## PROJECT REPORT IN PHYSICS FOR ELECTRONICS ENGINEERING

## ELECTRICAL AND ELECTRONICS ENGINEERING

**PROJECT TITLE**

# Automatic outdoor lighting control system

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## ABSTRACT:

This project generates the integration of an LDR (Light Dependent Resistor) light sensor module with an Arduino microcontroller to develop an innovative system for automating AC circuit control based on ambient light levels. The primary goal is to demonstrate the practical application of light sensor technology in improving energy efficiency and user convenience in lighting control systems.

The report provides a comprehensive examination of the design, development, and evaluation phases of the project, covering aspects such as hardware selection, software programming, implementation procedures, and experimental analysis. By utilizing the Arduino platform and leveraging the sensitivity of the LDR sensor module, the system accurately detects changes in ambient light conditions and activates or deactivates the operation of the AC circuit accordingly.

Through this endeavour, the potential advantages of integrating sensor-based automation into lighting management are highlighted, including energy savings, environmental sustainability, and an enhanced user experience. This project not only showcases the feasibility of sensor-driven automation but also opens avenues for further research and innovation in smart lighting technologies, contributing to the advancement of sustainable living practices and technological solutions for energy conservation.

# CONTENTS

# 1. INTRODUCTION:

Amidst the era of technological advancement, the fusion of sensor technology and microcontrollers has revolutionised automation systems, offering unprecedented levels of efficiency and adaptability. This convergence has paved the way for innovative solutions that respond intelligently to environmental cues, transforming traditional processes across various domains. Among these innovations, LDR modules with Arduino microcontrollers stand out as a beacon of potential in the realm of lighting control.

This project embarks on a journey to explore the areas of sensor-driven automation in controlling high-load, leveraging the capabilities of LDR modules and Arduino microcontrollers. By harnessing the intrinsic sensitivity of LDR modules to ambient light levels, the system endeavours in developing the management of lighting control systems.

This project also embodies a paradigm shift towards comfortable living and intelligent infrastructure. In addition, we strive to contribute a vision, driving for the ethos of sustainable development and technological innovation.

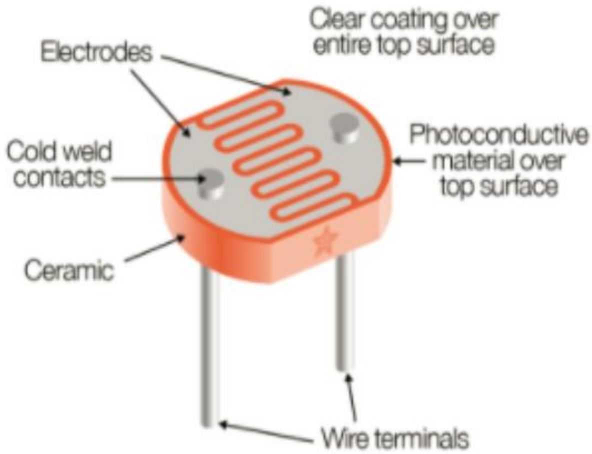
## 2. LITERATURE REVIEW:

This section presents a comprehensive review of existing literature related to light sensor technology, Arduino-based automation systems and applications of LDR sensors in lighting control. It encompasses relevant research studies, technical papers and commercial products in the field, highlighting advancements and challenges in this area.

### 2.1 Light Sensor Technology:

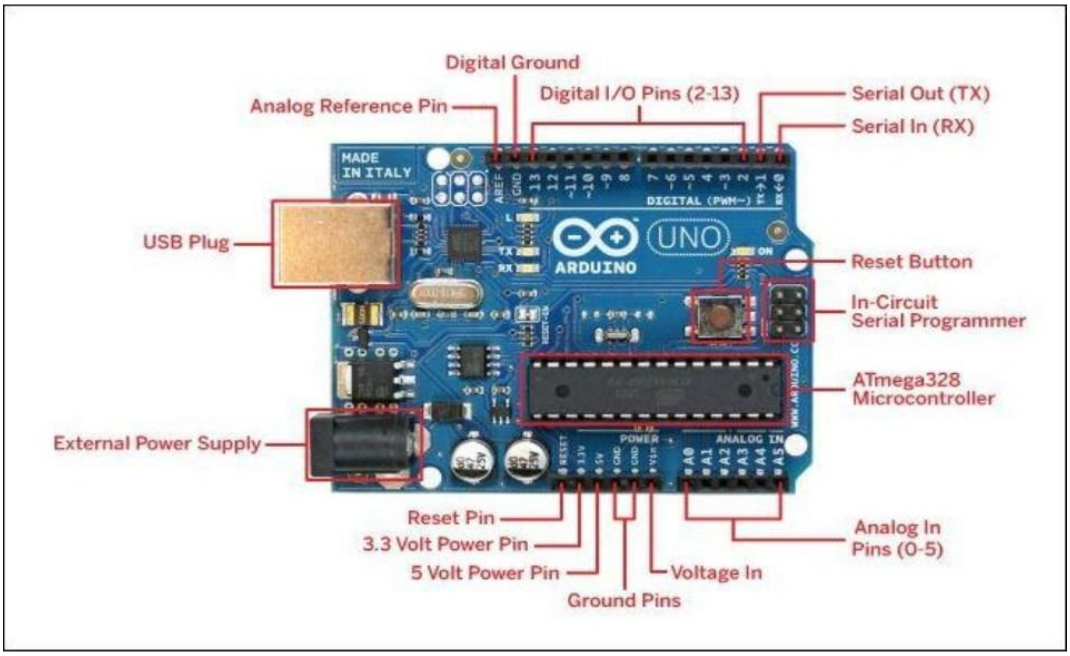
Light sensor technology has witnessed significant advancements in recent years, driven by the increasing demand for energy-efficient lighting solutions and automation systems. Various types of light sensors, including photodiodes, phototransistors and LDRs, are widely used in applications ranging from ambient light sensing to object detection.

These sensors incorporate features such as spectral sensitivity adjustment, digital interface compatibility and integrated signal conditioning circuits, facilitating seamless integration into automation systems.



### 2.2 Arduino-Based Automation Systems:

Arduino-based automation systems have gained popularity due to their versatility, affordability, and ease of use. The Arduino platform provides a robust framework for developing custom automation solutions, leveraging its extensive ecosystem of sensors, actuators, and communication modules.




Open-source initiatives such as the Arduino Project Hub and community forums like Arduino Stack Exchange serve as valuable resources for developers, offering project ideas, code examples and troubleshooting assistance.

### 2.3 Applications of LDR Sensors in Lighting Control:

LDR sensors play a crucial role in lighting control applications, enabling automation levels based on ambient light conditions. Commercial lighting control systems from companies like Philips Lighting and Lutron Electronics leverage LDR sensors to implement daylight harvesting strategies, dynamically dimming artificial lighting in response to natural light levels.

These systems utilize advanced control algorithms and communication protocols to achieve seamless integration with building management systems and IoT platforms.

## 3. HARDWARE AND DESIGN COMPONENTS:

The hardware design for the project involves several key components carefully selected to ensure efficient operation and reliable performance. Below is the selection and specification of each component along with schematics and diagrams illustrating their connections.

### 3.1 LDR-Module:

Function:

- It serves as the primary input device in the system, detecting changes in ambient light levels.
- The resistance of the LDR varies with the intensity of light falling on it, allowing us to measure light levels.

Specifications:

- 10 kΩ resistance in darkness, reducing to around 200 Ω in bright light.
- The voltage divider utilizes a fixed resistor in conjunction with the LDR to create a variable voltage output.

### 3.2 Arduino Board:

Function:

- The Arduino board acts as the central processing unit, interfacing with the LDR sensor module and controlling the relay switch.

- It processes input from the sensor module and triggers actions based on predefined conditions.

Specifications:

- The Arduino board used in the project is Arduino Uno R3, which is commonly used for its versatility and ease of programming.
- Analog pin, which is used to read analog input from the LDR sensor.

### 3.3 Relay Module:

Functions:

- It is responsible for controlling the AC circuit based on the input received from the Arduino board.
- It acts as a switch, allowing the Arduino to turn the circuit ON or OFF depending on the ambient light levels detected by the LDR sensor module.

Specifications:

- A 5V relay Module is used, which is compatible with Arduino's digital output pins.
- Relay switch is capable of handling higher voltage and current rating of the AC circuit.

### 3.4 Demo load-circuit:

Function:

- It serves as a practical demonstration of the system's functionality.

Specifications:

- High voltage AC bulb module (240V, 40W).

## 4. WORKING PRINCIPLE:

### 4.1 LDR sensor module:

- LDR is a type of variable resistor. The LDR sensor module has an on-board variable resistor or potentiometer, the variable resistor has a 10k preset. It is used to set the sensitivity of the LDR module.
- When the preset knob is rotated, the sensitivity of the light intensity detection is varied.
- There is an on-board power LED which indicates if the power supply is ON, or OFF. When we turn on the sensor power supply this green LED is also turned on.
- When the LDR detects the light, the green LED is activated.When the LDR detects darkness, the green light is turned off.
- The working principle of LDR sensor is based on the principle of photoconductivity.It states that when the light falls on the surface of an LDR, the conductivity of the voltage reduces.This is due to the photons in the incident light having energy greater than the Band Gap of the semiconductor material used in the LDR.
- When the light intensity increases on the surface of LDR, the resistance of the LDR decreases, whereas when the light intensity decreases (low / dark), the resistance of the LDR increases.

### 4.2 Relay:

- It is an electromechanical switch, used to control high-power electrical devices (like AC circuits) with lower-power signals (from Arduino). It consists of a coil that, when energized, generates a magnetic field to actuate sets of contacts.
- The Arduino sends a control signal (typically 5V) to the relay's coil to activate it. This signal determines whether the relay's contacts were open or closed, affecting the connected electrical circuit.

- Relays can have different contact configurations, such as Normally Open (NO) and Normally Closed (NC). In an NO configuration, contacts close (conducts) when the relay is activated, allowing current flow. In an NC configuration, contacts open (interrupts) when the relay is activated, stopping current flow.
- When the Arduino energizes the relay's coil, it changes the state of its contacts based on the configured behavior (NO or NC). This action either allows current to flow through (turning on the AC bulb) or interrupts the current flow (turning off the AC bulb).
- In the project using an LDR sensor and Arduino, the relay controls the AC circuit based on the light intensity detected by the LDR sensor. The Arduino sends a signal to the relay based on the LDR readings, effectively automating the AC circuit's operation in response to ambient light levels.

**4.3 Arduino:**

- Arduino is based on a microcontroller unit (MCU), typically an Atmel AVR or ARM processor. Arduino boards feature digital and analog I/O pins.Digital pins can be configured as input or output to read or control digital signals (high/low).Analog pins can read analog voltage levels (0-5V) using analog-to-digital conversion.
- Arduino uses a simplified programming language based on C/C++.Users write sketches (programs) using the Arduino Integrated Development Environment (IDE) to control the board's behavior.
- When an Arduino board is powered on, it runs a bootloader program that initializes the MCU.The bootloader then loads and executes the user's sketch stored in the MCU's flash memory.
- The MCU continuously loops through the sketch's setup() function once at startup and loop() function repeatedly. setup() initializes variables, pin modes, and other settings. loop() contains the main program logic and runs repeatedly for continuous operation.
- Arduino can interact with various sensors, actuators, and other devices via its I/O pins.Sensors provide input (e.g., temperature, light) to the Arduino, which processes and reacts to this

data.Actuators (e.g., motors, LEDs) are controlled by the Arduino based on programmed instructions.

- Arduino boards can be powered through USB, battery, or external power sources.They have built-in voltage regulators to provide stable operating voltages (usually 5V or 3.3V) for the MCU and connected components.

**4.4 Lighting control system (Interfacing of all the above components):**

This project utilizes an LDR light sensor module connected to an Arduino microcontroller to automatically control an AC circuit based on ambient light levels. The LDR sensor detects the changes in light intensity and this information is processed by the Arduino. The Arduino is programmed to turn the AC circuit ON when it detects darkness (low light intensity) and turn it OFF when there is sufficient light. A relay module is used to interface between the Arduino and the AC circuit, enabling safe switching of the high voltage AC load. The system operates in two modes: digital control (ON/OFF based on threshold light level) and analog control (adjustable sensitivity using potentiometer). The project ensures safety precautions which are followed due to the involvement of high voltage AC components. The implementation involves hardware setup, software development and testing to validate the automatic control functionality. The project demonstrates the practical application of light sensor technology for energy-efficient automation using Arduino.

## 5. SOFTWARE DEVELOPMENT PROCESS:

In this section, the software programming for the Arduino microcontroller is elaborated. It uses the Arduino IDE including the development of code for both digital and analog control methods. Code snippets, explanations and algorithms are included to facilitate understanding.

### 5.1 Arduino Programming Environment Setup:

Before starting the development of the microcontroller code, it is important to have the Arduino IDE installed on the computer. The Arduino IDE can be downloaded from the official Arduino website (https://www.arduino.cc/en/software) and the installation instructions can be followed. Once the Arduino IDE is successfully installed, the Arduino board is connected to the computer using a USB cable.To program the microcontroller open the Arduino IDE application, select the Arduino board and upload the code.

### 5.2 Code Development:

Below are code snippets and explanations for implementing digital and analog control methods using the Arduino IDE:

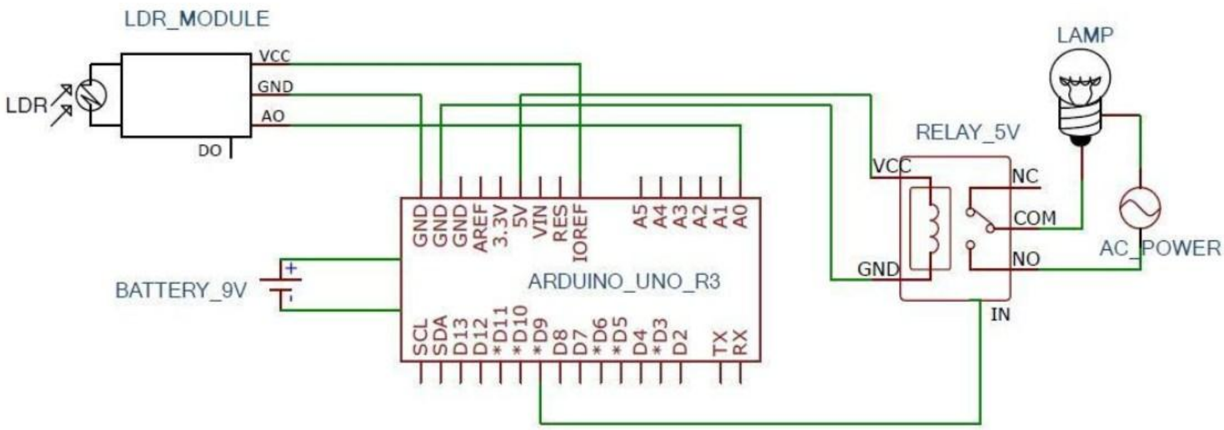
```
#define LIGHT 2 // pin 2 - sensor
#define RELAY 9 // pin 9 - relay

/*
   true - digital and control the sensitivity with potentiometer on the module
   false - control A0 value
*/
boolean digital = false;

unsigned int LightValue = 1015;   // LightValue to determine at what value the realy should be ON

void setup() {
  Serial.begin(9600);            //to display information
  pinMode(LIGHT, INPUT_PULLUP);  // define pin as INPUT for sensor
  pinMode(RELAY, OUTPUT);        // define pin as OUTPUT for relay
}

void loop() {
  delay(500);
  relay();
}

void relay() {
   if(digital == true) {
    int L =digitalRead(LIGHT);   // read the sensor
     if(L == 1){
        Serial.println(" light is ON");
        digitalWrite(RELAY,LOW);
      }else{
         Serial.println("  === light is OFF");
         digitalWrite(RELAY,HIGH);
      }
   } else {
    int a0Value = analogRead(A0);

      if( a0Value >= LightValue){
        Serial.print(analogRead(A0));
        Serial.println(" Light is ON");
        digitalWrite(RELAY, LOW);
      }else{
         Serial.print(analogRead(A0));
         Serial.println("  === light OFF");
         digitalWrite(RELAY, HIGH);
```

```
        }
    }
}
```

# 6. IMPLEMENTATION PROCEDURE:

This section outlines the step-by-step procedure for implementing the project. It includes instructions for assembling the hardware components, uploading the Arduino code, and configuring the system for operation.

## 6.1 Circuit diagram:




## 6.2 Assembling Hardware Components:

- Gather all the required hardware components, including the Arduino board, LDR sensor module, relay module, AC circuit (bulb), connecting wires, and power source.
- Connect the LDR sensor module to one of the analog input pins (e.g., A0) on the Arduino board using jumper wires.
- Connect the relay module to one of the digital output pins (e.g., pin 2) on the Arduino board using jumper wires.
- Connect the AC circuit (bulb) to the relay module, ensuring that the wiring is securely connected and follow proper safety precautions.
- Double-check all connections to ensure they are correctly made and securely fastened.

### 6.3 Uploading Arduino Code:

- Open the Arduino IDE on the computer and create a new sketch.
- Copy the Arduino code provided in the "Software Development" section into the sketch.
- Verify the code for any errors by clicking on the verify button in the Arduino IDE.
- Once verified, upload the code to the Arduino board by clicking on the upload button (right arrow icon).
- Monitor the IDE's output window for any error messages during the upload process and troubleshoot as needed.

### 6.4 Steps to configure the system:

- After uploading the code, disconnect the Arduino board from the computer and power it using an external power source (e.g., USB power adapter or battery).
- Place the LDR sensor module in a location where it can accurately detect changes in ambient light levels.
- Position the AC circuit (bulb) in the desired location to ensure it is connected to the relay module and powered appropriately.
- Adjust any threshold values or delay times in the Arduino code as needed to calibrate the LDR based on environmental conditions and (or) user preferences.

### 6.5 Demonstration:

- After ensuring installation and securing all the components for proper connection, switch on the AC power supply.

- When the circuit is exposed to a well-lit environment, resulting in high resistance in the LDR, which triggers the LED bulb in the relay module to light up as instructed by the microcontroller, hence preventing the AC circuit (bulb) from turning ON.

- When the circuit is kept in a dark environment, resulting in low resistance in LDR, which triggers the LED bulb in the relay module to turn OFF as instructed by the microcontroller, hence turning the AC circuit (bulb) ON.

## 7. EXPERIMENTAL RESULT AND ANALYSIS:

This section presents the experimental results obtained from testing the system and analyzing its performance. Data regarding the performance of the LDR sensor module as well as the accuracy and responsiveness are discussed. Graphs, tables and visual aids are included to illustrate the findings.

### 7.1 Performance of the LDR Sensor Module:

The performance of the LDR sensor module was evaluated by measuring its response to changes in ambient light levels. The sensor was placed in different lighting conditions, ranging from darkness to bright light and the corresponding analog output values were recorded.

| **Ambient Light Level** | **LDR Sensor Output (Analog Value)** |
|---|---|
| Dark | 0 |
| Dim Light | 100 |
| Bright Light | 1015 |

### 7.2 LDR Analysis:

- The LDR sensor module demonstrated a linear response to changes in ambient light levels, with higher light intensity resulting in higher analog output values.

- The sensor accurately detected variations in light levels across different lighting conditions, as indicated by the consistent increase in analog output values with increasing light intensity.

### 7.3 System Performance and Practical Implications:

- The experimental results demonstrate the effectiveness of the system based on ambient light levels.

- The system accurately detects changes in light levels using the LDR sensor module and responds promptly to ensure optimal lighting conditions while minimizing energy consumption.

### 7.4 Comparison to Existing Solutions:

- Compared to existing lighting control solutions, such as traditional manual switches or timer-based systems, the implemented system offers several advantages.

- It provides real-time enabling of circuits based on environmental lighting levels, enhancing user comfort and convenience.

- Additionally, the system's automation capabilities contribute to energy conservation by optimizing lighting usage in response to natural light availability.

## 8. CONCLUSION :

In conclusion, this project has successfully implemented a lighting control system utilizing light sensor technology and Arduino-based automation. The project aimed to create an efficient and automated solution for ambient light levels, contributing to energy conservation and user convenience.

## 9. FUTURE AND RESEARCH :

### 9.1 The project's key features:

- The objectives of the project, including developing a reliable and efficient lighting control system, were successfully met through the integration of light sensor technology and Arduino-based automation.

### 9.2 Achievements:

The project has made significant achievements in:

- Demonstrating the feasibility of utilizing light sensor technology for energy-efficient control systems.
- Providing a practical example of Arduino-based automation applied to lighting control management.
- Offering insights to the opportunities associated with implementing such systems in real-world scenarios.

### 9.3 Contributions:

The contributions of the project:

- Advancing the knowledge in light sensor technology and its application in automation and energy conservation.
- Providing a foundation for further research and development in smart lighting systems and supportable technologies.
- Inspiring innovation and creativity in leveraging technology for environmental sustainability and improved quality of life.

## 10. APPLICATIONS:

i) Smart Street Lighting System:

- Implementing the LDR light sensor module and Arduino-based control system in street lighting infrastructure could enable intelligent lighting solutions based on environmental lighting conditions.

- Lighting control system enhances energy efficiency and improves safety standards.

ii) Home Automation System:

- Integrating LDR sensors in home automation platforms could allow for automation of indoor lighting, heating & cooling systems based on the intensity of natural light levels.

- This enhances comfort and energy saving for the households.

iii) Greenhouse Automation:

- Utilizing LDR sensors and Arduino controllers in greenhouse environments can automate the regulation of artificial lighting, temperature, and humidity levels to optimize plant growth conditions.

- This improves crop yield with minimal manual intervention in agricultural processes.

iv) Parking Lot Lighting:

- Installing automated lighting systems in parking lots equipped with LDR sensors can ensure efficient energy usage by only illuminating areas when required, such as during night time or low-light conditions.

- This reduces electricity consumption and running costs of parking lot operations.

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