Footstep Electricity Generation using ESP32 and IoT

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Abstract

This paper presents a system that generates electricity from human footsteps using The concept of harvesting energy using human activity is considered one of the sustainable ways to generate power. In this paper, the concept of harvesting electrical power using footsteps by using piezoelectric sensors in conjunction with the ESP32 microcontroller and IoT platform is proposed. The mechanical stress is converted into electrical current, which is stored using the IoT platform. The proposed system is considered suitable for smart cities, railway stations, and walking areas. In the proposed paper, the concept of sustainability is considered in the design.

Keywords: Footstep energy, Piezoelectric sensor, ESP32, IoT, Energy harvesting, Smart city

Introduction: As the demand for energy increases and the environment deteriorates, alternative sources of energy are needed [1]. Footstep energy generation is a technique that uses the movements of the human body to produce electricity [2]. This technique uses piezoelectric sensors that convert pressure into a voltage [3]. Then, the produced voltage is processed by ESP32 and sent to cloud services like ThingSpeak or Blynk [4][5]. This technique could be applied in crowded areas to produce electricity on a small scale.

Piezoelectric Sensor: The Piezoelectric sensors are the main components in the energy generation system from foot steps. The Piezoelectric sensors operate based on the Piezoelectric effect, where an electrical charge is generated through mechanical stress on specific materials [3]. When an individual steps on the platform, pressure is applied to the Piezo sensors, generating an alternative voltage. A number of sensors operate in series and in parallel to improve the voltage and output currents. The energy generated is very small; thus, multiple sensors improve efficiency [1]. The sensors are compact, cost-effective, and sensitive to pressure changes. The sensors are thus effective in energy harvesting. The voltage generated is, however, unstable and thus needs to be rectified and regulated for effective use. The Piezo sensors have extensive applications in vibration detection, sound detection, and energy harvesting [2]. The Piezo sensors in this project operate as the main source of energy, where kinetic energy is converted to electrical energy.

Fig 1: Piezoelectric Sensor

Bridge Rectifier: The role of the bridge rectifier is to ensure the conversion of the current generated by the piezoelectric sensors into direct current. The piezoelectric sensors generate alternating current as a result of the changing pressure. The current generated by the piezoelectric sensors cannot be used to power any electronic devices. The bridge rectifier consists of four diodes connected in a specific way to ensure the flow of current in one direction [6]. This ensures the generation of direct current. The rectified current is smooth compared to the current generated by the piezoelectric sensors. However, the rectified current has ripples, which are eliminated by the capacitors. The efficiency of the bridge rectifier is crucial in ensuring maximum efficiency in the conversion process. The Schottky diodes are used because the voltage drops are low [6].

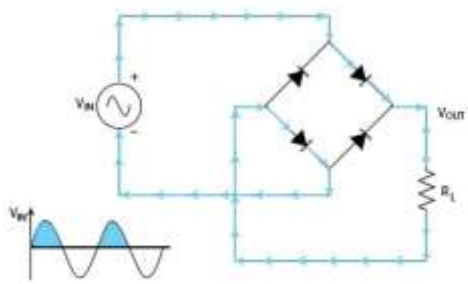

Fig 2: Bridge Rectifier

Capacitor (Energy Storage & Filtering): The capacitors are also used in the circuit to store the energy as well as to filter the output. The output obtained after the rectification process consists of ripples, which might affect the ESP32 microcontroller. The capacitors are used to filter the output by storing the charge in them and supplying it gradually [6]. Supercapacitors are used in the footstep energy harvesting circuit due to their high capacitance values and charging characteristics [2]. They are used to store the energy generated due to the footsteps.

Fig 3: Capacitor

Voltage Regulator: The voltage regulator will ensure that the components attached to the ESP32 circuit are supplied with a stable voltage. Since the output from the piezoelectric system is not stable, it cannot be used as is. Voltage regulators such as 7805 or buck converters are used to regulate the voltage [6]. In most cases, the regulated voltage is in the range 3.3V to 5V depending on the needs of the system. Buck converters are efficient in the process, thereby reducing the loss of energy. They protect the system from voltage spikes.

Fig 4: Voltage Regulator

ESP32 Microcontroller:

ESP32 is a powerful microcontroller with the ability to connect to the internet via Wi-Fi and Bluetooth connectivity [4]. The microcontroller is used in various IoT applications. In this system, the microcontroller receives the voltage data using the ADC pins and sends it to the cloud platforms. The microcontroller supports various communication protocols such as UART, SPI, and I2C. The microcontroller has the ability to work in low power modes, which makes it suitable for harvesting power.

Fig 5: ESP32

IoT Platform (ThingSpeak / Blynk): IoT technologies like ThingSpeak and Blynk are used to monitor and analyze the generated energy. ESP32 transmits the data to the cloud using Wi-Fi technology, where the data is stored and visualized [5]. ThingSpeak also supports MATLAB analytics, whereas Blynk supports mobile access. The addition of IoT technologies improves the functionality of the system.

Circuit Diagram

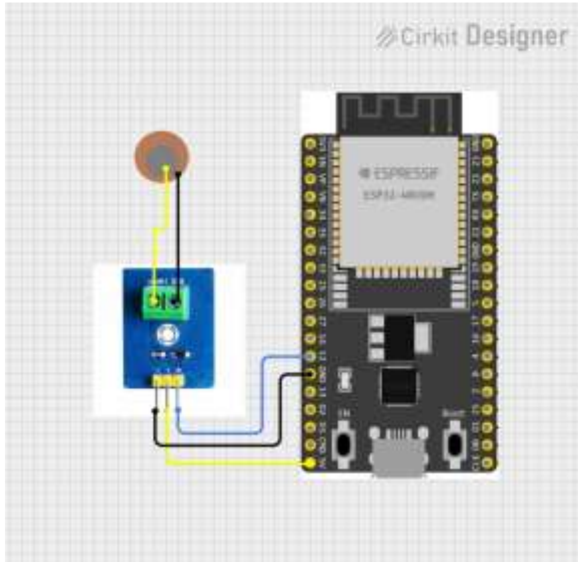

Fig 6: Circuit Diagram

Flowchart

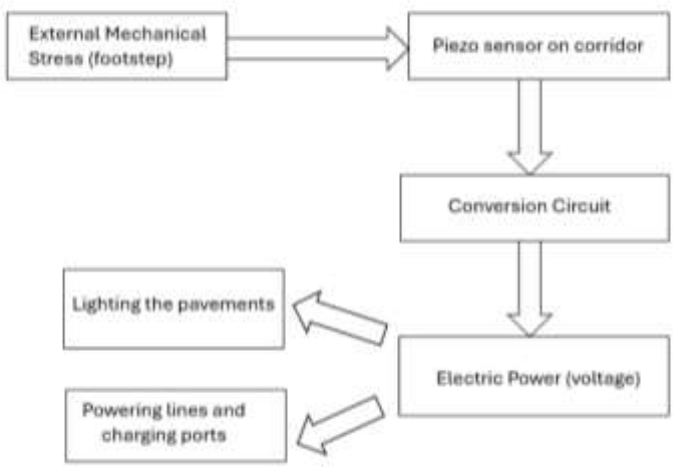

Fig 7: Flow Chart

Result and Discussion: The developed footstep electricity generation system, incorporating a piezoelectric sensor, ESP32, and IoT, was successfully implemented. From the experimental results, it was evident that each footstep was capable of producing a small voltage output, but this increased significantly when several piezoelectric sensors were connected in series and parallel. It was evident that the bridge rectifier was successful in converting the AC signal to a DC signal, whereas the capacitor was successful in smoothing out the fluctuations and temporarily storing the energy. Similarly, it was evident that the voltage regulator was successful in producing a constant output, thus being able to power the ESP32 microcontroller.

The ESP32 was successful in monitoring the voltage output and transmitting real-time data to IoT platforms such as ThingSpeak and Blynk. From the experimental results, it was evident that the system works effectively in high footfall areas, whereas in areas of low footfall, it was evident that the output was limited, thus dependent on user activity.

In terms of engineering, it was evident that the system was cost-effective, thus suitable for implementation. Similarly, it was evident that it was environmentally friendly. The incorporation of IoT was successful in enhancing the functionality of the system.

Conclusion: The proposed system for generating electricity based on foot steps shows an innovative method for sustainable energy production. The proposed system shows how energy can be produced from human activities by using piezoelectric sensors and ESP32 in conjunction with IoT technology. The energy produced by this system is not very high, but it is enough for small-scale operations such as lighting an LED.

The proposed system shows how renewable energy can be used in cities. The proposed system is especially suitable for areas such as railway stations, malls, etc., where there is heavy footfall. The proposed system is an innovative method for generating energy, and it has immense scope for being used in smart cities in the future. The proposed system can be further improved by increasing energy storage capabilities and by making it hybrid.

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