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(Telangana State Private Universities Act No. 13 of 2020 and G.O.Ms.No.14, Higher Education (UE) Department)
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IoT-Enabled Street lighting System Using Piezoelectric Energy Harvesting

Introduction:

The rapid growth of urbanization has led to increased demand for energy-efficient solutions in public infrastructure. Streetlighting, a vital aspect of urban environments, consumes a significant amount of electricity, contributing to higher operational costs and environmental impact. This project introduces an IoT-enabled streetlighting system powered by piezoelectric energy harvesting. Piezoelectric materials have the unique ability to convert mechanical stress, such as vibrations from passing vehicles and pedestrians, into electrical energy. By strategically placing piezoelectric sensors on road surfaces, we can harness energy from daily traffic and foot movements. This energy is then used to power streetlights, significantly reducing reliance on traditional electricity grid.The system employs Arduino microcontrollers for managing and controlling energy flow, ensuring that the energy generated is stored and distributed effectively. The integration of IoT technology enables remote monitoring and management of the streetlight system, making it more efficient and adaptable. Through light and motion sensors, the streetlights can automatically adjust to environmental conditions, such as turning on when it gets dark or when motion is detected.

Objective:

The primary objective of this project is to develop an energy-efficient and sustainable streetlighting system by integrating IoT technology with piezoelectric energy harvesting. This system aims to reduce dependence on the conventional electricity grid by utilizing the mechanical stress generated from vehicular and pedestrian movement to power streetlights. Additionally, it seeks to lower operational costs and minimize environmental impact by leveraging renewable energy sources. The implementation of Arduino microcontrollers ensures efficient energy management, storage, and distribution, optimizing power utilization. Furthermore, the integration of IoT technology enhances remote monitoring and control, allowing for real-time adjustments based on environmental conditions. Through the use of light and motion sensors, the system ensures intelligent lighting by activating streetlights only when needed, there by promoting energy conservation and improving urban infrastructure efficiency. By integrating smart automation and renewable energy, the system contributes to the development of technologically advanced urban infrastructure. Ultimately, this innovation aligns with global efforts to promote green energy solutions and smart city initiatives.

Analysics:

The IoT-enabled piezoelectric street lighting system operates by harnessing energy from pedestrian and vehicular movement using piezoelectric sensors embedded in road surfaces. When pressure is applied, the sensors generate electrical energy, which is then converted from AC to DC using a bridge rectifier and stored in a rechargeable battery or supercapacitor. An Arduino microcontroller monitors the stored energy levels and controls the streetlight operation based on sensor inputs. A lightdependent resistor (LDR) detects ambient light conditions, ensuring that the streetlights turn ONs only when required, conserving energy. This project provides a sustainable, smart, and energy-efficient solution for urban street lighting, reducing power wastage while enhancing automation in smart cities. The analysis of this project focuses on evaluating the feasibility, efficiency, and impact of the IoT-enabled streetlighting system powered by piezoelectric energy harvesting. The system's performance is assessed based on energy generation. By analyzing traffic density and pedestrian movement, the project determines the optimal placement of piezoelectric sensors to maximize energy harvesting. Additionally, the integration of IoT technology is examined to ensure seamless remote monitoring, adaptive lighting control, and real-time data analysis for improved system efficiency.

Methodology:

The design methodology of the IoT-Enabled Street lighting System Using Piezo electric Energy Harvesting starts with system architecture design, such as the location of piezoelectric modules, smart streetlights, and IoT controllers. The appropriate piezo electric sensors are chosen to effectively transform mechanical vibrations from traffic or pedestrians into electrical energy, which is stored in batteries or super capacitors to be used later. Hardware development phase is where the piezoelectric energy harvesting system, smart streetlights with LED lights and motion sensors, and energy storage coupled with power management units are installed. Upon deployment, the system is connected to real-time monitoring, data analysis, and remote control, maximizing energy usage, streetlight operation, and system performance. The system also integrates IoT-enabled sensors for remote monitoring, motion detection, and adaptive lighting control. The next step involves strategically placing piezoelectric sensors on road surfaces to maximize energy harvesting from vehicular and pedestrian movement. Different sensor placements are tested to determine optimal energy generation efficiency. The harvested energy is then stored in rechargeable batteries, ensuring a continuous power supply for streetlights. An intelligent energy management system is developed to distribute stored energy efficiently based on real-time demand. IoT technology is integrated to enable remote monitoring, data analysis, and automated adjustments for improved system performance. The system undergoes testing and evaluation to measure its efficiency, energy savings, and overall effectiveness compared to conventional streetlighting solutions.

Results:

Fig 1 : LCD Display

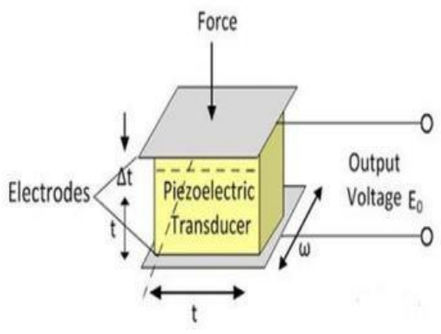

Fig 2 : Pizeo electric function

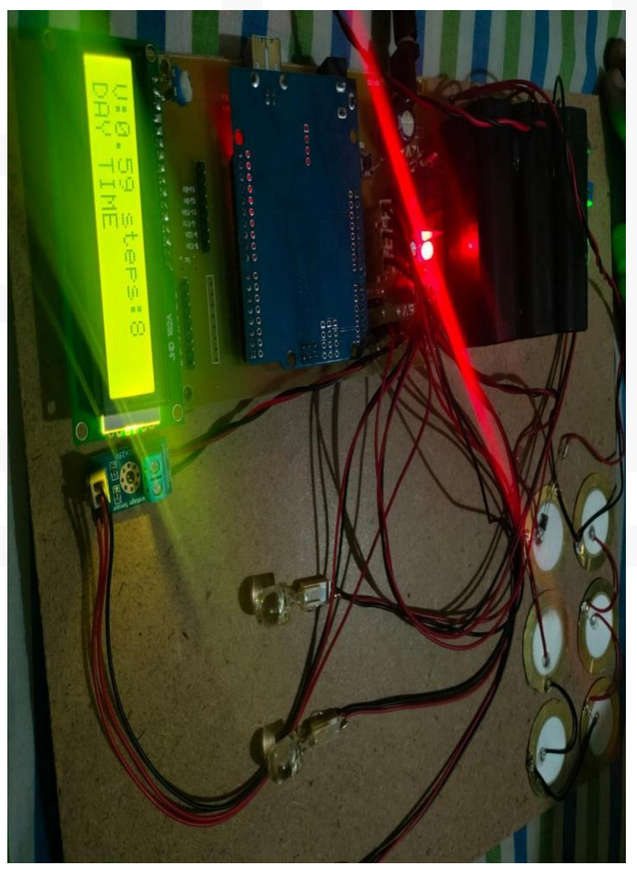

Fig 3 : Proto Type

The IoT-enabled piezoelectric street lighting system successfully demonstrates an energy efficient and smart lighting solution by utilizing piezoelectric energy harvesting and Arduino based control mechanisms. The system was tested under various conditions to evaluate its performance in terms of energy generation, lighting automation, and IoT integration. During testing, the piezo electric sensors effectively converted mechanical pressure from foot traffic and vehicle movement into electrical energy. The generated energy was rectified, regulated, and stored in a battery or supercapacitor, providing a stable power source for the street lights.The LDR sensor ensured that the streetlights turned ON automatically in lowlight condition. It is an ideal solution for smart cities, promoting green energy adoption and efficient urban infrastructure management.

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