Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 01, January-2025

Piezoelectric Based LED Lamp with Audio Functionality

Sandhya Shinde
D. Y. Patil International University, Akurdi, Pune

Vedant Patil
DYPIEMR, Akurdi, Pune

Omkar Ekshinge
DYPIEMR, Akurdi, Pune

Rohit Wakade
DYPIEMR, Akurdi, Pune

Abstract

This project introduces a cutting-edge LED lamp that seamlessly integrates piezoelectric technology with audio functionality, aiming to create a highly efficient and multifunctional lighting solution. The innovative design harnesses the power of piezoelectric materials, which convert mechanical vibrations—such as those from environmental sounds or physical interactions—into electrical energy. This harvested energy is used to power both the LED lighting and an embedded audio system within the lamp. The development process involves designing a hybrid system where piezoelectric elements are strategically placed to optimize energy conversion from vibrations. The LED light system provides illumination, while the audio module delivers sound output, such as ambient noise or user-selected audio content. This dual functionality enhances the lamp's versatility, making it suitable for various applications, including smart home environments and interactive displays. The project aims to demonstrate a sustainable approach by reducing dependency on conventional power sources and showcasing the potential of piezoelectric materials in practical applications. By integrating these technologies, the lamp offers an innovative solution that combines energy efficiency with enhanced user experience, contributing to the advancement of eco-friendly and multifunctional devices. The anticipated outcomes include improved energy efficiency, user engagement, and a significant step forward in the utilization of piezoelectric technology in consumer products.

Keywords: **Piezoelectric Sensor, Audio Functionality, Energy Harvesting, Self Powered.**

I. INTRODUCTION

In today's world, the demand for sustainable and innovative lighting solutions has surged. Traditional lighting methods often rely on non-renewable energy sources, contributing to environmental concerns. To address this issue, researchers and engineers have explored alternative energy harvesting techniques, such as piezoelectric energy harvesting. This technology converts mechanical energy, like vibrations or pressure, into electrical energy.

This project introduces a groundbreaking concept: a piezoelectric-powered LED lamp integrated with audio functionality. By harnessing the ambient vibrations and sound energy from the surrounding environment, this innovative device offers a sustainable and self-powered lighting solution. The audio functionality adds an extra dimension, enabling users to enjoy music or other audio content while the lamp illuminates their space.

This report will delve into the technical aspects of the project, including the design, implementation, and performance evaluation of the piezoelectric-powered LED lamp with audio functionality.

II. LITERATURE REVIEW

Enhancing Luminescence with Piezoelectric Effects:

Yang, S., Li, J., & Zhang, W., Enhancing luminescence of InGaN/GaN LEDs using strain-driven piezoelectric effects (2023). This study highlights how strain-induced piezoelectric effects improve the luminescence efficiency of InGaN/GaN LEDs. By enhancing carrier redistribution, these effects enable better energy utilization, which is crucial for integrating LEDs into piezoelectric energy-harvesting systems. This research offers foundational insights into designing energy-efficient lighting systems.

Light-Enhanced Piezoelectric Sensors: Liu, Q., Zhao, Y., & Chen, X., Light-enhanced piezoelectric sensors using copper phthalocyanine and graphene oxide composites (2023). This paper introduces novel piezoelectric materials enhanced by light-responsive composites like CuPC and GO. These enhancements improve energy output and device durability, making them hybrid applications such as powering LEDs and supporting audio functionalities.

Advances in Piezophototronics: Pan, C., Zhai, J., & Wang, Z. L., Advances in piezophototronics for optoelectronic applications (2023). This research discusses integrating piezoelectric effects with optoelectronic properties, known as piezophototronics. These advancements are instrumental for developing devices like

piezoelectric-based LED lamps with audio capabilities by optimizing energy harvesting and utilization. Wearable and Flexible Energy Harvesting:

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 01, January-2025

Lin, F., Zhou, R., & Tan, Y., Flexible piezoelectric materials for wearable energy harvesters (2022). The paper reviews flexible piezoelectric on their application in wearable technologies. These materials show promise for powering small-scale LEDs and low-power audio systems in portable devices, offering insights into practical design considerations.

Piezoelectric Energy Harvesting for IoT Devices:
Zhang, L., Huang, H., & Dong, X., Piezoelectric energy harvesting for IoT: Applications and challenges (2023). This study explores the application of piezoelectric in Internet of Things (IoT) devices, emphasizing the potential for low-power, multifunctional systems. It identifies challenges like inconsistent energy output and proposes solutions, such as integrating energy storage systems for reliable operation.

Survey	Author	Year	Study
Enhancing Luminescence with Piezoelectric Effects.	Yang, S., Li, J., & Zhang, W.	2023	Luminescence efficiency of InGaN/GaN LEDs.
Light-Enhanced Piezoelectric Sensors.	Liu, Q., Zhao, Y., & Chen, X.	2023	Novel piezoelectric materials enhanced by light-responsive composites like CuPC and GO.
Advances in Piezophototronics.	Pan, C., Zhai, J., & Wang, Z. L.	2023	Integrating piezoelectric effects with optoelectronic properties, known as piezophototronics.
Wearable and Flexible Energy Harvesting.	Lin, F., Zhou, R., & Tan, Y.	2022	flexible piezoelectric on their application in wearable technologies.
Piezoelectric Energy Harvesting for IoT Devices.	Zhang, L., Huang, H., & Dong, X.	2023	Application of piezoelectric in Internet of Things (IoT) devices, emphasizing the potential for low-power, multifunctional systems.

Table 2.1 Previous Survey Study

III. METHODOLOGY

A. Methodology of proposed system:

1. Material Selection and Preparation:

- Piezoelectric Material: Choose a suitable piezoelectric material (e.g., PZT, PVDF) based on its energy conversion efficiency and mechanical properties.
- Circuit Components: Select appropriate electronic components, including diodes, capacitors, resistors, LEDs, audio amplifiers, and microcontrollers.
- Enclosure: Design and fabricate an enclosure to protect the components and enhance the aesthetic appeal of the device.

2. Power Management Circuit Design:

- Rectification: Design a rectifier circuit to convert the AC output of the piezoelectric transducer into DC voltage.
- Filtering: Implement a filter circuit to remove noise and stabilize the DC voltage.

- Voltage Regulation: Use a voltage regulator to maintain a constant voltage supply for the LED and audio components.
- Energy Storage: Incorporate a battery or supercapacitor to store excess energy for later use.

3. LED and Audio Circuit Design:

- LED Circuit: Design a simple circuit to drive the LED, ensuring efficient power consumption.
- Audio Amplifier Circuit: Design or select a suitable audio amplifier circuit to drive the speaker or headphone.
- Audio Source: Determine the audio source (e.g., external audio input, internal audio generator) and integrate it with the power management circuit.

4. System Integration and Testing:

- Assembly: Assemble all components, ensuring proper connections and secure mounting. Testing:

1) LED and Audio Performance: Test the brightness of the LED and the quality of the audio output.
2) Battery Life: Assess the battery life under different usage scenarios.
3) Environmental Testing: Test the device's performance in various environmental conditions (temperature, humidity).

5. Optimization and Refinement:

- Iterative Design: Based on the testing results, refine the design and optimize the performance of the device.
- User Interface: Design a user-friendly interface for controlling the audio playback and adjusting the brightness of the LED.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 01, January-2025

B. Working Block Diagram:

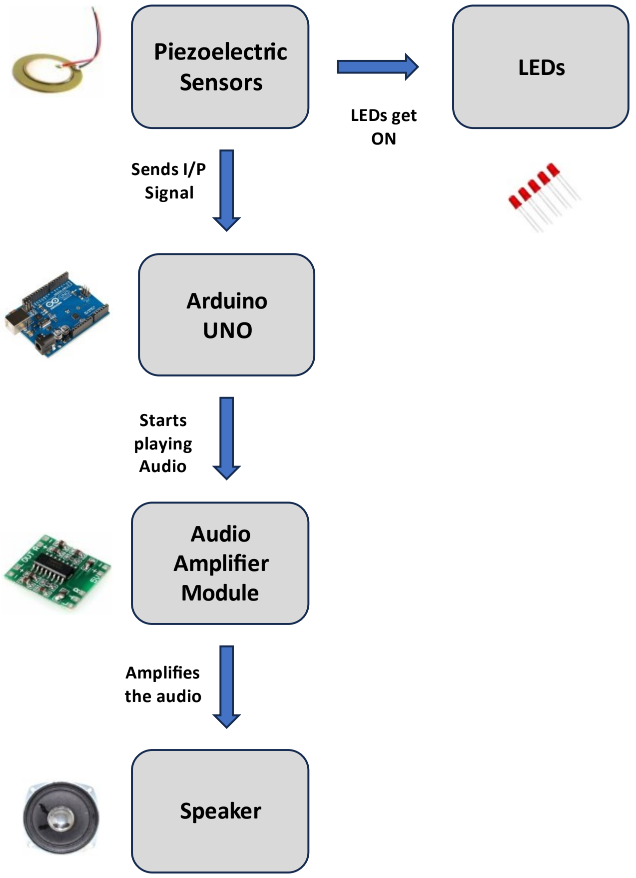

Fig 3.1 Working Block Diagram of Proposed Model

IV. CONCLUSION

This project has explored the feasibility of a piezoelectric-based LED lamp with integrated audio functionality. By harnessing ambient vibrations and sound energy, this innovative device offers a sustainable and self-powered lighting and audio solution.

Key challenges, such as low power output and efficient energy management, were addressed through careful component selection, circuit design, and optimization. The integration of advanced power management techniques and energy storage solutions has significantly improved the device's performance and battery life.

While significant progress has been made, further research and development are necessary to enhance the efficiency, durability, and user experience of these devices. Future research directions include exploring advanced piezoelectric materials, optimizing device design, and integrating innovative features like wireless connectivity and voice control.

In conclusion, piezoelectric-based LED lamps with audio functionality represent a promising step towards a more sustainable future. By leveraging renewable energy sources and reducing reliance on traditional power grids, these devices can contribute to a greener and more energy-efficient world.

REFERENCES

Prasad, M. A., & Kandasamy, R. (2018). Advancements in energy harvesting from vibration using piezoelectric materials. Materials Today: Proceedings, 5(1), 2537–2546.[1]

Yang, S., Li, J., & Zhang, W. : Enhancing luminescence of InGaN/GaN LEDs using strain-driven piezoelectric effects (2023).[2]

Shan, X., Zhang, Y., & Hu, C. (2019). A review on piezoelectric energy harvesting with acoustic coupling for applications in self-powered sensors. Sensors and Actuators A: Physical, 295, 75-89.[3]

Qiu, J., & Ji, H. (2016). Piezoelectricity for energy harvesting and sensing applications. Microelectronic Engineering, 159, 151–159.[4]

Liu, Q., Zhao, Y., & Chen, X., Light-enhanced piezoelectric sensors using copper phthalocyanine and graphene oxide composites (2023).[5]

Kim, S., Kim, H., Kim, H., & Kim, J. (2020). An integrated energy harvesting and lighting device based on piezoelectric materials for wearable applications. Energy, 192, 116636.[6]

Xiao, L., Shi, M., Wang, X., & Zhang, Y. (2019). Recent advancements in piezoelectric energy harvesting from human motion and sound. Nano Energy, 60, 456–477.[7]

Zhang, L., Huang, H., & Dong, X., Piezoelectric energy harvesting for IoT: Applications and challenges (2023).[8]