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IOT BASED ENERGY EFFICIENT SMART STREET LIGHTING TECHNIQUE WITH AIR QUALITY MONITORING

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ABSTRACT

The "IR Sensor-Based Smart Street Lighting System for Sequential Object Detection" project presents an innovative solution to urban energy efficiency and safety concerns. Utilizing a network of four strategically placed Infrared (IR) sensors along a street, the system employs sequential object detection to activate streetlights selectively. As an object is detected by each IR sensor, a corresponding set of streetlights is sequentially illuminated, optimizing energy consumption while enhancing visibility and safety for pedestrians and vehicles. Intelligent control algorithms process real-time sensor data, allowing for adaptive lighting based on the detected object's speed and proximity. This responsive and energy- efficient smart street lighting system contributes to sustainable urban development, aligning with the principles of smart cities and promoting a safer and more resource-conscious urban environment.

Keywords: Air Quality Monitoring, Smart Street Lighting, Internet Of Things.

1. INTRODUCTION

The “IoT-Based Energy-Efficient Smart Street Lighting Technique with Air Quality Monitoring” project represents a pioneering endeavour aimed at addressing the complex challenges associated with urbanization. As cities continue to expand and evolve, the demand for sustainable solutions becomes paramount. In this context, the project leverages the transformative capabilities of the Internet of Things (IoT) to create an intelligent and energy- efficient street lighting system with integrated air quality monitoring.

The core focus of the project is to revolutionize traditional street lighting by incorporating sensors and smart algorithms that respond dynamically to the surrounding environment. By utilizing real- time data on ambient light levels, traffic flow, and pedestrian activity, the system intelligently adjusts the brightness of streetlights. This adaptive lighting approach not only enhances safety and security in urban areas but also significantly reduces energy consumption, contributing to a more sustainable and cost-effective infrastructure.

A pivotal feature of the project is its commitment to environmental health through air quality monitoring. Integrated sensors continuously assess the levels of particulate matter, carbon monoxide, and nitrogen dioxide in the air. This data is invaluable for assessing and mitigating urban pollution, providing city officials and residents with accurate information to make informed decisions about their environment.

The project’s holistic approach reflects the broader vision of smart city initiatives, where technological innovation is harnessed to create urban spaces that are not only efficient but also promote the well-being of their inhabitants. By seamlessly integrating energy-efficient lighting with real-time air quality monitoring, this project aims to contribute to the development of smarter, healthier, and more sustainable cities for the future. IoT is the network of physical devices that allows the devices to communicate with each other.

connectivity issues. These problems can be resolved by IoT technology. The system is based on smart and weather adaptive automatic street lighting and management.

The system will show the air quality in PPM on the dashboard so that it can be monitored very easily. In this IOT project, it can monitor the pollution level from anywhere using computer. This system can be installed anywhere and can also trigger some device when pollution goes beyond some level, like we can send alert in cloud. The project prototype is given in fig.

2. PROPOSED METHDOLOGY

In this chapter the block diagram of the project and design aspect of independent modules are considered. Block diagram is shown in figure.

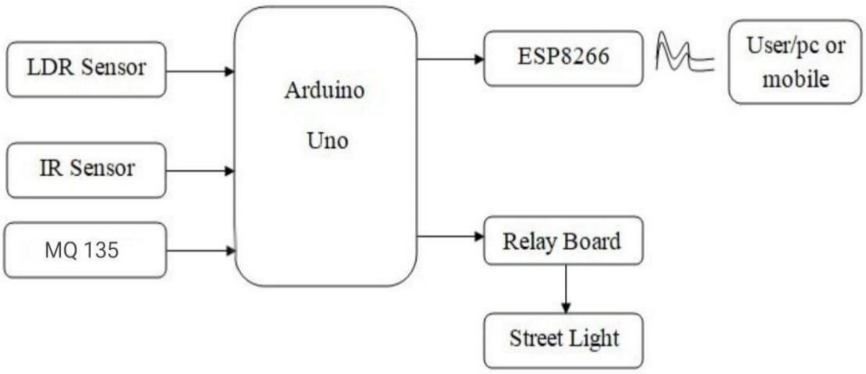

Fig. 1: Block diagram of IoT Based energy efficient smart street lighting technique with air control monitoring

The main blocks of this project are:

Node MCU ESP8266.

IR Sensor module. 3)LDR or Photo resistor. 4)MQ-135 Sensor.

5)5V Single- channel relay module. 6)Arduino Uno.

7)Street lights. 8)LDR sensor

NODE MCU ESP8266

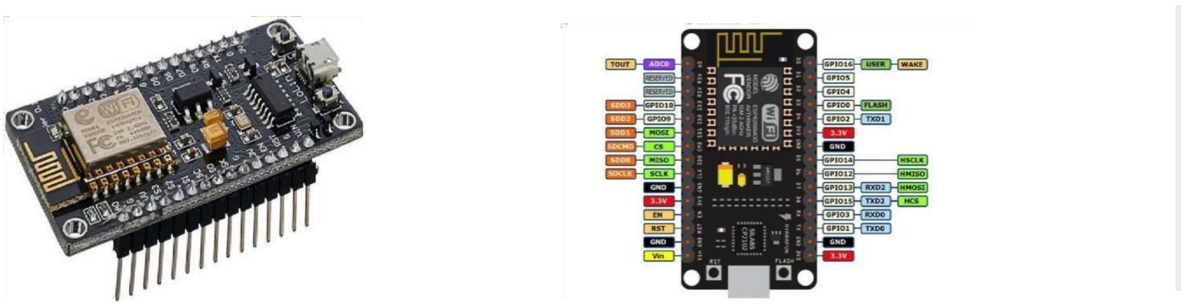

Fig. 2: Node MCU ESP8266

Node MCU is an open-source Lua based firmware and development board specially targeted for IoT

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based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

Node MCU ESP8266 Specifications & Features

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB

The Node MCU ESP8266 development board comes with the ESP-12E module containing the ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. Node MCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects.

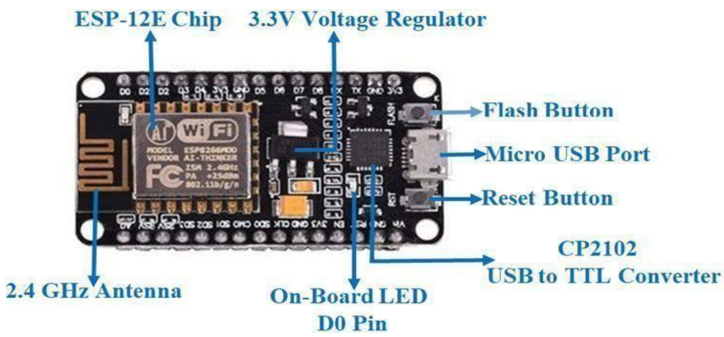
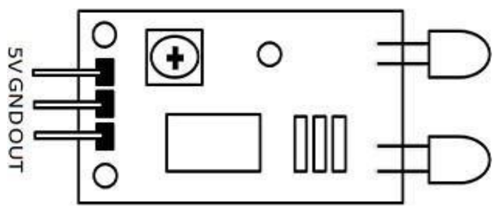


Fig. 3: Components Of Node MCU ESP8266

Programming Node MCU ESP8266 with Arduino IDE

- Prototyping of IoT devices
- Low power battery operated applications
- Network projects
- Projects requiring multiple I/O interfaces with Wi-Fi and Bluetooth functionalities
- IR Sensor Module



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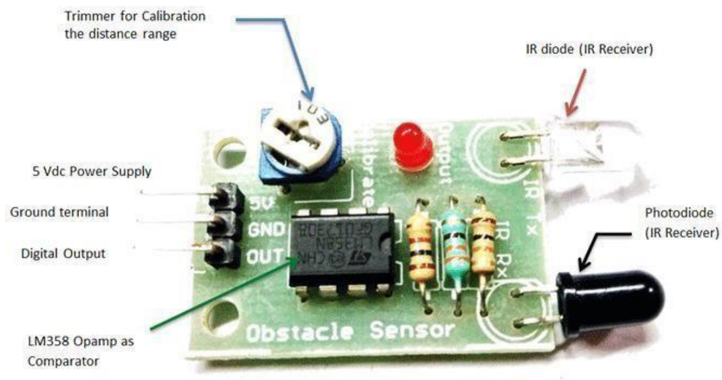
. Fig. 3: IR Sensor Module.

- IR Sensor Module Pin out Configuration
- Table: 2.3: IR Sensor Module Pin out Configuration
- IR Sensor Module Features
- 5VDC Operating voltage
- I/O pins are 5V and 3.3V compliant
- Range: Up to 20cm
- Adjustable Sensing range
- Built-in Ambient Light Sensor
- 20Ma supply current

Brief about IR Sensor Module

The IR sensor module consists mainly of the IR Transmitter and Receiver, Op-amp, Variable Resistor (Trimmer pot), output LED along with few resistors.



LM358 Op-amp

Fig. 4: About IR Sensor Module

- LM358 is an Operational Amplifier (Op-Amp) is used as voltage comparator in the IR sensor. The comparator will compare the threshold voltage set using the preset (pin2) and the photodiode's series resistor voltage (pin3).
- Photodiode's series resistor voltage drop > Threshold voltage = Op-amp output is High
- Photodiode's series resistor voltage drop < Threshold voltage = Op-amp output is Low
- When Op-amp's output is high the LED at the Op-amp output terminal turns ON (Indicating the detection of Object).
- Variable Resistor
- The variable resistor used here is a preset. It is used to calibrate the distance range at which object should be detected.
- How to Use IR Sensor Module?

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— The 5 VDC supply input is given to the VCC pin and the supply negative is connected to the GND terminal of the module. When no object is detected within the range of the IR receiver, the output LED remains off.

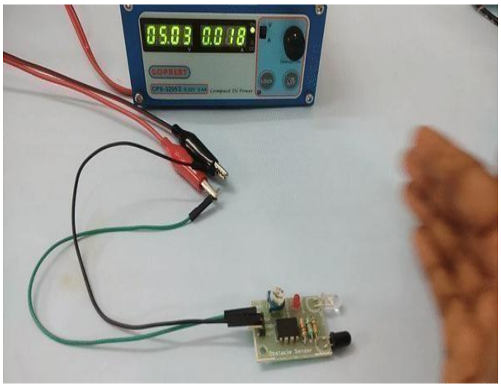

Fig. 5: Using of IR Sensor Module

When a object is detected within the range of the IR sensor the LED glows.

Application

— Obstacle Detection

— Industrial safety devices

— Wheel encoder

— LDR (Light Dependent Resistor) or Photo resistor

Fig. 6: LDR (Light Dependent Resistor) or Photo resistor

The Light Dependent Resistor (LDR) or also popularly known as Photo resistor is just another special type of Resistor and hence has no polarity so they can be connected in any direction. They are breadboard friendly and can be easily used on a perf board also. The symbol for LDR is similar to Resistor but includes inward arrows as shown above in the LDR pin out diagram. The arrows indicate the light signals.

LDR Features

— Can be used to sense Light

— Easy to use on Breadboard or Perf Board

— Easy to use with Microcontrollers or even with normal Digital/Analog IC

— Small, cheap and easily available

— Available in PG5 ,PG5-MP, PG12, PG12-MP, PG20 and PG20-MP series

- How to use a LDR Sensor

As said earlier a LDR is one of the different types of resistors, hence using it is very easy. There are many ways and different circuit in which an LDR can be used. For instance it can be used with Microcontroller Development platforms like Arduino, PIC or even normal Analog IC's like Op-amps. But, here we will use a very simple circuit like a potential divider so that it can be adapted for most of the projects. A potential Divider is a circuit which has two resistors in series. A constant voltage will be applied across the both the resistor and the output voltage will be measured from the lower resistor.

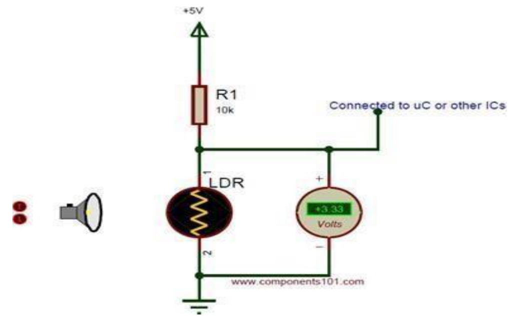

Fig. 7: LDR sensor setup

A DC multimeter is used to monitor the voltage across the LDR. As the Lamp is moved towards the resistor the resistance value of the LDR will decrease as a result the voltage drop across it will decrease. The near you bring the Lamp the lower the voltage will get and the farther you move away your Voltage value will increase. The working simulation is shown below.

Applications

- Automatic Street Light
- Detect Day or Night
- Automatic Head Light Dimmer
- Position sensor
- Used along with LED as obstacle detector
- Automatic bedroom Lights
- Automatic Rear view mirror
- Single-Channel Relay Module Specifications
- Supply voltage – 3.75V to 6V

The single-channel relay module is much more than just a plain relay, it contains components that make switching and connection easier and act as indicators to show if the module is powered and if the relay is active first is the screw terminal block. This is the part of the module that is in contact with mains so a reliable connection is needed. Adding screw terminals makes it easier to connect thick mains cables, which might be difficult to solder directly. The three connections on the terminal block are connected to the normally open, normally closed, and common terminals of the relay.

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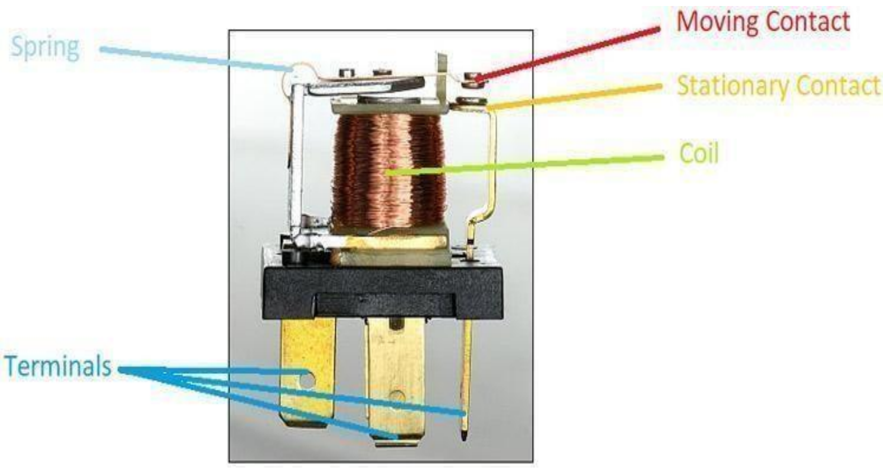

Fig. 8: Working of relay

4. RESULTS DESCRIPTION

Energy Efficiency:

- Dynamic control of street lights based on ambient light conditions and real-time traffic data leads to significant energy savings.
- The implementation of energy-efficient LED lights and smart dimming further contributes to reduced energy consumption.
- Environmental Impact:

Move your hand form first IR sensor to the last and check the streetlights are turn on & off

Data-Driven Decision Making:

The collection and analysis of air quality and lighting data provide valuable insights for urban planning and policy decisions.

- Trend analysis over time can inform long-term strategies for improving air quality and energy efficiency.
- Remote Monitoring and Control:
- The centralized control unit and dashboard enable remote monitoring and control of the entire street lighting system.
- Maintenance personnel can be alerted to issues promptly, reducing downtime.
- Integration with Smart City Infrastructure:
- Integration with existing smart city infrastructure fosters a cohesive and interoperable urban ecosystem.
- The system becomes part of a larger framework for intelligent city management.
- Public Awareness:
- Sharing air quality data with the public through informational campaigns or mobile apps can

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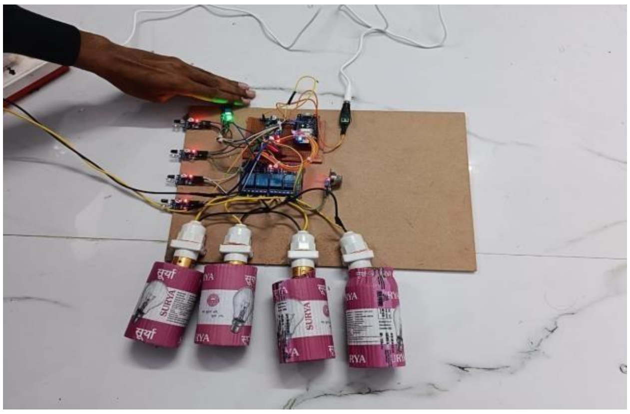
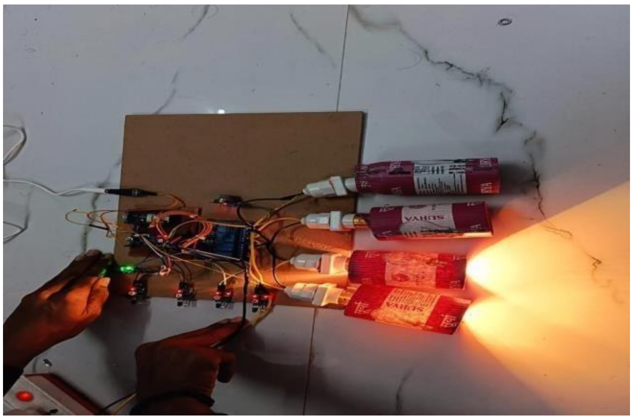
raise awareness and encourage environmentally responsible behaviour.





visitors.

Scalability and Future Expansion:

— The modular design allows for scalability, enabling the addition of more sensors or features as needed.

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- The system can serve as a foundation for future smart city initiatives and innovations.
- Positive Community Impact:
- A smart street lighting system contributes to a more pleasant and safer urban environment, positively impacting the quality of life for residents.

5. CONCLUSION

The implementation of an IoT-based energy-efficient smart street lighting system with air quality monitoring offers a comprehensive solution with numerous advantages. This technology not only enhances energy efficiency and environmental sustainability but also provides benefits in terms of cost savings, safety, data-driven decision-making, and community impact

In conclusion, the integration of smart LED lights, advanced sensors, and intelligent control systems represents a significant step towards creating smarter and more sustainable urban environments. By leveraging real-time data and adaptive technologies, cities can achieve a balance between energy conservation, improved air quality, and enhanced safety, ultimately contributing to the development of smarter and more liveable communities. Ongoing maintenance and scalability considerations are crucial to ensuring the continued success and relevance of these systems in evolving urban landscapes

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