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Smart Street Lighting that Monitors Air Quality to Save Energy

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ABSTRACT: During the night time, all the street lights will be on. So, the consumption of energy is higher. To overcome this issue, a solid energy-saving plan must be created along with lighting control. The proposed work will have two controls: one that will turn off the lights when there are no vehicles on the street and turn them back on when there are, and another that will provide pedestrians with lower-intensity light while turning on the bright mode when there are vehicles on the side of the road. In this work, the street layout is done with LED lights, and vehicle moments are detected with air quality and ultrasonic sensors. The control logic is implemented in the microcontroller to regulate lights based on vehicles and pedestrians with bright and dim modes of operation and to turn off lights when there are no vehicles or pedestrians. The suggested solution can reduce the amount of energy currently used for illumination. Due to the expansion of cities and an increase in the standard of living, automatic and intelligent management systems are also necessary to manage complex lighting systems. In addition, we measure the air quality to determine how much of the air is polluted at the roadside.

Keywords: ArduinoUNO, Sensors, Street lights

I. INTRODUCTION

As technology advances, the term "smart city" has grown more and more popular. Due to the quick industrialization, rapid urbanization, increasing population, and sudden increase in traffic on roadways, the air quality has increased, causing health hazards and other issues. Just like other areas of city life, street lighting is changing to keep up with the fast modernization of urban centers. Traditional streetlights, like high-pressure sodium (HPS) lamps, normally operate at a constant brightness level until the power is turned off.

The cost of resources (such as gasoline and labor) and system maintenance consequently rises as a result. Moreover, a lot of people have complained that some streetlights don't work and others beam excessively brightly during the day. A solid-state lighting system (SSLS) using LED streetlights is suggested as a solution to these problems. By providing real-time air quality monitoring and enabling authorities to take corrective action when the air quality index exceeds safe levels, this system will improve system dependability, reduce maintenance issues, and raise system reliability.

Keeping the lights on at full power throughout the night not only increases the lifespan of the lights but also reduces the load on the electrical system. This suggests that there will be hopeful future progress in this field, which will improve city smartness [1]. Offers a traffic-adaptive intelligent LED street lighting system, which is one of the works taken into consideration. A smart network LED street lighting system with features that increase vehicle visibility and decrease the probability of accidents was shown [2]. A system that would alert a maintenance worker if the light was stolen and alter the brightness of a smart street lamp based on the number of people in the area was presented [3]. Piezoelectric transducers were used to transform mechanical energy from rolling train wheels into electrical power [4]. Light-dependent resistors (LDR) and ultrasonic sensors were used to automatically control streetlights in response to daylight, with intensity varying from 100% to 60% depending on the presence of vehicles or people [5]. creates another suggestion for a smart street lighting system, suggesting the use of LDR sensors to regulate the streetlights' on/off status and closed-circuit television (CCTV)

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cameras to remain on the lookout for any incidents [6].

The lights would be activated by the presence of cars that were switched on or off, but regardless of how much traffic was there, the light intensity would not change [7]. An energy-saving solution that replaces high-intensity discharge (HID) streetlights with light- emitting diodes (LEDs) has been proposed. The ultrasonic sensor is used to automatically monitor and control the LEDs. Although this idea depended on an air monitoring sensor-based weather adaptive strategy to monitor and manage the ON/OFF status of streetlights based on cars' frequency at various times of the night, it did not propose a specific energy generation system for streetlights.

A technique called pulse width modulation (PWM) has been published [8] for altering a light's brightness depending on a variety of variables, such as the time of day and the presence or absence of vehicles.

[9] Developed a way for controlling and monitoring streetlights in real-time that used solar power and a wireless network to achieve the internet idea. An air quality monitoring sensor-based approach to air pollution monitoring and forecasting was developed, which uses the current trend of pollution levels to predict the future trend of air quality [10]. Also, employing a variety of environmental factors that influence air pollution, such as daily mean temperature, air pressure, etc., an artificial learning model was developed for air pollution forecasting [11].

An affordable system for monitoring air quality is given that uses population detection, where the air quality index data gathered from multiple sensors is uploaded to the cloud via an Android app [12]. There isn't much information available that addresses the problem of online monitoring and controlling of streetlights and city air quality, along with the detection of faulty streetlights, while also generating energy through the integration of solar panels and piezoelectric transducers, as far as I could tell from my review of the literature. The following are some of the primary outcomes of this work: Streetlights are intelligently controlled at four distinct intensities (i.e., 50%, 40%, 30%, and 20%) in the absence of a vehicle or person, while maintaining their intensity at 100% in the presence of the vehicle at night, using light-detection and response (LDR) and ultrasonic sensors.

LED streetlights can save up to 84 percent of their energy use using sensors. Moreover, air quality sensors can be installed in every sixth streetlight so that city officials can monitor pollution levels. Due to its independence from the power grid, it has cheap operating and maintenance expenses and requires less maintenance because there are no moving parts. The following format will be followed throughout this essay: We go into more depth on the proposed SSLS in Section II. The third section explains how electricity can be produced by piezoelectric transducers. We'll discuss the system's structure and layout in Section IV. The final section includes discussions and results. The sixth segment contains the conclusion.

II. LITERATURE SURVEY:

a) Low-Power, Traffic-Adaptive Street Lighting Control

Finding strategies to reduce the amount of power used by indoor and outdoor lighting is difficult. A potential solution to the issue of excessive light emission from outside buildings is the smart regulation of public lighting. With the help of "smart lighting," which employs electronically controlled light-emitting diode (LED) lamps for adjustable illumination and monitoring, lighting systems are becoming more energy efficient. Smart control combined with traffic control, however, has not been utilized much for power management.

In this study, we introduce a novel traffic flow-based strategy for energy-efficient smart (LED) street lighting. In order to provide optimum energy efficiency in reaction to adaptive traffic on the road, the proposed system is built on a smart grid design and uses a low-power wireless mesh network. The flexible wireless network of smart LED lighting offers advantages such as improved reliability, decreased expenses, and contented clients. The deployment and testing of the suggested system in a practical environment on a university campus served to confirm its efficiency. Taking into consideration seasonal variations in daylight hours, the experimental findings demonstrate that our system may cut energy usage by 68% to 82% when compared to traditional metal halide lighting. Smart control has improved system reliability, decreased maintenance requirements, and reduced greenhouse gas emissions—all positive indicators for future widespread adoption.

b) Planning a web-based management system for smart LED streetlights.

The smart LED streetlight system is one of the technologies required to build a smart city; it may offer low-cost, low-power outdoor lighting that is advantageous for both drivers and pedestrians. The combination of sensors and ZigBee-based wireless sensor modules can offer

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the best infrastructure for a modern LED streetlight application. Several psychological studies have shown that only altering the environment's color temperature can significantly change a person's circadian rhythm. As a result, illumination based on correlated color temperature (CCT) offers noteworthy lighting performance in terms of energy savings and reduces the likelihood of traffic accidents in low-visibility locations.

When developing smart LED streetlights in the past, researchers have only considered one platform and neglected CCT-based lighting. In this research, we consider the importance of CCT-based lighting and suggest a novel integration of public weather data awareness, ZigBee-based wireless communication, and a dynamic internet management system for the most advanced smart LED streetlight systems suitable for smart cities. Our work focuses on developing a centrally managed web server that can collect weather information as well as real-time sensor data from all LED streetlights, providing authorized users with a dynamic and flexible web interface. Also, the wireless communication range and signal quality between each LED streetlight are met since the transmissionreception characteristics of the suggested system, such as throughout and signal intensity, are implemented in real-time.

III. PROPOSED SYSTEM

Existing system:

With the advancement of technology, the term "smart city" has grown increasingly popular. Due to rapid industrialization, rapid urbanization, quick population expansion, and a sharp rise in vehicle traffic, the air quality has grown worse, creating health hazards and other problems. Just like other areas of city life, street lighting is changing to keep up with the fast modernization of urban centers. High-pressure sodium (HPS) lamps, a common type of classic streetlight, normally operate at a steady brightness level until the power is turned off. As a result, the price of resources (such as labor and fuel) and the cost of maintaining the system both rise.

The existing system street light systems are automatically ON and OFF according to the situation. This smart light system automatically detects the movements of objects on the street. In the traditional system, IR sensor is used to detect the object. The microcontroller is used to control the process involving the net. This project is focused on the controlling intensity of the light considering the object movement near the light.

Two different sensors named light sensor and photoelectric sensor are used. Once the sunlight goes under the visible region, then this system automatically switches ON light [13]. As soon as the sunlight is visible then automatically switches OFF the lights.

Proposed system:

This paper detects the movement of vehicles on highways or roads, turning on the lights when the vehicle is in front of them and turning them off when it moves past them. It allows us to conserve energy. There is a significant energy loss when there are no moving vehicles because all the lights on the highway turn on at night. This paper offers a way to conserve electricity [14]. All of the lights will turn off if there are no vehicles on the road. It achieves by using this system. The LDR sensor won't provide an output signal in the morning, when the street lights are turned off. Also, when there is low lighting during the night, the LDR sensor will produce an output signal.

The ultrasonic sensor will send out a signal when a vehicle approaches a road. If there is any signal from the ultrasonic sensor when the Arduino receives it, it instructs the lights to glow brightly. Once the vehicle has passed the first light, the lighting automatically dims, and the next light glows brightly in a manner similar to all the others. All lights will be dim if the ultrasonic sensor does not provide a signal. Also, the vehicle distance will be determined by the ultrasonic sensors.

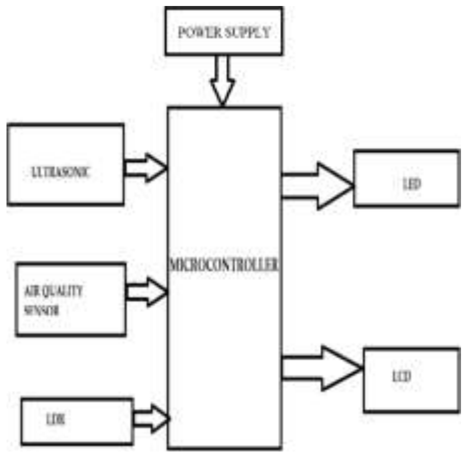

Fig-1:Block Diagram

IV. FUNCTIONAL BLOCKS OF PROPOSED SYSTEM

ARDUINO UNO BOARD:

A microcontroller board called the Arduino Uno is based on the ATmega328. It contains a 16 MHz ceramic resonator, six analogue inputs, 14 digital input/output pins (of which six can be used as PWM outputs), a USB port, a power

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jack, an ICSP header, and a reset button.

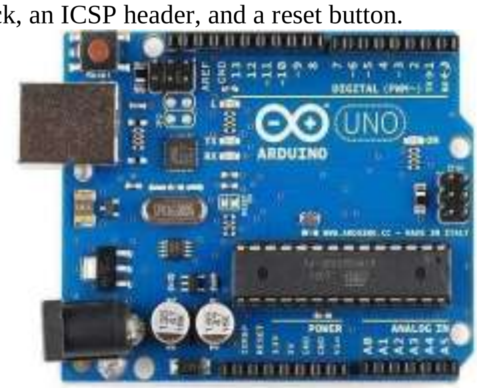

Fig-2: Arduino Uno Board

It comes with everything required to support the microcontroller; to get started, just use a USB cable to connect it to a computer or an AC-to-DC adapter or battery [15].

The Uno is unique from all earlier boards in that it doesn't make use of the FTDI USB-to-serial driver chip. Instead, it has an Atmega16U2 (Atmega8U2 up to version R2) that is configured to function as a USB-to-serial converter.

ULTRASONIC:

Fig-3:UltrasonicSensor

An ultrasonic sensor is a piece of technology that uses ultrasonic sound waves to detect the distance to a target item and then turns the reflected sound into an electrical signal. Compared to audible sound, ultrasonic waves move more quickly (i.e., the sound that humans can hear). The transmitter of an ultrasonic sensor, which uses piezoelectric crystals to generate sound, and the receiver are its two primary parts (which encounters the sound after it has travelled to and from the target).

The sensor measures the amount of time that passes between the transmitter's sound emission and its contact with the receiver in order to determine the distance between the object and the sensor. D = 12 T x C, where D is the distance, is the formula to use for this computation. The speed of sound is 343 meters per second, and T is the time. An illustration. The distance between an ultrasonic sensor and a box would be D = 0.5 x 0.025 x 343 LED if a scientist put up an ultrasonic sensor pointing at the box and it took 0.025 seconds for the sound to bounce back.
D=0.5 x 0.025 x 343LED

LED:
A light-emitting diode is what it stands for.

Up to 90% more light is produced by LED lighting devices than by incandescent bulbs. How do they function? Visible light is produced when an electrical current flows through a microchip and ignites the tiny light sources known as LEDs.

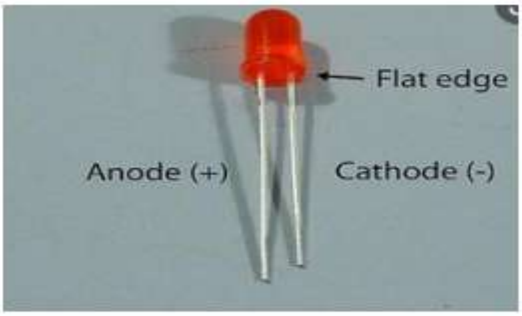

Fig-4: LED

LDR SENSOR:

The most common uses for photoresistors, often referred to as light dependent resistors, are to detect the presence or absence of light or to gauge the strength of the light. When the LDR sensor is exposed to light, the resistance reduces rapidly, perhaps even to a few ohms, depending on the light intensity. In the dark, their resistance is very high, often reaching 1 M. LDRs are nonlinear devices with variable sensitivity depending on the wavelength of applied light. Although they are utilized in many applications, other gadgets like photodiodes and phototransistors frequently carry out this light-sensing function [16]. LDRs constructed of lead or cadmium have been outlawed in some nations due to environmental safety concerns.

Fig-5: LDR

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LIQUID CRYSTAL DISPLAY (LCD):
Liquid Crystal Display is referred to as LCD. Due to the following reasons, LCD is increasingly being used in place of LEDs (seven-segment LEDs or other multi-segment LEDs).
The LCDs' falling prices.
The capacity to show numerical data, characters, and images In comparison, LEDs can only display a few characters and digits. Adding a refresh controller to the LCD frees the CPU from having to update the display In contrast, for the LED to continue showing the data, the CPU must update it.
● Simple character and graphic programming

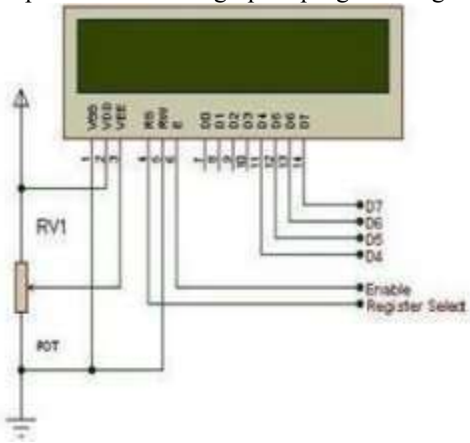

Fig: LCD

These parts cannot be actuated by conventional IC circuits because they are "specialized" for use with microcontrollers. They are employed to write various messages on a tiny LCD.

The model detailed here is the one that is most frequently utilized in practice due to its low cost and great potential. The HD44780 microcontroller, on which it is based, allows for the display of messages in two lines of sixteen characters each. The entire alphabet, Greek letters, punctuation, mathematical symbols, etc., are displayed. Moreover, it is possible to display custom symbols that the user creates[17]. It is thought that beneficial properties include an automatic message on display (shift left and right), the presence of the pointer, lighting, etc

V. HARDWARE EXPERIMENTAL RESULT:

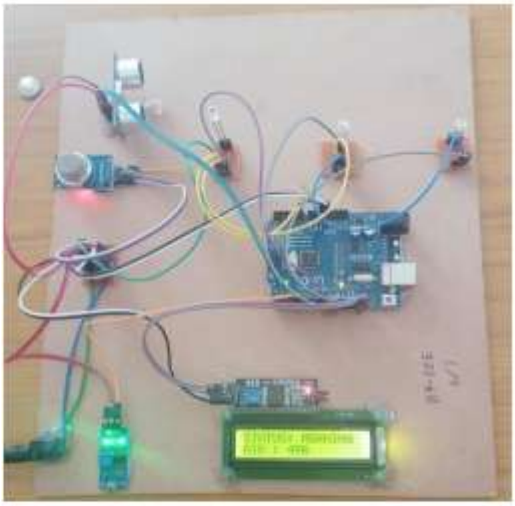

Fig-7:Day Time

Figure-7 depicts that, the LDR light indicates the time of day when the system is turned on. As a result, street lights are turned off at that time.

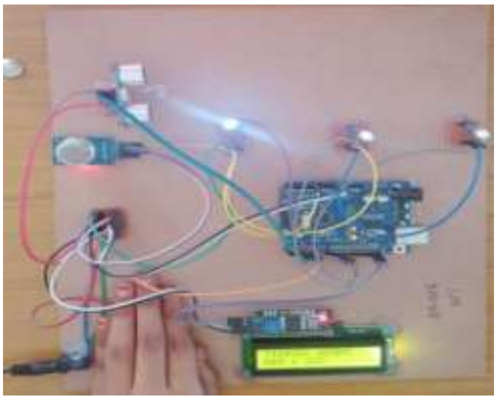

Fig-8:Night Time

At night, the LDR light is turned off, and the street lights are turned on. This is visible in figure-8

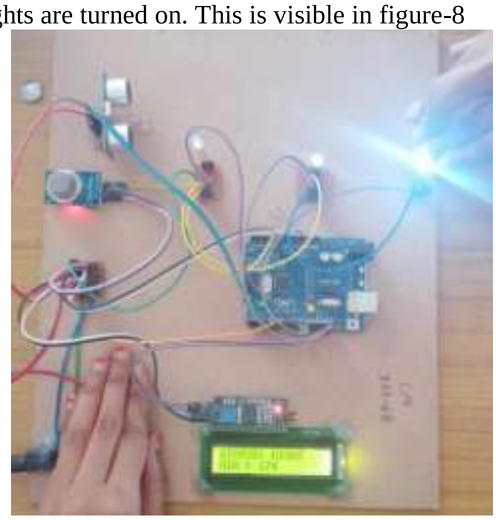

Fig-9: At the Time of Movement

Figure-9 depicts how the intensity of the street lights is controlled while the vehicle is moving on the road, as detected by an ultrasonic sensor

VI. CONCLUSION

Streetlights are currently the largest consumers of electricity in the world. Streetlights are automatically turned on when it gets dark and instantly turned off when it gets bright. In this paper, a smart street light system combines ultrasonic and air quality monitoring sensors. When individuals are detected, the lights will turn on fully in this system, otherwise, they will turn on dimly or turn off.

This occurs with or without people on the streets, reducing manual work and electricity consumption to some level [18]. Yet, it is possible to prevent excessive energy waste from lamps that use energy even when no one is around, thereby using less energy overall.

APPLICATION AND ADVANTAGES

The paper can also be utilized in parking lots of malls, hotels, industrial lighting, etc. The street light control circuit can be used on regular roads, highways, motorways, etc.

- If the lighting system uses only LED lights, the cost of maintenance can be decreased because LEDs have a longer lifespan and greater durability than neon-based street lights, which are typically employed.
- A tremendous amount of energy can be conserved as the lights are automatically turned on and off.

As compared to other systems, this one is more affordable, requires less installation and maintenance, and is more effective.

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