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Design Battery Charger Mobile Device Using Sound Energy

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Abstract: In this study, performance of piezoelectric piece which is converted an audio energy into electrical energy, was used to build mobile battery charger. The effective parameters on output power and the efficiency of system depends on the sensitive layer thickness of piezoelectric convertor, acoustic energy intensity and also the distance of the audio source and the device. Signals produced by piezoelectric convertors are weak and they will not be usability hence, AMP amplifier circuits are used to strength the generated signals. The simulation results show that AMP amplifier output has changes because of the audio energy alternation as well as the distance from audio energy source, so using MAX756 chip which is a switching DC-DC convertor of voltage step, we are tried to remove these changes on the output system. The proposed circuit will be very efficient to the rural regions and those where natural disasters have been occurred and there were no access to electric energy.

Key words: Piezoelectric, super capacitor, green energies, switching convertors, DC-DC convertor

INTRODUCTION

Now, mobile is the most basic device in human's everyday life. People in every age, group, gender or professional use them in their daily activities. Most cell phones use small rechargeable batteries that are charged via the national electricity network. Mobile chargers have become a very important element without which mobile devices will be completely unusable.

According to the International Energy Agency in October 2011 showed that 1.6 billion people in the world cannot be used their mobiles due to the lack of energy. Given to advances in science and technology, large parts of the rural areas in third world countries still do not have access to energy. We may have no access to electricity for days in the natural disasters such as floods or earthquakes. So, if we can alternative another source of electrical energy to direct mobile batteries chargers, not only we could solve above problems but also we have a lot savings in consumption of national electricity network.

Scientists and researchers are desperately searching for renewable green energy sources for production. Up to now, fuel was used as the main energy source in Iran. Production electricity is produced through an electromechanical process of combustion and heat generation. Fuel usually was used for minerals energy such as coal, oil, gas as a fuel in the combustion chamber. These resources are limited on the earth and they continually reduced due to the widespread use. So, searching among renewable sources is the only way that will meet the needs of future generations about energy.

Now sunlight and wind are become operational as renewable resources for electricity generation by solar cells and windmills while the investigation is ongoing about them. Above resources are largely depend on the nature so that they are not suitable to different climate areas (Zahedi, 2006; Burton *et al*., 2011). In this study we will be proposed a new source of energy, i.e., the noise or air pressure that they can fully charge our mobile batteries.

Simply sound arises from a movement of particulate material, it can be air, water or any other substance (Littrell, 2010). Acoustic energy detected by a variety of acoustic sensors. Piezoelectric materials are one of the most effective acoustic sensors. Piezoelectric sensors will be generate in response to mechanical charge pressure. Piezoelectric effect is an internal charge production resulted mechanical force applied to the piezoelectric convertor. High capacity of piezoelectric materials to receive any vibration and convert it into electrical energy arises attraction to many scientists and researchers who tried to conversion implement the pressure-vibration circuit to electrical energy (Takeuchi *et al*., 2007).

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One of the important advantages of piezoelectric components may be their generation using micro-electromechanical systems technology as well as the integration possibility of these components with electronic circuits that makes these elements have more applications in the small and portable wireless systems. The approach is proposed in this study is that the mechanical energy of sound or air pressure is applied directly to the piezoelectric crystal with powerful features.

Piezoelectric crystal would generate very little voltage level in response to mechanical energy which this produced voltage will be depend to factors such as the piezoelectric crystal size, sensitive piezoelectric layer thickness and the force that is applied to it.

MATERIALS AND METHODS

The main purpose of this study is making a mobile battery charger with utilization of renewable energy sources. Therefore, we will be introduced different circuits convert acoustics energy into electrical energy and achieved to the most and best effective circuit to convert acoustic energy into electrical energy by examining each of them so that we would be used to charge the battery from the charger to your mobile phone in the disaster areas or areas where we do not have access to electrical energy.

Piezoelectric convertors are sensitive to air pressure or sound, therefore, they will be produced electrical loads through mechanical pressure to crystals. A relation was established between the force and charges in the piezoelectric crystals. This relationship indicates that if F be the force applied to the charge production and Q be the total produced charge and K to be considered as a piezoelectric constant, Q and F have a direct relationship with each other, i.e., given to KF = Q. The reduction in force is proportional to the reduction charge is produced in the crystal. A signal that is produced by the piezoelectric convertor will be small and it is to be noted that the nature of generated signal is AC. So, we have amplified and corrected generated AC signal and converted it to a DC voltage that can charge mobile phone batteries.

The general conversion of the acoustic energy into electrical energy is shown in Fig. 1. We will be able to convert available acoustic energy or air pressure into electrical energy using little piezoelectric convertors in this scheme. Uper-capacitors were used to electrical load temporary storage generated by piezoelectric convertors in the proposed circuits. Super-capacitors is a relatively new technology and is known as a double-layer capacitors (Barbehenn, 2012; Shin *et al*., 2011). Super-capacitors are the highest capacitor per volume unit and the highest energy density compared with other capacitors (Barua *et al*., 2015).

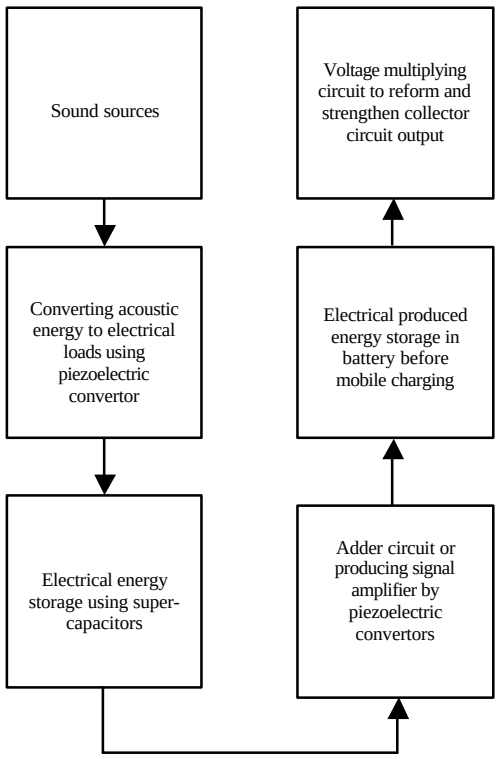

Fig. 1: Block diagram of convert acoustic energy into electrical energy

The main feature that makes selection as a super-capacitor charge storage element was produced by the piezoelectric transducers high-capacity super-capacitors than ordinary capacitors. Given to highlight role of super-capacitors in the electronics industry, very high price of super-capacitors compared to conventional capacitors is the only reason caused to they are less used in Iran, it was used only in the proposed circuits of the piece.

Piezoelectric convertors application in the electronics industry: One of the projects undertaken by the Defense Department, United States of America under the name of "receiving energy from soldiers' boots on the battlefield" the research was conducted that including trying to charge the battery of battlefield equipment such as wireless battery, flashlight battery by piezoelectric power generators embedded in soldiers boots. The organization is trying to absorb the energy of shoes that were constantly moving and the above energy was wasted because of its impractical. Researchers were carried out

the energy recovery in the similar idea of human mobility in train stations and waiting rooms by the piezoelectric power generator embedded on the halls floor (Romero *et al*., 2009; Richard, 2006).

In some researches researchers had planned to place a sensitive crystal to vibrate piezoelectric under mobile keyboards, so using press any key the generated vibration converted to electrical energy and to charge mobile batteries (Dikshit *et al*., 2010). These reports indicate the high potential of piezoelectric material to convert any kind of pressure or vibrations caused by acoustic energy into electrical energy.

Proposed circuits to convert acoustic energy into electrical energy: Various suggestions have been stated to convert acoustic energy into electrical energy using piezoelectric crystals in different parts of the world. So, we were evaluated the proposed circuits to find the most optimal method and at last we present a comprehensive plan for the utilization of acoustic energy.

The first innovative design: In the above design, a buzzer is used to generate the required acoustic energy. Then the acoustic energy applied to the piezoelectric convertor. Super-capacitor 1F and 5.5 V was placed in parallel piezoelectric transducer to quickly store a very weak signal produced by the piezoelectric crystal (Jamal *et al*., 2013).

A schematic of the circuit shown in Fig. 2. An amplifier AMP, LM386 is used to collect the signals generated by the piezoelectric crystal as shown in Fig. 2. An amplifier AMP 2 equalizer circuit voltage of a diode used to amplify the signal at the output to charge the mobile battery voltage in the desired range. The diode D3 is used to avoid the mobile battery discharging when the acoustic source environment do not have the required intensity to setup AMP collector (adder) circuit. So, if there is no acoustic energy or piezoelectric doubling diode circuit will be >5 V. As a result the battery trying to its discharge in reverse order of the circuit.

Thus, D3 diode cuts the above reverse flow whereas only one flow exists to charge the mobile battery and the battery cannot be discharged in the absence of acoustic energy to the desired size.

RESULTS AND DISCUSSION

First innovative design simulation results: In the first innovative circuit simulation that it was utilized Cadence SPB Orcad v16.60 Software, we achieved to a stable voltage 5.3 V at circuit output using only five piezoelectric

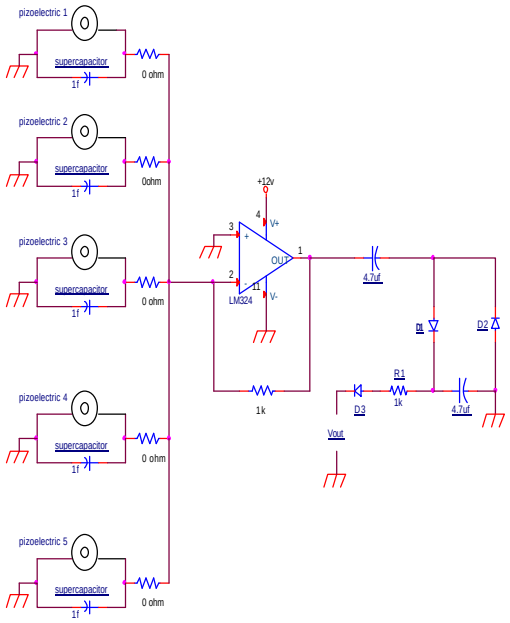

Fig. 2: Schematic of first innovative circuit to convert acoustic energy into electrical energy

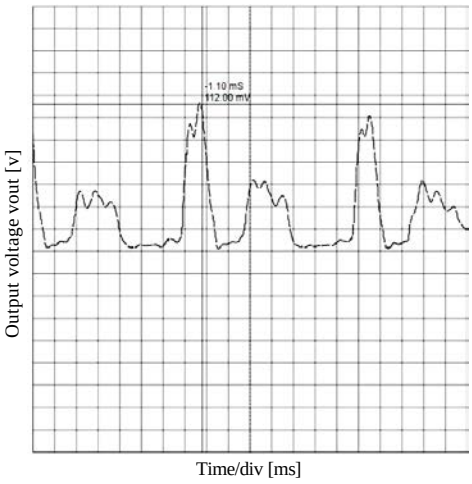

Fig. 3: The input signal amplitude of adder circuit for audio signal with a maximum 280 mV amplitude

crystals. We are able to use more piezoelectric crystals to produce a higher voltage >5.3 V, it should be only noted that the maximum voltage that can be generated by this circuit is a voltage that AMP collector is not entered to the saturated region or in other words a maximum output voltage cannot be exceeds from the feeding AMP voltage in the best conditions. Figure 3 and 4 illustrated the AMP input and output signal range collector in terms of audio signal with a maximum 280 mV amplitude.

In the above circuit simulation results the value of output voltage system is also changes by varying the

intensity of the signal generated by the piezoelectric crystal, so the amplitude of the acoustic energy tested in 4 steps of the above circuit. Table 1 shows the output voltage value in terms of acoustic energy with variable amplitude.

The first innovative design disadvantages: Given the circuit shown in Fig. 2 we could only achieve to a stable 5.3 V using 5 piezoelectric crystal but the number of piezoelectric crystals and super-capacitors that was placed parallel to these crystals in the circuit caused to increase the cost of making suggested design.

Table 1: Output voltage range for acoustic energy with variable amplitude

Variables	First step	Second step	Third step	Fourth step
The signal generated by first crystal	80 mV	80 mV	120 mV	200 mV
The signal generated by second crystal	80 mV	90 mV	140 mV	220 mV
The signal generated by third crystal	80 mV	100 mV	160 mV	240 mV
The signal generated by fourth crystal	80 mV	110 mV	180 mV	260 mV
The signal generated by fifth crystal	80 mV	120 mV	200 mV	280 mV
Output voltage of AMP adder circuit	0.5 V	0.75 V	2 V	2.8 V
The generated voltage on circuit output	1 V	1.8 V	4.2 V	5.3 V

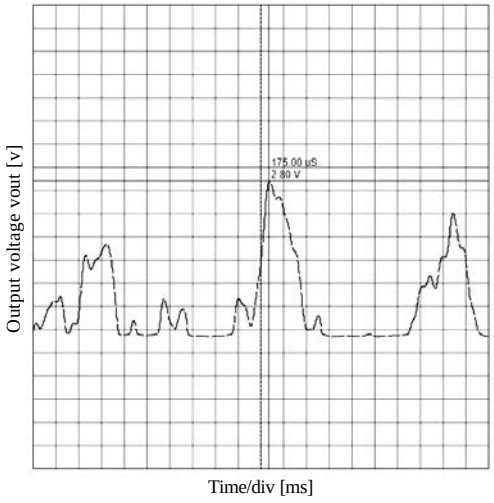

Fig. 4: The output signal of adder circuit for audio signal with 280 mV an amplitude

The circuit doubling diode voltage used in Fig. 2 circuit was used to amplify the voltage amplitude produced by AMP the adder circuit but it caused to increase consumption flow, so the time required to fully battery charge of mobile increased. Therefore, in the second innovative design, diode voltage doubler circuit was removed and we were only used a crystal piezoelectric to build mobile battery charger.

The second innovative design: In this design we achieved to a comprehensive model to convert acoustic energy into electrical energy. Therefore, we largely tried to remove the first innovative circuit problems. In this design, we are used CMOS, MAX756 chip that it's a voltage multiplier DC-DC switching to solve the problem of Fig. 1 loses rising consuming flow because that circuit was a dobler diode voltage. The above chip is capable to convert very little positive voltage about 0.7 V to a constant voltage 5 V. The super-capacitors prices and the high number of piezoelectric crystals is caused to use an amplifier AMP 200 coeffiecent reinforcement. A clear signal by the piezoelectric convertor is very weak, so the above weak signal is strengthen by AMP high-gain amplifier and the C4 filter capacitor stored with capacity of 150 µf. Now it needs only a 0.7 V DC voltage to generate a 5 V constant voltage in the circuit output for the converter start-up chip MAX756.

Simulation results of second innovative design: In the circuit shown in Fig. 5 without the use of super-capacitors and just using a piezoelectric crystal we achieved to a 5 V constant voltage in the output system. Figure 6 and 7 show the inputs and outputs simulation results of the AMP amplifier circuit for audio signals with 20 mV amplitude. Figure 7 shows output signal amplitude of 3.5 mV piezoelectric convertor after 580 µs that this voltage is strongly depends to acoustic resource.

MAX756 voltage required for the construction of a. bridge diode chip output amplifier circuit of operations as

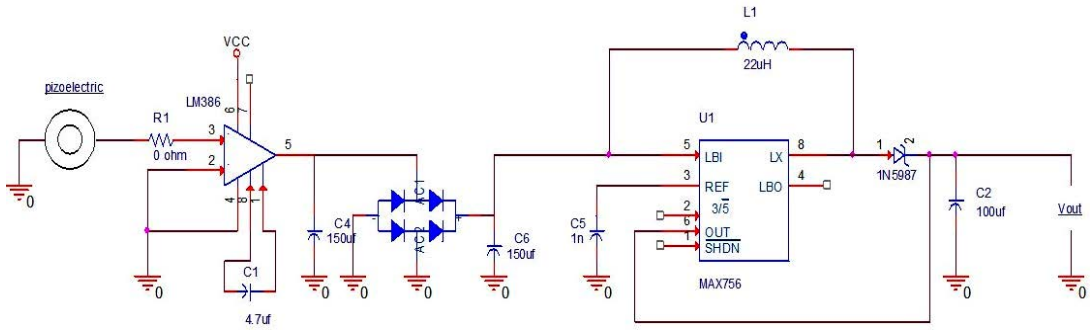

Fig. 5: The second innovative schematic circuit to convert acoustic energy into electrical energy

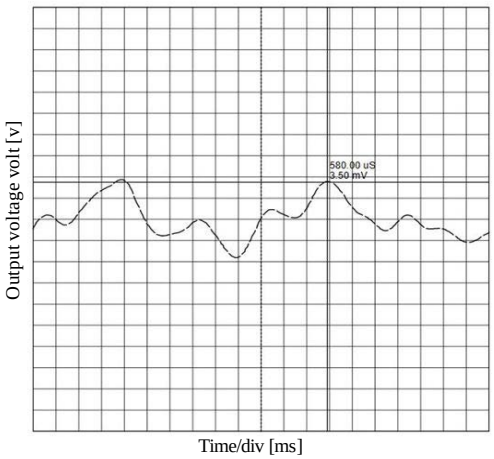

Fig. 6: The input signal amplitude of AMP amplifier circuit for acoustic signal with a 20 mV maximum range amplitude

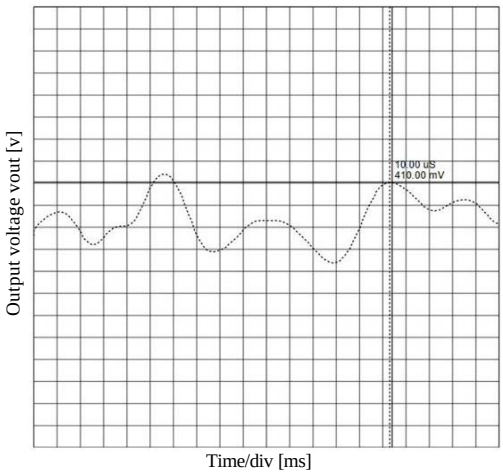

Fig. 7: The output signal amplitude of AMP amplifier circuit for acoustic signal with a 20 mV maximum range amplitude

shown in Fig. 5 which it is convert the variable voltage output of the AMP amplifier to a direct DC voltage.

The output signal amplitude of AMP voltage amplifier circuit after 10 μs is reached to 410 mV as has been shown in Fig. 7. Simulation results show that, if a signal with the intensity reaches to the AMP input amplifier that this amplifier generated a voltage about 0.7 V, we can be converted this alternate signal to DC voltage using bridge diode. Now we can apply the above voltage to the MAX756 switching chip input. These chips will be able to addition to eliminating voltage fluctuations DC, stabilized voltage 5 V to build mobile battery charger simultaneously.

CONCLUSION

In this study, a mobile battery charger designed and discussed using acoustic energy or air pressure. In the first innovative design we achieved to a 5 V stable voltage using 5 piezoelectric convertors but in the simulation results specified that system consuming flow faced to a considerable increase because the use of diode voltage doubler circuit. Therefore, we introduced the second innovative circuit that it is a comprehensive design to convert acoustic energy into electrical energy to increase system efficiency and reduce manufacturing costs due to the use of super-capacitors circuit.

In the second innovative design CMOS, MAX756 chip that it is a voltage multiplier DC-DC switching converter that we alternated to diode doubler voltage for solving the above problems and reduce battery charging time.

The optimization results applied on the second compressive design showed that we can be provided a 5 V required voltage to make mobile battery charger with minimum consuming flow only using a piezoelectric convertor. The proposed circuit is introduced a new source of green energy to the world search for electrical energy consumption saving.

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