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IoT Enabeled Speed Breaker Power Generation System

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ABSTRACT

The IoT-Integrated Campus Speed Breaker Power Generation System is an innovative and eco-friendly solution that transforms everyday vehicular movement into usable electrical energy. This system captures the kinetic energy produced when vehicles drive over a specially engineered mechanical speed breaker. Using mechanisms like spring-loaded or rack-and-pinion systems, the kinetic energy is converted into rotational energy, which in turn powers a DC generator or alternator to generate electricity. This electricity can either be stored in batteries or used directly to power essential campus utilities such as street lighting, charging ports, and security infrastructure. To improve monitoring and efficiency, the system incorporates Internet of Things (IoT) technology. A network of sensors collects real-time data on parameters including vehicle count, speed, pressure, energy output, and system temperature. This data is processed through a microcontroller (such as an Arduino or Raspberry Pi) and sent to a cloud platform via Wi-Fi or GSM modules. A real-time digital dashboard allows campus administrators to track energy generation, monitor traffic flow, and assess system performance remotely. Additionally, AI-powered analytics help predict maintenance needs, enhancing reliability and reducing operational downtime. This system not only promotes sustainable energy practices but also represents a smart infrastructure upgrade for educational campuses, reducing dependence on conventional energy sources like thermal and hydroelectric power.

Keywords: Kinetic Energy, Speed Breaker, Smart Infrastructure, Sustainability, Microcontroller, Real-time Monitoring.

1. INTRODUCTION

The growing demand for sustainable and cost-effective energy solutions has led to innovative approaches to power generation. The IoT-Integrated Campus Speed Breaker Power Generation System is designed to harness the kinetic energy of vehicles passing over a speed breaker and convert it into electricity. This system utilizes a mechanically operated speed breaker that, when compressed by vehicle movement, drives a generator to produce electrical power. The generated electricity can be stored in batteries or directly used to power essential campus utilities such as streetlights, charging stations, and surveillance systems. To enhance efficiency and real-time monitoring, the system incorporates Internet of Things (IoT) technology. Various sensors track vehicle count, speed, and pressure applied to the speed breaker, along with power generation levels. A microcontroller (such as an Arduino or Raspberry Pi) processes the collected data and transmits it to a cloud-based dashboard via Wi-Fi or GSM modules. This enables remote monitoring, data analysis, and predictive maintenance to ensure optimal performance and system longevity. By utilizing wasted kinetic energy, this system offers a renewable, eco-friendly, and cost-efficient alternative to conventional power sources. It helps reduce reliance on fossil fuels while promoting smart infrastructure and energy sustainability on campuses and urban areas.

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2. LITERATURE REVIEW

Patel et al. (2015) proposed a rack-and-pinion mechanism to convert the downward motion of a speed breaker into rotational energy, which was then used to generate electricity. However, the study found that friction losses and system wear reduced the efficiency of power generation.

Kumar et al. (2016) developed a spring-loaded system, where the motion of a vehicle pressing the speed breaker caused a spring to compress and release, generating power through a DC generator. The study concluded that the amount of power generated depended on the vehicle's weight and speed, but there was no efficient way to monitor or optimize the system.

Sharma et al. (2017) experimented with a roller-based mechanism, where the speed breaker contained rotating cylinders that turned when vehicles passed over them. This system showed better efficiency than previous models, but lacked data collection capabilities to measure system performance accurately.

Verma et al. (2018) explored the use of electromagnetic induction alongside mechanical speed breakers. The study proposed using magnets and coils to generate power, which resulted in higher energy conversion efficiency compared to previous models. However, the system still required frequent maintenance due to wear and tear in moving parts.

Gupta et al. (2019) introduced a hybrid system that combined mechanical speed breaker power generation with solar panels to improve energy output. The research showed that combining two renewable energy sources could make the system more sustainable and reliable for long-term use.

Das et al. (2019) analyzed the economic feasibility of speed breaker-based power generation and found that while initial installation costs were high, the long-term return on investment (ROI) was favorable, especially in high-traffic areas.

Singh et al. (2020) developed a system using Arduino-based microcontrollers to monitor power generation efficiency, system wear, and vehicle load. Data was transmitted using Wi-Fi/GSM modules to a cloud-based dashboard, allowing for remote monitoring of the system.

Raj et al. (2020) implemented pressure and speed sensors to measure the force applied by vehicles on the speed breaker. The study found that analyzing sensor data in real-time helped optimize energy output, ensuring that maximum power was extracted from each passing vehicle.

Sharma et al. (2021) introduced AI-based predictive maintenance algorithms, which used historical data to predict system failures before they occurred. The study concluded that IoT-enabled predictive maintenance significantly reduced downtime and repair costs, making the system more efficient.

Das et al. (2022) conducted a large-scale field study, installing speed breaker power generation systems in campus environments and urban roads. The research found that IoT integration significantly improved energy efficiency and that AI-based data analytics helped optimize energy storage and distribution.

Khan et al. (2022) proposed using machine learning models to predict traffic patterns and adjust the power generation mechanism accordingly. This study demonstrated that adaptive energy generation based on real-time traffic data could enhance overall efficiency.

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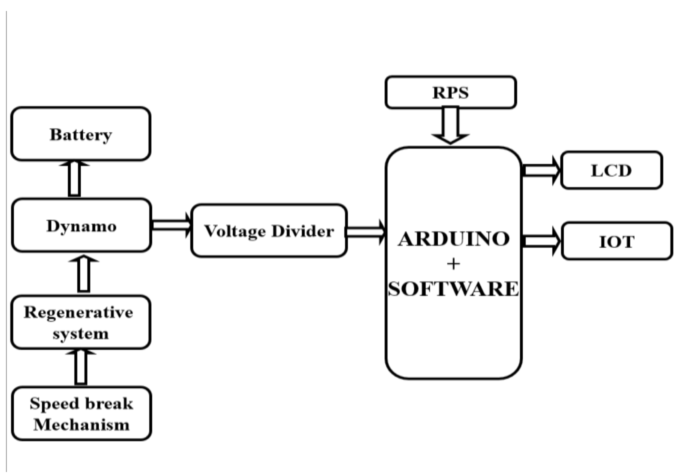
Gupta et al. (2023) focused on hybrid energy storage solutions, where generated power was distributed

3. PROPOSED SYSTEM

The proposed IoT-Integrated Campus Speed Breaker Power Generation System is designed to efficiently convert kinetic energy from vehicles into electrical power while integrating IoT technology for smart monitoring and optimization. When a vehicle moves over the speed breaker, its downward force is converted into rotational motion using a rack-and-pinion, spring-loaded, or roller-based mechanism. This rotational motion is then transferred to a DC generator or alternator, which produces electricity. The generated power is either stored in batteries for later use or immediately supplied to campus utilities like streetlights, security cameras, and charging stations. Unlike traditional power generation systems, this system optimizes power usage, minimizes energy wastage, and enhances overall efficiency.

To ensure real-time monitoring and performance tracking, the system incorporates IoT-based sensors, such as pressure sensors, speed sensors, energy meters, temperature sensors, and vibration sensors. These sensors continuously collect data on vehicle count, energy generation, system efficiency, and mechanical stress. A microcontroller (Arduino or Raspberry Pi) processes this data and transmits it via a Wi-Fi/GSM module to a cloud-based dashboard. This allows campus administrators or system operators to remotely monitor energy production, detect faults, and analyze power consumption trends in real time. By automating data collection and system tracking, the proposed system eliminates manual inspection efforts, ensuring more reliable and optimized energy generation.

The proposed system overcomes major challenges faced by traditional speed breaker power generation models, including energy losses, inconsistent power generation, and lack of real-time tracking. It promotes renewable energy adoption, reduces dependency on fossil fuels, and enhances smart infrastructure development in campuses, urban areas, and highways. With its scalable, low-maintenance, and eco-friendly design, this system offers a sustainable and intelligent energy solution that can contribute to smarter and greener cities.



ADVANTAGES:

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Renewable Energy Source: Converts wasted kinetic energy from vehicles into usable electrical power, promoting clean and green energy solutions.

IoT-Based Real-Time Monitoring: Equipped with sensors (pressure, speed, energy meters, etc.) that track system performance and power generation in real time. Data is sent to a cloud-based dashboard, allowing remote monitoring and analysis.

Predictive Maintenance with AI: Uses AI-driven analytics to predict mechanical failures and schedule preventive maintenance, reducing downtime and repair costs.

Efficient Energy Storage & Distribution: Smart energy management allows for better battery storage and direct power distribution to streetlights, surveillance systems, and charging stations. Excess energy can be fed into the smart grid, preventing wastage.

Cost-Effective & Self-Sustaining: Reduces dependency on fossil fuels and grid electricity, cutting down electricity bills. Uses existing infrastructure (speed breakers), avoiding additional space or major installation costs.

Scalable & Versatile Application: Can be implemented in campuses, highways, toll booths, parking lots, and smart cities to generate power efficiently.

Eco-Friendly & Sustainable: Helps reduce carbon footprint by utilizing an alternative renewable energy source. Reduces environmental pollution caused by conventional power plants.

APPLICATIONS:

Campus Streetlights & Security Systems: Provides electricity for streetlights, CCTV cameras, and security alarms in schools and universities. Reduces electricity costs and ensures continuous campus safety.

Smart City Infrastructure: Powers streetlights, traffic signals, and pedestrian crossings in urban areas. Helps cities reduce electricity consumption and promote renewable energy use.

Highways & Toll Booths: Generates electricity to run toll booths, barrier gates, and lighting systems. Ensures uninterrupted power supply in remote highway locations.

Parking Lots & Commercial Buildings: Provides power for parking lights, security cameras, and entry gates in malls, offices, and public parking areas. Improves energy efficiency in commercial spaces.

4. RESULTS

After the setup is ready when the force is applied on the speed breaker dome the physical force of mechanical energy is converted into electrical energy generating electricity and storing in the batteries.

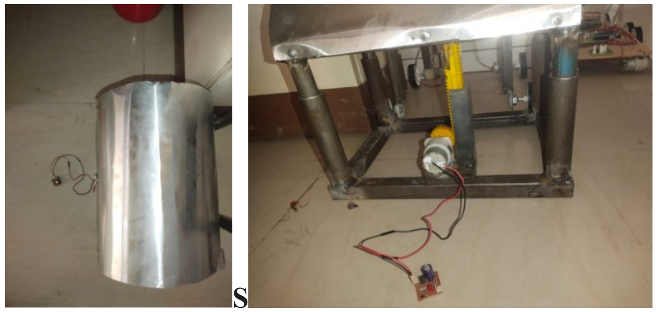

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Fig. showing the speed breaker setup with motor

This is the basic setup of speed breaker when the force exerts on the dome then it makes the pinion makes the motor move in turn generates mechanical energy into electrical energy.

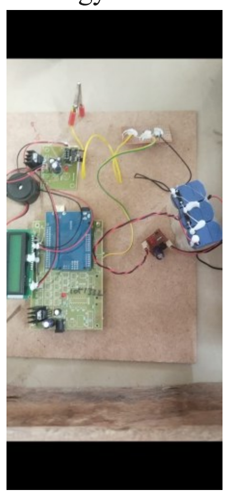

Fig. The led display and battery and the bulb is off

On idle state the bulb connected to the dome doesn’t glow, but when the pressure is exerted on the dome and the mechanism start then the energy is generated and stored in the batteries and the bulb starts to glow while the energy is generated and stored in the batteries. When there is no pressure then the bulb agains go to off state.

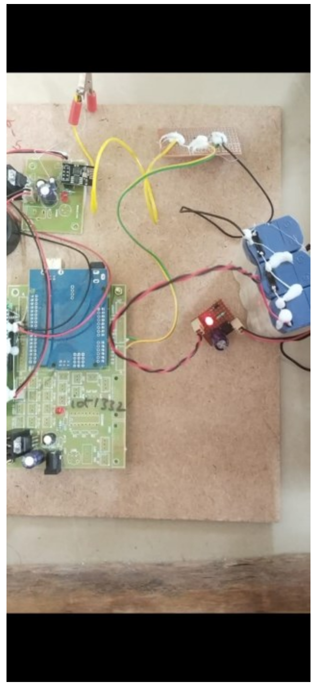

Fig. the energy is generated as aresult bulb glows

On the digital board which is connected with power supply lies the main control panel which controls everything. When the control panel is supplied with power it is turned on and shows the text on display that "Iot Speed Breaker Power Generation".

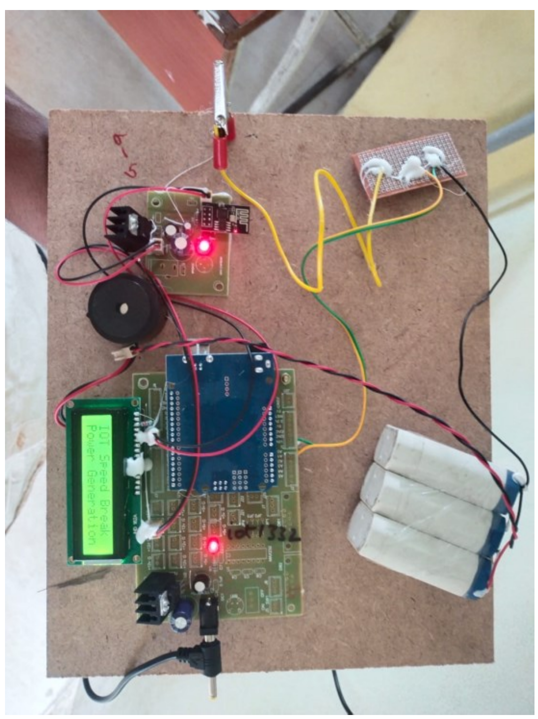

Fig when power supply the display turns on

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Then it is connected with local wifi hotspot and ready to transfer the details of the power generation through ESP8266 processor.

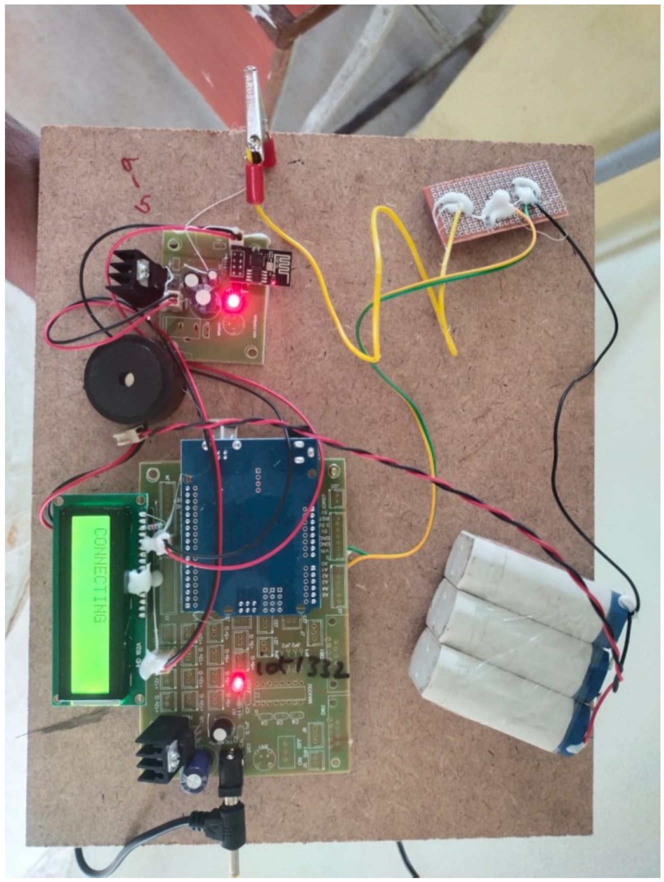

Fig display showing connecting to the wifi

After successful connection the ESP 8266 processor starts to send the generated electricity voltage details which is displayed on the led screen transfer to the web server.Here in this image the screen is showing the voltage of the battery.

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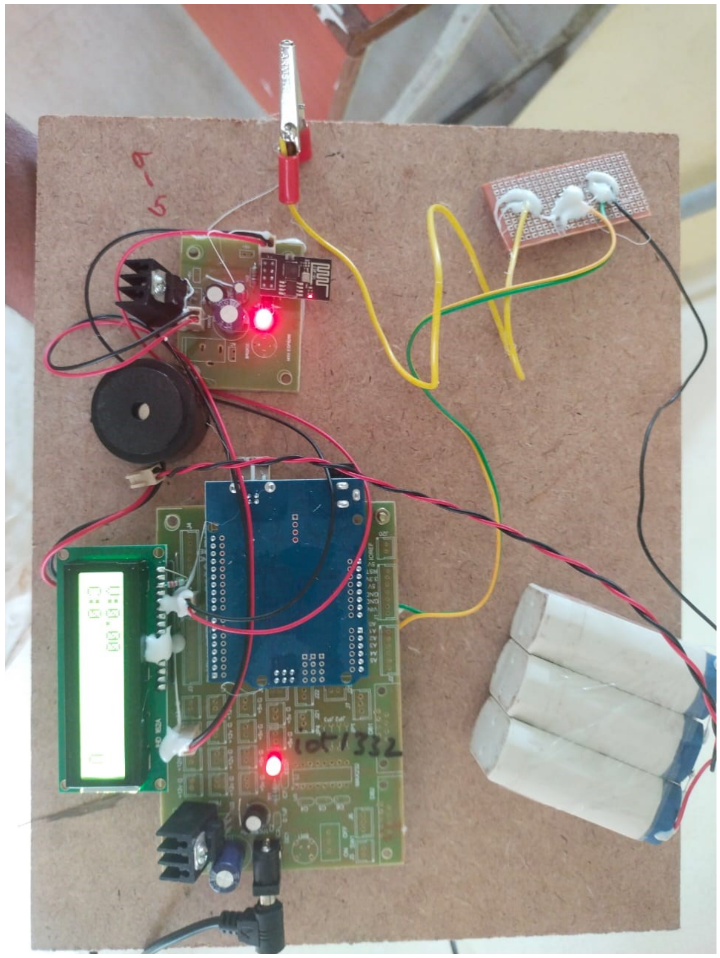

Fig Display showing the voltage of battery that is 0

After successful travel of vehicles and generation of enough electricity when you connect the battery to the main control panel via the plug then the display shows the electricity already present in the battery.

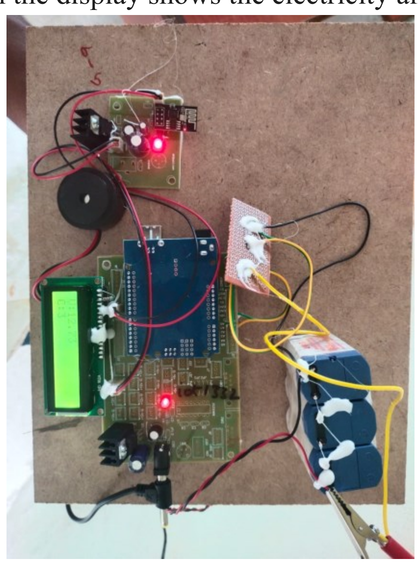

Fig the display shows the voltage in battery i.e 12v

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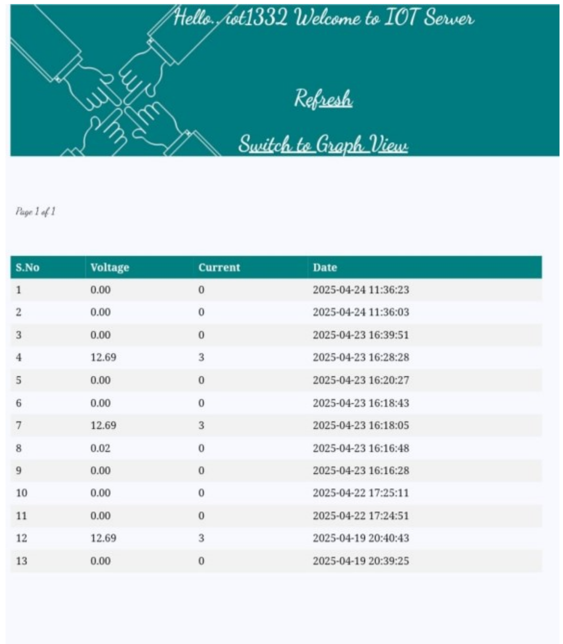
All these results which display has shown can be retrieved by using iot server as ESP 8266 sends all the data generated here through wifi to the server which can be acessed at any time by the user.



S.No	Voltage	Current	Date
1	0.00	0	2025-04-24 11:36:23
2	0.00	0	2025-04-24 11:36:03
3	0.00	0	2025-04-23 16:39:51
4	12.69	3	2025-04-23 16:28:28
5	0.00	0	2025-04-23 16:20:27
6	0.00	0	2025-04-23 16:18:43
7	12.69	3	2025-04-23 16:18:05
8	0.02	0	2025-04-23 16:16:48
9	0.00	0	2025-04-23 16:16:28
10	0.00	0	2025-04-22 17:25:11
11	0.00	0	2025-04-22 17:24:51
12	12.69	3	2025-04-19 20:40:43
13	0.00	0	2025-04-19 20:39:25

Fig. showing the values generated by speed breaker

In this way the Iot integrated speed breaker power generation equipment not only generates the electricity from mechanical energy and gives the user the advantage to track the electricity generation through the web server and ESP module and can be retrieved anywhere within the fraction of seconds. also this setup has a buzzer which gives us an alert when the electricity voltage in the battery goes to null giving the alert to the user.

5. CONCLUSION

The speed break power generator project demonstrates an innovative approach to harnessing kinetic energy from moving vehicles and converting it into usable electrical power. By utilizing a mechanical system integrated with a speed breaker, the setup efficiently captures energy generated by vehicle motion and transforms it into electricity through a dynamo or alternator. This renewable energy solution offers a sustainable way to power streetlights, traffic signals, or nearby infrastructure while promoting energy conservation. The system is cost-effective, environmentally friendly, and requires minimal maintenance, making it a viable addition to smart city initiatives. Its implementation contributes to reducing reliance on conventional energy sources and enhances energy efficiency in urban and rural areas.

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