A Real Time Research Project Report

On

SMART ENERGY HARVESTING FROM PIEZOELECTRIC SPEED BREAKERS

Submitted In partial fulfillment for the Degree of B. Tech.

In

Artificial Intelligence

by

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2024 – 2025

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CERTIFICATE

This is to certify that the project report entitled "**SMART ENERGY HARVESTING FROM PIEZOELECTRIC SPEED BREAKERS**" submitted by **Shikha Upadhyay, Pranitha, Shashi Vardhan** and **Goutham Mudhiraj** to Vidya Jyothi Institute of Technology, Hyderabad, in partial fulfillment for the award of the degree of B. Tech. in Artificial Intelligence a *bonafide record* of project work carried out by us under my supervision. The contents of this report, in full or in parts, have not been submitted to any other Institution or University for the award of any degree.

Signature of Supervisor	Signature of HOD
M.RATNAKAR BABU	**Dr.A.Obulesu**
Assistant Professor	Associate Professor

DECLARATION

We declare that this project report **"SMART ENERGY HARVESTING FROM PIEZOELECTRIC SPEED BREAKERS SYSTEM"** titled submitted in partial fulfillment of the degree of **B. Tech. in Artificial Intelligence** is a record of original work carried out by under the supervision of **Mr. M.RATNAKAR BABU**, and has not formed the basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with the ethical practice in reporting scientific information, due acknowledgements have been made wherever the findings of others have been cited.

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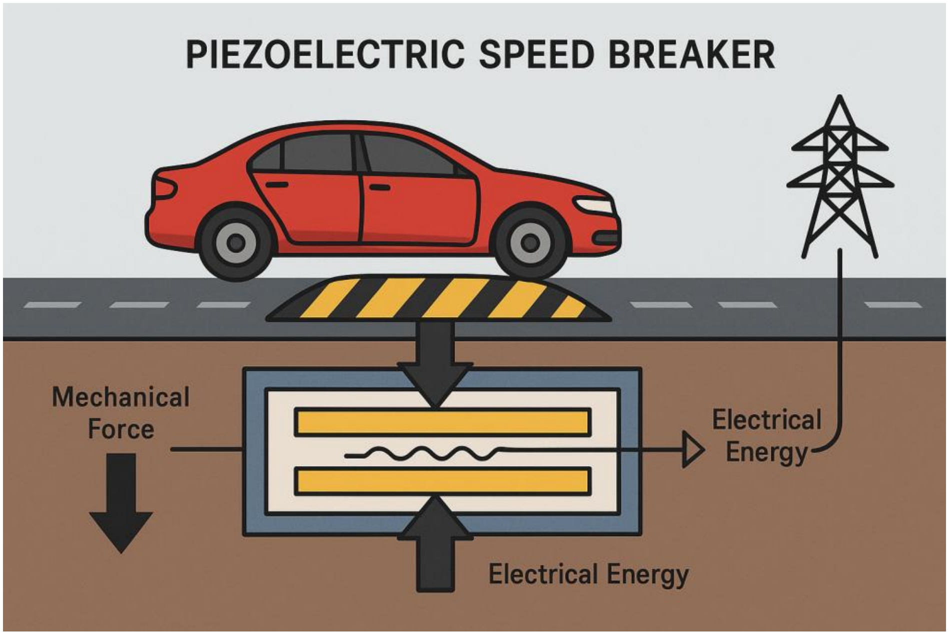
ABSTRACT

Urban areas consume a significant amount of electricity for road infrastructure, including street lighting and smart surveillance systems. To address this growing energy demand sustainably, this project presents a smart energy harvesting system using piezoelectric speed breakers. The concept involves capturing mechanical stress from moving vehicles and converting it into usable electrical energy through embedded piezoelectric sensors. The generated energy is utilized to power low-voltage applications such as street lighting, helping reduce reliance on conventional power sources. An automatic lighting feature is included to ensure energy is used only during low-light conditions, enhancing overall efficiency. This solution promotes the use of clean, renewable energy in public spaces, while also being cost-effective, scalable, and suitable for various settings like highways, educational institutions, and transit zones. It serves as a step toward sustainable and smart urban infrastructure.



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CHAPTER 1

INTRODUCTION

1.1 Introduction

In today's urban landscape, the ever-growing need for sustainable energy solutions has become a global priority, especially in rapidly developing countries like India. The increasing reliance on electricity for essential infrastructure—such as street lighting, traffic monitoring, and public transport systems—has led to higher energy consumption and significant operational costs. With urban centres like Hyderabad experiencing a surge in vehicular movement, the constant wear and pressure on road surfaces offer a unique opportunity to harvest otherwise wasted mechanical energy.

1.2 Problem Statement

This project proposes the development of a "Smart Energy Harvesting System Using Piezoelectric Speed Breakers," an innovative solution aimed at utilizing the pressure generated by moving vehicles to produce clean, renewable electricity. The concept centres on embedding piezoelectric sensors beneath speed breakers on frequently used roads. As vehicles pass over these breakers, the applied pressure is converted into electrical energy, which can then be stored and repurposed for low-voltage urban applications such as street lighting or powering sensors for traffic management. The idea for this project emerged after observing the untapped energy potential from vehicular movement, especially in areas with heavy traffic like college campuses, market roads, or bus stops. These locations typically see high foot and vehicle traffic but lack energy-efficient infrastructure. Instead of allowing this mechanical energy to dissipate, the goal is to convert it into usable electricity using a cost-effective and scalable prototype.

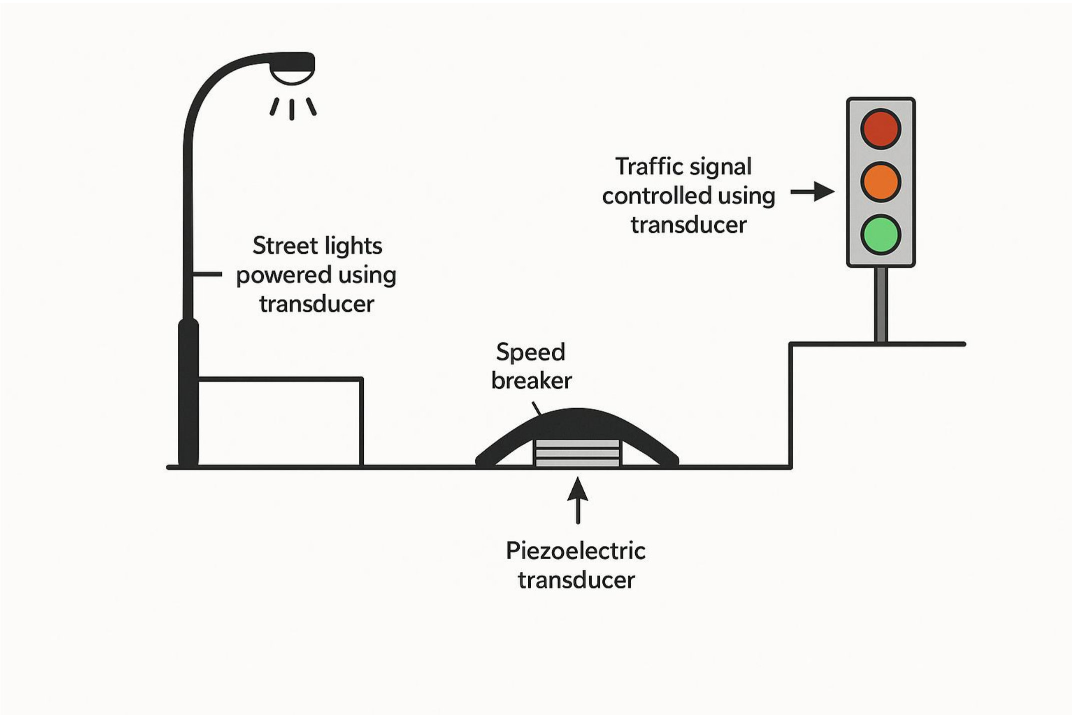
1.3 Objective

The primary objective of the "Smart Energy Harvesting System Using Piezoelectric Speed Breakers" project is to design and develop an innovative, cost-effective solution that converts the mechanical pressure exerted by vehicles into usable electrical energy through the use of piezoelectric sensors. By embedding these sensors beneath speed breakers on busy roads, the system aims to harness otherwise wasted kinetic energy and transform it into clean, renewable electricity. This harvested energy is intended for low-voltage urban applications such as powering street lights or traffic management sensors, especially in high-traffic areas like college campuses, marketplaces, and bus stops. The project seeks to promote sustainable energy practices, reduce reliance on conventional power sources, and contribute to smart city infrastructure through a practical and scalable prototype.

1.4 Scope of the Project

This project aims to design a practical and affordable piezoelectric speed breaker system that captures mechanical energy from vehicle movement and converts it into electrical energy. The scope includes building a working prototype using only essential hardware components—piezoelectric sensors, bridge rectifiers, capacitors, resistors, switches, and LEDs—without relying on microcontrollers or programming.

The system is designed for real-world conditions and is intended to power low-voltage applications like street lights and indicator systems. It focuses on creating a simple, scalable, and low-maintenance setup that can be deployed in high-traffic zones such as educational institutions, toll booths, parking lots, and market roads. By promoting renewable energy usage through vehicle pressure, the project contributes to sustainable urban infrastructure while keeping the design minimal, efficient, and budget-friendly.



1.4.1 Piezoelectric Speed Breaker

CHAPTER 2

LITERATURE REVIEW

Key Areas of Research

2.1 Energy Generation in Speed Breakers by Using Piezoelectric Sensors

Authors: Khan M., Shaikh A.

Published by & Year: IJCRT, India – 2024

The paper highlights a simple, low-cost energy harvesting model using piezoelectric sensors and capacitor banks to power low-voltage devices like LEDs. It emphasizes converting pressure from moving vehicles into usable energy without any microcontrollers, making it highly suitable for rural roads, public spaces, and small infrastructure upgrades.

2.2 Harvesting Energy from Traffic Breakers using Piezoelectric Discs

Authors: Reddy P., Narayana P.

Published by & Year: IJRET, India – 2020

This study presents a working prototype that uses piezo discs along with bridge rectifiers and capacitors to store energy generated from vehicle pressure. It demonstrates reliable power output under both light and heavy traffic conditions, reinforcing the system's practicality for real-world applications like lighting and basic electronics.

2.3 A Greener Approach to Harvest Energy Using Piezo-Speed Breaker

Authors: Alam S., Rafi M., Farhan H.

Published by & Year: ResearchGate, Bangladesh – 2019

The study focuses on building a cost-effective piezoelectric energy harvesting setup using PZT plates and voltage rectifiers to power street lights and similar loads. With its emphasis on simple hardware, no use of microcontrollers, and successful real-time output, it aligns closely with affordable, scalable solutions for energy generation in traffic-heavy zones.

CHAPTER 3

METHODOLOGY

Developing a **Smart Energy Harvesting System using Piezoelectric Speed Breakers** involves a strategic and layered approach focused on real-world applicability, minimal cost, and high efficiency. The methodology is broken down into **planning**, **component selection**, **system design**, **hardware integration**, **power management**, **testing**, and **scalability assessment**. The goal was to create a standalone, self-powered prototype that could demonstrate renewable energy harvesting in vehicular zones without relying on microcontrollers or complex digital systems.

3.1 The Main Components Used in this System

This system functions entirely through passive and analogue components, making it durable, budget-friendly, and ideal for areas where advanced digital setups may not be feasible. Each component is carefully selected based on cost-effectiveness, availability, and reliability.

3.1.1 Piezoelectric Sensor

The core of the energy harvesting lies in the piezoelectric discs, which are embedded under the speed breaker surface. These sensors convert mechanical stress into alternating current (AC) through the piezoelectric effect. The number of sensors and their placement are optimized to maximize the pressure-to-electricity conversion with every passing vehicle.

3.1.2 Bridge Rectifier

To ensure the generated AC can be effectively utilized, it is passed through a bridge rectifier. This consists of four diodes arranged in a bridge configuration to convert the bidirectional AC voltage into unidirectional DC voltage. This is crucial because most storage and output components operate on DC power.

3.1.3 Capacitor

A capacitor is employed to store the rectified DC voltage. It temporarily holds the charge and smooths out any voltage fluctuations. This makes sure the output power remains stable and can be released on demand to power loads like LEDs or sensors.

3.1.4 Resistors

Resistors are inserted into the circuit to act as current regulators. Since the power from the piezoelectric discs can vary with traffic weight and speed, resistors prevent overcurrent from damaging sensitive output components, especially the LEDs.

3.1.5 Switch

A manual switch is placed between the storage and output section to control the flow of current. This helps in demonstrations, testing, and safe disconnection of the circuit during rest or maintenance.

3.1.6 LEDs

As a proof-of-concept, LEDs are connected at the output to visually demonstrate the successful energy harvesting. These low-power indicators light up whenever the system has stored enough energy in the capacitor, giving immediate and practical feedback.

3.1.7 Breadboard

All the above components are arranged on a breadboard, allowing for non-permanent, modular, and easy-to-debug circuit prototyping. This approach is ideal for testing various configurations and improving scalability without any need for soldering.

3.2 Workflow

This piezoelectric energy harvesting setup is designed to generate, regulate, and demonstrate usable electrical energy in a simplified and replicable model. The architecture consists of the following layers based on your components:

3.2.1. Energy Generation Layer

- **Component:** *Piezoelectric Sensors*
- **Function:** This layer initiates the energy harvesting process. When mechanical pressure—such as from a vehicle or foot traffic—is applied to the piezoelectric sensors, they generate alternating current (AC) through the piezoelectric effect.

3.2.2. Rectification Layer

- **Component:** *Bridge Rectifier*
- **Function:** The AC voltage produced by the piezoelectric sensors is unsuitable for direct use or storage. A bridge rectifier is used to convert this alternating current into direct current (DC), enabling consistent and unidirectional energy flow to the subsequent layers.

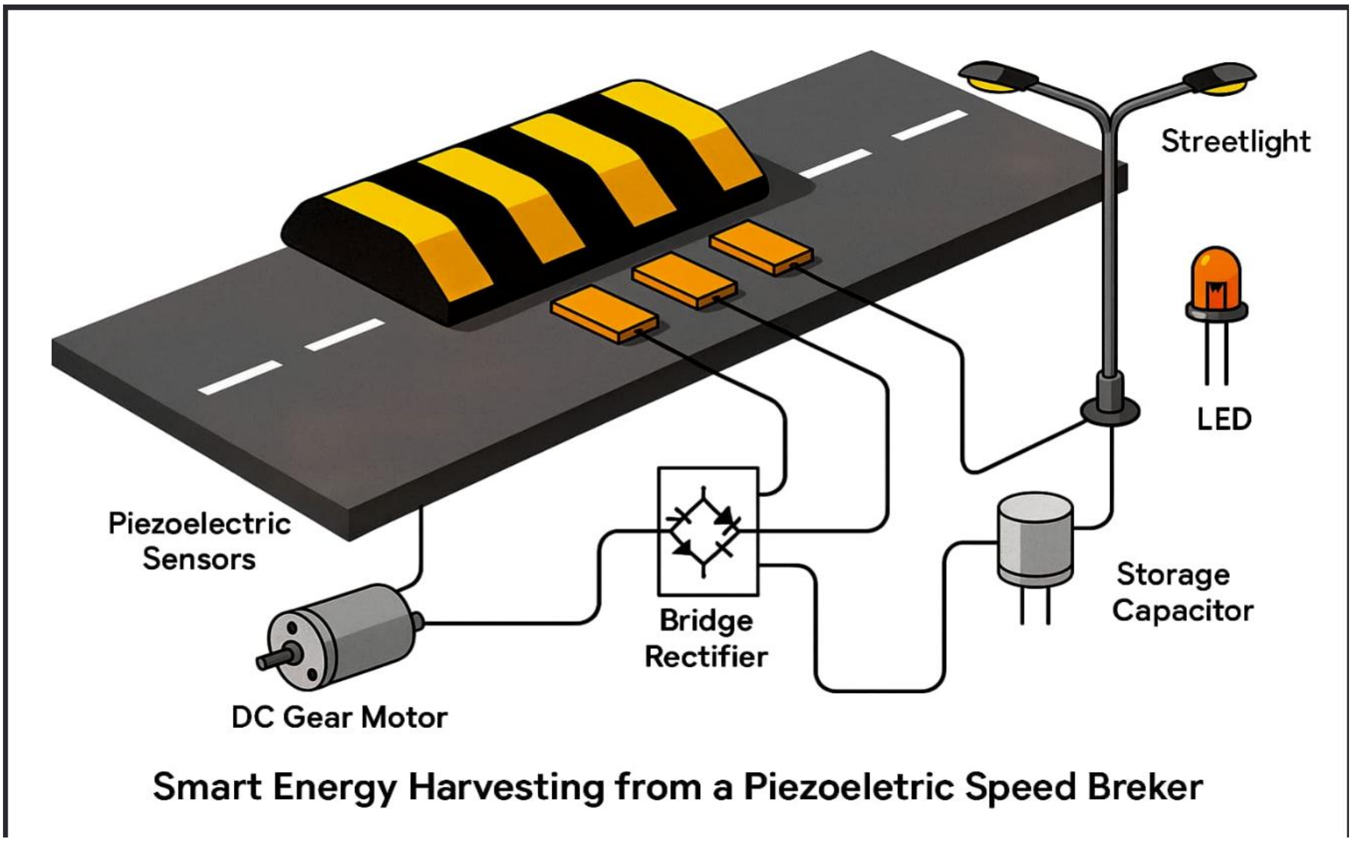
3.2.3. Energy Storage Layer

- **Component**: *Capacitor*
- **Function:** The rectified DC voltage is stored temporarily in a capacitor. The capacitor serves two roles: smoothing voltage fluctuations and storing small amounts of energy for immediate or short-term use.

3.2.4. Load Management and Output Layer

- **Components:** *LEDs, Resistors, Switch*
- **Function:** This layer demonstrates the output of the system.
  - *LEDs* are used as indicators to visualize the harvested energy.
  - *Resistors* are integrated to limit current flow and prevent damage to the LEDs.
  - A *switch* is included to manually control the flow of electricity from the storage unit to the load.**3.2.5. Prototyping and Integration Layer**

- **Component:** *Breadboard*
- **Function:** All components are assembled on a breadboard, allowing for a modular and flexible configuration. This setup facilitates easy testing, modification, and demonstration without permanent soldering.



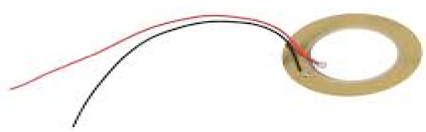
This image shows a smart energy harvesting system using a piezoelectric speed breaker, where pressure from passing vehicles generates electricity through piezo sensors, rectified and stored to power LEDs and streetlights.

3.3 Hardware Setup

A smart energy harvesting system using piezoelectric speed breaker involves several key hardware components as follows

COMPONENTS REQUIRED :

1. **Piezoelectric Sensor:** Piezoelectric sensors are the core energy-generating components of the system. When mechanical pressure is applied—such as from vehicles passing over the speed breaker—these sensors produce an alternating voltage due to the piezoelectric effect. This phenomenon converts the mechanical strain into electrical energy, forming the initial stage of the energy harvesting process. Their ability to operate without external power makes them ideal for sustainable energy applications in high-traffic areas.



3.3.1 Piezoelectric sensor

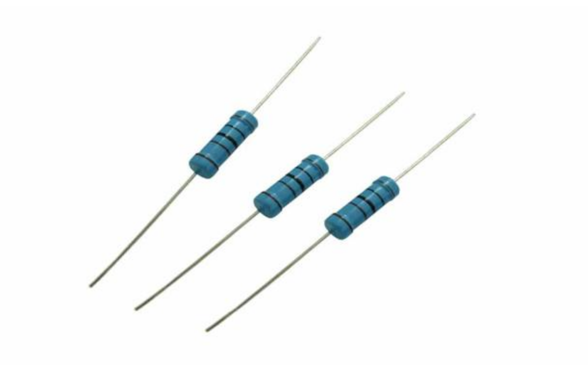
2. **Capacitor:** The capacitor plays a vital role in stabilizing and temporarily storing the electrical energy generated by the piezoelectric sensors. Since the output from the sensors can be inconsistent depending on the traffic load, the capacitor smooths these fluctuations by collecting and holding the charge. It then releases the energy in a steady manner, ensuring a continuous and regulated power supply to the load, even during brief periods without vehicular movement.

3.3.2 Capacitor

3. **LEDs:** Light Emitting Diodes (LEDs) are used in the system as a practical demonstration of the energy harvested. Once the capacitor releases stored energy, the LEDs light up, indicating successful energy generation and storage. As low-power output devices, LEDs are ideal for showcasing the working model without requiring significant power, making them effective indicators in both testing and real-world demonstration.

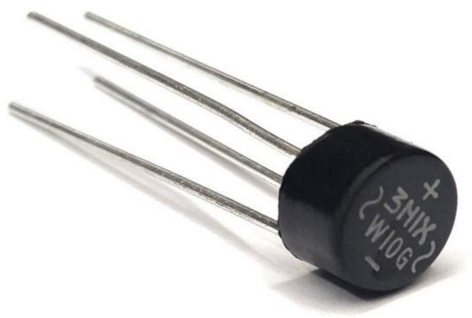
3.3.3 LEDs

4. **Resistors:** Resistors are included in the circuit to limit the amount of current flowing to the LEDs and other sensitive components. Without them, the stored energy could potentially damage the LEDs by delivering excess voltage or current. By controlling and reducing the current, resistors protect the overall circuit and ensure safe and efficient operation, extending the life of all components involved.



3.3.4 Resistors

5. **Bridge Rectifier:** The bridge rectifier converts the alternating current (AC) produced by the piezoelectric sensors into direct current (DC), which is more suitable for storage and powering DC devices like capacitors and LEDs. It typically consists of four diodes arranged in a bridge configuration, ensuring a continuous and unidirectional current flow regardless of the input polarity. This conversion is essential for the stability and usability of the harvested energy.

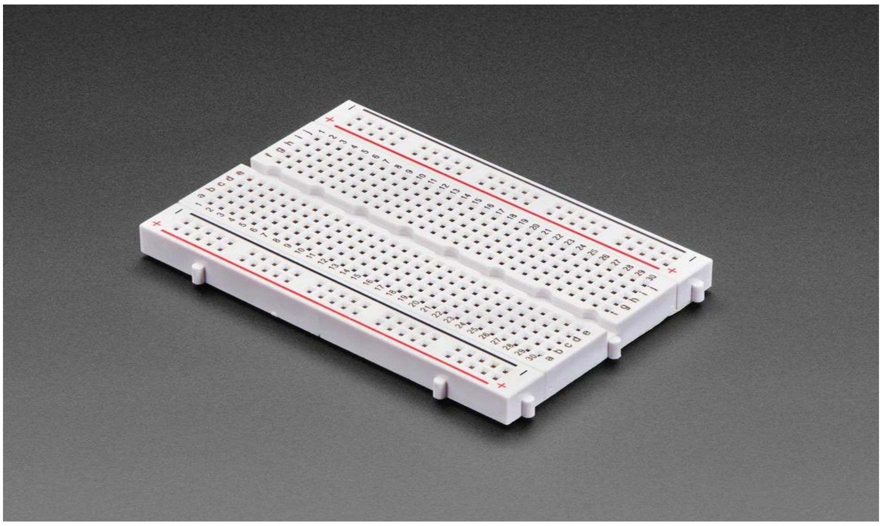


3.3.5 Bridge Rectifier

6. **Switch:** The switch acts as a manual control unit within the circuit. It allows the user to activate or deactivate the flow of electricity from the capacitor to the LEDs at will. This not only aids in testing and demonstration but also provides an extra layer of safety by letting users interrupt the circuit during maintenance or troubleshooting.

3.3.6 Switch

7. **Breadboard:** The breadboard is a reusable platform used to prototype the circuit without the need for soldering. It allows for quick assembly, easy modification, and flexible arrangement of all components during the design and testing phases. This makes it an ideal tool for experimenting with circuit configurations and ensures that changes can be made efficiently as the project evolves.



3.3.7 Breadboard

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Prototype

This shows full prototype setup showcasing the piezoelectric speed breaker system connected with capacitors, rectifier, switch, and LEDs. This layout visually demonstrates the working energy-harvesting circuit in its entirety.

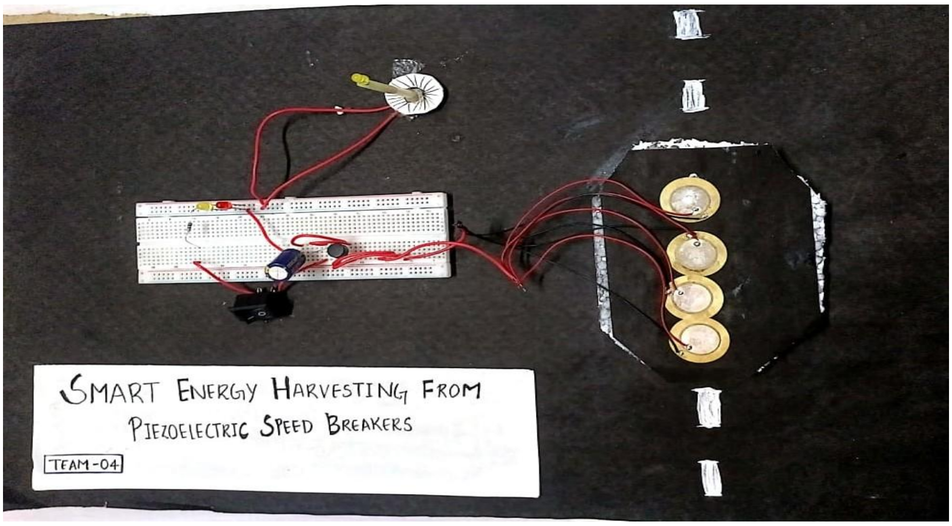


Fig. 4.1. Prototype Model Overview

4.2.1 Setting up Piezoelectric Sensors

This shows close-up view of piezoelectric sensor placement beneath the speed breaker surface. These sensors convert mechanical stress from vehicle pressure into alternating current (AC).

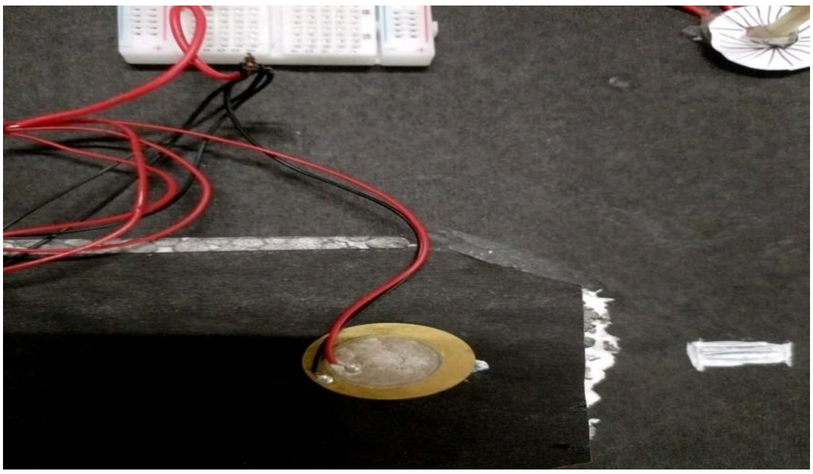


Fig.4.2.1 Close-Up of Piezoelectric Sensor Placement

4.2.2 Establishing Connections

Fig 4.2.2 shows bridge rectifier and capacitor circuit used to convert AC to DC and store the harvested energy. The capacitor helps stabilize voltage output before powering the load.

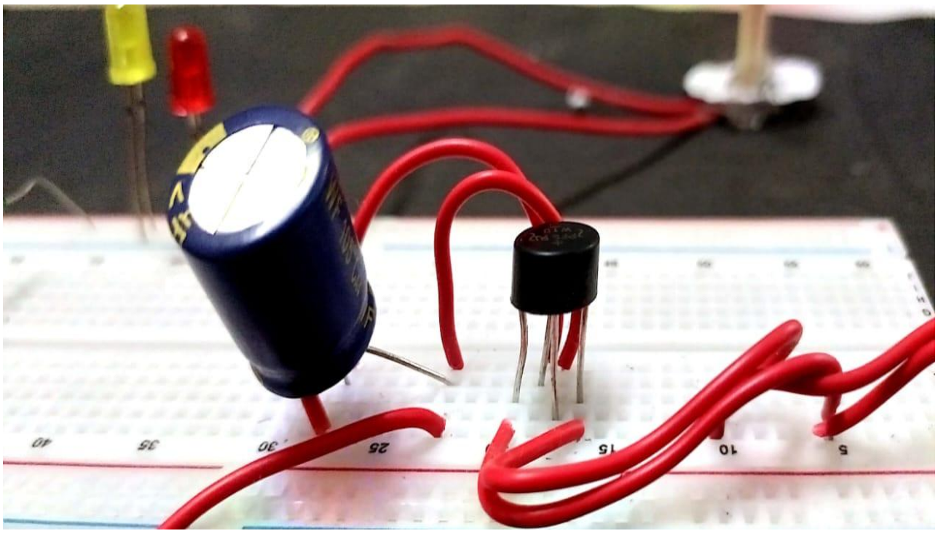


Fig 4.2.2 Bridge Rectifier & Capacitor Circuit

4.2.3 Breadboard Connection

Fig.4.2.3. shows internal circuit wiring on the breadboard integrating all major components—piezo sensors, bridge rectifier, capacitor, resistors, and LEDs. This modular layout allows flexible testing and real-time observation of energy flow and output.

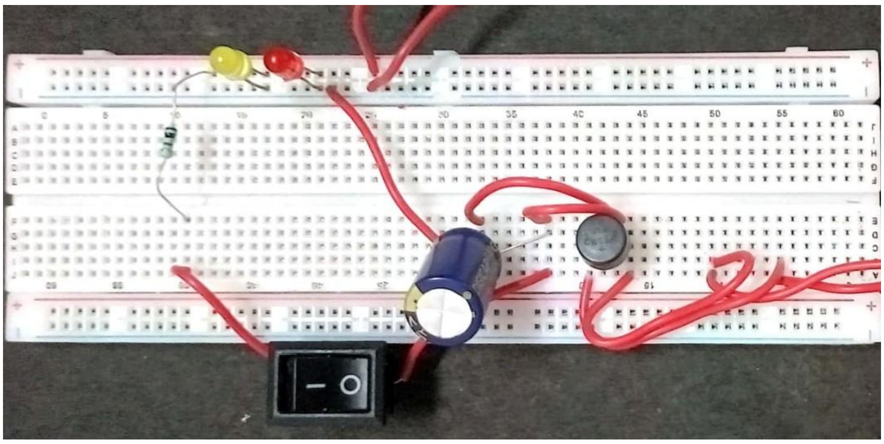


Fig. 4.2.3. Internal Circuit Connections on Breadboard

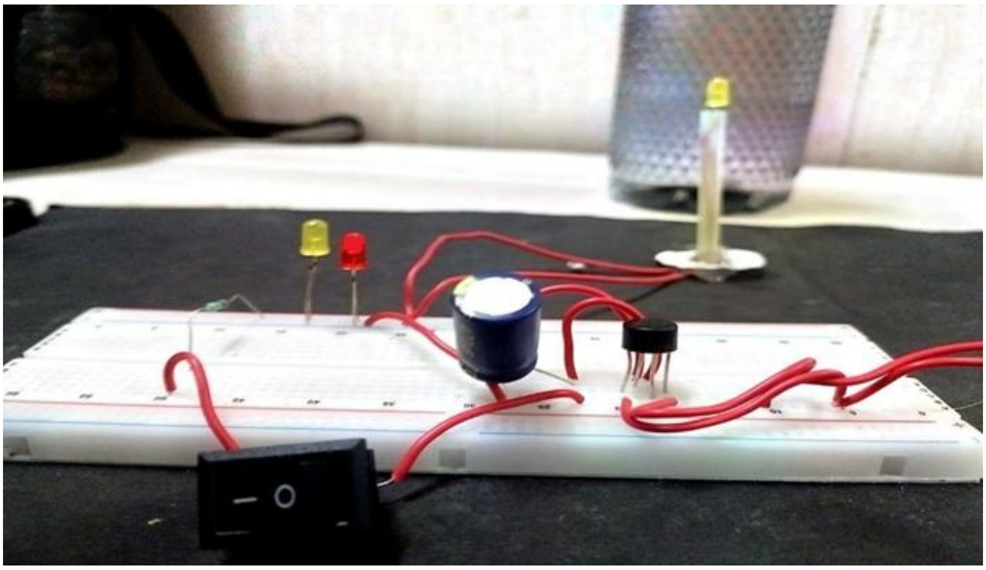
4.2.4 Load Test

Fig.4.2.4. shows load testing using multiple piezoelectric discs arranged to increase energy yield. The applied force simulates vehicular pressure, demonstrating scalability and consistent voltage output across combined sensors.

Fig. 4.2.4. Load Test with Multiple Piezo Discs

4.2.5 Output obtained

Fig.4.2.5 shows LEDs glowing as an indication of successful energy generation and storage from vehicular pressure. This confirms the effective working of the piezoelectric energy harvesting circuit



CHAPTER 5

CONCLUSION

This research focuses on an often overlooked but highly impactful area of sustainable infrastructure—energy harvesting from vehicular motion. With the growing pressure on urban power resources and rising traffic density, finding alternative, eco-friendly energy solutions has become more critical than ever. The developed system harnesses piezoelectric technology embedded within speed breakers to convert mechanical stress from moving vehicles into electrical energy. Using components like piezoelectric sensors, bridge rectifiers, capacitors, resistors, and LEDs, the prototype successfully demonstrates real-time energy generation and utilization. This low-cost, non-invasive solution offers significant advantages in terms of scalability, affordability, and simplicity, making it suitable for deployment in areas such as toll booths, parking lots, and campus roads. Throughout this project, the team gained practical experience in energy conversion, circuit design, and sustainable technology integration. While built as an academic prototype, the system shows strong potential for future expansion—such as storing the harvested energy for larger applications or integrating it with smart city infrastructure. With further refinement, this model can contribute to greener urban development and efficient energy management in high-traffic zones.

CHAPTER 6

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