ENERGY PRODUCTION IN PUBLIC TRANSPORT USING PIEZOELECTRIC MATERIAL

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ABSTRACT

In recent years, in order to supply increasing energy demand due to technological development, industrial improvement and increasing population; micro-level systems were improved. These systems are suitable to obtain electrical energy in micro-level. By the help of the motion energy in electrical devices, usable electrical energy can be produced by using piezoelectric materials. In this study, different type piezoelectric materials and springs were used to generate electricity in hand holders of public transportation vehicle. According to applied force electricity was generated as a result of flexion on piezoelectric material surface. Energy alignment circuit was used to supply voltage in optimum level and in order to transmit the obtained energy to load by minimizing the losses. Several experiments were done by applying the load in different value at output of piezoelectric material.

Keywords *– piezoelectric, micro electric energy, public transportation, hand holder.*

I. INTRODUCTION

The energy requirement increases with the development of the technology day by day. Energy sources have shifted to alternative energy sources such as the environmental damage of the consumable energy sources, most researchers are wind energy, solar energy and geothermal energy [1]. Because of the many problems such as installation, cost and so on of alternative energy sources, micro-level energy production systems are used. Such systems are a potential source of energy to generate micro-level electricity as a result of mechanical vibrations stresses and forces [2-3].

Today, most researchers are working on converting mechanical energy into electrical energy. Piezoelectric materials are the most important choice used to perform this transformation. [4-5]. In most engineering applications, piezoelectric materials are used as sensors or actuators. Piezoelectric materials have a wide range of applications, including in microphones, vibration detectors, loudspeakers, bells, speedometers, headphones and the like [6-8]. They are preferred because they are cheap and have high strength. The biggest disadvantage is that it has a low voltage-current ratio. Such disadvantages can be avoided thanks to the developed electronic cards [9].

Piezoelectricity; Quartz (SiO2), Tourmaline, Lithium Sulphate, Barium Titanate, Lead Zirconate Titanate (LZT) are found in materials with a crystalline polar axis. LZT materials are currently the most widely used piezoelectric ceramics [10-12].

Due to the force or pressure applied on the piezoelectric materials and the displacements that occur on the material, they produce stress. This voltage can be recharged through a suitable converter circuit. It is called inverse piezoelectric effect to the shape change which occurs in the end result of energy supply to the piezoelectric material.

People spend part of their daily lives on public transport (metro, metro bus, bus and tram) vehicles. Especially in metropolitan cities, such vehicles are very busy at some hours of the day. Due to this density, hand holders available in vehicles during the journey are frequently used. Thanks to their hand holders, people can protect themselves from sudden braking or wreckage, which can happen in vehicles during the journey.

There are many studies in the literature about the production of electric energy at micro level using piezoelectric materials. With the force applied on the piezoelectric material, vibration or expansion occurs in the material. As a result, electric energy can be produced [13-15].

Electrical energy is produced by flexing force on the piezoelectric material. William and his colleagues produced energy at the micro-watt level with the piezoelectric materials they placed on the leaves of the tree swinging in the wind [16] Rofouei and his colleagues produced electrical energy through the sensors they placed under the keyboard keys [17].

When we look at the studies in the literature; piezoelectric materials are used on different systems. The target has been to utilize motion energy in the environment and convert it into a usable electrical energy.

In this study, unlike the literature, electric energy is generated from the hand holdings used by people in urban transportation; It is aimed to meet the electricity needs of the electronic devices they use during transportation. Piezoelectric system modules developed in addition to the hand-held mechanisms used in public transport will be used.

II. DESIGNING

Piezoelectric materials are materials that convert mechanical energy into electrical energy and produce energy at a micro level. In this study, piezoelectric plate materials were used on the prototype product as shown in Fig. 1. This piezoelectric material is Cat.#40-2010 and manufactured by American piezo firm. Its dimensions are 60 mm long, 20 mm wide, 0.69 thick. It can produce voltage up to 150 volts.

The designed system is shown in Fig. 1. On this system 2 piezoelectric plate materials and 2 spring mechanisms is used. As a result of the applied force on the piezoelectric, a spreading load is generated on this surface. The spreading load causes the bending stress influence on the piezoelectric material. Electrical energy is generated in this way.

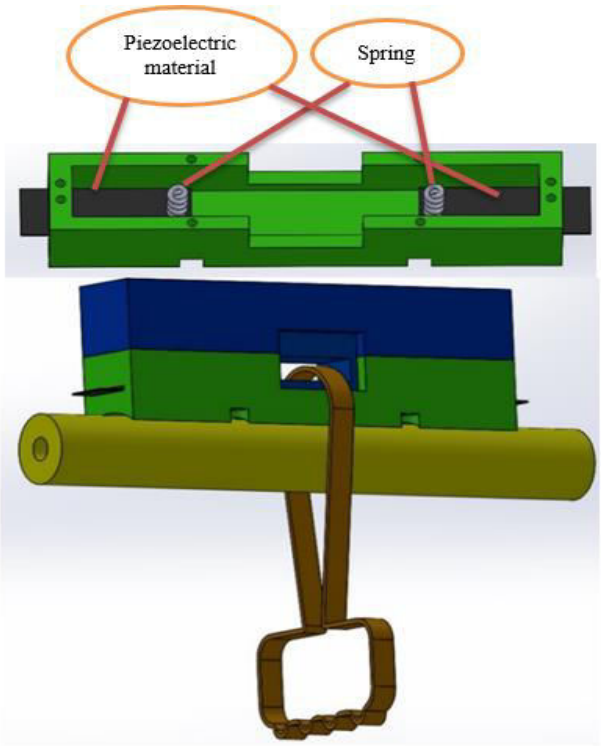

Fig. 1 Prototype hand holder system solid model

In the designed model, the LTC 3588-1 integration is used for piezoelectric material output. With this integration, it is aimed to provide the optimum level of voltage and to transfer the electric energy obtained by reducing the losses the most. Energy storage circuit is used because the losses of a circuit model that can be generated by existing power electronics elements will be larger (Figure 2).

The generated voltage is rectified by the LTC 3588-1 energy storage circuit, and the current is increased and stored in battery. It can output up to 100mA of output current with input voltage operating range of 2.7-20V.

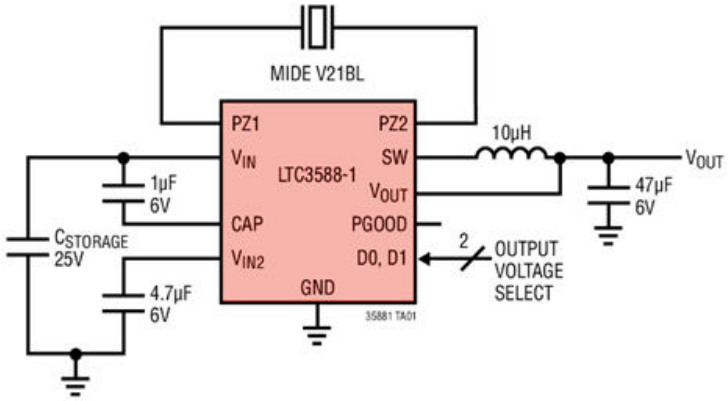

Fig. 2 Piezoelectric energy harvesting power supply

III. FINDINGS AND ANALYSIS

In this experiment, the electric energy obtained from the piezoelectric materials by the force applied on the hand holder system is examined. Experiments were carried out by connecting different resistances (380 and 666 ohms, 1 and 4.7 Kohm) to the output of the piezoelectric material. Voltage-power data for each load is calculated. The voltage produced due to force in the experiments which were performed without any load is shown in Fig. 3. After examining the graph in Figure 3, it is observed that it produces a voltage of about 22 V. This value varies with respect to the applied force.

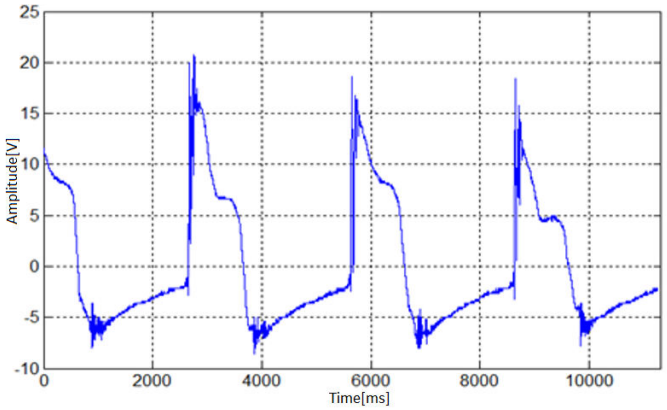

Fig. 3 The measured voltage values

The measured voltage values over the load is shown in Fig. 4. As expected, the voltage value decreased with respected to the without any load state. It has been observed that there is a linear relationship between the load resistance and the measured voltage. It is observed that voltage is produced at maximum 4 V.

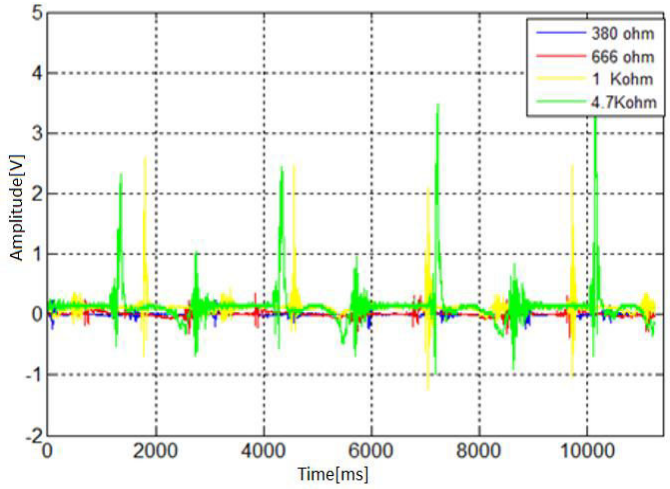

Fig. 4 The measured voltage values over the load

The measured power values is shown in Fig. 5. Power values are calculated over voltage and current data. As expected, the calculated power values are in a linear relationship with the load values. The maximum power values produced are approximately 6500µW.

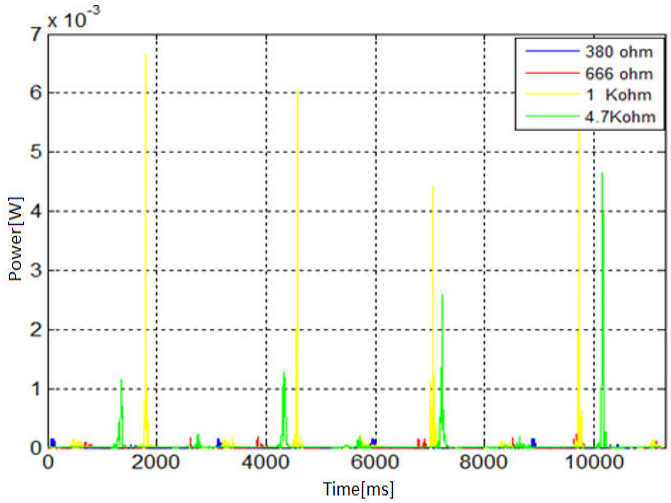

Fig. 5 The measured power values over the load

IV. CONCLUSION

With the developed micro-level systems, it is possible to convert the physical changes in any environment into electrical signals and transfer them to electronic systems and generate energy.

In this study, a mechanics based on spring-piezoelectric material is developed to be used in the hand holders frequently used in public transportation vehicles for generating electrical energy from mechanical energy.

Using a prototype hand holder system experiments were carried out at different loads, results of those are shown. As a result of the experiments performed, the force applied to the system was transmitted to the whole surface by means of spring mechanisms and motion on the piezoelectric materials a signal of 22V amplitude was obtained. The obtained signal is transferred to the energy storage circuit and through which a capacitor of 1F is charged. Experiments on different resistance values produced 0.1-4 V of voltage and 100-6500 µW of power.

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