Ministry of Higher Education And Scientific Research.

University Of Diyala.

College Of Engineering.

Electronic Department

# Using Piezoelectric Transducer as Renewable Electric Energy

A project Submitted to the Department of Electronic Engineering University Of Diyala in Partial Fulfillment of the requirements for the Degree of Bachelor in Electronic Engineering.

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**1.1 OV ERVIEW**

Mechanical energy is one of the most ubiquitous energies that can be reused in our surroundings. The sources of mechanical energy can be a vibrating structure, a moving object, and vibration induced by flowing air or water. The energies related to induced vibrations or movement by flow of air and water at large-scale are wind energy and hydroelectric energy,respictevly.

Mechanical waste energies usually can be harvested by using vibration-to electricity conversion . The most distinguished characteristic of this kind of waste energy harvesting is initially identified for low power generations. Therefore one of the targeted applications is to power small recent development indicates that it can also ،electronic devices. However be used for large-scale applications .Vibration-to-electricity conversion can be realized through three basic mechanisms, including and piezoelectric transduction electromagnetic ,

Among the three mechanisms, piezoelectric transduction has received the greatest attention. This is because piezoelectric materials have large power densities and higher feasibility for practical applications than the materials used in the other two mechanism For example, voltage outputs in electromagnetic energy harvesting are typically very low and thus must be amplified to a level sufficiently high to charge storage devices. In contrast, however, piezoelectric energy harvesters output voltages that can be used directly.

harvested energy from the ambient environment been used to power the standalone micro systems devices which are installed in remote locations The piezo transducer converts the noises mechanical vibrations energy in to the electrical energy and the converted energy are capacitor of EH module The purpose of energy harvesting system is to power the standalone and handheld devices and recharge and replenish the without external interventipon consumed energy

## 1.2 PROBLM STATEMENT

i.In trips that take a long time to lose the human energy sourse

ii. May be you surprise that your children used your without you know

iii.May be you need to walk at night

## 1.3 OBJECTIVES OF THE

**i.** To find a suitable light weight source allows to generate electric energy through motion such as piezoelectric transducer.

**ii.** To find suitable and light, battery charging in order to storage this electric charge generated from piezoelectric transducer.

**iii**. To find a suitable battery charger to discharge this charging battery through connect with **USB** port.

## 1.4 SCOPE OF THE PROJECT

For the purpose of obtaining a renewable electric power source through a rambling use a piezoelectric transducer polymer because it is not exposed to break the terms of use this piece to convert kinetic energy generated by walking and directed on the piezoelectric transducer to energy electric, and then stored in a suitable battery to be able to consignment generated storage a piece of the piezoelectric transducer and then discharged later by a car mobile charger.

## 2.1 DESCRIPTION OF PIEZOELECTRIC TRANSDUCERS

The methodology in this section is represented in first section of Figure 2.1. This Figure is divided into three levels, and this section individually examines and compares each level. In this study, PCT-thickness vibration mode is selected as the emitter (sender) and receiver, and the parameters of this PCT are defined in detail.

### 2.1.1 Types of PTs

The three important kinds of PTs as shown in Figure 3.1 are the polymer piezoelectric transducer, composite piezoelectric transducer and PCT. They are described as follows. .

a. Piezoelectric polymer transducer:

Despite the fact that the piezoelectric polymers were discovered in 1924, interest in these polymers developed only in the 1960s [1]. Fukada has determined that many kinds of polymers, such as rolled polypeptide films, induce surface charges when stressed. Kawai [2] has reported o polyvinylidene fluoride (PVDF or PVF2), which is among the strongest piezoelectric polymers. The polymer material PVDF is very flexible

different applications, such as vibration sensors,

impact detectors [3], robots [4], and flow meters [5]. Figure 2.2 shows a type of piezoelectric polymer transducer

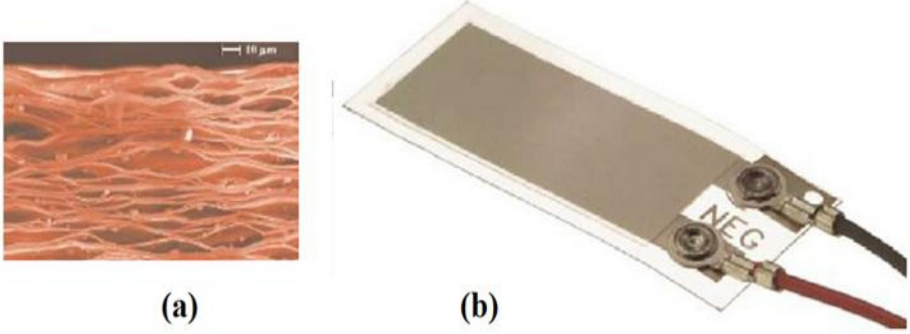


Figure 2.2 Piezoelectric polymers transducer (a) Electroactive polymer foams for ultrasonic transducers (b) Piezo-sensor LDT1-028K

Despite the flexibility and sensibility of the piezoelectric polymer transducer, the use of this type of PT in this work is limited because of the low values of acoustic impedance and electromechanical coupling factor at 3.91 b. Composite piezoelectric transducer

In the 1980s, studies began focusing on the enhancement of the properties of piezoelectric polymer transducers for use in NDTs [7]. Researchers have suggested embedding ceramic elements into polymers, as shown in Figure 2.3. As a result, many of the properties of composite PTs are mixtures of polymer and ceramic elements. Current composite PTs are very important in NDT [8] and in medical diagnosis [9]. The other features of these transducers are compared with those of other types of PTs × 106 kg/m2.s and 0.14, respectiv

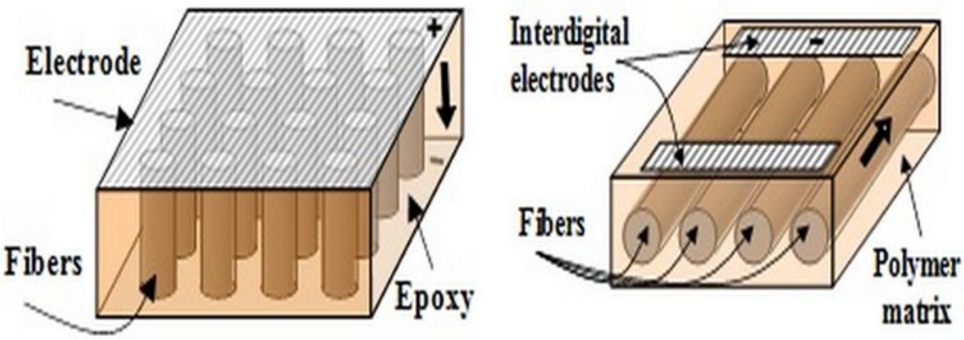


*Figure 2.3 Schematic representation composite piezoelectric transduce*

Source: ENS-Piezodevices-Ltd 2014

c. Piezoelectric ceramic transducer (PCT):

PCTs remain the most pervasive and the most important among PT types in most engineering applications. SM211 PCTs containing two silver electrodes are selected for this study as shown in Figure 2.4 because of their electrical and mechanical properties

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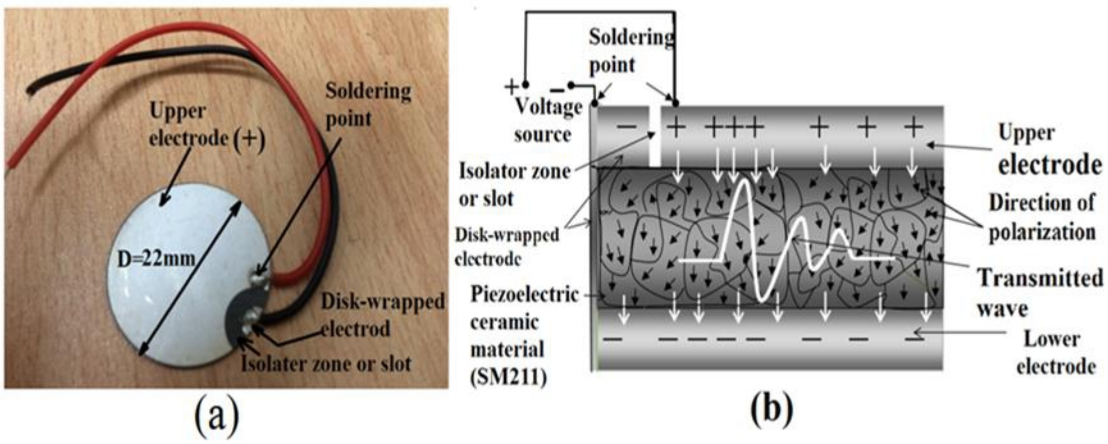


*.Figure 2.4 PCT (a) PCT SM211 (b) detailed sketch for PCT*

Table 2.1 shows the comparison of the SM211 PCT and the two other kinds of PTs (PVDF and composite PT).

As observed in Table 2.1, the properties of the SM211 PCT are significantly better than those of other types of transducers. However, the main problems of SM211 are its fragility and breakability. These limitations are present in all kinds of ceramic transducers, including barium titanate and lead zirconium titanate. This study proposes a procedure to address the damage to the SM211 carrier

Table 2.1 Comparison of PVDF, PCT SM211, and composite piezoelectric (2-1).

| Parameter | | PVDF | PCT SM211 | Composite Piezoelectric (2-1) |
|---|---|---|---|---|
| Electromechanical coupling coefficient | $K_t$ | 0.14 | 0.35 | 0.5-0.7 |
| Piezoelectric constant | $d_{33}$ *(m/v)* | -33 | 650 | 20-120 |
| Relative dielectric constant | $\epsilon_{33}{}^{T}/\epsilon_o$ (farad/m) | 8.4 | 5400 | 200-600 |
| Acoustic impedance | $Z$(Kg/m$^2$.s)10$^6$ | 3.916 | 29.952 | 8-12 |
| Contact with bodies | | good | excellent | excellent |
| Flexibility | | excellent | poor (breakable) | good |

Source: Day 1996; Lach et al. 1996; Ryu et al. 2001; Steminc 2014

### 2.1.2 Vibration Mode Shapes of PCT

The vibration modes of PCTs are categorized into five types [10] as shown in Figure 3.1, namely, the radial, length, longitudinal, thickness, and shear modes. The radial frequency mode is often used to detect cracks and faults in surfaces. Shear mode typically generates shear waves (*S* waves). In this study, $C_L$ waves are produced to explore the deeps. The longitudinal mode is generally designed to square and cylindrical columns; therefore it is not suitable for this work. The length mode is limited in the market and must be special-ordered at additional cost. Thus, the thickness frequency mode is most appropriate for this work given its excellent features, ease of connectivity with other bodies, availability in markets, and low cost in comparison with the other frequency modes.

### 2.1.3 Important Thickness Mode-PCT Parameters

Chapter IV presents a new repair procedure for damaged PCTs that utilizes silver epoxy. The performance of the established PCT before and after adding the silver epoxy is analysed by a new mathematical model. This mathematical model is composed of the group of parameters depicted in the first section of Figure 2.1. These parameters are defined below as the bases to understand this mathematical model.

1. Frequency constant $N_t$ (Hz.m) is calculated using equation 3.3, which is generated based on the certain shape of the piezoelectric ceramic by which a relationship between vibration wavelength ($\lambda$) and propagation by Equation 3.1 [10]. The sound velocity is constant in piezoelectric ceramics; thus, Equation 3.2 is obtained as well.

$$\frac{\lambda}{2} = t \qquad (2.1)$$

$$C_L = f_r \times \lambda \qquad (2.2)$$

$$f_r \times t = \frac{C_L}{2} = N_t \ (Hz.m) \qquad (2.3)$$

2. Relative dielectric constant ($\epsilon_{33}{}^{T}$ / $\epsilon_o$ = 5400 for SM211) is determined when the electric displacement of a unit electric field applied on unstressed ceramic material, which is called the dielectric constant ($\epsilon_{33}{}^{T}$)

, is divided by the dielectric constant in a vacuum ($\epsilon_o$), [11]

Where $\epsilon_o = 8.89 \times 10^{-12}$ F/m.

3. Piezoelectric constant ($d_{33}$) is also known as the piezoelectric distortion constant and denotes the distortion generated by the application of an unstressed electric field of uniform strength. Equation 3.4 represents the relationships among $d_{33}$, $\epsilon_{33}{}^{T}$, the Young's modulus of the ceramic material ($Y_{33}{}^{E}$), and the electromechanical coupling coefficient ($k_{33}$) [12]:

$$d_{33} = k_{33}\sqrt{\frac{\epsilon_{33}^{T}}{Y_{33}^{E}}} \quad \text{.......} (2.4)$$

where $h_{33} = 1/d_{33}$ (electric field/strain under constant charge v/m).

4. ($Z_1$) and ($Z_2$) impedances represent the ceramic as the lossless mechanical transmission line of length $t$.

5. Static capacitance ($C_o$) is the maximum amount of electric charges that can be obtained from the ceramic material when mechanical load is applied. It can be calculated by using equation 2.5 [13].

$$C_o = A * \in_{33}^{T} / t \quad \text{(Farad)} \ldots\ldots (2.5)$$

where $A$ is the effective area of PCT ($m^2$).

6. The acoustic impedance ($Z_o$) of the plate composed of SM211 can be determined using Equation 2.6.

$$Z_o = \rho A C_L \text{ (ohm) } \Omega \ldots\ldots (2.6)$$

where $\rho$ is the density of SM211 ($kg/m^3$).

7. Transformer voltage ratio ($\phi$) is the ratio between the load applied to the PCT and the voltage obtained from the PCT. It can be calculated by Equation 2.7 [13].

$$\phi = C_o h_{33} \text{ (N/v)} \ldots\ldots (2.7)$$

8. Time delay ($T$) is the time required for an acoustic wave to travel from one electrode to another (second, s) and can be computed using

Equation 2.8.

$$T = t/C_L \text{ (s)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.8)$$

## 3.1 PIEZO POLYMER TRANSDUCER

Despite the fact that the piezoelectric polymers were discovered in 1924, interest in these polymers developed only in the 1960s [1]. Fukada has determined that many kinds of polymers, such as rolled polypeptide films, induce surface charges when stressed. Kawai [2] has reported on polyvinylidene fluoride (PVDF or PVF2), which is among the strongest piezoelectric polymers. The polymer material PVDF is very flexibel different applications, such as vibration sensors.as shown in fig. (3.1)

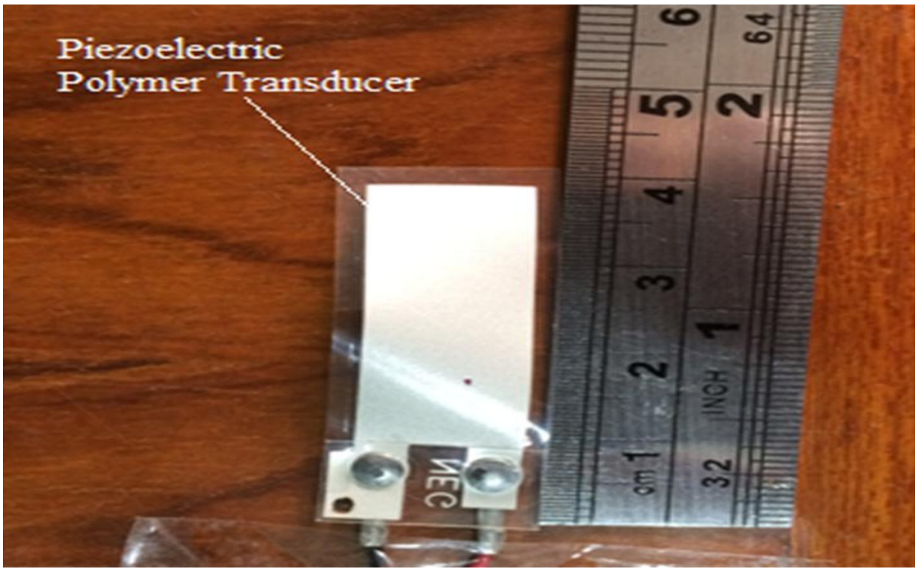


Fig.(3.1) piezoelectric polymer image

### 3.2 Regulator

Regulator designed to automatically maintain constant voltage level.voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may Electronic voltage .be used to regulate one or more AC or DC voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line. As shown in fig. (3.2).

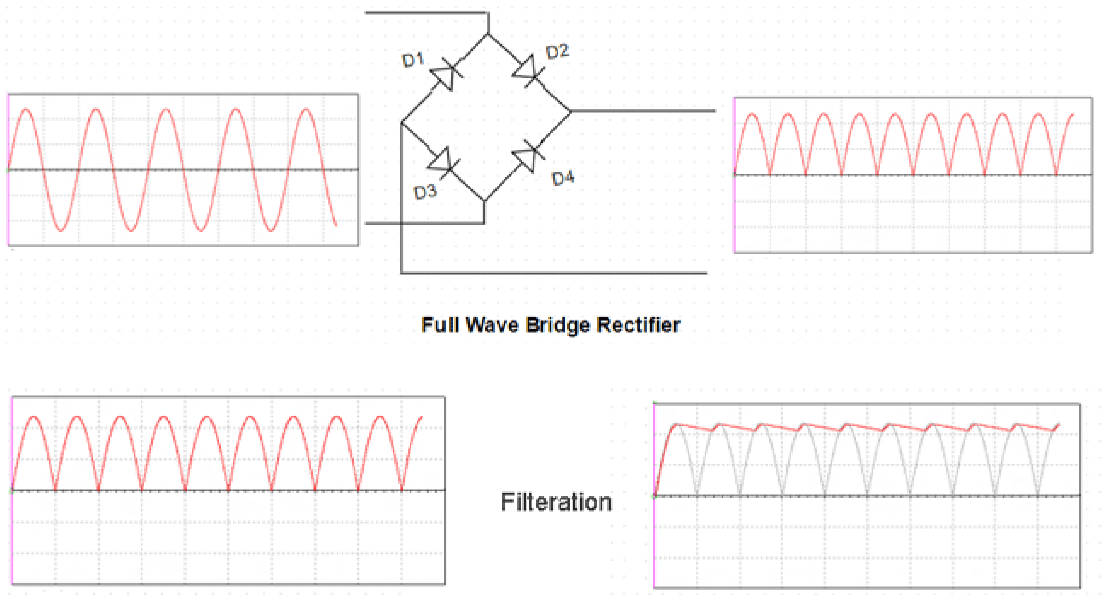

Fig.(3.2)

### 3.3 Battery

For voltage resulting from piezoelectric transducer storage use three batteries each one with a capacity of stored3.8volts in series for the purpose of raising the voltage from 3.8 volts to 11.4 volts and then we use regulator voltage for the purpose of reducing the voltage of the 11.4 volt to be suitable with car charging mobile where noticed we cannot discharge the battery is fully charged in another battery in the same capacity but it empty because the transport process requires turning part of the energy to the electric current for the purpose of overcoming this problem we connect three in series


*Fig. (3.3) theree battery connecter series)*

### 3.4 Car mobile charger

This is a Home Made Usb charger with this device you can charge in your car any Usb charged device like mobile phones, Bluetooth headsets, Gps , cameras, mp3 players, etc..

This device I made haves 0.5Amp output that is the normal power output on a computer, if you use a bigger transistor you can  get more output amps. As shown in fig.(3.4).

*Fig.(3.4) car charger*

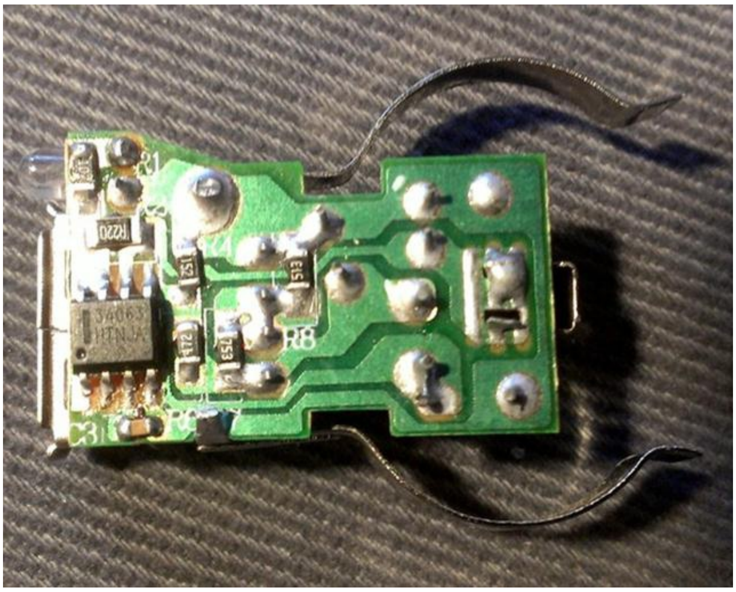

*Fig.(3.5) internal form to car charger*

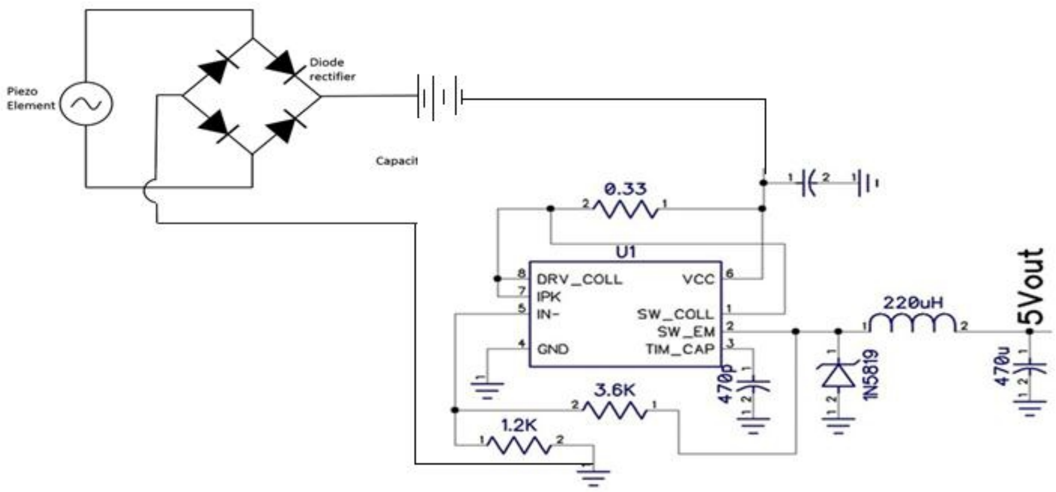


*Fig (3.6) block daigram of whole system*

In order to create charging circuit we have capacity 1000 micro farad connect with full bridge rectifer also connected piezoelectric transducer typs of polymer to convert mecanical energy to voltage

### 3.5 capacitor:

A device that stores energy, similar to a battery, but can be recharged and discharged much. This type of power is needed for the capacitor and LEdiode: An electrical component that only permits current to flow in one direction

### ٣.٦ LED:

Acronym for light emitting diode. An LED does the same thing as a multimeter: A .diode, but lights up when the current is sufficiently high device for making a variety of electrical measurements. In this activity it piezo element: The piezoelectric material .is used to measure DC voltage that converts mechanical energy into electrical energy

*How much energy are we converting*? We measure the voltage across the capacitor in our piezoelectric generators for two reasons. The first is simply to make sure it is working. The second, more important reason, is because we can use this voltage to calculate the amount of energy stored in our capacitors using the equation:

$$E = \frac{1}{2}CV^2$$

Where E is the energy stored in the capacitor, C is the capacitance and V is the voltage measured across the capacitor. When using this equation, make sure the units are correct. We want the capacitance to be in farads; if it is given in µF, simply divide by 1,000,000 to convert. We want the voltage to be in volts (V). Then, the units of energy will be joules (J) or equivalently, in watt-seconds (W-s).

### 3.7 OVERALL WORKING

**i. Using piezoelectric transducer is the main idea of this project**

**ii. Location of piezoelectric Transducer as in fig(3.7)**

**polymer shown**

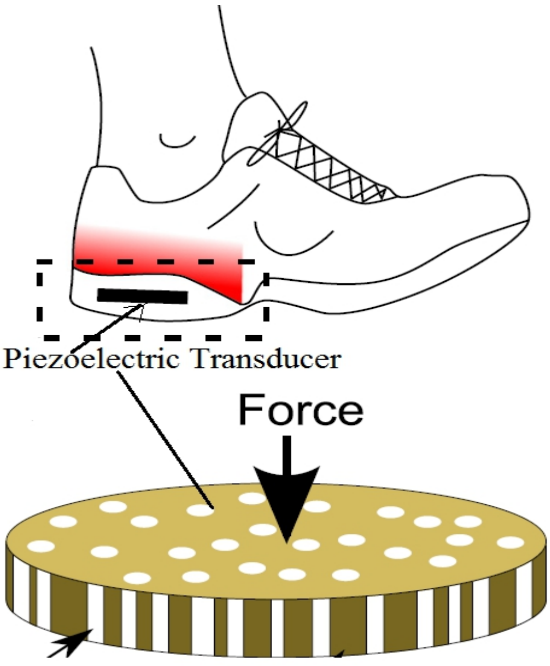

*Fig (3.7): piezoelectric transducer location*

**iii. System of charging from Piezoelectric transducer to the Battery then to USB port**

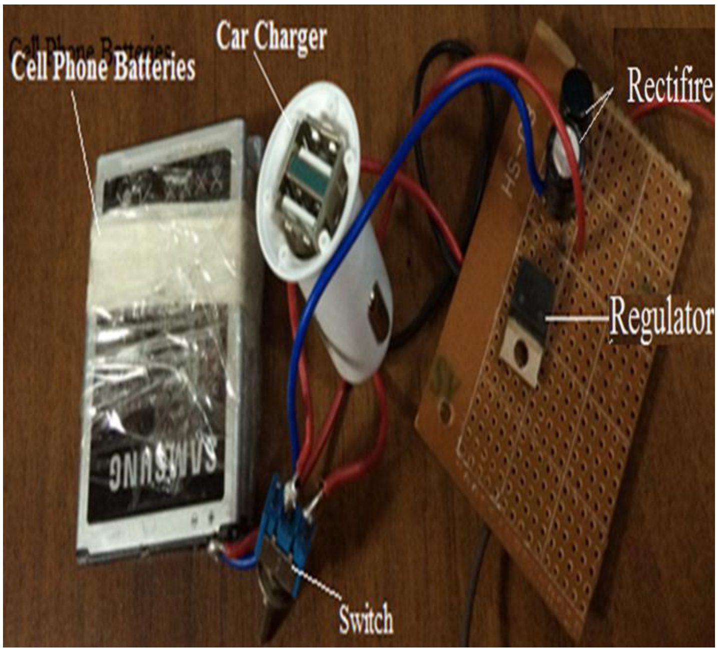


*Fig.(3.8)System of charging From Piezoelectric transducer to the Battery then to USB port*

iv. connect the circuit of charging on the shoes as shown in figure (3.9).


fig (3.9): final show of the piezoelectric shoe

## 4.1 Conclusion

The piezoelectric transducer can convert mechanical enegy to electrical energy the amount of energy that produced by piezoelectric is 2.80 volt peak to peak for each pulse, use piezoelectric polymer transducer better than other types 0f piezoelectric transducer,to discharge the energy from one battery to another battery required a long time or do not happen so connect three battery in series and after that discharge in other battery. the amount of energy produced by piezoelectric transducer increase as the pressure on piezoelectric transducer increase also the continously press on piezoelectric do not produce energy

## 4.2 Future Work:

**i.** Entrance of UniversityEntrance of University**.**

ii. External Check  Point.

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