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Piezoelectric Breakers

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Abstract: *The energy demand and power consumption is going on increase day by day . The concept of harvesting new sources of energy is the need of hour . One of the ways of developing electricity can be with the use of piezoelectric materials .Piezoelectric material are electromechanical elements .When a mechanical stress is applied to piezoelectric material a voltage is developed across its ends. The voltage generated depends directly on mechanical pressure. Our project focuses on utilizing the generated potential from piezoelectric material into electrical energy which can glow street lights . A circuit containg piezoelectric disks is designed and inserted beneath the speed breakers. Speed breakers consist of mechanicals spring which are directly in contact with piezoelectric disks elements. PZT can be used as a medium which can convert ambient vibrations and stress in the form of electrical energy. The electrical energy can be stored and used for the functioning of electrical and electronics devices. With the recent advancement in micro scale devices, PZT power generation can provide a conventional alternative to traditional power generating sources .*
Our research focuses on an innovative way of using piezoelectric circuit, fitted beneath the speed breakers to develop electricity .The Frequency of vehicles on roads is increasing exponentially day by day , hence speed breakers can serve better option for developing piezoelectricity.
Keywords: *piezoelectricity , mechanical pressure , strain .*

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I. Introduction

The demand of electricity and its consumption is increasing day by day due to rise in our basic needs . Power generation in India is almost 67.1% dependent on non-renewable sources (Ex : coal , Petroleum) , 30.8% is contributed by renewable resources , and almost 2.1% through nuclear power plants .Our research project focuses on giving a small contribution and supporting solar energy to fulfill the demand of electricity on roads which include traffic lights ,street light etc. Our research uses Lead Zirconate Titanate crystals which helps in making of piezoelectric transducers.

The piezoelectric material when undergoing mechanical stress , tension , vibration results in development of charge at its opposite ends generating potential difference at its end . The principle of piezoelectric material is to produce an electric charges on the crystal surface like quartz, Lead Zirconate Titanate when they subjected to compressive force .The electricity produced is termed as piezoelectricity. Piezoelectricity can be defined as the electrical polarization produced by mechanical strain on certain class of crystals. The amount of charge produced will be proportional to the rate of change of force applied as input.. A circuit is made containing series-parallel combination piezoelectric transducer, rechargeable battery which is to be setup beneath the speed breakers. Passing of a vehicle over it will exert tension on piezoelectric material developing charge on opposite ends. Potential developed will be directly proportional to mechanical pressure applied by vehicle .

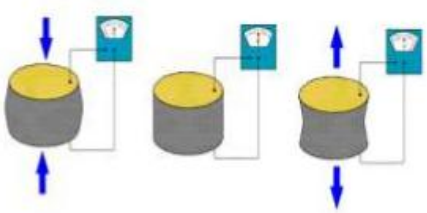

Fig. 1 Basic Principle

Experimentally electric potential developed will be proportional to mechanical pressure applied by vehicle as shown in figure.

Mechanical properties of EPDM

Property	Value
Appearance	
Hardness, Shore A	40–90
Tensile failure stress, ultimate	25 MPa
Elongation after fracture in %	≥ 300%
Density	Can be compounded from 0.90 to >2.00 g/cm^3

Thermal properties of EPDM

Property	Value
Coefficient of thermal expansion, linear[4]	160 µm/m·K
Maximum service temperature[5]	150 °C
Minimum service temperature[5]	−50 °C
Glass transition temperature	−54 °C

Fig.3: Properties of EDPM rubber

$$V \propto P$$

$$V = K \times P \qquad (1.1)$$

where v =voltage developed on transducer
P = pressure exerted by vehicle
K= proportionality constant

II. Contruction Of Speed Breaker

A. SIZE :

For experimental purpose length of speed breaker is 4m and breath is 0.4m.

$$A = l \times b \qquad (1.2)$$

$$A = 4 \times 0.4 = 1.6 \text{ sq m}.$$

Where **A** = area of cross section of breaker

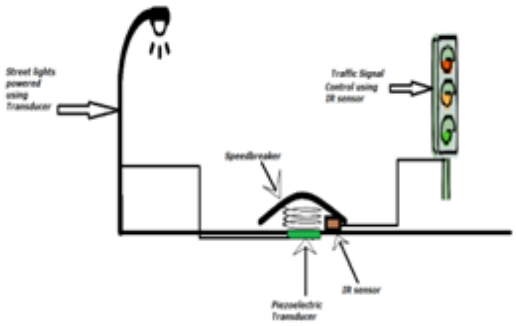

Fig2: Demonstration of speed breaker

B. MATERIAL REQUIRED FOR BREAKERS :

EPDM (ethylene propylene diene monomer) rubber, speed bumps are weather proof and can sustain heavy loads for longer time. These speed bumps are designed with an interlocking mechanism, and hence each unit forms a strong bonding with each other.

C. EFFECT OF PHYSICAL FACTORS:

Physical factors such as mechanical loading, environmental effects, effects of rubber formulation, are the area of study. Environmental factors affects fatigue behavior of rubber. The effects of temperature, oxygen, ozone, water resistance and electrical charges are depicted in table 1:

Table 1: Physical factors affecting EDPM rubber.

Environmental Performance	
Colorability	Good to Excellent
Flame Resistance	Poor
Gas Permeability	Fair to Good
Odor	Good
Ozone Resistance	Good to Excellent
Oxidation Resistance	Excellent
Radiation Resistance	Good to Excellent
Steam Resistance	Excellent
Sunlight Resistance	Excellent
Taste Retention	Good to Excellent
Weather Resistance	Excellent
Water Resistance	Excellent

III. Working of Piezoelectric Circuit

A. CIRCUIT ANALYSIS:

The circuit consists of piezoelectric transducers connected in series parallel combination. The circuit shown in fig inserted beneath the speed breaker. The circuit contain springs which are in direct contact with PZT which act as vibrating medium and continuously transmit pressure for long period of time. When a vehicle passes over it exerts a mechanical stress on the speed breaker. Due to application of stress charge is developed on the opposite ends of PZT resulting in potential difference which is directly proportional to mechanical pressure. This circuit is in directly contact with step down transformer, bridge rectifier, capacitor, and load resistors (Ex street lamp).

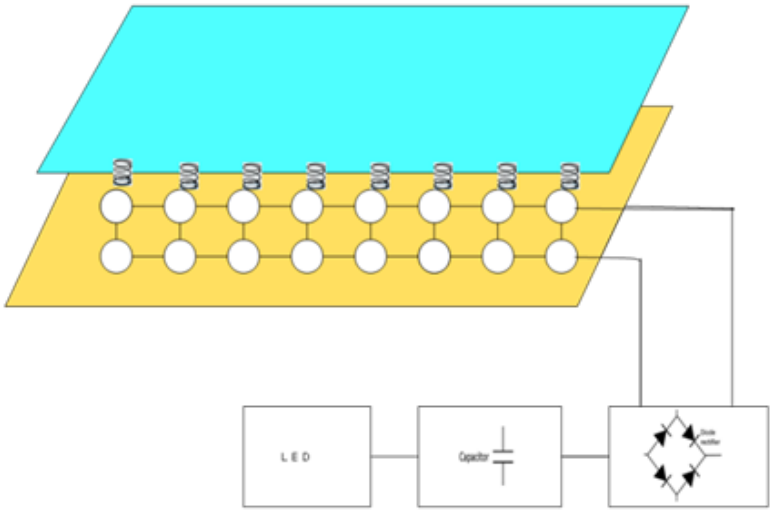

Fig4: Circuit to be placed beneath the speed bump

B. NO OF PZT'S USED IN CIRCUIT :

a = πr^2 (1.3)

a = 5.72 x 10-4 sq. m

n=A/a (1.4)

n = 2790

a= area of piezoelectric transducer
n = no of transducer which can inserted in breaker.

IV. Experimental Analysis

A. COMSOL SIMULATION OF BIOMORPHS

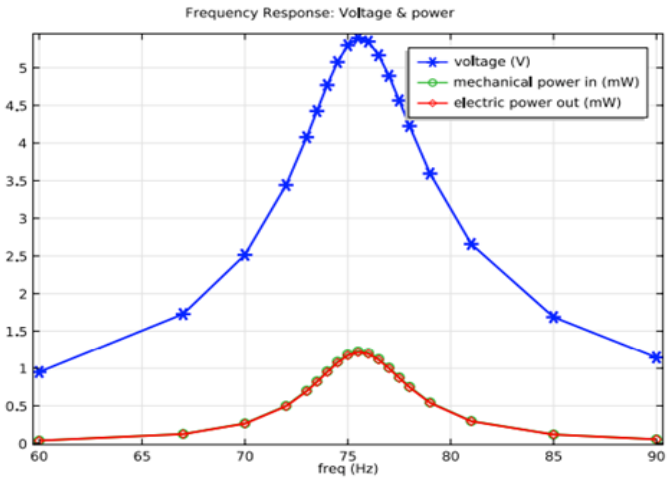

Figure 5: Energy harvester (in mW) and the peak voltage induced across the piezoelectric bimorph (in V) vs. excitation frequency. The load impedance is 12 kΩ with acceleration magnitude of 1 g.

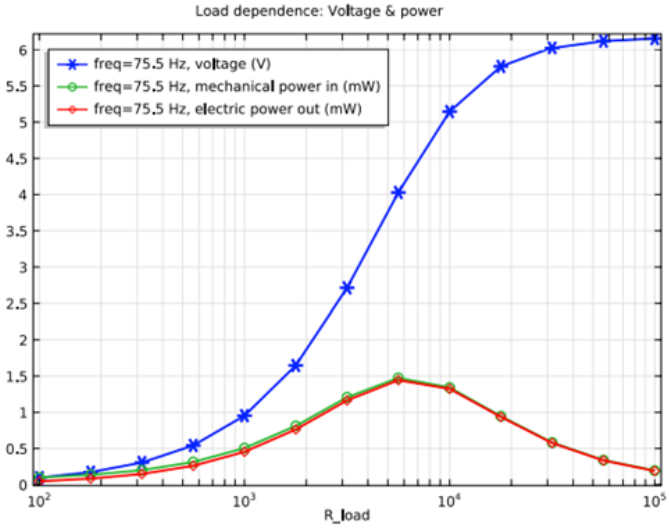

Figure 6: Power harvested from the device as a function of the electrical load resistance at an acceleration of 1 g oscillating at 75.5Hz.

B. GRAPHICAL CALCULATION OF VOLTAGE & PRESSURE:

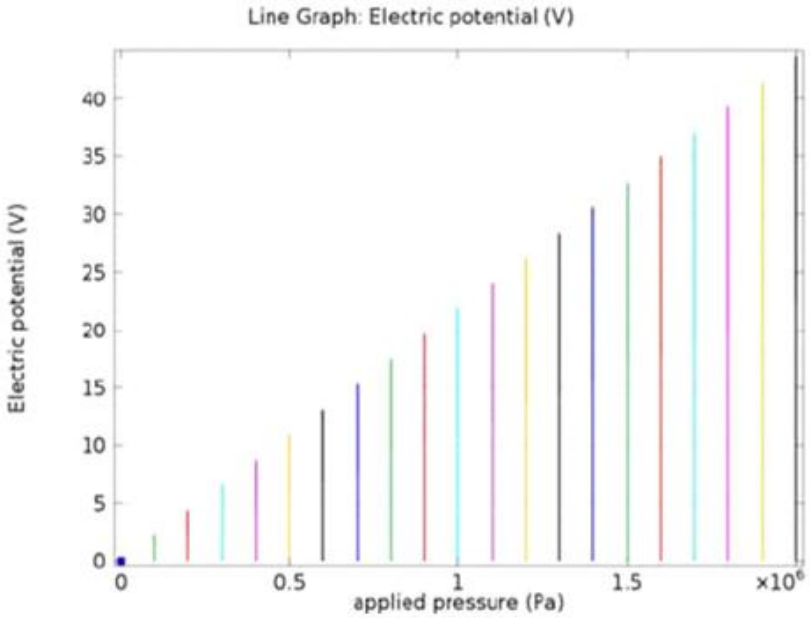

Fig 7: Plot of electric potential vs applied pressure for unit PZT.

V=K x P
Calculating the value of k constant from graph,
K=2.22 x 10^-5

Table2: Voltage generated due to application Of pressure

MASS (Kg)	Pressure(P=F/A) KNm^2	Voltage On unit PZT	VT
1500	9.196	0.204	570v
1600	9.810	0.217	606v
1800	11.036	0.245	684v
2000	12.262	0.272	760v

Where VT is the net voltage produced due to application of pressure on 2790 PZT.

C. SIMULATION ON MULTISIM :

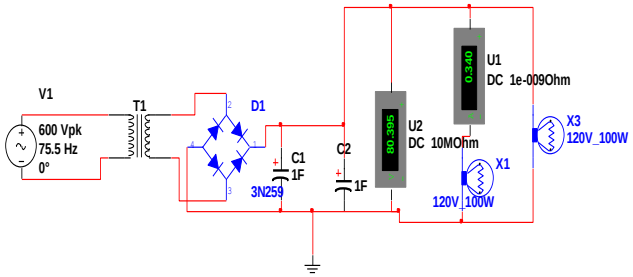

Fig8: Simulation circuit used in multisim.

Table3: Simulation result for fig 8 circuit

load resistance (RL)	Voltage across load(v)	Load current (Io)	Pout(I^2RL)
144 ohm	98 v	0.68 A	66.58 W
57.6 ohm	96.4 v	1.67 A	160.64 W
100 ohm	96 v	0.96 A	92.16 W
1000 ohm	98.54 v	0.099 A	9.801 W
500 ohm	96 v	0.198 A	19.6 W

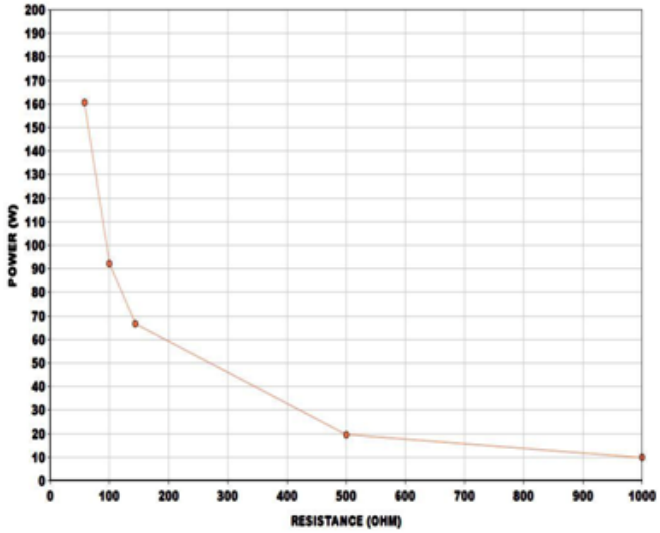

Fig9: power v/s load resistance plot from table 3 reading

V. Conclusion

This idea can be better utilized in area of heavy traffic , Toll tax booth , crowded parking places in order to light the street bulbs. The motive of representing this idea is to utilize the energy which can be used to support solar energy on street. However, further concentration is required to quantify result in a greater power outcome to become a reliable source of electricity. This idea yet needs a lot of effort to make it practically possible.

Acknowledgement

I take this opportunity to thank my friends who gave their very best and shown dedication to complete this task

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