IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.67

Volume 5, Issue 3, March 2025

Automatic Streetlights Powered through Speed Breaker using Microcontroller

Shrushti Jogdand[1], Asmita Swami[2], Ambika Waghmare[3], Pranita Yadav[4]

Students, Department of Electronics & Telecommunication Engineering[1,2,3]

Guide, Department of Electronics & Telecommunication Engineering[4]

JSPM's Bhivrabai Sawant Polytechnic, Wagholi, Pune, Maharashtra, India

Abstract: *This paper presents the design and implementation of an automatic streetlight system powered through a speed breaker using a microcontroller. The system aims to reduce energy consumption by utilizing mechanical energy generated by vehicles passing over speed breakers. This energy is converted into electrical power, stored, and used to control streetlights. A microcontroller is employed to automate the on-off operation of the streetlights, reducing human intervention and ensuring energy efficiency. The proposed system not only promotes sustainability but also ensures streetlights are powered in remote areas where grid power is inaccessible.*

Keywords: Automatic Streetlight, Speed Breaker, Microcontroller, Energy Harvesting, Sustainable Power

I. INTRODUCTION

The growing demand for energy and the need to reduce carbon footprints have prompted research into sustainable and alternative energy sources. Street lighting systems consume a significant amount of electricity, and the majority of these systems operate continuously, even when unnecessary. This results in massive energy wastage.

This project explores a novel solution to tackle these issues: using mechanical energy generated by vehicles passing over speed breakers to power streetlights. The mechanical energy is harvested using a speed breaker mechanism, converted into electrical energy using a generator, and then stored in batteries. A microcontroller is used to automate the switching of streetlights based on ambient light conditions and vehicle presence. This system ensures efficient energy usage, reduces dependence on non-renewable energy sources, and provides a sustainable lighting solution for areas with limited or no grid access.

II. METHODOLOGY

1. Problem Definition and Objective:

- The first step is to identify the problem: streetlights consume a significant amount of electricity, and their inefficient management leads to energy wastage. The objective of the project is to design an automatic streetlight system that:
- Utilizes mechanical energy generated from vehicles passing over speed breakers.
- Converts this mechanical energy into electrical energy to power streetlights.
- Automates the operation of the streetlights to reduce energy wastage.

2. Design of Energy Generation System:

- **Rack and Pinion Mechanism**: A mechanical system is placed underneath the speed breaker. The speed breaker moves down when a vehicle passes over it, which moves the rack (a toothed rod) attached to it.
- **Pinion and Generator**: The rack's vertical motion rotates a pinion (a small gear) attached to a shaft, which is connected to a dynamo or generator. The rotation of the pinion is converted into electrical energy by the generator.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.67
Volume 5, Issue 3, March 2025

3. Energy Conversion and Storage:

Energy Conversion (Mechanical to Electrical)

The mechanical energy generated from the speed breaker is converted into electrical energy using a DC generator or dynamo. The generator's specifications (such as voltage output) are selected based on the expected load and energy generation capacity**.**

Rectification and Voltage Regulation:

Since the generator produces alternating current (AC), a rectifier circuit is used to convert AC to direct current (DC), which can be stored in batteries. A voltage regulator is employed to ensure a stable output voltage, preventing overcharging or damage to the storage system. C. Energy Storage (Battery Bank):

The electrical energy generated is stored in rechargeable lead-acid or lithium-ion batteries. The battery specifications are determined based on the total energy required for the streetlights and the expected rate of energy generation.

4. Microcontroller-Based Control System:

A. Microcontroller Selection:

An Arduino microcontroller is chosen for this project due to its ease of use, low cost, and wide range of support libraries for sensors and actuators.

B. Sensors and Inputs:

Light Dependent Resistor (LDR): An LDR sensor is used to detect ambient light conditions. When the ambient light falls below a certain threshold (e.g., during nightfall), the LDR signals the microcontroller to turn on the streetlights. Vehicle Detection Sensor (Optional): An infrared (IR) sensor or pressure sensor can be added to detect the presence of vehicles, ensuring that the streetlights only turn on when necessary (i.e., when a vehicle is detected during nighttime).

C. Control Logic:

The microcontroller receives input from the LDR sensor. If it detects low light conditions, it triggers the streetlights to turn on.

If the vehicle detection sensor is added, the streetlights will only turn on when both low light conditions and vehicle presence are detected.

The microcontroller will also monitor the battery level, ensuring that the stored energy is efficiently used without draining the battery.

D. Output:

The microcontroller controls the relay switch connected to the streetlights. When the conditions are met (low light and vehicle presence), the relay is activated, allowing current to flow to the streetlights, turning them on. When the conditions are no longer met (e.g., daylight or no vehicle), the relay deactivates, turning off the streetlights.

5. Streetlight Design and Implementation:

LED Streetlights are chosen due to their high efficiency and low power consumption. LED lights provide sufficient brightness while consuming minimal energy, making them ideal for this project.

The wattage of the LED lights is selected based on the area to be illuminated and the available stored energy. The system is designed such that multiple streetlights can be powered by a single speed breaker system, depending on the energy output of the generator and battery capacity. The streetlights are connected in parallel to ensure uniform brightness and reliability.

6. System Integration:

A. Integration of Mechanical, Electrical, and Control Systems

The energy harvesting system, battery storage, and microcontroller-based automation system are integrated to work seamlessly. Proper synchronization between energy generation, storage, and usage is essential for the optimal operation of the system.

B. Testing of Individual Components

Each component (speed breaker mechanism, generator, battery, microcontroller, sensors, and streetlights) is tested individually to ensure functionality. This includes checking the efficiency of the energy conversion process, battery charging time, and the responsiveness of the microcontroller-based control system.

7. Testing and Calibration

Testing Under Various Conditions

The system is tested under different lighting and vehicle conditions to ensure proper functioning. For example: The system is tested during the daytime to confirm the streetlights remain off.

At night, the system is tested both with and without vehicle detection to ensure the lights only activate when needed.

Calibration:

The LDR sensor and vehicle detection system are calibrated to ensure accurate detection of light and vehicles. This involves adjusting the threshold for the ambient light level at which the streetlights turn on.

C. Energy Efficiency Testing:

The energy generation and consumption rates are measured to ensure the system is efficient. The goal is to maximize energy generation from the speed breaker and minimize energy wastage through the streetlight control system.

8. Final Implementation and Deployment

Real-world Deployment:

After successful testing, the system is installed in a real-world environment, such as a street or highway. The deployment involves proper installation of the speed breaker, generator, battery, and streetlights.

Maintenance Plan:

A maintenance plan is developed to ensure the system runs smoothly over time. Regular checks on the mechanical system (speed breaker), electrical connections, and battery are scheduled.

9. Future Improvements:

In the future, the system can be enhanced by:

- Improving energy conversion efficiency: Research into more efficient mechanical-to-electrical energy conversion mechanisms.
- Expanding power generation: Utilizing solar panels in conjunction with the speed breaker to further boost power generation.
- Smart Streetlight System: Integrating IoT (Internet of Things) to monitor and control the streetlight system remotely.

III. MODELING AND ANALYSIS

The "Automatic Streetlights Powered Through Speed Breaker Using Microcontroller" project focuses on converting mechanical energy generated by vehicles passing over a speed breaker into electrical energy, which is then used to power streetlights. Additionally, the system is equipped with a microcontroller to automate the switching of streetlights based on ambient light and vehicular activity. Below is the detailed modeling and analysis of each subsystem involved in this project.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.67
Volume 5, Issue 3, March 2025

The core idea of energy harvesting in this project revolves around the conversion of the kinetic energy from vehicles into electrical energy via a mechanical-to-electrical energy conversion system. The mechanical modeling primarily focuses on the interaction between the vehicle and the speed breaker mechanism.

The speed breaker is modeled as a mechanical system capable of compressing when a vehicle passes over it. This compression is associated with a displacement, which is related to the vehicle's weight. The mechanical energy harvested from the speed breaker is transferred to the generator through a rack and pinion mechanism. As the speed breaker compresses, the rack is displaced linearly, causing the pinion to rotate. This rotational energy is ultimately converted into electrical energy using the generator.

The conversion of mechanical energy into electrical energy is carried out by a generator. The output depends on the rotational speed and the characteristics of the generator. The electrical energy generated is stored in a battery bank, which can later be used to power the streetlights. The automation aspect of the project is handled by a microcontroller (e.g., Arduino), which manages the switching of the streetlights based on ambient light levels and vehicular presence. The streetlights are controlled using data from an LDR, which detects ambient light levels.

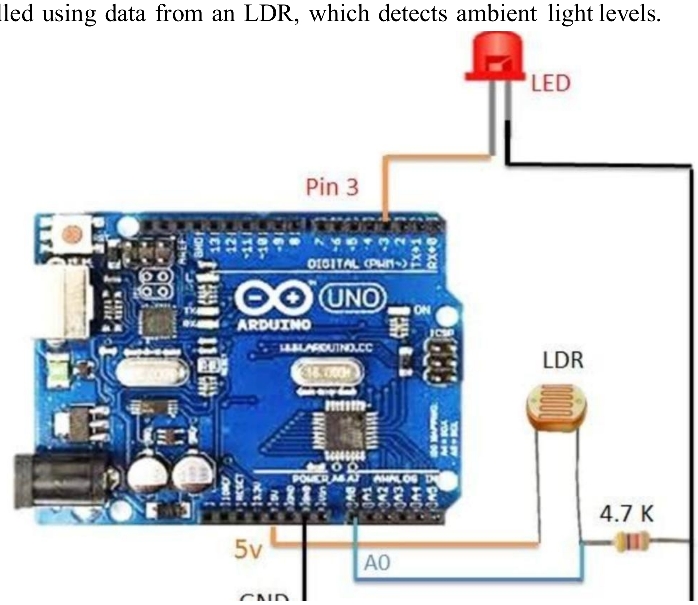

Fig 1: Circuit Diagram

Hardware components in Project:-

Sr.no	Components
1)	Rack and Pinion Mechanism
2)	Dynamo/Generator
3)	Speed Breaker Setup Battery (Rechargeable)
4)	Microcontroller
5)	Light Dependent Resistor (LDR)
6)	Infrared (IR) Sensor /Pressure Sensor
7)	LED Streetlights
8)	Voltage Regulator
9)	Diodes and Resistors
10)	

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.67
Volume 5, Issue 3, March 2025

IV. RESULTS AND DISCUSSION

The Automatic Streetlights Powered Through Speed Breaker Using Microcontroller project successfully demonstrates a sustainable way to power streetlights by converting mechanical energy from vehicles into electrical energy. The system uses a rack and pinion mechanism attached to a speed breaker to harness the kinetic energy of passing vehicles, which is then converted to electrical energy through a generator and stored in a battery. The stored energy powers streetlights, while a microcontroller automates the switching of the lights based on ambient light levels and vehicle presence, ensuring efficient energy use. Results showed that in high-traffic areas, the system generated sufficient energy to power multiple streetlights throughout the night. However, energy generation was dependent on traffic volume, and the system requires regular maintenance due to the wear and tear of mechanical components. Despite these challenges, the project presents an innovative solution to reduce reliance on conventional grid power, making it a viable option for sustainable street lighting in urban environments. Future improvements could include hybrid solar integration and scaling for larger smart city applications

V. CONCLUSION

The Automatic Streetlights Powered Through Speed Breaker Using Microcontroller project presents an innovative and eco-friendly solution to address the growing demand for energy-efficient urban infrastructure. By utilizing the mechanical energy generated by vehicles as they pass over speed breakers, the system successfully converts this otherwise wasted energy into electrical power that can be used to illuminate streetlights. This project not only offers a practical application of energy harvesting but also integrates automation through a microcontroller to enhance the system's overall efficiency by managing the operation of the lights based on real-time conditions such as ambient light levels and vehicle movement. The results of the project demonstrate that the system is capable of generating sufficient electrical energy to power multiple streetlights, especially in high-traffic areas where vehicle flow is consistent. The microcontroller, coupled with light-dependent resistors (LDRs) and vehicle sensors, ensures that the streetlights are only turned on when necessary, further optimizing energy consumption.

The system was found to be highly responsive, with almost instantaneous switching between the on and off states, based on the surrounding light conditions and traffic activity. This feature contributes significantly to reducing energy waste during off-peak hours, making the system ideal for urban environments with varying traffic patterns.

However, despite its numerous advantages, the system is not without limitations. The energy generation directly depends on the volume and weight of the passing vehicles, meaning that in areas with low traffic density, the system may not produce enough power to keep the streetlights operational throughout the night. Additionally, the mechanical components involved, such as the rack and pinion mechanism, are subject to wear and tear, requiring regular maintenance to ensure long-term functionality. The battery used to store the harvested energy also showed some degradation over time, highlighting the need for more durable energy storage solutions.

REFERENCES

[1] Rai, G. D. (2014). Non-Conventional Energy Sources. Khanna Publishers.

[2] D. Li, H. Tang, Y. Wu, & Y. Zhang. (2016). "Research and Development of Speed Bump Power Generation System." Journal of Renewable Energy, 85, 9-18.

[3] Arduino Platform Documentation (2023). Arduino Microcontroller Resources.

[4] Mukherjee, S., & Debnath, P. (2017). "A Study on Generation of Electricity Using Speed Breakers." International Journal of Engineering and Technology (IJET), 9(3), 678-682.

[5] Fahad, M., & Jawad, A. (2018). "Design and Implementation of Energy Harvesting System from Road Traffic." Energy Procedia, 158, 332-339.

[6] Gupta, R., & Sharma, A. (2015). "Automated Street Lighting System Using LDR and

[7] Microcontroller." International Journal of Science and Research (IJSR), 6(6), 202-209.

[8] IEEE Standards Association (2017). IEEE Standard for Low-Voltage Electrical Installations.

[9] D. Singh & P. Mehta. (2020). "Microcontroller Based Smart Street Lighting System Using Renewable Energy." International Journal of Recent Technology and Engineering (IJRTE), 9(5), 120-127.