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# Piezoelectric Based Energy Source Model for Street Lights

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## *Abstract*

**Piezoelectric as an energy source has great potential that has remained largely untapped. The aim of this paper is to bring to the fore one of the many ways in which piezoelectric materials can be used as a cost effective and renewable source of energy. The specific area of hypothesis of the paper is to use of the electrical energy produced by a piezoelectric material as a source for lighting street lights on highways.**

## 1. INTRODUCTION

The recent awareness among scientists and researchers about global warming and exhaustion of conventional sources of energy has turned their attention towards finding alternative or non conventional sources of energy.

Piezoelectric, though being in use for more than a century has still not found its use as an energy resource. Piezoelectric crystals produce electricity when they come under some mechanical stress. The change of polarization ***P*** when applying a mechanical stress is the deciding factor for the voltage produced by piezoelectric. This might either be caused by the re-configuration of dipole-inducing surroundings or by the re-orientation of molecular dipole moments under the influence of external stress. Piezoelectricity may then manifest in a variation of the polarization strength or its direction or both, with the details depending on the orientation of ***P*** within the crystal, the crystal symmetry and the applied mechanical stress.

The power produced by piezoelectric is very small so its use is still very limited but when we apply a large amount of pressure a considerate amount of power is produced which can be stored in a battery and used later. This large amount of pressure can be obtained on the highways where multiple heavy weight vehicles pass frequently. So, to properly harness the power of piezoelectric, we can embed it on busy highways with a proper circuit to store the electric power generated. The only prerequisite for this circuit to work is the presence of high flux of traffic, the absence of which will result in the charging of the battery to be erratic.

## 2. STRUCTURE, OPERATION AND MODEL

The circuit is shown in the form of a block diagram in Fig.1. A piezoelectric crystal is embedded in a highway. When vehicles will pass over the crystal, mechanical stress will be produced which in turn will generate an AC voltage.[7] Experimental data shows that Applying 80 gram force to the tip of the crystal at a frequency of 60 Hz produces an open circuit voltage of 15V peak between the two electrical leads. When the leads are connected to an 8 KΩ

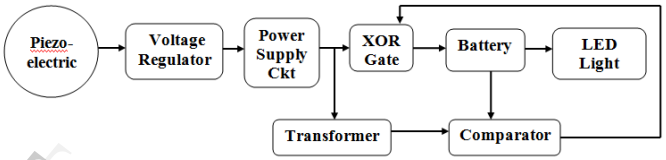


Fig.1. Block Diagram

resistive load, the output at the load is 5.3 VRMS, representing a power output of 3.6mW. If we take this value as reference then 300Kg of weight will producev15 V peak to peak voltage and 1 Ampere of current which can easily charge a 12 V battery.

### *2.1 Voltage regulator*

A zener diode is used as a voltage regulator to control the voltage spikes that might arise due the heavy weight of bigger vehicles that may destroy the circuit. The function of a regulator is to provide a constant output voltage to a load connected in parallel to it, in spite of the ripples in the supply voltage or the variation in the load current. The zener diode will maintain a constant output voltage till the diode current falls below the minimum current value in reverse breakdown region. The circuit is shown in Fig.2.

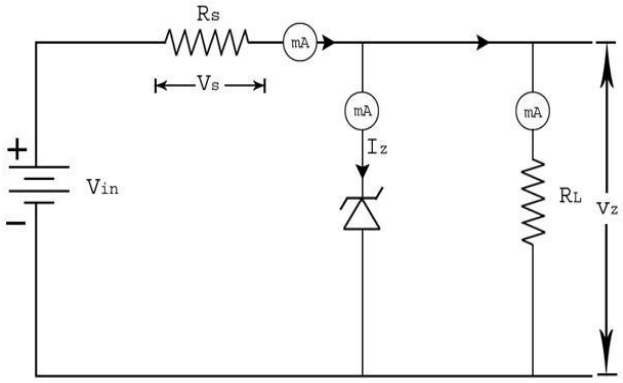


Fig.2. Zener Diode as voltage regulator

### *2.2 Power Supply Circuit*

A power supply circuit takes AC voltage as input and provides DC voltage as output. As shown in Fig.3, a step down transformer changes the incoming AC voltage which is at a higher voltage to a lower value, which is required for our device to function properly. It also includes a full bridge rectifier whose input is as shown in Fig.4. It converts the AC voltage to a DC voltage which, although unidirectional, consists of pulses of voltage; here we are converting the whole AC voltage to positive polarity as shown in Fig.5. This pulsating DC still cannot be used as DC power source so we have to use multiple capacitors which smoothens out the pulsating DC into constant DC power as shown in Fig.6. IC 7805 or zener diode can be used for regulation purpose. We are using this IC as a precautionary measure. However, the use is not mandatory as we have already used a zener diode earlier in the circuit.

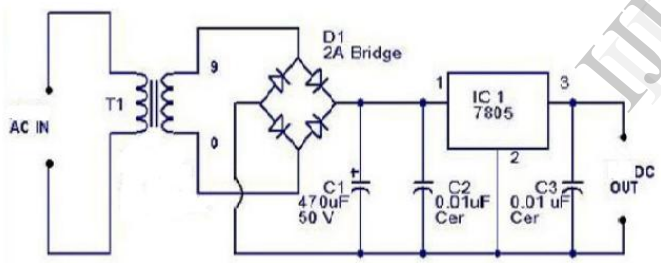


Fig.3. Power Supply Circuit

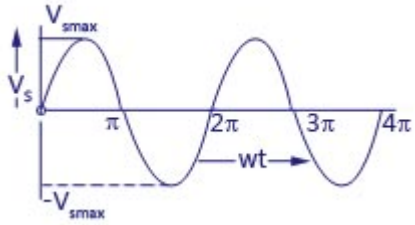


Fig.4. Input Waveform to power supply circuit

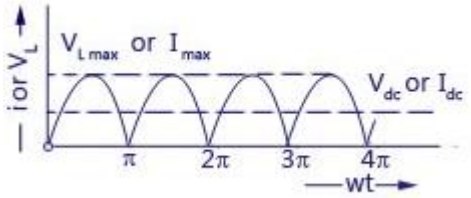


Fig.5. Waveform after rectification

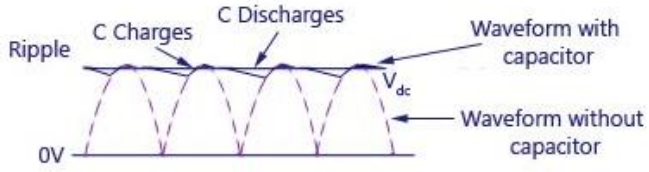


Fig.6. Waveform after passing through capacitors

### *2.3 Comparator*

A comparator is an electronic device which compares two input voltages and gives an output digital signal indicating which input signal is greater. It has two analogue input signals V+ and V- and a digital output signal Vo. If V+ > V- then Vo is 1 otherwise its 0.

### *2.4 Battery*

A lead acid type rechargeable battery will be used which is made of six galvanic cells in series to provide a 12 volt output. Lead-acid batteries are made up of plates of lead and separate plates of lead dioxide, which are submerged into an electrolyte solution of about 38% sulfuric acid and 62% water. This causes a chemical reaction that releases electrons, allowing them to flow through conductors to produce electricity. As the battery discharges, the acid of the electrolyte reacts with the material of the plates, converting their surface to lead sulfate. When the battery is recharged, the chemical reaction is reversed: the lead sulfate changes back to lead dioxide and lead. With the plates restored to their original condition, the process may now be repeated.

### *2.5 Operation*

The voltage coming from power supply circuit will be around 15V. This value has been taken keeping in consideration that a value slightly greater than 12V will be required to charge a 12V battery. The purpose of the comparator is to prevent the battery from overcharging. The power supply is fed to a step down transformer which gives the output of 12V. The output of the transformer is then used as the reference voltage for the comparator. So the comparator has two inputs- one from the transformer and the other from the battery. The output coming from the battery is V+ input for the comparator and the one coming from transformer is V- so whenever battery exceeds 12V then a high signal is sent to XOR gate which will turn it

off. This disconnects the input of the battery and charging of battery stops thus preventing overcharging.
LEDs are used for street lights as they use less power and are as bright as the normal tube lights.

Table.1. Truth Table of XOR Gate

| X | Y | Output |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

## 3.SWITCHING OF THE LIGHT

It won't be very effective to use a manual switch for the whole circuit so to switch on the lights LDR based night light control is used. [8]The circuit uses a Light Dependent Resistor (LDR) to sense the light .When there is light the resistance of LDR will be low. So the voltage drop across POT R2 will be high. This keeps the transistor Q1 ON. The collector of Q1 is coupled to base of Q2. So Q2 will be OFF and so do the relay. The bulb will remain OFF. When night falls the resistance of LDR increases to make the voltage across the POT R2 to decrease below 0.6V. This makes transistor Q1 OFF which in turn makes Q2 ON. The relay will be energized and the bulb will glow. The circuit is as shown in Fig.4. As LDR is very sensitive so this circuit should be placed beneath the street lamp where there's darkness while the street lamp is on otherwise the light of street lamp will close the circuit.

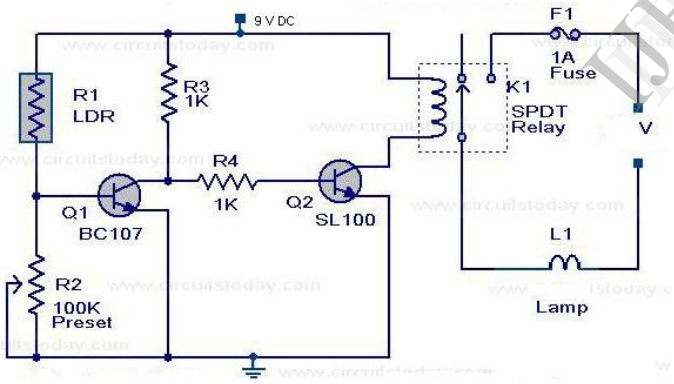


Fig.7. Circuit of LDR Based Night Light Control

## 4. CONCLUSION

The work gives a clear picture of the working of the piezoelectric as a renewable source of energy. An effective model of energy conversion and storage has been depicted. In addition to effectively harnessing mechanical energy a simple circuitry is designed so as to keep the implementation cost low.

Moreover it can be seen that piezoelectric produce no waste while converting mechanical energy to electrical energy so one does not have to deal with the potent problem of waste disposal.

All these considerations put together point to the fact that further research in energy conversion property of piezoelectric can help in developing a non-conventional source of energy that is both renewable and harmless to the environment.

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