SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A++" by NAAC | 12B Status by UGC | Approved by AICTE

Abstract : Wearable Power : Energy Harvesting for future

Kinetic energy harvesting is an innovative technology that converts ambient motion and vibrations into electrical energy, offering a sustainable and self-sufficient power source for low-energy devices such as wearable electronics, IoT sensors, biomedical implants, and industrial monitoring systems. Unlike traditional batteries, which require periodic replacements and contribute to environmental waste, kinetic energy harvesters provide a long-term solution by utilizing mechanical energy from human movement, structural vibrations, and machine operations. This makes them highly beneficial for applications in remote and inaccessible locations where frequent battery maintenance is impractical. Currently, kinetic energy harvesters primarily rely on three key mechanisms: electromagnetic, piezoelectric, and triboelectric conversion. Electromagnetic harvesters operate based on Faraday's law of electromagnetic induction, where relative motion between a magnet and a coil generates electricity. These systems are efficient for large-scale energy harvesting but are often bulky and require significant displacement for optimal performance. Piezoelectric harvesters utilize materials that generate an electric charge when subjected to mechanical stress, offering a compact design with moderate power output. However, they suffer from limited efficiency, degradation over time, and dependence on specific vibration frequencies. Triboelectric harvesters work by creating charge separation through friction between different materials, generating a high voltage output but facing challenges related to wear and stability over prolonged usage. Although hybrid harvesters that combine multiple mechanisms have been explored, existing designs still struggle with energy losses, restricted operational frequency ranges, and limited durability. The main challenges in kinetic energy harvesting include low energy conversion efficiency, as a significant portion of kinetic energy remains unutilized due to design and material limitations. Additionally, most harvesters operate efficiently only within specific motion frequency ranges, making them less effective in real-world applications where vibrations and movements vary unpredictably. Mechanical wear and material degradation pose another major concern, particularly in triboelectric systems where continuous friction is required. Furthermore, integrating energy harvesters into compact, flexible, and wearable devices without compromising performance remains a significant hurdle. Cost-effectiveness is also an issue, as advanced fabrication processes and expensive materials increase production costs, limiting widespread adoption. To address these challenges, this research presents an advanced multi-mode kinetic energy harvester that integrates piezoelectric and triboelectric mechanisms to maximize energy conversion efficiency and broaden the operational bandwidth. By leveraging the combined advantages of both mechanisms, the proposed harvester is capable of capturing a wider range of motion frequencies, ensuring consistent energy generation even in unpredictable movement conditions. Additionally, the use of high-durability materials minimizes wear and enhances the lifespan of the device, making it a more reliable and long-term energy solution. The harvester is designed to be compact, lightweight, and flexible, allowing seamless integration into a variety of applications, including self-powered medical devices, smart textiles, and industrial sensors. Moreover, an optimized energy storage and management system ensures efficient storage and delivery of the harvested energy, reducing energy losses and improving overall performance. The expected output of the proposed kinetic energy harvester is a stable and enhanced electrical power supply, capable of sustaining low-power devices such as sensors, medical implants, and smart wearable electronics. The key parameters achieved include higher energy conversion efficiency, increased power density, extended operational lifespan, and improved adaptability to different motion conditions. Compared to conventional systems, this novel harvester offers greater durability, enhanced efficiency, and broader frequency adaptability, ensuring better performance in diverse environments. In comparison to existing harvesters, the proposed system provides several advantages. Its hybrid energy conversion approach significantly enhances energy capture, ensuring a more efficient and reliable power output. The wideband operational design makes it more effective across various movement patterns, unlike traditional harvesters that function optimally only within specific frequency ranges. The use of advanced materials reduces mechanical wear, increasing longevity and reducing maintenance costs. Additionally, the cost-effective fabrication process makes it a viable option for mass production and commercial applications, accelerating the adoption of kinetic energy harvesting technologies. In conclusion, the proposed kinetic energy harvester represents a major advancement in energy harvesting technology, overcoming key limitations such as low efficiency, restricted frequency response, and material degradation. By combining piezoelectric and triboelectric mechanisms, it ensures higher energy capture, broader frequency adaptability, and long-term reliability, making it an ideal solution for various self-powered electronic applications. The ability to generate stable electrical power from ambient motion enhances the feasibility of autonomous electronic devices, reducing dependence on batteries and promoting sustainable energy solutions. This research contributes to the future of energy-efficient technologies, paving the way for widespread adoption in wearable electronics, industrial monitoring, and IoT networks.

Team Members :

M. Vaibhav Varshith – 43611255
Krishika Soni - 43611236
Sanjana kumari – 43611233
Mandla Ganesh Kumar - 43611259
Konka Sudheer - 43611244
Harsh Pandey – 43611274

Domain : Wearable power : Energy Harvesting system

Team Name : The Swift Charge