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Charging of a Cell Phone Using Vibrations of a Drum

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ABSTRACT

This paper presents a novel technique to charge cell phones by converting the mechanical vibrations of a drum into electrical energy, these vibrations are produced when the drum head is struck by the musician or drummer. The technique applied involves the use of piezoelectric sensors that convert the input kinetic energy to output electrical energy or alternating current which is further converted into direct current or D.C using a rectifier and is then stored in the battery, in this case, the cell phone battery.

Keywords: Piezoelectric sensors, Rectifiers, Vibration measurements.

1. INTRODUCTION

One particular field of technology that has grown unprecedentedly over the past decade is cellular technology, Evolving from the basic landline to the modern day smart phone, this field has had numerous amount of research been dealt with in every aspect. One particular topic that has not been evaluated as much as the standards, protocols and features of these smart devices is the use of alternate means to recharge a cell phone battery. The standard phone charger uses supply from mains and although reliable it is neither economic nor does it use renewable energy.

Efforts are being made to draw power from renewable sources such as solar or wind energy but neither of them is as reliable as the current chargers in use. In order to address this issue energy harvesters or transducers which convert one form of energy such as kinetic energy into electric energy are being considered. This paper presents an approach of converting vibrations produced by a drum being played by a drummer into electric energy which is further converted to a form suitable for charging the handheld device.

A transducer is a device that converts one form of energy to another, the most common example of a transducer that we come across in our daily life is the dynamic microphone or simply the “mic” which converts sound energy into electric energy, or more accurately electric pulses, this signal is amplified and converted back into sound energy at the output side by another transducer called a speaker.

The dynamic microphone picks up vibrations from the air which serves as an input, this signal may merge with noise from neighboring sources which adds a requirement of filtering techniques to separate the signals of interest. Mostly the low pass filter is applied to separate the high-frequency noise from the low-frequency message signal. However a piezoelectric crystal directly picks up vibrations from the source as it is attached to the source which provides isolation between the message signal and any other noise that may interfere with the source signal, thereby minimizing the need for a filtering circuit and thus making the choice of using a piezoelectric crystal for picking up vibrations in this model obvious.

The use of PZT or Lead Zirconate Titanate as a transducer it’s working and related simulations are clearly explained in [1]. The main aspects of [1] that are put to use in this idea is the citing that PZT transducers are ideal for conversion when input vibrations are in the range of a few 100Hz. It is essential to note that the range of vibrations of a standard drum varies in the range 180Hz to 530Hz. [1] Presents a device applied for zero current stand-by which prevents energy from dissipating while the equipment is in stand-by mode, which is mostly caused by front end devices such as Bluetooth devices which are kept active in order to receive the wake-up signals from the user.

The idea of using everyday objects to generate electricity was incorporated from [2], which presents a table of how much energy is utilized in various portable devices such as heart rate and respiratory rate meter. It also introduced the concept of drawing power using a transducer which is fitted in a person’s shoe. [2] Begins with an in-depth analysis of the piezoelectric effect, the production of charge by applying physical strain on the piezoelectric crystal, and further explains the circuit used in order to charge the phone.

The only disadvantage of the method presented in [2] was that uneven application of force on the sensors causes physical damage to the sensors, it was, therefore essential to look for alternate methods

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of supplying input kinetic energy to the sensor, one such technique as in [3], uses a hand fan to generate input for the sensor this method required the sensors to be attached to the hand fan and used circuitry similar to that in [2]. Although this innovative approach produces charge by keeping the sensors safe, hand fans [3] are seldom used in today's modern world. Also, this product does not seem likely to attract a market for itself, thereby leaving room for better innovative approaches for its simple yet useful idea.

Musical instruments, especially the drum [4], have become common in all sectors of the society used in both rural sectors, during traditions, and urban areas during fests. On close observation we notice that massive amount of force is applied on each drumbeat which produces large vibration on the skin of the drum, it would therefore be helpful if we were able to use this energy for running a home appliance. Although the power generated is insufficient to drive a conventional consumer electronic device it is enough to charge a smaller device such as a flashlight or mobile phone. This paper presents the basic needs and requirements for the model along with simulation results from various sources related to this idea

1.1 Devices Used

a) Piezoelectric Sensors

There are several families of piezoelectric sensors commercially available; the common classes being, Natural and synthetic materials. Common examples of naturally occurring crystals that exhibit piezoelectric effect are Quartz and Topaz.
Whereas synthetic materials can be divided into:
1) Synthetic crystals: Langasite, Gallium Orthophosphate and Lithium Tantalate (PZT).
2) Synthetic ceramics: Lead Zirconate Titanate, Potassium niobate, and Sodium tungstate.

Out of the above-mentioned piezoelectric materials, the synthetic ceramic based Lead Zirconate Titanate (PZT) is much more sensitive than the naturally occurring crystals and also, consists of multiple layers of the polycrystalline structure. A PZT can be considered of two layers the non-active bottom layer and a conducting upper layer.

Application of a force or vibration on a particular face of a PZT produces an A.C voltage on its other face, the dielectric constant of a PZT depends on the dielectric constant of a PZT depends on the type of dopants used and can vary from 300 to 3850.

b) Rectifier

The A.C voltage thus produced is not in a form suitable for storage and hence must first be converted to D.C. In order to do this the output D.C voltage is passed through a rectifier circuit that converts input A.C voltage to output D.C voltage, the rectifier of choice is the full wave bridge rectifier. The full wave bridge rectifier is chosen as it has a ripple factor value of .693 almost half of that of the half wave rectifier (1.21).

Also, the efficiency of a full wave rectifier is 81.2% whereas that of a half wave rectifier is only 40.6%, as the bridge rectifier conducts for both half cycles whereas the half wave rectifier conducts for only one-half cycle. The bridge rectifier is preferred to a center-tapped rectifier, even though the efficiency and ripple factor of both versions of full wave rectifiers are same, as it is a tedious process to locate the center tap on the transformer secondary. The bridge rectifier also produces almost double the output D.C voltage as compared to a center-tapped rectifier. The bridge rectifier used is represented in Fig 2.

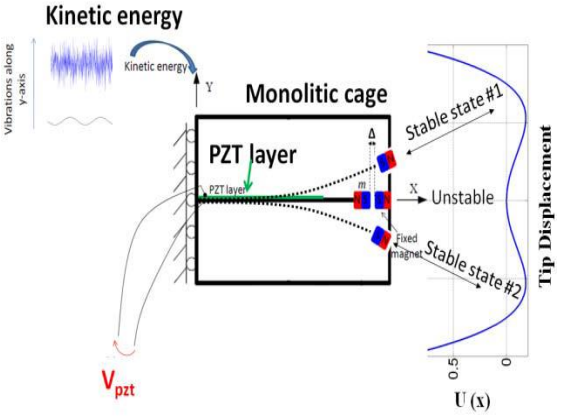

Fig.1. Schematization of the sensor

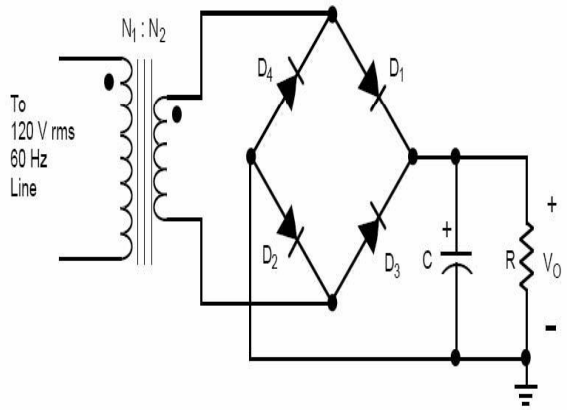

Fig 2: Bridge rectifier with RC load

c) Capacitor

The output of the rectifier circuit is a pulsating D.C signal however in order to charge the phone a linear D.C signal is needed hence the obtained signal is passed through a capacitive filter that smoothens the output waveform thereby making it suitable for the desired purpose. The capacitor chosen is a .1mF electrolytic capacitor as represented in Fig 3.

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Fig 3: Basic drum structure

The drum belongs to a family of music instruments called percussion instruments [4] and consists of a membrane called the drum head stretched on both sides of a hollow cylindrical body known as the shell. The sound is produced by the vibration of the drum head when sufficient force is applied to it by the drummer. The procedure to be followed in this model is to firmly place a layer of PZT sensors just below the drum head for it to pick up vibrations from the drum and convert this energy into an alternating current.

The amount of voltage generated depends on how the PZT's are connected and also the number of PZT's used, the simulations of different arrangements and also the value of power in each case is incorporated in [3]. The best orientation was chosen for implementation.

A typical PZT generates a voltage of about 3V when a force is applied, using the arrangement above marked as (a) below a voltage of 16V and a current of 2.5µA was obtained, using (b) which consists of 28 PZTs, generates a power of about .42µW however the soldering of the wires may deteriorate due to force applied on the drum and hence is not the complete solution, a third orientation which consists of 4 sets of 7 PZT's in series with each set connected parallel to each other uses a thin metal plate as a connector it also consists of a thick polymeric plate at the base to prevent damage from being inflicted to the PZT's due to force applied by the drummer.

The A.C voltage thus produced is passed through the bridge rectifier to produce a pulsating D.C voltage which is further filtered by a capacitor to produce a linear D.C voltage. The experimental setup is as displayed in Fig 7.

2. EXPERIMENTAL PROCEDURE AND SIMULATION RESULTS

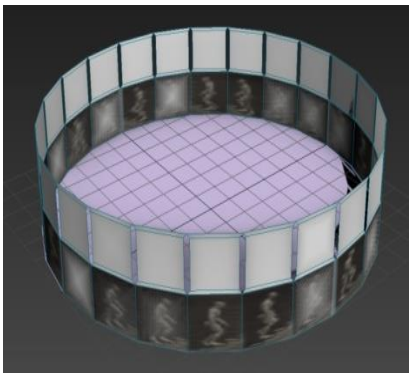

Fig 5: Interior of a Drum Head.

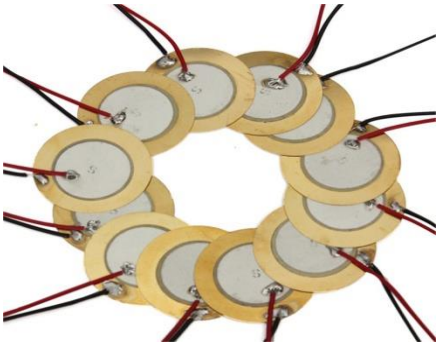

Fig 6: PZTs to be arranged on the drum head

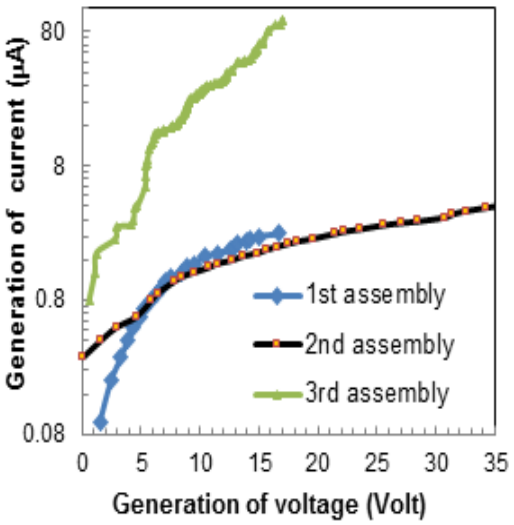

Fig 7: Arrangements of PZT and simulation of voltage and current in each trial

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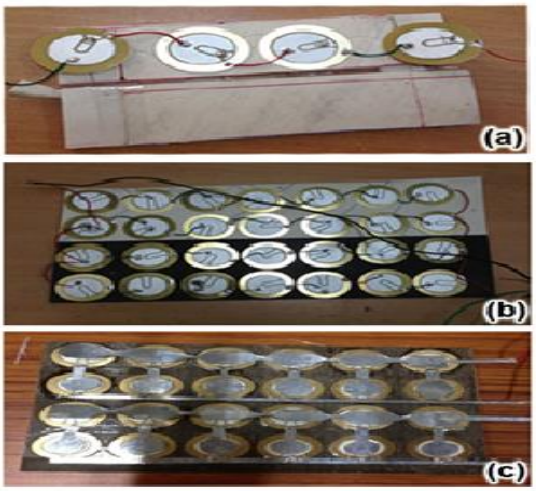

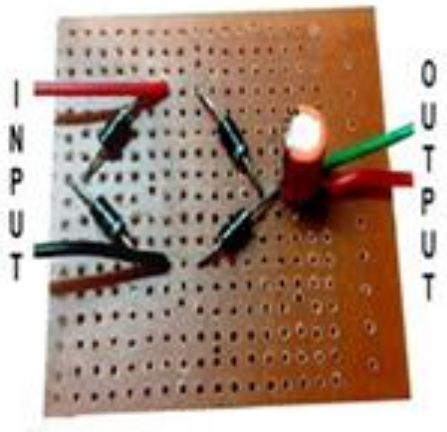

Fig 8: Rectifier and Filter circuit.

3. CONCLUSION

This paper brought forth a novel approach in producing D.C and using it to charge a cell phone, the idea of using drums as a source of power marks the beginning to a wide variety of changes in the world of musical instruments and electronic devices. Although other methods of charging a phone using unconventional means are now made available, such as footwear with piezoelectric crystals embedded in them, the piezoelectric sensors would often get damaged due to exposure to harsh terrain or ware and tear. This method uses drums which involves force applied to it in a more systematic manner and hence reduces the damage caused to the peizoelectric sensors to a great extent.

The future scope of this idea would be to implant a data processing unit which receives input from the drummer, whicch can be recorded as a standard and then can be analyzed to help novice drummers in perfecting the art.

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