JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design and development of energy harvesting system using piezoelectric transducer

[1] Abhishek Kumar Mourya, [2]Saikat Chakraborty
Student
LPU

[1-6]School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, Punjab
Abstract— *Utilizing the energy harvesting system as a foundation, this project requires the design and development of an energy harvesting circuit with a piezoelectric transducer. This equipment uses the piezoelectric effect which is when some materials produce an electric charge in response to mechanical stress thereby converting surrounding mechanical vibrations into electrical power. By integrating piezoelectric substances into mechanical structures, the invention can effectively absorb and convert mechanical strain to useful electric energy. This process taps into universal everyday mechanical vibrations thus providing a sustainable substitute for traditional sources of energy that is also environmentally friendly. Key components of the system include optimized power output and energy conversion efficiency through mechanical designs. With wearable electronics and wireless sensor networks, gadgets can become self-powered and eco-friendly thanks to this technique. Through the use of piezoelectric transducers, this scalable energy harvesting system demonstrates a sustainable approach towards meeting increasing demands for alternative sources of power in different industries.*

Keywords— Energy Harvesting, piezoelectric, sensors

I. INTRODUCTION

With the potential to completely change how we power our world, the concept of energy harvesting has emerged as a glimmer of hope in the hunt for sustainable energy sources. A testament to human creativity and our relentless pursuit of cleaner, more efficient power sources is the evolution of energy harvesting devices from their humble origins to the cutting-edge innovations of todayEnergy harvesting has its roots in the basic yet clever techniques used by ancient societies to extract energy from the environment. Ancient human attempts to harness the force of nature are exemplified by windmills, water wheels, and solar architecture. Even though they were archaic by today's standards, these simple systems served as a precursor to the complex technology we use every day. Due to rising worries about environmental deterioration and the limited nature of fossil fuels, energy harvesting saw considerable breakthroughs in the twentieth century. A cleaner, more sustainable energy environment was made possible by technological advancements like solar cells, wind turbines, and hydroelectric dams, which completely changed the way humanity produced power. But these traditional techniques have drawbacks as well, which is why engineers and academics are looking into different ways to capture energy.

Entering the era of contemporary energy collection technology, advancements in materials science, nanotechnology, and renewable energy have created numerous opportunities. Utilizing piezoelectric crystals, kinetic energy harvesters, and thermoelectric generators are just some of the numerous technologies we have available. These devices provide a preview of a time when energy will be plentiful and accessible from various sources like waste heat, human movement, and ambient vibrations, leading to a novel method of energy collection. Energy harvesting has great promise for the future as we move closer to a new age. Small, efficient energy solutions that can operate independently and sustainably are becoming more and more necessary as Internet of Things (IoT) gadgets, wearable technologies, and smart infrastructure gain traction. Energy harvesting devices, which offer a sustainable alternative to grid electricity and traditional battery power, are prepared to play a significant role in meeting these demands. Enhancing the efficiency, scalability, and dependability of energy harvesting devices is the aim of future research. Technological developments in the fields of materials engineering, device design, and system integration are lowering prices and broadening the spectrum of sectors in which these systems may be applied, including transportation, healthcare, agriculture, and telecommunications. Further boosting resilience and effectiveness are integrated systems that may be created by integrating with other renewable energy sources like solar and wind. These systems can simultaneously harvest energy from many sources.

II. LITERATURE SURVEY OF ENERGY HARVESTING SYSTEMS.

Research Paper 1

A Unique Step Towards Generation Of Electricity, Via New Methodology

First and foremost, the increasing demand for electricity is the reason for the necessity to look into new energy sources. The concept of using piezoelectric crystals to capture human bioenergy is intriguing. This research explores the possibilities of this technology in light of the growing need for environmentally friendly power sources.

Piezoelectric crystals have the amazing ability to transform mechanical vibrations into electrical energy and the other way around. Their reversible characteristic makes them ideal for applications involving the collection of energy. It is possible to transform applied vibrations into practical electrical power thanks to their crystalline structure, which is a significant achievement in the field of renewable energy technology.

In order to use piezo devices, high-traffic areas like airports require their implantation beneath the flooring. Steps produce energy, which may be transformed and stored for use in practical applications using inverters or capacitors. By adding to the current power sources, this installation can support a more sustainable energy ecology.

In conclusion, the creation of piezoelectric energy offers a financially viable and environmentally sustainable way to address the growing need for power. Its broad adoption and current deployment in several nations offer hope for the future of the energy sector. Its adaptability also reaches public spaces like bus stops and house doors, suggesting that it has the ability to completely transform energy production in a variety of contexts.

Research Paper 2

Piezoelectric Energy Harvester Design and Power Conditioning, Via IEEE

The need of diversifying energy sources to reduce dependency on nonrenewable fuels and promote sustainability is emphasized in the article. It emphasizes how mechanical strain may be captured using piezoelectric transducers, which can then be used to transform mechanical energy into useful electrical power. This method provides a workable alternative for powering portable gadgets and wireless sensors in addition to addressing energy waste. These kinds of applications are especially relevant in embedded or remote locations where there is a great need for self-sustaining power sources.

The study explores the use of PZT sensors—a kind of piezoelectric transducer—for energy harvesting applications. To transform the AC signals produced by these transducers into useable DC voltage, a MATLAB-based circuit model must be created and put into practice. The integration of a complete bridge rectifier for AC to DC voltage conversion and the electrical equivalent model of piezoelectric transducers are also examined in this work. It also looks at how many transducers are arranged in a parallel grid to maximize power output efficiency in the harvester system.

The study demonstrated the effective conversion of AC impulses from piezoelectric transducers into usable DC voltage, highlighting the technology's usefulness for practical uses. Through the use of many transducers arranged in a parallel grid, the study showed increased power production efficiency in the harvester system. Additionally, it highlighted how potential piezoelectric energy conversion is at providing long-term power solutions for wireless sensor technologies and portable devices.

In conclusion the study demonstrated how piezoelectric transducers can convert AC impulses into DC voltage, and the parallel grid configuration greatly increased power output efficiency. It emphasized how piezoelectric energy conversion is a viable option for providing portable electronics and wireless sensors with sustainable power.

Research Paper 3

A Shoe-Embedded Piezoelectric Energy Harvester for Wearable Sensors, Via MDPI journal

The project's main goal is to use human motion to power activity detection and health monitoring sensors by creating a shoe-embedded piezoelectric energy harvester specifically designed for wearable sensors. Designed to fit neatly inside shoes, the harvester produces an output power of one mW when walking at a frequency of one Hz. Trials of power management circuits for DC power supply systems and charge amount measurements were carried out to calculate the results of the prototype within shoes.

The aim of the project is to develop a piezoelectric energy harvester integrated into shoes for wearable sensors, with a focus on capturing mechanical energy from motion. To improve energy generation and wearer comfort, two prototypes were made and put through testing. Experiments measuring charge amounts and evaluating DC power supply systems' power management circuits were part of the performance evaluation process.

The piezoelectric energy harvester integrated into the shoe produced an average of one mW at a frequency of one Hz while walking, indicating its potential for use in wearable sensors. Larger PVDF film deformations were responsible for Prototype 1's higher
energy production per step, as demonstrated by prototype testing. Furthermore, gathered energy was efficiently transformed by the power management circuit into a DC power supply system that could run a fictitious wireless transmitter load.

In conclusion the efficient production of electricity for wearable sensors has been confirmed by the shoe-integrated piezoelectric energy harvester. Prototype 1 performed better in prototype testing due to its higher energy output. Furthermore, the power management circuit demonstrated its potential for powering wearable sensors by efficiently converting mechanical energy into a DC power supply system.

III. Description

This project makes use of the capability of piezoelectric transducers to generate energy from vibrations, providing a sustainable solution for upcoming energy demands. By using amplifiers such as the LTC3588 op-amp, we enhance energy conversion efficiency, guaranteeing optimal power generation from ambient vibrations. In addition, our security measures are improved by incorporating RFID technology, which permits only designated users to access the system. In order to ensure smooth monitoring and control, we link the entire system to the cloud with ESP32 and Blynk. This integration enables users to observe energy production, system efficiency, and view logs with an internet connection. Real-time alerts and notifications improve proactive maintenance and troubleshooting abilities even more. This project takes a comprehensive approach to sustainable energy management by integrating energy harvesting, amplification, access control, and cloud connectivity. It provides a sustainable energy option, as well as effective usage and safe access, which makes it appropriate for various uses, from IoT gadgets to intelligent infrastructure. Our goal is to speed up the use of vibration-based energy harvesting systems, working towards a more sustainable and interconnected future.

IV. BLOCK DIAGRAM

The main focus of our project is the central components, beginning with the ESP32 microprocessor that includes a pre-installed WiFi module. This allows for smooth internet connection, making remote monitoring and control easier. The piezoelectric transducers power the energy harvesting process by converting vibrations into electrical energy, which is then optimized using amplifiers like the LTC3588 and operational amplifiers.

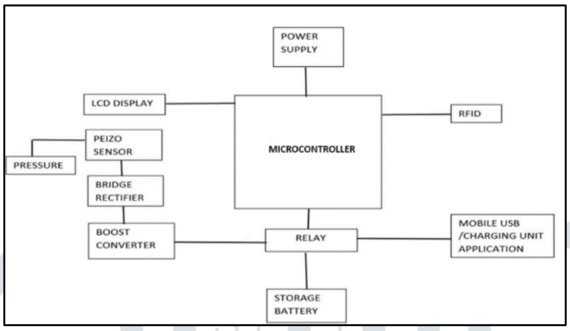

Figure 1 Block Diagram

To control access, we incorporate an RFID reader that allows only approved individuals to engage with the system. The electricity produced is saved in a battery for later consumption, improving energy independence and dependability. In order to be useful in everyday situations, a USB charging module is linked to a relay, allowing external devices to be charged when there is enough power. This all-encompassing system guarantees both efficient energy collection and secure access control, providing a flexible solution for sustainable energy management.

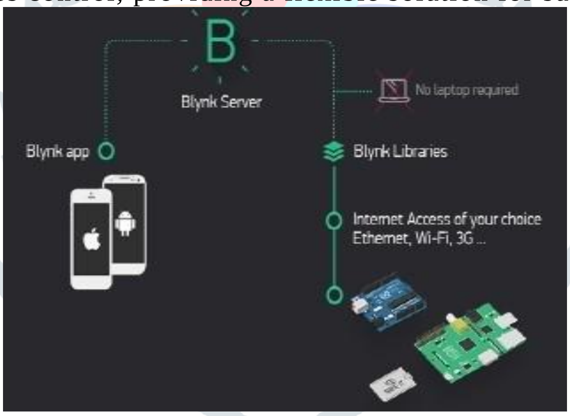

Figure 2 BLYNK Application

V. WORKING

The main focus of our project is using piezoelectric sensors to collect energy from surrounding vibrations. Pressure applied to these sensors produces electricity via the piezoelectric effect. This small amount of electrical energy forms the basis of our sustainable energy solution.

In order to maximize the energy captured, we use amplification circuits that include both the LTC3588 and operational amplifiers (op-amps). These parts increase the voltage and current of the produced electricity, improving its usability and effectiveness. The increased power is then sent to a battery for storage, guaranteeing a consistent and dependable energy source even when vibrations are not being collected. Our system utilizes an RFID reader for access control when the stored energy is required for use. The system can only be activated by individuals with verified RFID cards, ensuring security and preventing unauthorized access. The RFID reader is linked to a relay, serving as a device that regulates the transfer of power from the battery to outside equipment. After being successfully confirmed, the relay turns on and permits the stored energy to pass to a small power bank circuit. This power bank circuit offers a practical and easily transportable way to charge gadgets like smartphones, tablets, and other electronic devices. Our project improves the usefulness and functionality of energy harvesting technology in everyday situations by using the stored energy in this way. The ESP32 microprocessor integrates all these components and functionalities seamlessly, acting as the system's central processing unit. The internet can be accessed through the ESP32's integrated WiFi module, allowing for remote supervision and operation control of the system. This connectivity also allows users to monitor the system's voltage levels in real-time using the Blynk platform, offering valuable insights on energy consumption and availability.

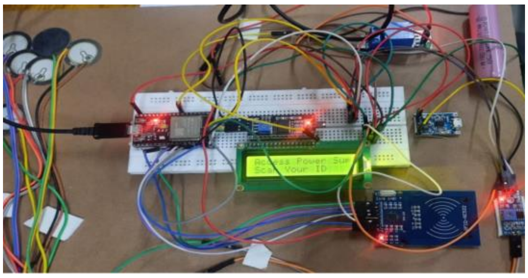

Figure 3 shows the circuit design.

VI. RESULTS

In our research, the energy production system utilizes several piezoelectric transducers to generate a high voltage output between 3 and 4 volts. The energy that is collected is stored effectively in a rechargeable lithium-ion battery, guaranteeing a constant supply of power. The battery can restore its power by reacting to pressure on the piezoelectric transducers, making sure it has a lasting energy supply. The battery provides a consistent 3.7 volts to the mini power bank circuit, allowing for the charging of different devices like smartphones, tablets, and other gadgets when necessary. Furthermore, the system's ability to scale means that it can incorporate multiple lithium-ion batteries, therefore extending the runtime of the mini power bank circuit. This implies that individuals can have longer periods of use before having to recharge or change batteries, making our energy generation system a dependable and effective solution for powering portable electronic devices in various environments.

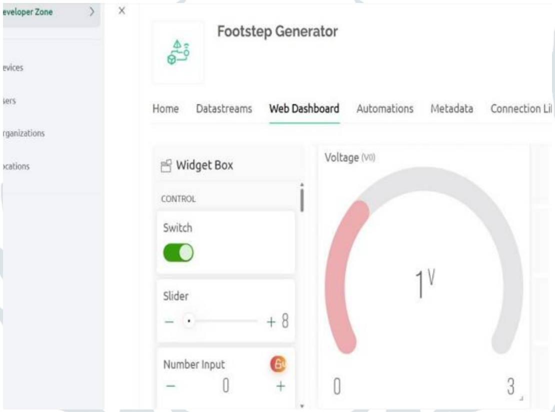

Figure 4 analysis of voltage generated at the initial stage of the research.

VII. CONCLUSION

The development and use of an energy harvesting system based on piezoelectric transducers has marked a significant advancement in the search for sustainable power generation. By using the inherent vibrations present in stairs, this experiment has demonstrated that it is both practical and effective to employ ambient mechanical energy to generate electricity using piezoelectric materials. Piezoelectric transducers have been successfully integrated with sophisticated circuitry and amplification techniques to successfully achieve the fundamental idea of transforming mechanical vibrations caused by foot traffic into electrical energy. Higher power levels necessary for practical applications have been made possible by the effective conversion and amplification of the produced electrical output made possible by the usage of parts like the ltc3588 and operational amplifier (op-amp) circuitry. A dependable and sustainable power source has also been made possible by the installation of a rechargeable battery storage system combined with an esp32 microcontroller for effective control and monitoring. The system's functionality and usability have been improved by the inclusion of rfid technology for user authentication and a blink system for real-time monitoring. This ensures safe access and effective management of stored energy resources. Looking ahead, this project's future scope includes a number of opportunities for more innovation and growth. Optimizing energy conversion efficiency, investigating different urban contexts for deployment, and connecting with iot platforms and smart grid infrastructure can be the main areas of continued research and development. Building regulations and green building standards may be integrated and implemented more widely with the help of municipalities and energy providers.

Ultimately, there is a great deal of promise for resolving rising energy needs and environmental issues in urban settings when mechanical energy is harnessed for sustainable power generation using piezoelectric transducer-based energy harvesting devices. This initiative opens the path for the construction of future cities that are smarter, greener, and more energy-efficient by combining cutting-edge technology with a dedication to sustainability.

VIII. References

[1] Richard, Michael Graham,Japan: Producing Electricity From Train Station Ticket Gates, Tree Hugger. Discovery Communications, Llc , (2006)

[2] Becker, Robert O; Marino, Andrew A. Chapter 4: Electrical Properties Of Biological Tissue (Piezoelectricity). Electromagnetism & Life. Albany, New York: State , 1982.

[3] Anil Kumar, International Journal Of Scientific & Engineering Research Volume 2,

Issue 5, May-2011 .

[4] Andrew Townley, Electrical Engineering, University Of Pennsylvania.

[5] Jedol Dayou, School Of Science And Technology, University Malaysia Sabah,

Kinabalu, Sabah, Malaysia.

[6] Man-Sang, Faculty Of Science, Art And Heritage, University Tun Hussein Onn Malaysia,

Parit Raja, Batu Pahat, Johor, Malaysia.

[7] S.Trolier-Mckinstry.Chapter3: Crystal Chemistry Of Piezoelectric Materials. In A. Safari, E.K. Akdoˇgan. Piezoelectric And Acoustic Materials For Transducer Applications. New York: Springer . 2008

[8] Https://Www.Slideshare.Net/Ahabkhan/Thesis-Of-Footstep-Power-Generation