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Piezoelectricity Generation for Charging Mobile Phones and Compared with Conventional Charging Methods

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Abstract

Due to our busy lifestyles, our health is quite precarious these days. We designed a device using piezoelectric materials. Electric charges are generated on the surfaces of certain materials as a result of applying mechanical tension. The induced charges are proportional to the mechanical force. This phenomenon is known as the piezoelectric effect. The materials that leverage the piezoelectric functionality effect include ceramics, polymers, composites, thin films, relaxer-type ferroelectric materials, and crystalline structures, which have been successfully applied over the past decades. A wide range of applications has been identified in smart devices such as mobile phones, sensors, actuators, transducers, and harvesters. These materials convert mechanical strain and vibration energy into electrical energy. This property creates opportunities for implementing renewable and sustainable energy through power generation for many applications. Our research aims to achieve sustainability in energy sources for small devices by employing new and renewable energies, particularly piezoelectric energy, and establishing a system that generates electrical energy from applied mechanical force or any physical force, which can be converted into electrical energy. This energy can then be stored and used for various electrical purposes, such as charging devices like mobile phones, allowing us to compare the percentage of charging achieved through piezoelectric energy with that from traditional electricity also imagines that the phone is getting charged while you go. The resulting electric power was used to charge three mobile phones, which were fully charged in 100, 185, and 165 minutes for Nokia, Huawei, and Samsung, respectively. The charging of a mobile phone depends on the type of battery, and the amount of power generated will vary depending on the force. There is no difference in the charging time, which confirms that piezoelectricity is a clean, healthy energy source for charging mobile phones. This suggests that piezoelectricity is another renewable energy source for charging mobile phones.

Keywords

Energy Harvesting, Piezoelectric Materials, Mobile Phone Charging

1. Introduction

Nowadays, an increase in energy consumption of portable electronic devices, the concept of harvesting renewable energy in our surroundings, and pollution losses have sparked renewed interest in cutting-edge power generation methods [1]. Where it is used, ninety-seven percent of people use smartphones and often struggle with short battery life. Consequently, every smartphone user wishes for more battery life. We are introducing a piezoelectric wireless power transfer mobile charger that generates electricity by walking and running over a mat of piezo materials to charge mobile phones, envisioning a future where your phone charges while you walk [2]. Walking is the most common human resulting in energy being lost to the ground—a waste of potential energy. We need a solution to harness that energy, and piezoelectric crystals convert mechanical energy into electrical energy [3]. This phenomenon is known as piezoelectricity, which refers to the electrical energy generated from mechanical pressure. The maximum pressure occurs at the toe and heel. When pressure is applied to the shoe, a negative charge is produced on the expanded side and a positive charge on the compressed side of the piezoelectric generator. As the pressure is released, an electric current flows across it [2]. The piezoelectricity comes from the Greek word "piezein," meaning pressure, reflecting the pressure applied to crystals to generate an electric current. Electricity is defined as the movement of electrons. Piezoelectricity is utilized in many everyday electronic devices, from quartz watches to loudspeakers and microphones. It describes the process of using crystals to convert mechanical energy into electrical energy or vice versa [4]. The human body provides two distinct types of mechanical energy: one associated with ongoing processes like heart rate and breathing, and the other related to passing motions [5]. This activity offers a substantial power source for devices operating bikes, or other portable devices, bikes, or other portable devices Electrical energy can also be generated from traffic vibrations (vibrations in the road surface) using piezoelectric material. Shown in (**Figure 1**) [6]. The electrical energy thus produced can be used to power devices aboard the bike, or other portable devices that the cyclist uses. Electrical energy can also be generated from traffic vibrations (vibrations in the road surface) using piezoelectric material [7].

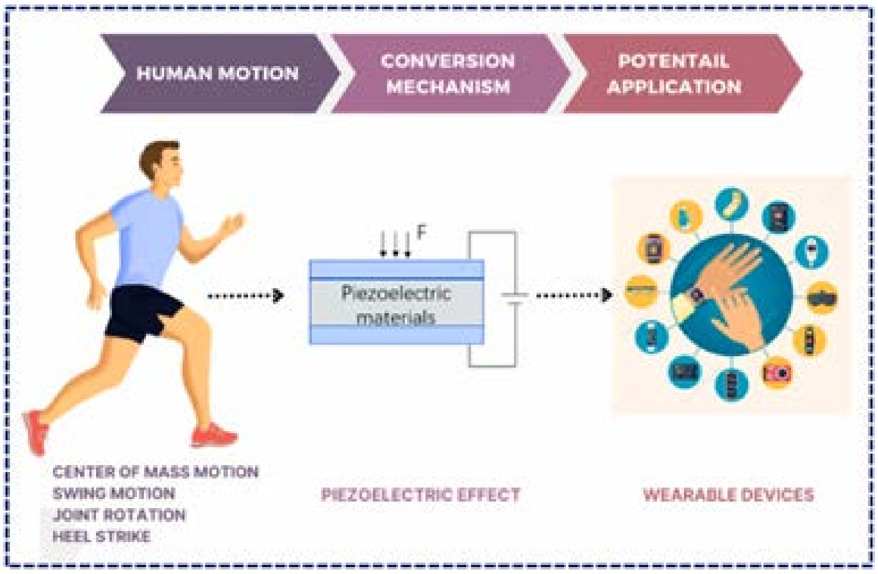

Figure 1. Schematic diagram of recent advances in piezoelectric energy harvesting from wearable devices that harness human motion.

2. Materials and Methods

2.1. Materials

The basic structure of the project consists of various materials such as:

1) Piezoelectric sensor

A piezoelectric sensor is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. When mechanical energy is applied to a piezoelectric material, an electric charge is generated across the faces of the crystal. The piezoelectric crystal will be placed between metal plates where mechanical pressure is applied onto the material with the help of the metal plates which will force the electric charge within the crystal to go imbalance This can be measured as a voltage proportional to the pressure A piezoelectric sensor converts physical parameter—for example, acceleration, strain or pressure into an electrical charge which can then be measured. They are highly sensitive and very small in size making them well suited to everyday object force the electric charge within the crystal to go imbalance [8].

2) Battery

The battery is a device that stores chemical energy and converts it into electrical energy.

It is a rechargeable battery that uses lithium-ion Phosphate as a cathode material. Li-ion batteries have a somewhat high energy density, and light weight offering a longer lifetime. Some types of primary batteries used, for example for telegraph circuits, were restored to operation by replacing the components of the battery consumed by the chemical reaction. Secondary batteries are not indefinitely rechargeable due to the dissipation of the active materials, loss of electrolytes, and internal corrosion [8].

3) Arduino Uno

The Arduino Nano is a small, complete, and breadboard-compatible. Consists of many pins with various functions. Thus, the components are connected to the Arduino board based on their compatibility. Firstly, the positive terminal (red) of the piezoelectric sensor is the input of the sensor was connected to analog pin 10 of the Arduino Mega 2560 while the negative terminal (black) was grounded through a 1.0 MΩ resistor [9].

4) (20x4) LCD

A liquid-crystal display (LCD) is a flat-panel display or another optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead, used backlight or reflector produces images in color or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays, as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements [8].

2.2. Diodes

1) I2C driver.

2) Electrical box size 25 cm × 25 cm.

3) DC to DC step down: The device has at least 2 semiconductors and one energy storage element. It is a class of switched-mode power supply.

4) Step Down (DC to AC Step Down).

5) USB cable.

6) Mobile phones (Samsung, Nokia, and Huawei).

3. Methods

Power harvesting, energy harvesting, power scavenging, and energy scavenging are four terms commonly used to describe a process of extracting useful electrical energy from other ambient energy sources using special materials called transducers that can convert one form of energy into another. While the words power and energy have vastly different definitions, the terms "power harvesting" and "energy harvesting" are used interchangeably throughout much of the literature to describe the same process of extracting electrical energy from ambient sources. Even though most of the energy coupling materials currently available have been around for decades, their use for power harvesting has not been thoroughly examined until recently, when the power requirements of many electronic devices have reduced drastically. Energy harvesting can be obtained from different energy sources, such as mechanical force when it's applied to the piezoelectric material, AC is generated. This voltage is proportional to the amount of pressure applied [10]. D.C voltage was needed to store in the battery [11]. The output is AC voltage. The bridge rectifier with diodes was used to convert the AC signal to DC as shown in **Figure 2** [12]. The rectifier can use either a half-wave or full-wave rectifier. Our concern is with the full-wave rectifier because it provides the full value of the DC voltage stored in the battery but, for most of the loads that require AC voltage. This AC voltage is used in different appliances, for charging laptop batteries, mobile phone batteries, and handsets. This is done using a step-down converter (DC to AC Step Down) [11]. The parameters of voltage, current, power, and temperature will be displayed on the LCD by using Arduino Uno as a microcontroller [13]. USB ports and a DC-to-DC booster are used to boost the voltage [12]. The USB charging converter translates 12V DC to 5V DC. It consists of IC-AD84064, a capacitor, a diode, and an LED. These components convert voltage to charge devices like Mobile, Pod, Tab, MP3 devices, charger lights, etc. [8].

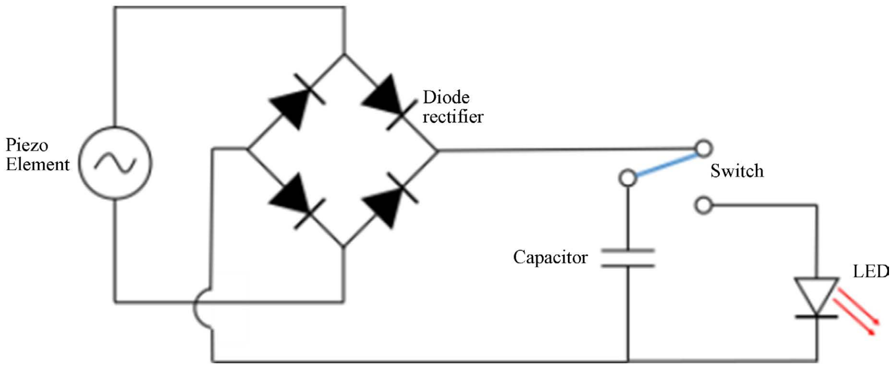

Figure 2. Bridge rectifier circuit.

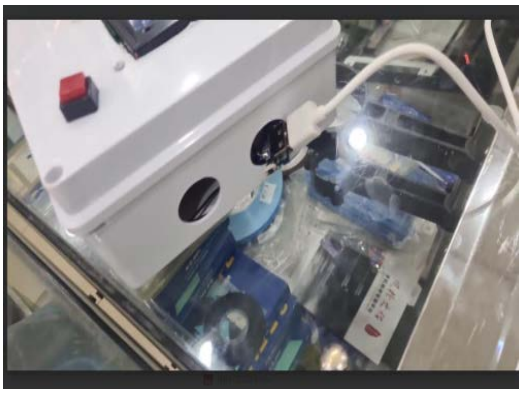

Figure 3. The power storage battery that the mobile is charging.

Figure 4. The image of: mobile charging.

Results and Discussion

The proposed project is evaluated, and the experimental results are discussed in this section. The result approved that Piezoelectricity is an exciting, promising technique that generates green energy during harvesting energy at act force on piezoelectric materials, converting mechanical strain to an electrical charge or voltage via the direct piezoelectric effect. Piezoelectric vibration-based energy harvesting systems have been employed as actuators and portable devices as an attractive alternative power source. **Figure 3** shows how the force is converted into electric power and stored in a battery while the mobile device is charged. **Figure 4** explains how mobile phones are connected to a USB cable and charging smart devices. The data in **Tables 1-3** indicate that the mobile phone is completely charged using energy produced from piezoelectricity and traditional electricity at 100, 185, and 165 minutes for Nokia, Hawaii, and Samsung, respectively. The graphical relationship between charge percentage and time is illustrated in **Figures 5-7** for the mobile phones Nokia, Huawei, and Samsung, respectively. Reading demonstrated that there is no difference in charging time when using the same charger method. This explains that piezoelectricity can be exploited to generate electrical energy through applied mechanical energy. It is very efficient and fast for charging mobile phones. It can also be used as a charging port and lighting for pavement-side buildings. Only 11% of renewable energy contributes to our primary energy. If this project is deployed, we can overcome the energy crisis problem and contribute to creating a healthy global environmental change. Also, studies are being carried out to utilize the vibrations in a vehicle, like clutches, gears, seats, shock absorbers, and footrests.

Table 1. The relationship between the charging time and the percentage of charge in Nokia phone.

Time (min)	Charging %	
	Piezoelectricity	General Electricity
10	5	4
20	10	10
30	15	14
40	20	20
50	25	24
60	30	30
70	35	36
80	40	40
90	45	44
10	50	50

Table 2. The relationship between the charging time and the percentage of charge in Huawei phone.

Time (min)	Charging %	
	Piezoelectricity	General Electricity
10	3	2
20	8	7
30	14	13
40	19	18
50	24	23
60	30	29
70	35	34
80	41	40
90	46	45
100	52	51
110	57	56
120	63	62
130	68	67
140	74	73
150	79	78
160	85	84
170	90	89
180	96	95
185	100	100

Table 3. The relationship between the charging time and the percentage of charge in Samsung phone.

Time (min)	Charging %	
	Piezoelectricity	General Electricity
10	7	6
20	13	12
30	19	18
40	25	24
50	31	30
60	37	36
70	43	42
80	49	48
90	55	54
100	61	60

Continued

110	67	66
120	73	72
130	79	78
140	85	84
150	91	90
160	97	96
165	100	100

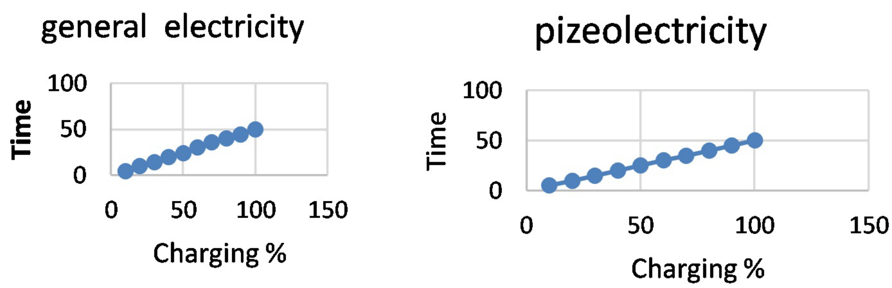

Figure 5. Time (min) vs charging % Characteristics by piezoelectricity and conventional methods (Nokia).

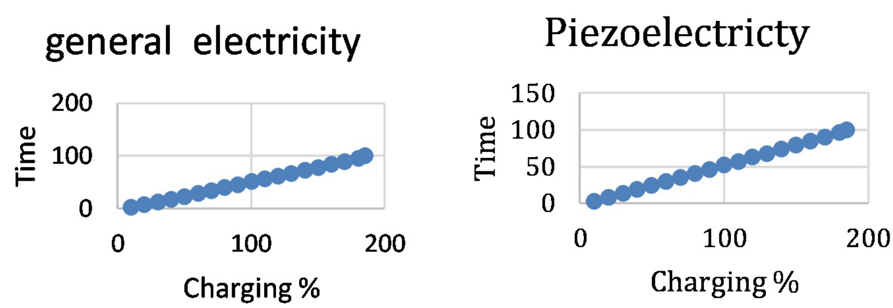

Figure 6. Time (min) vs charging % Characteristics by piezoelectricity and conventional method (Huawei).

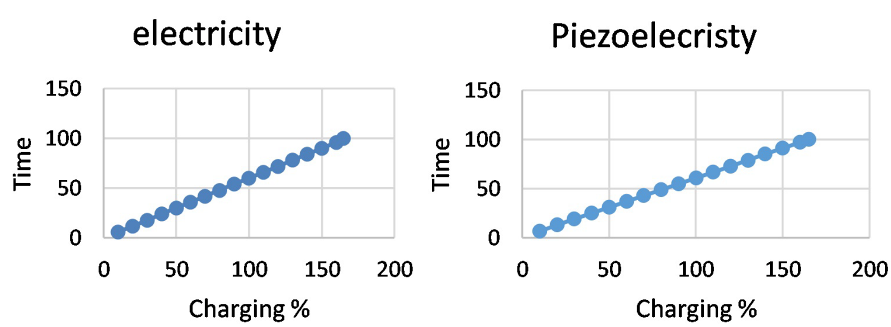

Figure 7. Time (min) vs charging % Characteristics by piezoelectricity and conventional method (Samsung).

4. Conclusion

The paper illustrated the design system that can harness the power generated by human movement, by using the non-conventional method on a single piezo crystal, and power transferred to a device wirelessly. Discuss a piezo-material-based gadget that uses trotter moment to produce a sufficient voltage capable of charging our mobile phone batteries Harvesting mechanical energy from human motion is an attractive method for obtaining sustainable electric energy. There are several methods available for harvesting human energy. From all of these methods, Piezoelectricity is another electrical source of renewable energy capable of generating enough energy to be utilized for commercialization in public places such as shopping malls, R&R areas, and railway stations, which can place solar panels and has a lot of people walking by. So that people can easily charge their mobile devices and some electrical devices. Also, it is an economically perfect human walking, wind, rain, tidal energy, waves, and any natural forces that can cause mechanical movement can be harnessed as a catalyst for piezoelectric and its transformation into useful energy. Piezoelectric cells can be used as a sustainable primary energy source for small devices. When there is a higher demand for this clean energy and more companies are needed, it will create additional jobs for experienced workers, keeping the economy growing.

5. Recommendations

Through theoretical studies and applied during practical experience, we recommend opening up research areas in the field of renewable energy and promoting public awareness of the use of renewable energy, especially piezoelectricity because power generation is simply walking on the step, with no need for fuel input, there is a non-conventional system, no moving parts long service life, compact yet highly sensitivity, self-generating no external power required easy to apply on shoes (small electric circuits inside shoes where the piezoelectric crystal is being placed, rectifier where rectification takes place and an inverter converts dc into ac. Transmits the energy produced by the piezoelectric to the receiver. The receiver charging unit consists of a rectifier that converts AC into DC, a boost converter that increases the rectified voltage, and a charging circuit where the mobile is charged outside homes, especially in non-developed countries like Sudan, where electricity is unavailable throughout the country. Additionally, many people in the villages lack the financial means to purchase solar cells.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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