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Master Street Light System Integrating Automation and Air Pollution Monitoring for Urban Sustainability

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***Abstract*— In the pursuit of sustainable urban development, our project proposes an innovative solution that combines smart street lighting and air pollution monitoring. The first phase focuses on automating street lighting through a master-student system, where a designated master street light, equipped with light sensors, controls adjacent street lights, reducing installation costs and enhancing system efficiency. The second phase extends the project's scope to environmental monitoring, incorporating air pollution sensors into each master street light. This creates a comprehensive data network, collecting real-time air quality data for transmission to relevant authorities. Our project addresses energy conservation and environmental awareness by seamlessly integrating smart street lighting with air pollution monitoring, offering a holistic solution for creating smarter, more sustainable urban spaces.**

I. INTRODUCTION

The 21st century is striving hard to save electrical energy. Street lights are essential but expensive, therefore there is a need to optimize the system in a way that it is affordable and efficiently conserves energy. Manually controlling the street lights is a time taking and tedious process. Working in such a manner could sometimes result in large disasters and destruction. The main problem that manual controls on the street lights face is that there would be a lot of time talking during evening times when they are to be switched ON and a significant waste of energy is done in the morning at all could not be turned OFF together at once. Another way in which the wastage is done is that at midnights lights glow at full intensity although there is not much traffic. Therefore, there is a need to come up with a system that overcomes the problems of existing systems. A system that reduces manual control and saves the energy efficiently. This could be done by using low power, robust and efficient components. Nowadays, the highest percentage of air pollution comes directly from road traffic and not anymore from large industries, currently placed outside metropolitan & urban areas. Road traffic is considered to be responsible for 25% of all emissions in Europe, rising up to 31% only in Spain. Moreover, 90% of all transport emissions are due to road traffic. Recently, natural disasters and extremely abnormal climate situations happen frequently and globally, the culprit of which is the exacerbation of global warming. One of the measure reasons behind global warming is Air Pollution. A human can live or survive without water and food for a few days but when it comes to air then surviving for 2 to 3 minutes may seem to be impossible. Air Pollution has a significant influence on the concentration of constituents in the atmosphere leading to effects like global warming and acid rains. Air pollutants are added in the atmosphere from a variety of sources that change the composition of the atmosphere and affect the biotic environment. The concentration of air pollutants depends not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. Transport has a significant impact on the environment in which we live. In general, these impacts can be divided into four broad headings: local air quality, climate change, noise, and watercourse pollution, while clean air is vital to human health. High levels of fine particulate (PM10) air pollution in 2005 were estimated to have caused 1,031 accelerated deaths and 1,088 respiratory hospital admissions in London. By considering all these issues and facts we will go to design a system which will help to overcome these issues. The system is all about detecting air pollution, monitoring the traffic density which is measure cause for air pollution also managing the Lamps brightness dynamically. This system is designed based on IoT. Internet of Things (IoT) is a recent communication paradigm that envisions a near future, in which the objects of everyday life will be equipped with microcontrollers, transceivers for digital communication, and suitable protocol stacks that will make them able to

communicate with one another and with the users, becoming an integral part of the Internet. The IoT concept, hence, aims at making the Internet even more immersive and pervasive. Furthermore, by enabling easy access and interaction with a wide variety of devices such as, for instance, home appliances, surveillance cameras, monitoring sensors, actuators, displays, vehicles, and so on. This paradigm indeed finds application in many Air pollution monitoring is extremely important as air pollution has a direct impact on human health and the environment. Here, we introduce IoT system for participatory air pollution monitoring. In contrast to traditional air pollution monitoring stations, we present the design, implementation, and evaluation of low power, low-cost IOT Based Air Pollution Monitoring System which provides real-time monitoring. And finally we designed a dash board to view the air pollution monitoring and automatic control for lights to adjust its brightness using vehicles count. This system is more efficient and energy saving one.

II. LITERATURE SURVEY

- **D. Mohan:** implemented automation of street lights using microcontrollers and Sensors.
- **K. Singh and R. Das:** developed air quality monitoring using MQ Series Gas Sensors in the year of 2018.
- **S. Agarwal et al. (2019):** that a smart street lighting system can automatically adjusts brightness based on motion detection, significantly reducing energy consumption.
- **Kumar et al. (2020):** implemented an automatic street lighting system using LDR and IR sensors with an Arduino microcontroller. Their work showed that lights could be controlled based on ambient light and movement, reducing energy usage by over 60%.
- **Rao and Jha (2020):** developed a system for real-time air pollution monitoring using MQ2, MQ7, and MQ135 sensors. Their system measured gases like CO, CO_2, and NH_3 and displayed data on an LCD and cloud dashboard.

III. EXISTING SYSTEM

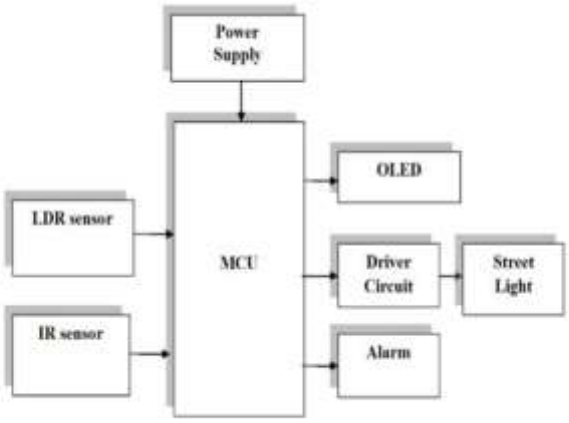
The existing street light systems in urban areas primarily consist of manual or timer-based controls that turn the lights on and off at predetermined times. These systems lack advanced automation and do not incorporate any environmental monitoring capabilities, such as air pollution detection. Consequently, they are inefficient in terms of energy usage and do not contribute to urban sustainability or environmental monitoring.

IV. PROPOSED SYSTEM

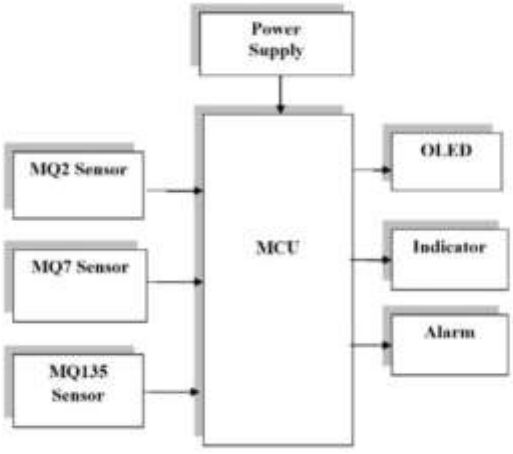
The proposed system aims to create a master street light system that integrates automation and air pollution monitoring to enhance urban sustainability. This system will use sensors to automatically adjust street lighting based on real-time environmental conditions, such as ambient light levels and pedestrian or vehicular movement. Additionally, it will incorporate air pollution sensors to monitor and report air quality data, helping to inform city management and residents. This intelligent system will optimize energy usage, reduce light pollution, and contribute to a healthier urban environment through continuous air quality monitoring.

V. METHODOLOGY

- **Master Street Light System**



- **Air Pollution Monitoring system**

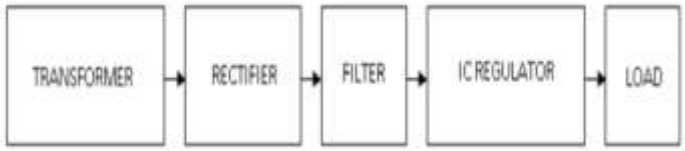


VI. HARDWARE DETAILS

POWER SUPPLY

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V.

The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.



TRANSFORMER

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC.

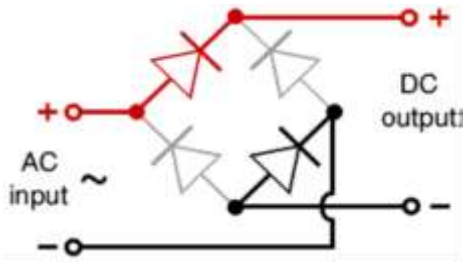
Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in India) to a safer low voltage.

RECTIFIER

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full-wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying Dc.

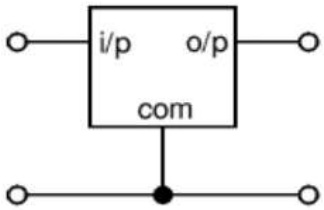
BRIDGE RECTIFIER

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.



VOLTAGE REGULATORS

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts totens of watts.



MICROCONTROLLER

The Raspberry Pi Pico is a compact and affordable microcontroller board powered by the RP2040 chip with a dual-core Arm Cortex-M0+ processor running up to 133 MHz. It includes 264KB SRAM, 2MB flash memory, and 26 GPIO pins with support for UART, SPI, I2C, and PWM. The board features USB 1.1, drag-and-drop programming, and operates within a wide voltage and temperature range. It also includes 8 PIO state machines for custom hardware functions and an onboard temperature sensor. The Pico supports low-power modes and provides efficient performance for embedded applications.

OLED (Organic Light Emitting Diodes)

OLED (Organic Light Emitting Diodes) is a flat light emitting technology, made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. OLEDs are emissive displays that do not require a backlight and so are thinner and more efficient than LCD displays (which do require a white backlight). OLED displays are not just thin and efficient - they provide the best image quality ever and they can also be made flexible, foldable and even rollable and stretchable in the future. OLEDs represent the future of display technology.

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SENSOR:

LIGHT DEPENDENT RESISTOR (LDR): Light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity or vice versa. As the name suggests, LDR is a type of resistor whose working depends upon only on the light falling on it. The resistor behaves as per amount of light and its output directly varies with it.

IR SENSOR: IR sensor is very useful if you are trying to make a obstacle avoider robot or a line follower. In this project we are going to make a simple IR sensor which can detect a object around 6-7 cm. IR sensor is nothing but a diode, which is sensitive for infrared radiation.

GAS SENSOR: A gas detector is a device which detects the presence of various gases within an area, usually as part of a safety system. This type of equipment is used to detect a gas leak and interface with a control system so a process can be automatically shut down. A gas detector can also sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave the area. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals.

RELAY:

A relay is an electromechanical switch, which perform ON and OFF operations without any human interaction. General representation of double contact relay is shown in fig. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

BUZZER:

A buzzer is an electronic signaling device that produces a buzzing or beeping sound, commonly used in appliances and game shows. Modern buzzers often use piezoelectric sounders for high-pitched tones and can lock out others when activated.

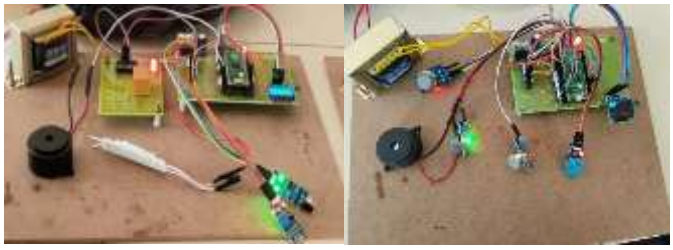
VI. SOFTWARE DETAILS

The Arduino Integrated Development Environment (IDE) is a software platform used to write, compile, and upload programs called sketches (with a .ino extension) to Arduino boards. It features a text editor, toolbar, message area, and console, along with menus like File, Edit, Sketch, Tools, and Help for managing code, libraries, and board settings. The IDE supports functions such as verifying and uploading code, opening the serial monitor for communication with the board, formatting code, managing libraries, selecting the correct board and port, and customizing preferences, making it a complete tool for Arduino-based development.

VII. CONCLUSION

In this project we have discussed the low cost, secure, accessible IOT based street light optimization based on the traffic and also we discussed the air pollution monitoring system. Wi-Fi module controls all the process to the internet and monitor is used to display all the web pages over the internet. The system can upload the measured temperature, Humidity and Air Quality data on a website based on IoT. This system could be used to integrate Lamp control based on intensity. For micro controller containing the whole system would need to be installed at the

monitoring site. The device to monitor the toxicity in the air environment is designed using Node-MCU, IoT technology is implemented to control the air quality in high traffic areas. The use of MQ135 sensor senses various hazardous gases, automatic lighting system and Node-MCU is the heart of this application, which controls the whole process. Micro controllers in build Wi-Fi module controls all the process to the internet and monitor is used for displaying all the web pages over the internet.



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