Footstep Power Generation

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***Abstract* - "The increasing demand for sustainable and renewable energy sources has led to the exploration of novel techniques for energy generation. This abstract presents an innovative approach called "Smart Footstep Power Generation" aimed at harnessing the energy generated by human ambulation to generate electrical power. The smart flooring system has an array of piezoelectric transducers, sensors, and power conditioning circuits. When a person walks or runs on the flooring surface, the exerted mechanical force by their footsteps causes the piezoelectric materials to deform, generating electrical charges. The embedded sensors detect the footstep and trigger the power conditioning circuits to harvest, convert, and store the generated electrical energy. For optimized energy conversion efficiency, advanced signal processing techniques are employed to detect and differentiate footstep signals from ambient vibrations or other sources of noise. The power conditioning circuits efficiently convert the harvested energy to a suitable voltage and current level for immediate use or storage in batteries**

Index Terms — Footstep power generation, Full-wave bridge rectifier, Piezo electric transducer, Power generation, Vibration energy.

I.INTRODUCTION

In recent years, sustainable and renewable energy sources have playing important role in Power generation. Researchers and engineers are constantly exploring innovative ways to tap energy from the environment. One such development is the concept of smart footstep power generation, a revolutionary technology that harnesses the energy generated by human footsteps to produce electricity. The population of the country increased and the requirement of the power is also increased. At the same time the requirement of energy is also increased. In order to meet the requirements, in addition with the traditional methods of power generation, people go for the new trends in power generation.

Smart footstep power generation operates on a simple yet ingenious principle converting the mechanical energy produced by human footfalls into electrical energy. The energy wastage can be converted to usable form using the piezoelectric sensor. This sensor converts the pressure on it to a voltage. So by using this energy saving method that is the footstep power generation system we are generating power. The proposed system works as a medium to generate power using force. This project can be implemented in public places like bus stands, theaters, railway stations, shopping malls, etc.

II. EXSISTING SYSTEM

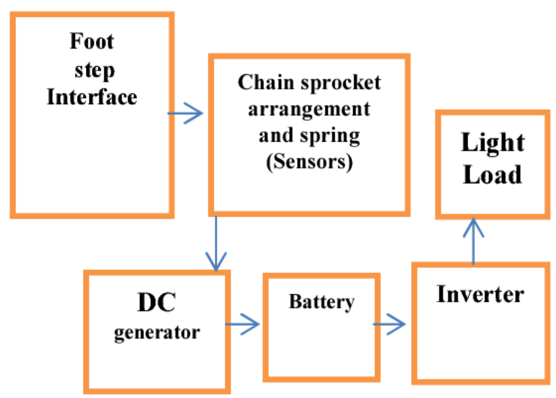


Fig.1` Block diagram

In this study, lead zirconate titante (PZT) piezoelectric transducer has been used to produce the kinetic energy from the footstep. The output voltage of this piezoelectric transducer is dependent to the structure of the ceramic and magnitude of strain and stress that applies on its structure. This transducer has diameter of 5 cm crystalline structure. The common output voltage is around 0-12 V. However, at instant impact on this transducer, it can achieve until 30 V while the output current is about 5 mA. There are two shapes of PZT piezoelectric transducer circular and the square shapes are used. The circular shape of piezoelectric transducer is more suitable to accept the stress or strain at the middle of the transducer meanwhile, the square shape of piezoelectric produce high output voltage when the strain or stress applied on the tip of the transducer. This circular shape piezoelectric transducer has been chosen because it is most suitable transducer for footstep rather than square piezoelectric transducer. The circular shape of piezoelectric give higher output voltage when testing on oscilloscope. This is due to the deflection on its structure when foot press is applied on it. The piezoelectric transducer is connected in series-parallel connection where voltage and current values are satisfactory. The output of the piezoelectric is in AC form. The produced AC form is converted into DC form and stored in storage components such as battery or capacitor. The stored DC form is used to supply the DC loads. In this study, the full wave bridge rectifier was used to rectify the output from the piezoelectric tile. The full wave bridge that is used in the study consists of four diodes and two capacitors. One of the capacitors acts as smoothing capacitor to filter the output waveform and another one as a storage component to store the energy. This full wave bridge rectifier operation is divided into two-cycle which are positive half-cycle and negative half-cycle. The four diodes labelled D1 to D4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are in OFF condition as they are now in reserve biased and the current flows through the two capacitors. During the negative half cycle of the supply, diodes D3 and D4 conduct in series as they are in forward biased, but diodes D1 and D2 are in reverse biased. The current flowing through the capacitors is the same direction as before. One of the capacitor acts as smoothing filter and another one acts as storage element. Both of them are connected in parallel. The voltage in the AC form is being rectified in the DC form in full brigde rectifier circuit, then it goes to the smoothing capacitor to remove any ripple factor that still left in the DC voltage form after the rectifier process. Lastly, the output from the piezoelectric tile is stored in the storage capacitor and ready to be used by other low power devices.

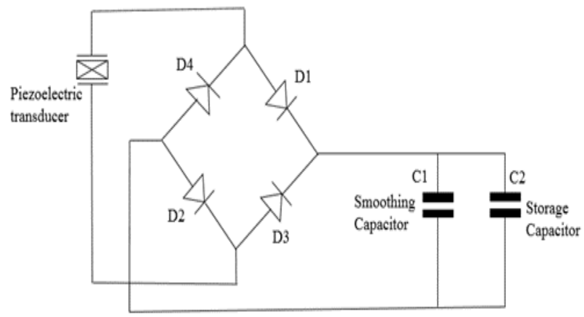
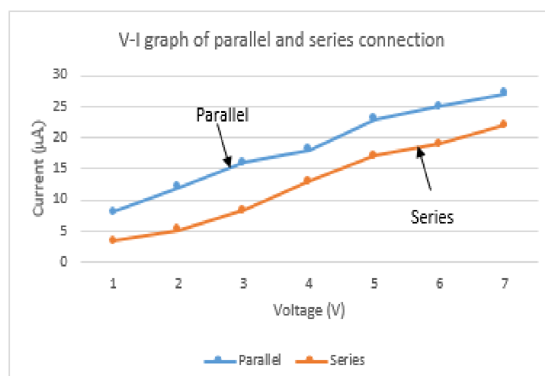


Fig. 2 Diagram of the full-wave bridge rectifier with smoothing and storage capacitor

Piezoelectric modules is used to generate a steady 5V of electrical energy. This energy is then efficiently stored in a 4V battery. Using voltage booster the stored voltage is stepped up to 12V.Once the battery reaches its target voltage; a DC to AC circuit is employed to convert the direct current into alternating current (AC). Finally, by simply flipping a switch, the AC current powers a bulb, causing it to glow. This innovative system presents several advantages, including environmentally-friendly energy harvesting from footstep pressure, efficient voltage conversion with the voltage booster, and the ability to power an AC device using the stored energy, providing illumination through the bulb.



When the piezoelectric are connected in series the output voltage is high but the output current is low when they are in parallel. It gives high current but low output voltage. In order to solve this problem, the combination of this connection needs to carry out. Two set of three piezoelectric transducers that connected in series was attached together in parallel to form series-parallel connection. The values of voltage as well as current output are both satisfactory.

III. PROPOSED SYSTEM

The proposed system utilizes a 9-tile piezoelectric sensor configuration to capture and convert mechanical energy from footstep pressure into electrical energy. This system aims to efficiently harvest energy from human footsteps and contribute to sustainable power generation.

System Configuration: Piezoelectric Tiles: The system consists of nine individual piezoelectric tiles arranged in a 3x3 grid pattern. These tiles are made of piezoelectric materials, such as PZT or PVDF, which generate an electric charge when subjected to mechanical stress.

Mounting and Wiring: Each piezoelectric tile is securely mounted beneath a walkway or floor surface, ensuring proper alignment with the expected footstep pressure points. The tiles are interconnected using appropriate wiring to ensure the generated electrical energy can be efficiently collected and utilized.

Energy Conversion Circuit: The electrical output from the piezoelectric tiles is fed into an energy conversion circuit. This circuit consists of rectifiers, capacitors, and voltage regulators to condition and optimize the harvested electrical energy for storage or immediate use.

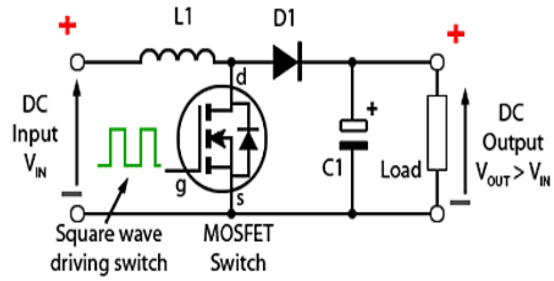
Energy Storage or Utilization: The conditioned electrical energy can be stored in batteries or supercapacitors for later use, or it can be directly utilized to power various applications. For example, it can be used to illuminate streetlights, charge electronic devices, or supplement the energy needs of nearby buildings.

Footstep Pressure: When an individual steps on one of the nine tiles, the pressure exerted by the foot compresses the piezoelectric material within the tile.
Electric Charge Generation: The mechanical stress applied to the piezoelectric material causes the release of electric charges. This charge generation is proportional to the applied pressure and the piezoelectric material's characteristics.

Electrical Output: The electrical charges generated by each tile are collected and channeled through the interconnecting wiring to the energy conversion circuit.

Energy Conversion: The energy conversion circuit processes the incoming electrical signals, rectifies them to convert AC to DC, and optimizes voltage levels for storage or immediate use.

Energy Storage or Utilization: The conditioned electrical energy can be stored in batteries or supercapacitors for later use when the demand arises. Alternatively, it can be directly utilized to power nearby applications."



Fig, 3 Boost converter with 9 tile piezoelectric transducer

A boost converter is a type of DC-DC converter that steps up the input voltage to a higher output voltage. It's commonly used in various applications, including power supplies, battery chargers, and energy harvesting systems.
If you want to integrate a boost converter with a 9-tile piezoelectric sensor, it suggests that you want to harvest energy from the piezoelectric sensor's vibrations and convert it to a higher voltage level. This energy harvesting method is often employed to power low-power devices or charge energy storage elements like batteries or capacitors.

To design a boost converter system with a 9-tile piezoelectric sensor, here are the general steps you can follow:
Determine the specifications: Understand the characteristics of the piezoelectric sensor, such as its output voltage, current, and frequency response. This information will help you choose appropriate components for the boost converter.

Choose a boost converter IC: Select a boost converter IC that meets your requirements in terms of input voltage range, output voltage, output current, efficiency, and other features. Some popular ICs for boost converters include LM2577, LT1376, and TPS61070.

Design the energy storage element: Decide on the energy storage element you want to charge using the boost converter. It could be a battery, a supercapacitor, or any other suitable energy storage device. Calculate component values: Based on the specifications of the piezoelectric sensor and the desired output voltage, you'll need to calculate the values of key components such as inductors, capacitors, resistors, and feedback network components. The datasheet of the selected boost converter IC will provide application notes and formulas to guide you in this process.

Layout and circuit design: Create a PCB layout for the boost converter circuitry, ensuring proper placement of components, signal routing, and thermal considerations. Follow best practices for high-frequency switching circuits to minimize noise and interference. Prototype and testing: Build a prototype of the boost converter circuit and connect it to the 9-tile piezoelectric sensor. Verify the performance of the system, measure the output voltage, and evaluate the efficiency and stability of the boost converter.

Optimization: Fine-tune the component values and circuit design if necessary to improve the efficiency and overall performance of the boost converter system."

IV. CONCLUSION

In conclusion, integrating a boost converter with a 9-tile piezoelectric sensor is used for the conversion of the sensor's mechanical vibrations into a higher output voltage. This energy harvesting approach can be utilized to power low-power devices or charge energy storage elements like batteries or capacitors.

To implement this system, several steps need to be followed. Firstly, the specifications of the piezoelectric sensor should be understood, including its output voltage, current, and frequency response. Then, an appropriate boost converter IC must be selected based on input/output voltage requirements, output current, efficiency, and other relevant features. Next, the energy storage element, such as a battery or capacitor, needs to be chosen, and component values for the boost converter circuit should be calculated based on the sensor's specifications and desired output voltage. A proper layout and circuit design should be created, considering signal routing, thermal considerations, and best practices for high-frequency switching circuits.

After constructing a prototype, the boost converter system should be tested to verify its performance, measure output voltage, and evaluate efficiency and stability.

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