Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 2, No.4, February : 2025

DESIGNING A LOW-COST DARK SENSOR SYSTEM FOR STREET LIGHTING

T. Sirisha, Assistant Professor, Department of Electrical and Electronics Engineering, Hyderabad Institute of Technology and Management, India: thrilangi.sirisha55@gmail.com
U. Divya, Assistant Professor, Department of Electrical and Electronics Engineering, Hyderabad Institute of Technology and Management, India: duggumudi@gmail.com
E. Sleshika UG Scholar, Department of Computer Science and Engineering, Hyderabad Institute of Technology and Management, India: sleshikaelpula@gmail.com
G, Nitya Sree, Department of Computer Science and Engineering, Hyderabad institute of technology and management, India: nityasreegundu@gmail.com.
K. Bhargavi, UG Scholar, Department of Computer Science and Engineering, Hyderabad institute of technology and management, India: bhargavik753@gmail.com
K. Sanjana Reddy, UG Scholar, Department of Computer Science and Engineering, Hyderabad institute of technology and management, India: sanjanareddykannaveni@gmail.com

Abstract-
This experiment showcases a simple yet innovative dark sensor circuit that leverages the principles of analog-to-digital conversion, digital logic, and relay operations to automatically switch on an LED in low-light conditions and off in bright conditions. The circuit, built on a breadboard, incorporates a 4017 decade counter IC, relay module, and light-dependent resistor (LDR) network to detect ambient light levels.The LDR's resistance varies in response to changing light conditions, triggering the BC547 transistor and 4017 IC to activate the relay and switch the LED's state. A variable resistance (1k) allows for adjusting the sensitivity of the light detection. This project demonstrates fundamental concepts in electrical engineering, including the conversion of analog light signals to digital outputs, digital logic operations, and relay-based control.The proposed dark sensor circuit has numerous applications in automated lighting systems, security systems, and energy-efficient solutions. The use of a decade counter IC and relay module enables the circuit to be easily expanded or modified for more complex applications. This project serves as a valuable learning tool for students and enthusiasts of electrical engineering, providing hands-on experience with circuit design, prototyping, and testing. Overall, this experiment highlights the potential for innovative and practical applications of electrical engineering principles in everyday life.

INTRODUCTION

The project's goal is to create an intelligent of "LIGHT glowing when its in DARK places". Dark sensors, also known as darkness detectors or light dependent resistors (LDRs), play a crucial role in home automation systems by detecting the presence or absence of light. These sensors are designed to automatically control lighting andother devices based on ambient light levels, enhancing convenience and energy efficiency. Dark sensors are versatile devices that significantly contribute to home automation by providing automatic control over lighting and enhancing security measures. Their simplicity in design and functionality makes them an attractive option for both DIY enthusiasts and professional installations. As technology evolves, integrating dark sensors with smart home systems will continue to enhance their utility and effectiveness. The design of a dark sensor for street lighting systems is a significant advancement in automated lighting technology. This system primarily utilizes a **Light Dependent Resistor (LDR)** to detect ambient light levels and control the operation of street lights based on the presence or absence of light. The primary aim of this project is to create a device that automatically activates street lights at sunset and deactivates them at sunrise. This automation reduces manual intervention, enhances energy efficiency, and ensures consistent lighting during night time hours. The design of a dark sensor for street lights represents an effective solution to modern urban lighting challenges. By leveraging simple electronic components like LDRs and transistors, this

system not only automates lighting but also contributes to energy conservation and operational efficiency in public infrastructure. The design of dark sensors for street lighting systems has evolved significantly, incorporating various technologies to enhance efficiency and sustainability. This section provides a comprehensive look into the design, functionality, and advancements in dark sensor systems primarily utilizing Light Dependent Resistors (LDRs). The design of dark sensors for street lighting represents a significant step toward smarter urban infrastructure.

Hardware components

EQUIPMENT NAME

1. Light Dependent Resistor(LDR)
2. NPN Transistor

3.Resistor

4.Bread Board 5.Battery(9v)

5 . Few Bread Board Connection Wires.

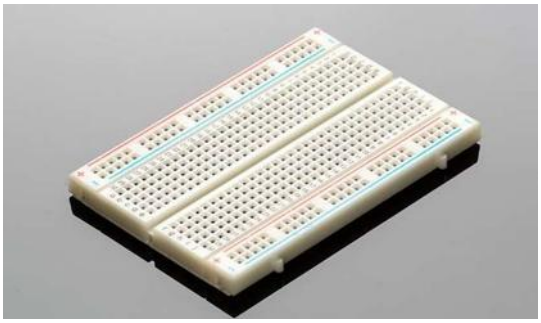
6.LED

Light Dependent Resistor(LDR) : Light DependentResistors (LDRs) are crucial components in automatic street lighting systems, functioning as sensors thatdetect ambient light levels. This technology allows street lights to operate efficiently by automatically turning on at dusk and off at dawn, thus conserving energy and control the operation of street lights accordingly, thereby enhancing energy efficiency and reducing operational costs. During daylight, the LDR's low resistance keeps the street lights off. As daylight fades, the resistance of the LDR increases, triggering the transistor to turn on the lights automatically. At dawn, the cycle reverses, turning off the lights once again. Reduces unnecessary power consumption by ensuring lights are only on when needed. Eliminates manual operation, enhancing convenience and reliability. Low- cost components and simple circuitry make it an economically viable solution for urban infrastructure. LDRs are versatile and can be employed in various environments Urban streets, Parks and recreational areas, Residential neighborhoods, Commercial properties. As daylight returns (morning), the resistance of the LDR decreases, increasing the voltage above the threshold and turning off the street light automatically. Incorporating Light Dependent Resistors into dark sensor circuits for street lighting is an effective way to enhance energy efficiency and automate lighting systems. By leveraging their unique properties, cities can ensure that street lights operate optimally, contributing to both safety and sustainability. The implementation of Light Dependent Resistors (LDRs) in dark sensor circuits for street lighting systems is a transformative approach that addresses several critical challenges in urban infrastructure. As cities continue to grow and face increasing demands for energy efficiency and sustainability, LDR technology offers a practical solution that aligns with these goals.

NPN Transistor

NPN transistors, particularly the BC547 model, are essential components in the design of dark sensors for automatic street lighting systems. These sensors utilize the properties of NPN transistors to control the operation of street lights based on ambient light conditions, providing an efficient and automated solution for urban lighting. NPN transistors, particularly the BC547, play a critical role in dark sensors used for home

automation. They function as switches that control the flow of current based on the input from a Light Dependent Resistor (LDR).An NPN transistor has three terminals: Emitter (E), Base (B), and Collector (C). In dark sensor circuits, the transistor operates as a switch that turns on or off based on the voltage at the base terminal.When the LDR detects darkness it affects the voltage at the base of the NPN transistor. If this voltage exceeds a certain threshold, it allows current to flow from the collector to the emitter, activating connected devices like LEDs or relays. The that are electrically connected underneath the surface. These strips are used to make electrical connections between components. The main grid area consists of rows and columns of holes, which are internally connected in a pattern (often in sets of 5 or 10). Components and wires can be inserted into these holes to create connections. Breadboards are essential tools in electronics prototyping and experimentation, allowing engineers and hobbyists to build and test circuits without the need for soldering. In the context of automatic street light systems, breadboards facilitate the assembly of circuits that utilize componentslike Light Dependent Resistors (LDRs), transistors, and LEDs, enabling quick modifications and troubleshooting.In automatic street light projects, breadboards are particularly useful for constructing circuits that respond to ambient light conditions. A typical dark sensor circuit using a breadboard involves connecting the LDR in series with a resistor to form a voltage divider. The output from this divider is fed into the base of an NPN transistor, which controls the flow of current to the LED or relay. Breadboards play a vital role in developing automatic street light circuits by providing a flexible platform for assembling and testing electronic components. Their modularity and ease of use make them ideal for both educational purposes and practical applications in electronics projects. As cities increasingly adopt smart lighting solutions, utilizing breadboards for prototyping these systems will remain an essential practice for engineers and hobbyists.



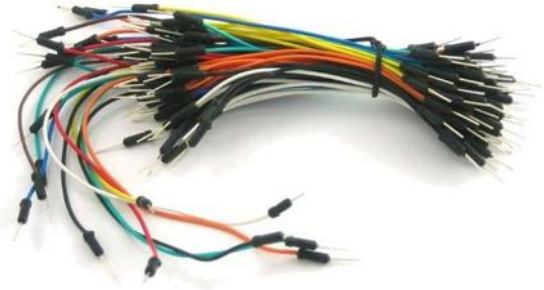
Battery (9V)

A 9V battery in a dark sensor system serves as the power source that provides the necessary voltage to operate the circuit components. The 9V battery powers the entire dark sensor circuit, which typically includes components like the Light Dependent Resistor (LDR), transistors, comparators, and relays. The 9V battery ensures that the circuit can function without being connected to an external power source, making the dark sensor system portable and independent. In automatic street light systems, 9V batteries serve as the primary power source for control circuits that include components like Light Dependent Resistors (LDRs), transistors, and timers. These components work together to turn the lights on at dusk and off at dawn. The design of 9V batteries allows for easy integration into various street light configurations without adding significant weight or bulk. This is particularly beneficial for solar-powered street lights where space is limited. 9V batteries are widely available and can be easily replaced when depleted, making maintenance straightforward for street lighting systems that rely on battery power. In a typical circuit, an LDR detects the ambient light level. When it gets dark, the resistance of the LDR increases, which triggers a transistor that allows current from the 9V battery to flow to the LED or other light sources.For example, a simple circuit might include an LDR connected in series with a resistor and an NPN transistor (like the BC547). The transistor acts as a switch that turns on the LED when darkness is detected. Many educational kits for teaching electronics include 9V batteries as part of automatic street light projects. These kits often feature components like LEDs, LDRs, and transistors to demonstrate basic principles of circuit design and automation.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 2, No.4, February : 2025

Few Bread Board Connecting Wires

In a dark sensor system, connecting wires on a breadboard are used to establish electrical connections between various components such as the Light Dependent Resistor (LDR), transistors, comparators, and other parts of the circuit. These wires play a crucial role in ensuring proper functionality of the system.Use red wires for positive connections (Vcc). Use black wires for ground (GND). Use other colors like blue or green to connect different components, especially for signalconnections between the LDR, comparator, and transistor. Connecting wires are essential components when working with breadboards, especially in projects like automatic street light systems. These wires facilitate connections between various electronic components, allowing for the efficient assembly and modification of circuits. This introduction will cover the types of connecting wires, their functions, and their importance in breadboard-based street light projects.Jumper wires are short, flexible wires with connectors on both ends. They come in various lengths and colors.

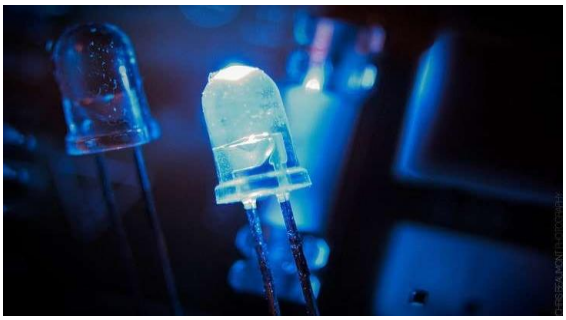


Light Emitting Diode[LED]

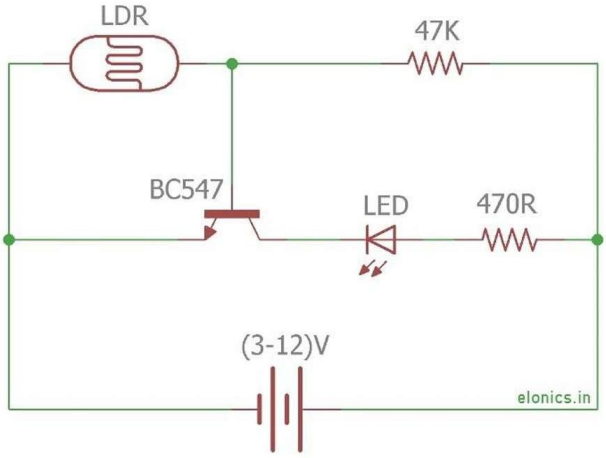
In a dark sensor system, an LED (Light Emitting Diode) is often used as a visual indicator that shows the status of the system, or it may be part of the output that gets controlled when the sensor detects darkness.

The most common use of an LED in a dark sensor system is to serve as a visual indicator that the system has detected darkness. When the Light Dependent Resistor (LDR) or other light sensors detect low light levels (indicating darkness), the LED can turn ON to show that the system has been triggered. LED street lights are advanced lighting fixtures that utilize light- emitting diodes (LEDs) as their primary light source. Unlike traditional street lighting technologies, such as high-pressure sodium (HPS) or metal halide lamps, LED street lights operate by passing an electric current through a semiconductor, which emits light when energized. This innovative approach has revolutionized street lighting, offering numerous advantages in energy efficiency, longevity, and environmental sustainability. LED street lights consume significantly less energy compared to conventional lighting systems. They can save up to 50% or more in energy costs, making them an economically viable option for municipalities looking to reduce operational expenses.Long Lifespan: One of the standout features of LED street lights is their impressive lifespan, typically lasting between 10 to 15 years or even longer. This extended longevity translates into reduced maintenance costs and fewer disruptions for road users, as municipalities do not need to frequently replace burnt-out bulbs. LED lights provide brighter and more uniform illumination than traditional street lights. This enhanced visibility improves safety for pedestrians, cyclists, and motorists by reducing accidents and increasing awareness of surroundings. Studies have shown that well- lit areas are associated with lower crime rates, as better lighting discourages criminal activities.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 2, No.4, February : 2025



CIRCUIT DIAGRAM & EXPLANATION



DARK SENSOR SCHEMATIC

LDR (Light Dependent Resistor): This is the key component that varies its resistance based on the amount of light falling on it. In darkness, its resistance is high, and in light, its resistance is low. Light Dependent Resistors (LDRs) are critical components in dark sensor circuits used for automatic street lighting systems. Their ability to detect changes in ambient light levels makes them ideal for controlling when street lights turn on and off, thereby enhancing energy efficiency and public safety. LDRs operate on the principle of photoconductivity. They are made from semiconductor materials, such as cadmium sulfide, which exhibit varying resistance based on the intensity of light falling on them. Here's how they function:**High Light Intensity**: When exposed to bright light, the resistance of the LDR decreases significantly, allowing more current to flow through the circuit. **Low Light Intensity (Darkness)**: In low light conditions or darkness, the resistance of the LDR increases dramatically, restricting current flow. This property allows LDRs to act as sensors that respond to changes in light levels. For example, during the day, when there is ample sunlight, the LDR's low resistance keeps the connected circuit off, preventing the street lights from illuminating. Conversely, at night or in dark conditions, the high resistance of the LDR allows enough voltage to trigger a connected transistor or relay, turning on the street lights.

RESISTOR

A fixed resistor used to form a voltage divider circuit with the LDR. Resistors are integral components in dark sensor circuits used for automatic street lighting systems. They work in conjunction with Light Dependent Resistors (LDRs) and transistors to control the operation of street lights based on ambient light levels. This explanation will delve into the specific roles that resistors play in these circuits, their types, and their impact on the functionality of dark sensors. Light Dependent Resistors (LDRs), also known as photoresistors, are pivotal components in dark sensor circuits used for automatic street lighting systems. Their ability to detect ambient light levels and adjust their resistance accordingly makes them ideal for controlling when street lights should turn on and off, enhancing energy efficiency and public safety. This comprehensive overview will delve into the principles of operation, characteristics, advantages, applications, and limitations

of LDRs, particularly in the context of street lighting. **Principles of Operation**: LDRs operate based on the principle of photoconductivity. They are made from semiconductor materials such as cadmium sulfide (CdS) or lead sulfide (PbS). When light photons strike the semiconductor material, they provide energy that excites electrons, allowing them to move from the valence band to the conduction band. This process results in a decrease in resistance: **High Light Intensity**: The resistance of the LDR decreases significantly (often to a few hundred ohms), allowing more current to flow through. **Low Light Intensity (Darkness)**: The resistance increases dramatically (up to several megaohms), restricting current flow.

NPN Transistor

NPN transistors, particularly models like the BC547, are fundamental components in dark sensor circuits used for automatic street lighting systems. Their primary function is to act as electronic switches that control the flow of current based on the input from a Light Dependent Resistor (LDR). This detailed analysis will explore the operational principles, circuit configurations, advantages, and applications of NPN transistors in dark sensors specifically designed for street lighting.

Operational Principles:-

Basic Functionality: An NPN transistor consists of three regions: the emitter (E), base (B), and collector (C). In dark sensor applications, the transistor operates in two primary states: **cut-off** and **saturation**. **Cut-off State**: When there is sufficient ambient light, the LDR's resistance is low, causing a low voltage at the base of the transistor. This keeps the transistor off (cut-off state), preventing current from flowing from collector to emitter and keeping the street light off. **Saturation State**: In darkness, the LDR's resistance increases significantly, raising the voltage at the base. When this voltage exceeds approximately 0.7V, it turns on the transistor (saturation state), allowing current to flow from collector to emitter and activating the street light..

Light Emitting Diode[LED]:

Light Emitting Diodes (LEDs) are crucial components in dark sensor circuits used for automatic street lighting systems. Their efficiency, longevity, and brightness make them the preferred choice for modern street lighting applications. This detailed exploration will cover the operational principles, advantages, and specific roles that LEDs play in dark sensor circuits designed for street lights. **Operational Principles :- Basic Functionality:** LEDs emit light when an electric current passes through them. In the context of dark sensors, they serve as the visible output that indicates whether the street light is on or off. When the ambient light level drops (e.g., at dusk), the dark sensor circuit activates the LED, illuminating the area. Conversely, when ambient light levels rise (e.g., at dawn), the LED turns off. **Integration with Dark Sensors:** Dark sensors typically consist of an LDR (Light Dependent Resistor) and an NPN transistor. The LDR detects changes in light intensity and sends a signal to the transistor to control the LED. **The circuit operates as follows:** Low Light Conditions: As darkness falls, the resistance of the LDR increases, causing a higher voltage at its junction with a resistor. This increased voltage turns on the NPN transistor, allowing current to flow from collector to emitter and activating the LED.

POWER SUPPLY

A 5V or 9V DC power supply to power the circuit. In dark sensor circuits designed for automatic street lighting, the 9V battery serves as the primary power source that energizes the system. This section will detail how the 9V battery operates within these circuits, its significance, and its integration with other components.

Function of the GV Battery in Dark Sensors:- Power Supply:

The 9V battery provides the necessary voltage for the entire circuit, including the Light Dependent Resistor (LDR), NPN transistor, and LED. It ensures that all components receive adequate power to operate effectively. Typical configurations involve connecting the positive terminal of the battery to the circuit's power rail and the negative terminal to ground. **Voltage Regulation**: The 9V battery helps maintain a stable voltage level that is crucial for the reliable operation of electronic components. This stability is especially important for the LDR and transistor, which rely on specific voltage levels to function correctly. **Circuit Operation**: In darkness, the LDR's resistance increases, which raises the voltage at its junction with a resistor connected to the base of the NPN transistor.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 2, No.4, February : 2025

Explanation Of Working:

Dark sensors are electronic circuits designed to automatically control street lighting based on ambient light levels. They utilize components such as Light Dependent Resistors (LDRs), transistors, and batteries to turn lights on at dusk and off at dawn. This comprehensive overview will cover the working principles, circuit configurations, and applications of dark sensors in street lighting systems. **Daylight:** The LDR's low resistance results in a low output voltage, which keeps the transistor off (cut-off state).

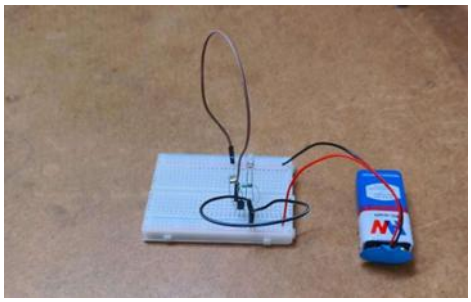
Darkness: The LDR's high resistance causes the output voltage to rise, turning on the transistor (saturation state).

Enhanced Safety: Reliable automatic lighting improves safety for pedestrians and drivers by ensuring streets are illuminated during dark hours. **Cost-Effectiveness:**

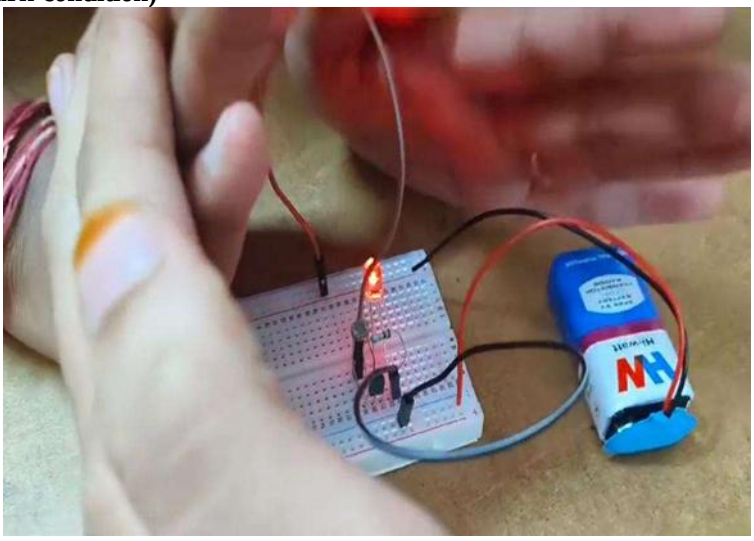
Utilizing inexpensive components like LDRs and transistors makes these systems affordable for municipalities. **Sustainability:** By reducing energy consumption through automation, dark sensors contribute positively to environmental sustainability efforts

.understanding how dark sensors operate will be essential for developing innovative lighting systems that contribute to sustainability and improved urban living conditions. Daytime (Light Condition): When the light level is high, the LDR has low resistance. This creates a low voltage across the LDR, and the base of the transistor (Q) gets no or insufficient voltage to turn ON. As a result, the transistor remains OFF, and the load (e.g., a lamp or LED) will not receive current. Nighttime (Dark Condition): When there is no light, the resistance of the LDR becomes very high. This causes the voltage across the LDR to rise, which in turn provides enough base current to turn ON the NPN transistor (Q).

HARDWARE KIT:-



Indication of LED(in dark condition)



RESULT & CONCLUSION

A dark sensor, often referred to as a light sensor or photoelectric sensor, is a device used to automatically control street lighting based on the ambient light level. When the surrounding light level drops below a certain threshold the sensor triggers the street lights to turn on. This system helps reduce energy consumption by ensuring that street lights are only on when necessary. It also enhances safety by ensuring streets are properly illuminated during night hours. The automatic control of street lighting based on ambient light levels. When the sensor detects low light conditions (such as dusk or nighttime), it activates the street lights. Conversely, when the sensor detects sufficient ambient light (like at dawn or during bright daylight), it turns off the lights.

REFERENCES:

1. Müller, D., & Schneider, T. (2018). Smart Street Lighting and Energy Efficiency: The Role of Automatic Sensors. Journal of Urban Technology, 25(3), 45-58.
2. This paper discusses the integration of smart technologies, including dark sensors, into street lighting systems for energy efficiency and sustainability.
3. Patel, S., & Kumar, A. (2019). A Review of Light Sensing Technologies for Street Lighting Systems. International Journal of Renewable Energy, 41(5), 1124-1137.
4. This article provides a detailed overview of various light sensing technologies used in modern street lighting, including dark sensors.
5. Yang, L., & Zhang, J. (2020). Cost and Energy Savings in Urban Street Lighting with Dusk-to-Dawn Sensors. Energy and Buildings, 224, 40-50.
6. A study on the cost-effectiveness and energy savings from using dusk-to-dawn sensors in street lighting applications.
7. Hernandez, R., & Wu, L. (2021). Urban Lighting Management: The Role of Photoelectric Sensors in Energy Reduction. Smart Cities Journal, 14(1), 27-34
8. Jain, V., & Gupta, N. (2022). Optimizing Street Lighting with Automatic Light Sensors: Environmental and Economic Benefits. Journal of Sustainable Urban Development, 18(2), 77-89.