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An Overview on Basic Model of Piezo-Electric Mobile Charging Shoe

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ABSTRACT

In our modern world of technologies our lifestyles have become very busy and restless, which also gives a simultaneous increase in usage of our portable electronic devices in our daily life. Just like our mobiles and laptops. But these devices consume a lot of energy and get drained up pretty easily because it has many apps and software which uses very much power [1] whilst using them, and in some situations, it puts us in a very hard situations where we might require a little bit of extra time to communicate and express your device situation. Therefore, it requires a source of power supply in that particular situation which can keep them going on for those extra few minutes. As we know, it is next to impossible to get a charging point anywhere and everywhere, and even we also seen people fighting and standing a queue to get access to the charging port. Nowadays, the concept of renewable energy in human surrounding instigates a renewed interest. The aim of our project is that we deal with a device which is using piezoelectric material [2] that provides an alternate means for powering mobile/portable devices. A piezoelectric material generates an electric charge while a mechanical stress is applied to it. The ambient mechanical energy can be transformed to vibration of electrical energy by using the mechanism with piezoelectric materials and that energy can be stored and used to supply power to other devices [3]. On the other hand, when an electrical field is applied a mechanical deformation is produced. Piezo-film has the capacity to create enough electrical energy that can be stored in a rechargeable battery for future use for a necessary situation where there is no power supply is present and need your mobile for just few minutes more [4].

Since, it is an energy revitalization device, it motivates walking and which makes it as an electrical health gadget which esteems physical fitness. There is one more characteristic that is integrated into this device, is a battery power bank which is used to store the extra charge that is produced when the phone is fully charged. After doing some research and consulting a medical staff, we have discovered that the pressure point of a foot is heel, mid foot, metatarsophalangeal joint, hallux, and the toes [5]. Consequently, piezoelectric crystals are placed into the maximum pressure points which are the sole and the heel of the shoes. In the brisk moment and vibrations on the crystals, the crystalized structured piezoelectric generates voltage pulses and minute quantities of current.

Keywords: piezo electric, mobile charging, piezo plate, charging circuits, electricity generation.

I. INTRODUCTION

With the rapid evaluation and development of Technology, the number of smartphone users worldwide is projected to amount to almost 2.7 billion. A smartphone is not only a device used for communication but also it actually becomes smart day by day. Now a considerable size of battery is required to keep it running throughout all the day. As per our knowledge, smartphone's battery lifespan is very short. So, every user wishes if he had extra battery life. A full discharge of battery depends upon the uses. That may be in 1-2 days or may be just in few hours. To meet their needs, we propose a new technology - piezoelectric energy, which will replace the cell, the energy of which will be equal to the steps taken. In this article, we focus on the use of technology during energy production and operation.

We can use the wasted energy in human collaboration [6]. Piezoelectricity is electrical energy that can be obtained by mechanical means (walking, running etc.). When the piezoelectric material is subjected to mechanical stress, the movement of positive and negative occurs and an external electric field is created. When reversed, an external electric current stretch or compresses the piezoelectric material. The piezoelectric effect has proven useful in many applications, including the generation and detection of high voltages, sound, microbalances, electrical frequency generation, and ultrafine focusing of optical devices. It is also used in various scientific measurements with atomic resolution, such as diagnostic probes (STM, AFM, etc.). The piezoelectric effect can also be used in many applications.

Therefore, we create a power bank that can charge while walking, the power of the power bank will be equal to the power we produce while walking. When we walk in piezoelectric shoes, the maximum pressure is produced a on toes and heels. While walking, a pressure is applied to the shoes which creates a negative effect on the expansion of the piezoelectric generator and a positive value on the compression side. The device will then be equipped with electrical energy generated by the piezoelectric material inside the shoe and stored in the battery, which will provide a small portion of emergency power that can be used to charge the phone and help to generate some revenue. If necessary, by using a USB cable we can connect the timer for a few seconds [7]. Focusing on awareness of recycling and energy waste in our environment, it can be a great invention in our society.

II. WHAT IS PIEZO-ELECTRICITY?

Piezoelectricity is a distinctive property which is shown by few materials where they generate an electrical charge or voltage as a result of their applied external force. On the other hand, these materials also deform or exhibit mechanical strain when subjected to an electric field. This phenomenon is known as the 'Piezo-Electric' effect [8].

The word piezoelectricity is derived from the Greek word "piezein" meaning pressure or pressure, while electron means "amber" and is the origin of electricity. French physicists Jacques and Pierre Curie determined in 1880 that electronic devices needed access to certain materials to respond to mechanical forces.

Piezoelectric material allows the conversion of energy from mechanical energy to electrical energy and vice versa [9]. They can be used to create many sensors or actuators; Timed electrical signals can produce ultrasound waves for imaging

These Piezo-Electric Materials can be classified into three categories -

1- Naturally occurring (single) crystal substrates.
2- Ceramics with perovskite structure
3- Polymer films.

This property has numerous practical applications, such as sensors, actuators, ultrasound transducers, piezoelectric motors, and various electronic devices. For example, piezoelectric sensors are used in a wide range of applications, including measuring pressure, detecting acceleration, and converting physical parameters into electrical signals. Additionally, piezoelectric actuators can be utilized in precise positioning systems and other applications where fine mechanical control is needed.

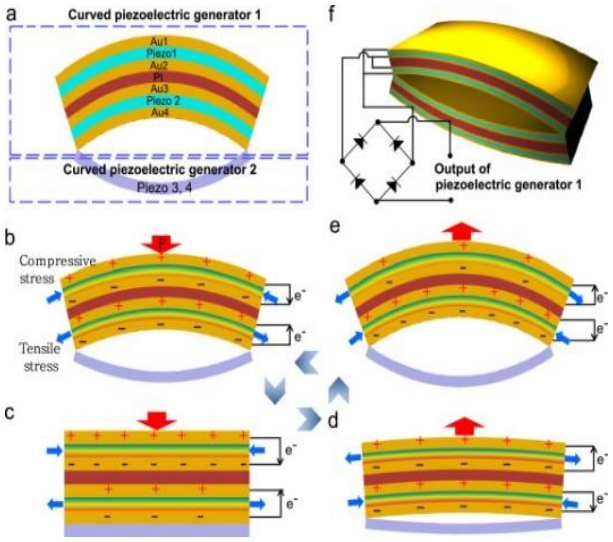


Fig. 1. Internal Working of Piezo Plates to Generate Electricity

III. WHAT ARE PIEZO-ELECTRIC PLATES?

Piezoelectric plates, also known as piezoelectric ceramic plates or piezoelectric elements, are thin, flat, and often disc-shaped components made from piezoelectric materials such as certain ceramics, polymers, or crystals (e.g., lead zirconate titanate, or PZT). These materials exhibit the piezoelectric effect, generating an electric charge or voltage when subjected to mechanical stress or vibration [10].

Piezoelectric plates are designed and manufactured to exploit the piezoelectric properties of these materials for various applications. The shape and size of the plate can vary depending on the specific application and requirements. Common shapes include discs, rectangles, and squares.

A. Applications of piezoelectric plates include

i. **Sensors:** Piezoelectric plates are used in various sensors to detect pressure, force, acceleration, and vibrations. When mechanical stress is applied to the plate, it generates an electric charge that can be measured and converted into a corresponding physical parameter.
ii. **Actuators:** Piezoelectric plates can act as actuators, converting electrical signals into mechanical movement. This makes them useful in precision positioning systems, micro positioning devices, and

other applications requiring precise and controlled mechanical motion.

iii. **Ultrasound Transducers:** In medical imaging and industrial applications, piezoelectric plates are used to generate and receive ultrasound waves. The piezoelectric effect enables the conversion between electrical signals and mechanical vibrations, crucial for ultrasound imaging.

iv. **Energy Harvesting:** Piezoelectric plates can be used to harvest energy from ambient vibrations and mechanical movements, converting them into electrical energy for powering small electronic devices or charging batteries.

v. **Inkjet Printing:** Piezoelectric plates are employed in inkjet printers to precisely eject tiny droplets of ink onto the printing surface. The application of electrical voltage to the piezoelectric plate causes mechanical deformation, resulting in controlled ink ejection.

vi. **Sonar Systems:** Piezoelectric plates play a critical role in sonar systems by generating and detecting underwater acoustic signals. The piezoelectric effect helps in transmitting and receiving acoustic waves in water.

vii. Piezoelectric plates are valued for their reliability, efficiency, and precise control, making them a fundamental component in a wide range of devices and systems across various industries.

Fig. 2 Piezo Electric Plate

IV. WORKING OF PIEZO-ELECTRIC PLATES

We have the special materials required for piezoelectric usages, but we need to understand how does this working mechanisms work? It has a piezo-electric effect. The most important thing about this effect is that it works in 2 ways. Either we can apply electrical or mechanical properties to the same piezoelectric material and obtain vice-versa results as follows:

By referring from Fig.1 applying of external energy to the crystals is the direct piezo-electric effect and it works likes -

I. The piezo-electric crystal is positioned in the middle of two metal plates. At this time the equipment is well balanced and does not conduct electricity.

II. After applying some mechanical pressure on the metal plate and the plate applies pressure to the material, causing the balance of charges in the crystal to be disrupted. -ve and +ve charges occur on the other sides of the crystal plane.

III. The Metal plates collect this charge and can be used to generate electricity and send current through a circuit.

That's it, with a simple application of mechanical pressure, click on the crystal and suddenly an electric current appears. We can also do the opposite and use the electrical signal for the device based on the piezoelectric effect.

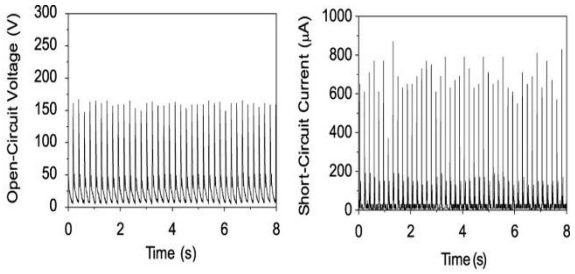
Here's how it works [11]

I. In the same situation as the example above, we have a piezoelectric crystal between two plates. Its crystal structure is in perfect balance.

II. Electric power is then applied to the crystal, causing the crystal structure to contract and expand.

III. As the crystal structure expands and contracts, it converts the electrical energy it receives into electrical energy and emits electrical energy in the form of sound waves.

The inverse piezoelectric effect has many applications. For example, being a speaker uses electrical power to piezoelectric ceramics, causing the material to produce air in the form of sound waves.



(a) (b)

Fig.3 Voltage and Current Generation of Piezo Plates

V. MOBILE CHARGING PHENOMENON

In our current day's scenario, our mobiles are evolving in every nature, the smart mobiles are also getting smarter and we are completely relying our daily lives on those

devices as well. So, as our high usage of mobiles we also need our device to completely charged as well. But all of us just plug our device on the charging cable and let the charging done on its own, but there are few things are which are needs to look upon and few details to get to know more about the charging phenomenon of mobile battery.

A battery is basically an instrument which can store electric energy as a form of chemical reactions and while discharging, the energy is converted to electricity. Most commonly li-ion batteries are used in modern smartphones. Battery consists of three major parts. They are anode, cathode and electrolyte. Anode represents the positive side of the cell where the oxidation occurs. Cathode represents the negative side of the battery where reduction takes place. The positive part made up of graphite and the negative part made up of lithium Cobalt oxide and the electrolyte which acts as a mediator, basically is in liquid or gel form.

while charging a battery, electrical energy passes through the battery, which causes a movement in the Lithium ions and they move from anode to cathode direction. This generates the negative charge in anode side and positive charge in the cathode side. When the battery is fully charged, all the lithium ions are in the cathode side and they are ready to free as a form of electrical energy while it is used.

While using mobile, the sufficient amount of electrical current is collected by the lithium ions from the cathode side. At that time the energy flows from battery circuit to power of phone. When battery is fully discharged, all the lithium ions flow reversely to anode side. That time phone losses it's power and turned off.

There are some key factors to look upon which determines the charging of a Li-ion battery [12]:

i. **Capacity:** The capacity of lithium-ion battery determines the amount of energy it can store. In case of Lithium-ion batteries, the capacity can be determined by measuring the number of lithium ions it can store. It is measured in ampere hour (Ah) or milli ampere hour(mAh).

ii. **Voltage:** The voltage of the battery depends upon the capacity of the battery. In case of Lithium-ion batteries, the voltage is considered between 3.7volts to 4.2volts.

iii. **Energy Density:** It can be determined by measuring the amount of energy stored in the battery for volume Faster power means more power can be stored in a battery of a given size or weight, making it more practical and suitable for portable devices of that size and weight. The unit of energy density is watt hours per kilogram (Wh / kg) or watt hours per liter (Wh / L). Lithium ions batteries have more energy compared to other batteries. So, it is very suitable and more efficient to use in mobile phones

iv. **Self-discharge rate:** Self-discharge rate: This feature of a battery is considered to be a demerit. Due to the internal chemical reaction, the battery releases the stored charge in the form of heat. Which is basically the energy or power loss. Self-discharging also reduces the lifespan of batteries. Lithium ions battery's self-discharging rate is less than other batteries. So, it is more efficient.

v. **Life cycle:** Battery cycle detects the operation of charging and discharge. One cycle of battery refers to the completely charged of a battery and then fully discharged. In the total lifetime of the battery, the total number of cycles the battery can go through is known as the life cycle.

vi. **Operating temperature:** It is an important feature to determine the performance of the battery. Due to high temperature, the electrolyte may decompose and the capacity of the battery as well as the lifespan of the battery is reduced. Lithium ions batteries have low operating temperature.

vii. **Charge and discharge:** It represents the speed of charging and discharging of the battery. It can be expressed in current's units which is ampere (A) or milli-ampere(mA). The fast charging and discharging where the battery can be charged and discharged at high speed, is beneficial for modern applications.

viii. **Battery management system:** It is also an important feature of Li-ion batteries BMS manages a battery by protecting the battery from external operation. It also provides the safety area of operation, controls the environment of connection and increases the lifespan of the battery.

All these features are important to determine the performance of lithium ions batteries.

Now to use all our daily essentials in their full potential, the apps in our device requires a specific amount of power even our device also needs some power to operate for a

long time but we don't know how to control and manage it so therefore the Battery Management System (BMS) in our device helps us to manage the battery usage in our device for all the apps and to keep our device alive throughout a long period.

VI. MOBILE CHARGING CYCLE [13]

When you charge your phone to 100% and then let it go to 0%, your phone's battery goes through a battery cycle.

But the battery cycle does not require complete discharge; Several partial discharges may accumulate in one battery cycle.

Charge your phone to 80% and then let it go to 30%; this is considered half the battery cycle. If you charge it to 80% a nd then use it to 30%, that counts as another half cycle. Tw o half cycles plus a cycle battery.

Cell phone batteries deteriorate somewhat after each cycle, so manufacturers indicate estimated battery life on the batteries. For example, Apple says its iPhones will retain at least 80% of their original battery after 500 cycles.

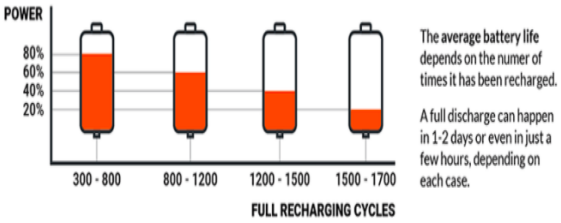


Fig. 4 Battery Charging Cycle

VII. COMPONENTS USED IN PIEZO ELECTRIC MOBILE CHARGING SHOE

The physical components required to make our project successfully work are listed as follows:

1. Pair of Shoes
2. 27mm Piezo-electric plates
3. IN4007 Diodes
4. Power Bank Charging Module (T6845C Power Bank Module)
5. Li-ion battery (3.7 Volt)
6. Single Cell Battery holder
7. Slide Switch
8. Connecting wires
9. Charging cable (120 cm)

VIII. CONSTRUCTION OF PIEZO ELECTRIC MOBILE CHARGING SHOE

Now, in this part we will discuss how we built our module using the components mentioned in the above.

A. Arrangement of piezo plates:

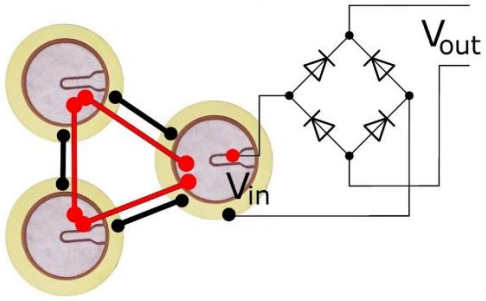


Fig. 5 Arrangement of Piezo-Plates

As we can see in the above, we will arrange piezo plates in series connection to generate maximum output through it. As shown in the above diagram we will make similar arrangements on the both side using a hardboard partition which is separated from our heel area of feet using the insole of the shoe. We are making these arrangements in our heel area because it is one of the highest-pressure points in our feet.

B. Arrangement of circuit:

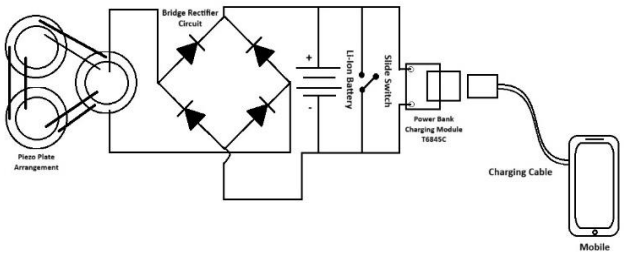


Fig. 6 Circuit Diagram

As described in the above circuit diagram we will attach those piezo-plate arrangements with a bridge rectifier circuits as we are walking the through step by step, we can consider that generation as a Step Input for the module, therefore we are using rectifier circuit to convert it in pulsating DC.

After generating this pulsating DC voltage, we are fetching that in the Li-Ion Battery connected in parallel as shown in the above circuit. Here we also have to attach the slide switch to detach the battery from the output module because we know as a fundamental that a battery cannot be

charged and discharged at the same time. Therefore, when we are placing the slide switch in Off-state we are simply charging state as we are walking. But whenever we start walking, we put the slide switch in the On-state to charge our mobile.

Now, we connect our connections that are coming out from the slide-switch to the Power Bank Charging module as we mentioned in the above in its 'B+' and 'B-' terminal. Mobile power modules like T6845C are not only suitable f or mobile phones, appliances, etc., with different models s uch as load control, output control, protection and LED ind icator. Provides power for. T6854C is like a mini-board & compatible with Li-ion battery which ranges from 3.7V to 4.2V. It includes a port like micro-USB for charging the battery & USB type A female output port that supports 5V DC 1A input & 5V 1A output. Once this module is connected to a battery then a portable power bank like this can be made.

C. Final output:

The output of this power bank charging module is thorough its USB type-A female port. Here we connect our USB cable for our device, and we can charge through it by simply turning on the slide switch.

We need to keep this in mind that we can only charge either our battery or our device at once, therefore keep that slide switch in mind to operate while we are using our module. We will only turn on our switch whenever we need to charge our device only and we need to charge our battery by turning of that switch only.

IX. DAILY LIFE APPLICATION

In our daily life scenarios, we face many situations where our most useful and most dependent device that is our mobile goes out of power and we need a little bit power to make some few calls where we can use 1%-2% charge to get ourselves thorough in that critical state where our little charge can get us out of turmoil, but we cannot get any recharging source, or we forget our charging device.

Now we don't need to worry about such conditions, our feet will be our power source where we just need to walk to generate power and after a certain time we can recharge our device with our self-generated power, we might not get so much power, which will charge our device fully but enough to get us out of that critical situation where we need that emergency support.

X. CONCLUSION

In this attempt we tried to make an emergency portable power bank which we do not need to carry our use much working space and not even bulky to carry. This charging device which will get us out of many emergencies situation where we need some sort power source to keep our devices charged for a bit. It should be completely used for emergency situation to get ourselves out through it.

It also promotes healthy life style as well which will motivate us to walk and to generate power for ourselves in daily life. When we walk, we use so much power in our body why not use some of it to generate a little bit of power which can help us in critical situation.

XI. FUTURE SCOPE

By using much higher technological equipment, we can make many more advances in our device which will be remarkable accomplishments and might can be convert it from an emergency power source to continuous power suppling system which can be used for many applications as stated below.

1. Continuous Power Generating Shoe which will not only help in critical situations but for every situation as well.
2. Precise Pedometer for accurate foot step tracking for athletes.
3. In-Buit GPS Tracking System for different adventure sports.
4. For using it every condition and places to make it Snow proof and Water proof as well.

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