

KineticVolt Nano Portable AI and IoT-Enabled Energy Module for Mobile Devices

Amina Farhanah M¹, Aarthi Rethina Bala R K², Dharshini S S³
^{1,2,3}*Arunachala college of Engineering for Women, Kanyakumari*

Abstract—The growing dependence on portable electronics has created an urgent need for sustainable, user-independent charging solutions. This paper presents KineticVolt Nano, a portable, smart energy power module for mobile devices, equipped with AI and IoT-enabled energy management. The device converts natural human motion into usable electrical energy via a miniature electromagnetic induction mechanism, while an AI-enabled controller optimizes harvesting performance. IoT connectivity allows remote monitoring and intelligent power distribution across connected devices. Compact in size, similar to a credit card, KineticVolt Nano can be attached magnetically or adhesively to smartphones, tablets, or other handheld electronics, offering a portable and eco-friendly charging alternative. Simulation studies and prototype testing indicate strong potential in efficiency, portability, and adaptability to diverse user motion patterns.

I. INTRODUCTION

The increasing reliance on smartphones, tablets, wearables, and IoT devices has amplified the demand for reliable, sustainable charging solutions. While advancements in battery technology have extended operating times, the need for frequent recharging remains a limitation, especially in outdoor or off-grid environments. Kinetic energy harvesting offers a promising alternative by converting mechanical energy from human movement into electrical power. However, current devices often suffer from low efficiency, bulky design, or lack of intelligent power optimization. KineticVolt Nano addresses these limitations through a compact electromagnetic harvesting system combined with AI-based optimization and IoT-enabled remote monitoring. Its portability and simple attachment system make it ideal for consumer, industrial, and emergency applications.

II. LITERATURE REVIEW

Kinetic energy harvesting technologies are primarily categorized into electromagnetic, piezoelectric, and hybrid systems. Electromagnetic systems rely on the relative motion of magnets and coils to produce voltage, offering durability and scalability. Piezoelectric systems generate energy through deformation of materials but often yield lower power output. Hybrid designs attempt to combine these benefits but may increase complexity. Recent advancements in AI have enabled real-time optimization of harvesting performance by detecting activity patterns and adjusting system parameters dynamically. Similarly, IoT integration has allowed for cloud-based monitoring, predictive maintenance, and energy analytics. Despite these improvements, a fully integrated, ultra-portable, and smart kinetic energy solution for mobile devices remains underrepresented in the commercial market.

III. DESIGN AND SIMULATION

KineticVolt Nano employs a precision-engineered electromagnetic induction assembly consisting of micro-wound copper coils and high-strength neodymium magnets mounted on a low-friction suspension. The generated AC is rectified through an ultra-low-loss bridge rectifier and stored in a hybrid system of thin-film lithium-polymer batteries and supercapacitors. The ESP32-S3 microcontroller, integrated with an MPU6050 motion sensor, processes motion data using TinyML algorithms to identify optimal harvesting opportunities. IoT connectivity via Wi-Fi and Bluetooth enables the device to transmit real-time energy data to a dedicated mobile application. MATLAB/Simulink and ANSYS Maxwell simulations validate voltage generation

efficiency, while COMSOL Multiphysics modeling optimizes coil geometry and magnet placement for maximum output under typical walking and running conditions.

IV. MATERIALS AND FABRICATION

The device utilizes Grade N52 neodymium magnets for high energy density, enameled copper wire for micro-coils, and a flexible PCB for space-efficient circuit integration. The outer casing is made from carbon-fiber-reinforced ABS to ensure durability with minimal weight. The embedded AI/IoT controller is built around the ESP32-S3, chosen for its high processing capability, wireless connectivity, and low power consumption. The casing includes waterproof sealing to support outdoor use, making the module practical for hikers, rescue teams, and defense personnel.

V. PERFORMANCE ANALYSIS

Prototype tests show that KineticVolt Nano can generate 80–150 mW during moderate walking, with higher outputs during intense activities such as jogging or cycling. AI-based optimization enhances overall efficiency by approximately 15%, and IoT monitoring provides real-time data visualization and usage analytics. The dual storage system offers both immediate power delivery through supercapacitors and longer-term storage via Li-Po batteries. Stress testing demonstrates resilience to vibrations, impacts, and adverse weather.

VI. FINANCIAL ANALYSIS

Prototype development costs range from ₹4,500 to ₹6,000, including components, fabrication, and assembly. Mass production could reduce unit costs to below ₹1,500, enabling competitive retail pricing between ₹3,500 and ₹4,000. The unique combination of portability, AI optimization, and IoT connectivity offers a strong competitive advantage in the wearable energy market. Projected return on investment is achievable within two years, assuming targeted marketing and sales through online platforms and outdoor gear retailers.

VII. APPLICATION AND CHALLENGES

KineticVolt Nano is applicable in charging smartphones, wearables, IoT devices, disaster-relief equipment, and remote communication gear. It is particularly valuable in regions with limited or unreliable electricity. Key challenges include ensuring adequate performance during low-motion scenarios, further reducing form factor, and maintaining compatibility across diverse device models.

VIII. MARKET ANALYSIS

The global portable renewable energy device market is expanding at a CAGR of over 20%, driven by demand for sustainable and mobile charging solutions. While kinetic chargers exist, most are either bulky, require manual shaking, or cannot provide sustained charging. KineticVolt Nano differentiates itself through compact design, AI-optimized harvesting, and IoT-based smart energy management, targeting consumers, professionals, and specialized field operators.

IX. FUTURE PROSPECTS

Future developments may include integration of graphene-based flexible supercapacitors for increased energy density, wireless charging via the Qi standard, and more advanced AI models for predictive energy harvesting. Expanded IoT features could enable cloud-based analytics, integration with smart city grids, and energy sharing between devices.

X. CONCLUSION

KineticVolt Nano demonstrates the feasibility of a portable, AI- and IoT-enabled kinetic energy harvesting module for mobile devices. Its combination of advanced motion prediction, efficient energy conversion, and connected energy management positions it as a sustainable, user-friendly charging alternative. With ongoing research and commercial scaling, KineticVolt Nano could significantly impact the future of portable renewable energy solutions.

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