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Power Generation and Storage by Piezoelectric Cells

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Abstract*— Energy consumption is an indicator of development of the universe. Modern world needs a huge amount of electrical power to meet up the current energy demand whereas the resources of conventional energy sources are diminishing steadily in response of vast consumption of energy. So, alternate sources of energy are required to fill up the large gap between demand and supply. This paper covers the production of energy through piezoelectric effect in which certain materials have the ability to build up electricity from having pressure or strain applied to them; this can be achieved through a design of piezoelectric tile/s. When people walk, their energy gets wasted, by using piezo electric transducers (PZT) like Lead Zirconium Titanate, we can convert this wasted energy produced by the pressure of moving people into electrical energy which can be used for different purposes such as auto street lighting, emergency lighting in commercial buildings, etc.

Keywords-Piezoelectric transducers (PZT), Piezoelectricity, PWM, Arduino.

Introduction

At present we mostly depend on non- renewable source which is believed to become exhausted in near future. The generation of electric power depends in the main in the burning of fossil fuels like the coal, oil, and natural gas or for the consumption of radioactive material which produce a high index of pollution in the environment and can put in risk the human life in case of some fault in the case of the radioactive materials [1]. And due to the increasing demand of electric power and the destruction of the environment there has been stimulated the investigation of new alternatives to obtain electric power. Hence, we have to increase our energy dependency on renewable source of energy [2].

In our day-to-day life we utilize a large part of our energy in moving from one place to another. So, it is possible to convert this energy used in movement to some form readily available for use. The main aim of the proposed system is to generate electrical power as non-conventional method by simply walking or running on the foot step that is by providing some mechanical stress. For such a motive, in this project there appears the design of a prototype of piezoelectric generator that transforms the mechanical force of pedestrians' compression into electric power to store the electrical energy in a battery or we can also feed a system of lighting of low power [3].Solar, wind energy may not be available all the time like in rainy or cloudy day but piezoelectricity can be available all the time because it can be generated by footstep and people are always going to walk when we install piezoelectric tiles on footpath or staircase of buildings which in turn is effective when it comes to recent times and piezoelectricity can become a demanding source.

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Problem Identification And Research Objectives

These are problems that have been identified during the project:

- As the voltage obtained from the tile depends on the pressure applied to it, different voltage levels can be observed at different pressure resulting in a non-constant and fluctuating output DC voltage.
- This output voltage if allowed to pass to charge a battery as load or is used to light a bulb, it may damage the battery or other load if the obtained output voltage is higher than the respective rating of the load.

Objectives of this research are as follows:

- To design and fabricate a proper power generation source with piezoelectric sensors.
- To maintain a constant DC output voltage across the load from the fluctuating DC voltage obtained from the piezo electric tile.

Proposed Approach

The main idea of our project is to obtain a constant DC output from which can be used to supply to load or also can be used to charge a battery.

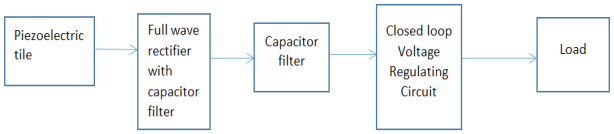

Figure 1: Basic block diagram of the project

When force is applied to the piezo tile and released, it provides an AC output voltage. The more force we apply, the higher output voltage we obtain. But, if we were to use this output voltage to supply to a load or store in a battery, we need a constant output voltage rather than continuously increasing voltage even the force supplied to the piezo tile keeps increasing. So, we must perform a closed loop operation to obtain a constant voltage across the load.

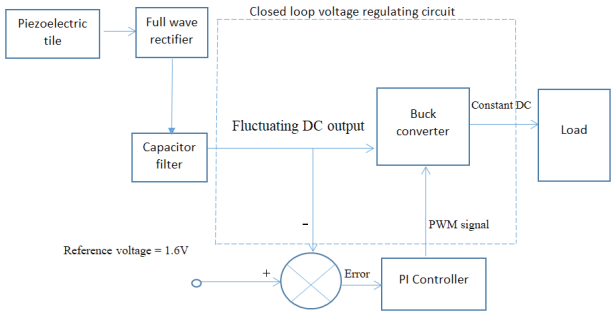

Figure 2: Proposed closed loop system for piezoelectric power generation.

PI controller is used as a feedback unit to provide PWM signals to the buck converter which provides constant acceptable DC voltage requiredby the load or required to charge a battery.

Methodologies

- Proper arrangement of a piezoelectric tile with series parallel combination of piezo electric sensors.
- When force is applied to this arrangement, fluctuating and gradually increasing AC output voltage is obtained depending on the pressure applied to it.
- AC voltage is rectified by bridge rectifier and passed through capacitor filter to eliminate the ripple and to hold this output.
- Now the main goal of our project is to obtain a constant DC output from fluctuating output which can be used to charge a battery or supply a constant load.
- The DC output is fed to Arduino which is used as PI Controller in our scheme where it is compared with a reference voltage 1.6V and PWM output signals were obtained as result of PWM generating code performed on PWM pin of Arduino.
- This PWM signal was passed as a Gate signal to the Gate pin of MOSFET used in buck converter which chopped the higher voltage obtained from capacitor output and only allowed a constant voltage to pass from the buck converter by adjusting the duty cycle of the switch.This constant output voltage obtained from buck converter is our required result.

Fabrication of hardware components

Open loop system:

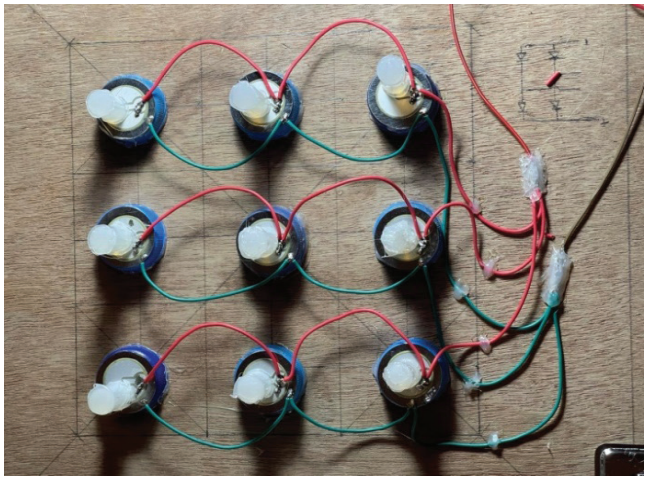

Figure 3: Open loop piezo tile connection

Figure 3 shows the fabrication of piezoelectric sensors into a wooden tile. Here total nine PZT elements are connected to each other in equivalent series parallel connection. Three piezoelectric sensors are connected in series in each row and three rows of series connected piezoelectric sensors are connected in parallel to each other.

Closed loop system:

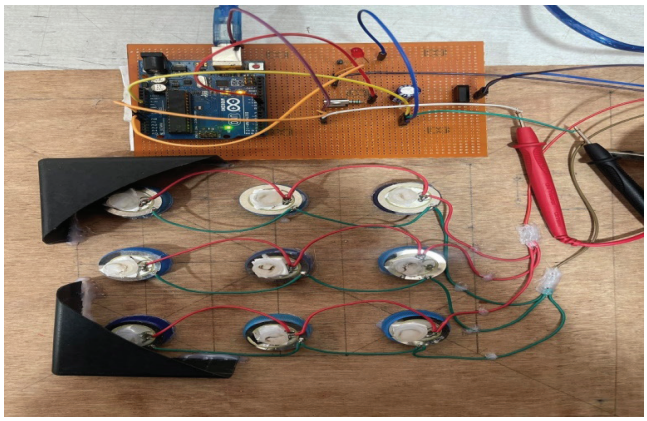

Figure 4: Closed loop piezo tile connection with Arduino as PI controller

We used Arduino coding as a closed loop voltage regulation system where the output voltage from piezo tile is compared with the reference 1.6V set in the reference pin. By generating PWM signals in Arduino and controlling the gate signal to the MOSFET used as a switch, the closed loop action was performed and the output voltage was constantly compared with the reference and the iterative process continued until the output pin of Arduino gave a constant voltage of 1.6V despite the increase in input voltage to the Arduino i.e. output from the piezo tile.

Discussion

Here, the piezo arrangement of the tile gave output voltage in the range of 5-6V AC and fluctuating in nature. This fluctuating AC voltage converted into DC by rectifier. In order to power the LED bulb as a load, a constant 1.6V should be maintained at the output as the lower voltage is not sufficient to power the LED whereas excessive voltage would wear out the bulb.

Thus, the rectified fluctuating output of the piezo tile is fed to Arduino where closed loop action is performed by coding that includes reading the input to Arduino and maintaining the 1.6V reference set to the output. Arduino performed the iterative process of reading the input and channeling the error between input and output and the generated gate signal to the MOSFET gate [4]. The gate signal was generated as the result of PWM process and fed into the gate switch in controlled manner such that the input to the Arduino is buck to an acceptable range resulting in constant DC output across the load due to which the LED was glowing continuously without any defect despite addition pressure applied to the piezo tile and more voltage generated in the input, which was the main goal of our project.

Outputs

The results open loop and closed loop operations of piezo tile is shown in the following plot of output voltage versus time:

Open loop system outputs:

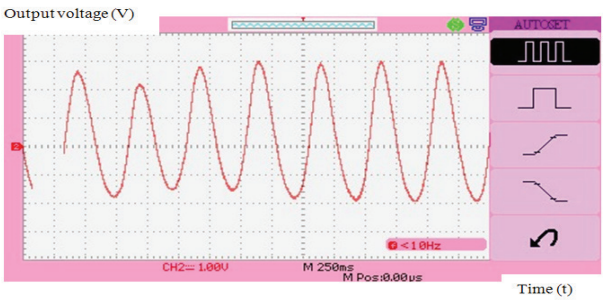

Figure 5: Piezo tile AC output signal

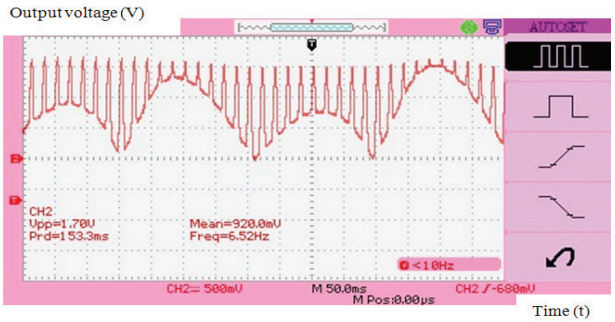

Figure 6: Rectified DC output signal

Closed loop system outputs:

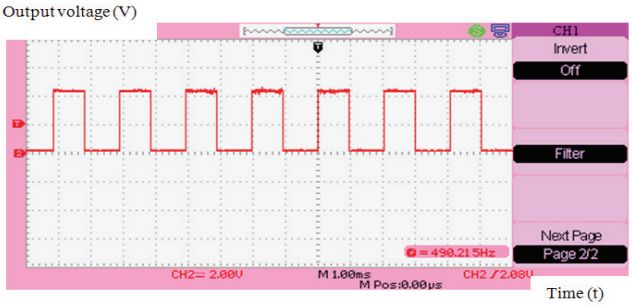

Figure 7: PWM gate signal to MOSFET of buck converter

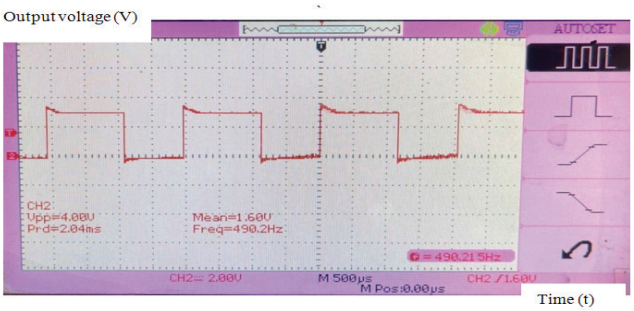

Figure 8: Constant 1.6V output voltage

Conclusion

Thus, this project illustrated the applicability of piezoelectric transducer in producing reliable and cost-effective means of electrical energy and how we were able to obtain a controlled constant power generation through closed loop operation of fluctuating ac output from the piezoelectric tile. With the help of Arduino programming and dc chopper we were able to harvest the constant electrical energy out of fluctuating electrical energy that could be used as a constant power source to a load or can be used in various other applications as favorable.

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