stored in a rechargeable battery. This stored energy can then be used as a backup power source for smart boards during power interruptions. The proposed system highlights a sustainable and eco-friendly method of energy harvesting by utilizing everyday human movement. This project not only ensures uninterrupted digital teaching in classrooms but also demonstrates the practical application of renewable energy technologies. With proper implementation, such systems can contribute to energy conservation and promote sustainable solutions in educational environments.

VI. REFERENCES

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