

# Evaluation of impact based energy harvesting using a piezoelectric ceramic disc

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**ABSTRACT** - This paper reports an impact based energy harvesting using a piezoelectric ceramic disc, whereby a useful electrical power is generated via the impact of the human weight on the piezoelectric plate transducer. A prototyping of a single human step piezoelectric plate based impact harvester consisting of a piezoelectric transducer was tested on a hydraulic pressing machine with variable forces and impact velocity. In this experiment a piezoelectric ceramic disc with a size of pallet 44mm in diameter and 10mm in thickness was able to generate an average output power of up to  $14.5\mu\text{W}$  across a resistive load of  $500\text{K}\Omega$  when a force of  $0.75\text{ kN}$  of force with a velocity of  $600\text{mm/min}$  is applied on it.

## 1. INTRODUCTION

Energy harvesting using piezoelectric has attracted many interest as a meant for powering up low-power electronic devices which have been reported but mainly in harvesting energy from both vibration sources [1,2]. These offer an advantage for systems in which battery replacement is challenging which limiting the system's life time. Kinetic energies derive from vibration as well as impact are ubiquitous from ambient environment which can easily be found from available energy sources, such as in industrial environments, transportations, and human life activities which has led to rapid development of energy harvesters to scavenge energy from vibration/impact for the past few years. Commonly, there are four types of transduction mechanisms which are suitable for vibrations are electromagnetic, electrostatic, magnetostriction and piezoelectric. Among these energy harvesters, piezoelectric have received more attention because it has the ability of converting the kinetic energy into useful electrical energy with high power density and high conversion efficiency. Beside that it is able to be miniaturized with simple structure and mass manufacturability [3]

However, compared to the vibration or resonance type piezoelectric generation mechanism, the impact type is not broadly available due to its low interaction chances with external impact and hence generating less averaging electrical power and therefore this paper objective is to evaluate the performance of a piezoelectric ceramic disc when an average human weight is applied on the device.

Recently, mechanical to electrical energy conversion technique based on impact, have been

investigated in [4]. Amat and Bunji in [5] presents a study to characterize the effect of two mechanical impact parameters (velocity and mass) on impact mode piezoelectric power generation, they have been proven that the instantaneous output voltage is proportional to the impact velocity and for output power it is in a straight line relationship with the same parameter. For this paper, a series of experiments has been conducted to evaluate the amount of voltage and power generated via piezoelectric ceramic disc when it is excited by different forces and velocity.

## 2. EXPERIMENT SET-UP

For the experiment a human single step piezoelectric generator prototype is designed as shown in Figure 1.

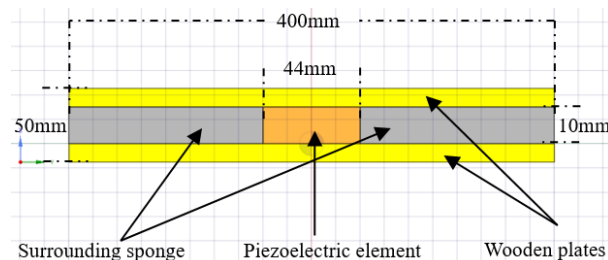


Figure 1 Schematic diagram of a human single step piezoelectric generator prototype.

The construction of the human single step prototype consisted of a piezoelectric ceramic disc with a diameter of 44mm and thickness of 10mm was sandwiched between two wooden plates, surrounded by a sponge, and then covered with a nylon in order to make it more compact and prevent it to be smashed by excessive mechanical load. The final measurement of the prototype is 400mm diameter by 50mm height.

Various impacts/velocities were generated by using AUTOGRAPH AG-I 100KN hydraulic pressing machine to simulate a single human step as shown in Figure 2.

## 3. EXPERIMENTAL RESULTS AND DISCUSSION

An AC voltage generated from the single step prototype is being measured with varying velocity with a fixed amount of applied impact force of  $0.5\text{KN}$ . The peak-to-peak AC voltage shows an exponential

increment as the velocity of the force is increased as shown in Figure 3. An AC peak-to-peak voltage of 27 V is recorded when the speed of the force is at 1000mm/min.

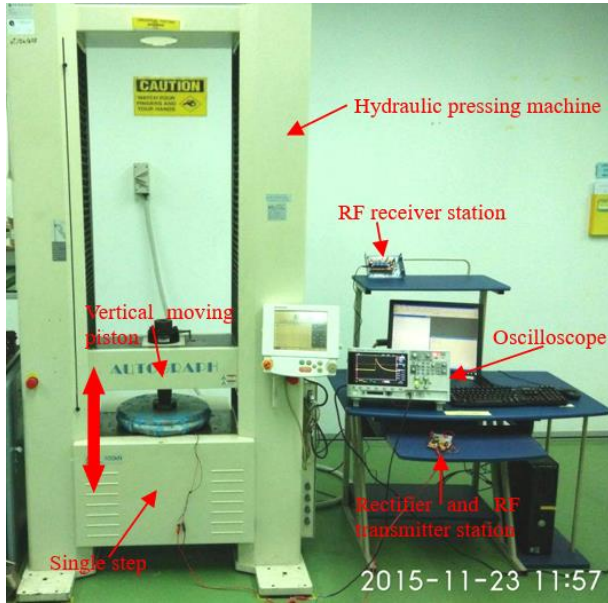


Figure 2 Experimental setup.

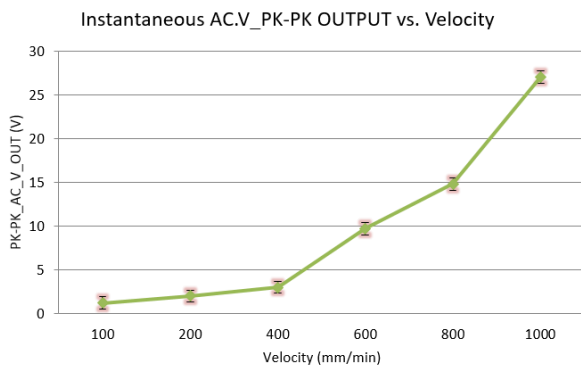


Figure 3 Instantaneous AC.V\_PK-PK OUTPUT vs. velocity.

Next experiment is varying the amount of force up to 3 kN at a fixed velocity at 700mm/min. A voltage of 16 V is being measured when 3 kN of force is being applied to the prototype as shown in Figure 4. Figure 5 shows the electrical output power and electrical output current when the output terminal of the piezoelectric is connected to a series of external electrical resistive loads. The force is fixed at 0.75 kN mimicking an average human weight. A maximum output power of 14.5  $\mu$ W is being measured across an external load of 500 k $\Omega$  while the maximum current is measured at around 12  $\mu$ A when connected to an external resistive load of 65 k $\Omega$ .

#### 4. CONCLUSION

A human single step prototype based on a piezoelectric powered device has been presented. It shows a potential of powering low electrical devices with a power of 14.5  $\mu$ W.

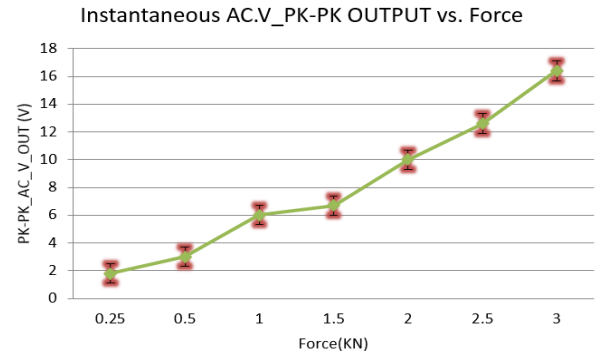


Figure 4 Instantaneous AC.V\_PK-PK OUTPUT vs. force.

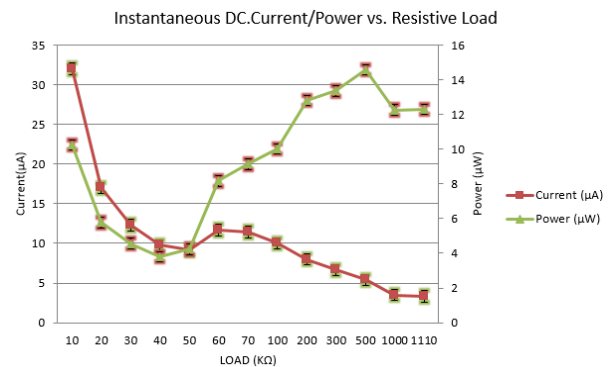


Figure 5 Instantaneous DC.V Current and Power vs. Resistive load.

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