ENERGY EFFICIENT AUTOMATIC WALKWAY LIGHTING SYSTEM USING A LIGHT DEPENDENT RESISTOR

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Abstract

In today's world, walkway lights are very much required in populated regions. Due to the busy lifestyle of humans, switching operations on walkway lights are not carried out on time, and a huge amount of electricity is being wasted. In the present system, it is observed that walkway lights are not turned OFF even when there is an ample amount of light after sunrise and are turned ON even before sunset. Even in timer based street light control systems, the ON and OFF time differ noticeably during sunny and rainy days. To overcome these problems, an automatic walkway light controller is designed. The project aims to eliminate the manual operations and to design an energy-efficient automatic walkway light controller using a light-dependent resistor (LDR). The Light Dependent Resistor (LDR) senses the light actually like our eyes. It automatically switches OFF lights whenever the sunlight comes visible to the sensor. This project demonstrates the working of the transistor in a saturation region and cut-off region. The working of the relay is also known. Implementation of this project encourages digital work. Light-dependent resistor, a photocell has been used as the transducer to convert light energy into electrical energy. The central dogma of the circuit is that the change in the voltage drop across the light-dependent resistor on illumination or darkness switches the transistor between the cut-off region or saturation region and switches OFF or ON the lights. The result was an efficient automatic lighting system for walkway that is highly economical, reliable and requires very little maintenance.

Keywords: Automation, Energy-Efficient, Light Dependent Resistor, Light, Sensor, Photocell

INTRODUCTION

In the 21st century, it is quite impossible to avoid accident or eventualities during the night without lights. So walkway light is the essential part of our busy lives for safety purposes. But the manpower required for controlling the light cuts a huge cost. Also, we need to save or conserve energy because most of the energy sources we depend on, like coal and natural gas can't be replaced. Once we use them up, they're gone forever. Saving power is very important, instead of using the power at unnecessary times, it should be switched off. Providing walkway lighting is one of the most important responsibilities. Lighting can account for 10-38% of the total energy bill in typical cities worldwide (Gouthami, Santosh, Kumar, Karthik & Ramya, 2016). Walkway lighting is a particularly critical concern for public authorities in developing countries because of its strategic importance for economic and social stability. The fixtures of walkway lights indirectly have assisted the public in the reduction of crime rate in the area. It also encourages social inclusion by providing an environment in which people feel they can walk in hours of darkness. Despite that, in today's busy lifestyle no one bothers to switch it OFF/ON when not required. Inefficient lighting wastes significant financial resources each year, and poor lighting creates unsafe conditions. The project necessitates the need to reduce the cost of manpower and reducing power consumption.

Electrical Power wastage can be reduced by using the light-dependent resistors as light-sensing devices or light sensors to indicate day or night time. A photoelectric sensor has been used to detect the movement of humans and vehicles on the streets (Saikumar, Vaibhav & Rrochish, 2018). However in this era advancement in Embedded systems, Automatic walkway light control can be achieved using microcontrollers and light-dependent resistors (Somasekhar & Umakanth, 2014).
The supply to the control unit and light the walkway light is being achieved by the implementation of solar power system . Again the LDRs are used to differentiate between day and night light. The discrete analogue signals sensed

by LDR due to variation in its resistance are converted to digital signals. This system is walkway light switching control and a lot more amount of power is conserved (Kodali & Yerroju, 2017; Sunehra & Rajasri, (2017).

MATERIALS AND METHOD

During the day time, there is no essence of walkway light so the light dependent resistor (LDR) as shown in figure 1 below, keeps the walkway light off. As soon as the light intensity is low then the LDR has started working and the light is switched on.

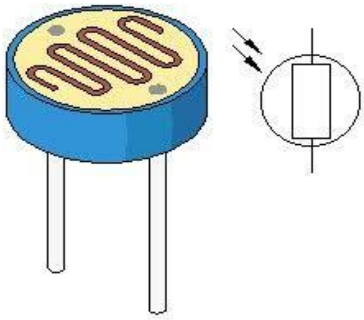

Figure 1: Light Dependent Resistor (LDR)

A light-dependent resistor as the name suggests depends on light for the variation of resistance. LDR is made by depositing a film of cadmium sulphide or cadmium selenide on a substrate of ceramic containing no or very few free electrons when not illuminated (Rashid, 2004). Light Dependent Resistors (LDRs) are very useful, especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000000 ohms, but when they are illuminated with light, the resistance drops dramatically (Agarwal, 2015). Photosensors are the devices that alter their electrical characteristics, in the presences of visible or invisible light. The best-known devices of this type are the light-dependent resistor, the photodiode and the phototransistors.

The LDR is made of high resistance semiconductor when light falls on such a semiconductor; the bound electrons get the light energy from incident photons. Due to this additional energy, these electrons become free and jump into the conduction band. The electron-hole pairs are generated. Due to these charge carriers, the conductivity of LDR increases; decreasing its resistivity

Features of LDR are as follows:

- High reliability
- Lightweight
- Wide spectral response
- Wide ambient temperature range.

Table 1: Major Components and Specifications

COMPONENTS	**SPECIFICATIONS**
Bulb	Type: GWL energy saving bulb, Rating 5 Watts
Cable	Type: E-confidence; Dual Core, Size: $1mm^2$
Miniature Circuit Breaker	Type: ABB; single-pole, Rating: 6 Amps
Photocell switch	Type: Photocontrols, Power supply: 220 V/AC, Power current: 10A, Power Frequency: 50/60 Hz, ON/OFF levels: 5-100Lux
Lamp holders	Type: Angled, Connector type: Dual connectors (E27 and B22)
Lamp holder base	Type: Wooden, Dimension: 12×12 cm

The table 1 above shows the list of major components and their specifications.

A. Component Description

1. 6 A Single-pole Miniature Circuit Breaker
2. 1mm dual-core cable
3. 10 A Photocell switch
4. 5 W Energy-saving bulbs
5. Lamp holders

1. **6 A Single-pole Miniature Circuit Breaker**: This is a protective switching device in figure 3 was used in the installation to prevent the flow of abnormal current from the supply. (i.e. values of current above the amp rating of the breaker)

Figure 3: Single-Pole MCB

2. **Dual-Core Cable**: The dual-core cable in figure 4 was used to connect the lamps in parallel and also to draw power from the supply.

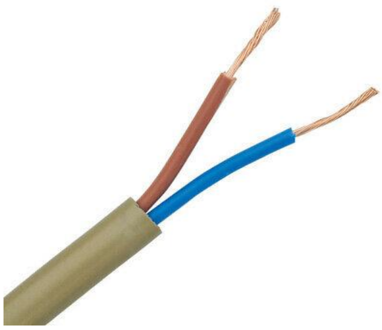

Figure 4: Dual-Core Cable

3. **10A Photocell Switch**: The photocell in figure 5 was used as the automatic switch for turning the bulbs on and off depending on the light intensity of the environment.

Figure 5: Photocell Switch

4. **5W Energy-Saving Bulbs**: These are the fittings used for lighting up the walkway when it's dark, shown in figure 6.

Figure 6: Energy-Saving Bulb

5. **Lamp Holders**: The lamp holder in figure 7 holds and connects the bulb. It is the double-use type that can be used for either E27(screw-based bulbs) or B22(pin-based bulbs).

Figure 7: Double-Connector Lamp Holder

B. Implementation

The photocell used in lighting application has three terminals as shown in figure 8 labelled as:

1. Load line (Lo)

2. Neutral line (N)

3. Supply or live line (Li)

- The load line is a red cable which is connected to the lighting phase terminal.
- The neutral line is a white cable which is connected to the Neutral Point of the lighting and also to the neutral terminal of the power source.
- The load line is a black cable which is connected to the phase cable that comes directly from the breaker.

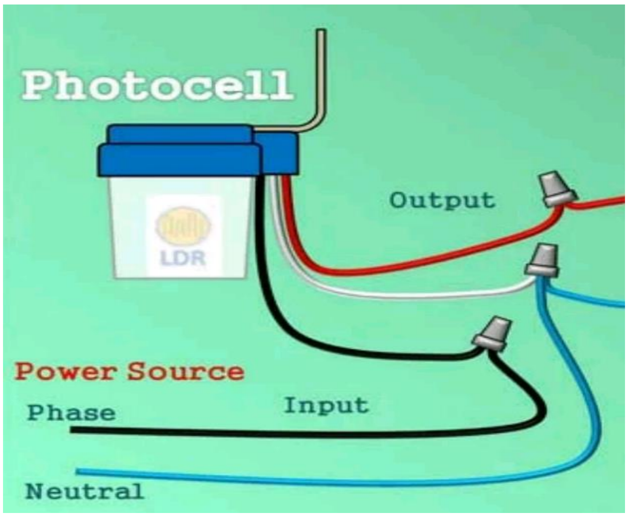

Figure 8: Photocell Switch Colour Code (Source: What is Photocell? The function, Working Principle and Wiring Diagram, 2020)

As shown in the figure 8 above, the load wire (Lo) goes to the lighting installations connected in series while the neutral (N) wire through a breaker is looped to all the lights. The supply line through a breaker supplies the photocell electrical power.

The following measures were taken when positioning the photocell switch:

- The photocell switch was installed in a position exposed to direct sunlight.
- Objects that could block sunlight were removed from the place of installation.
- The photocell was installed in a position that is protected from the light from fittings. (i.e they were placed far from lamps).
- The photocell switch was placed in the correct installation position with which it was designed to avoid the entry of water into the sensor and cause the sensor to be damaged (short circuit).

The wiring and installation of the photocell switch are illustrated in figure 9 and figure 10 below:

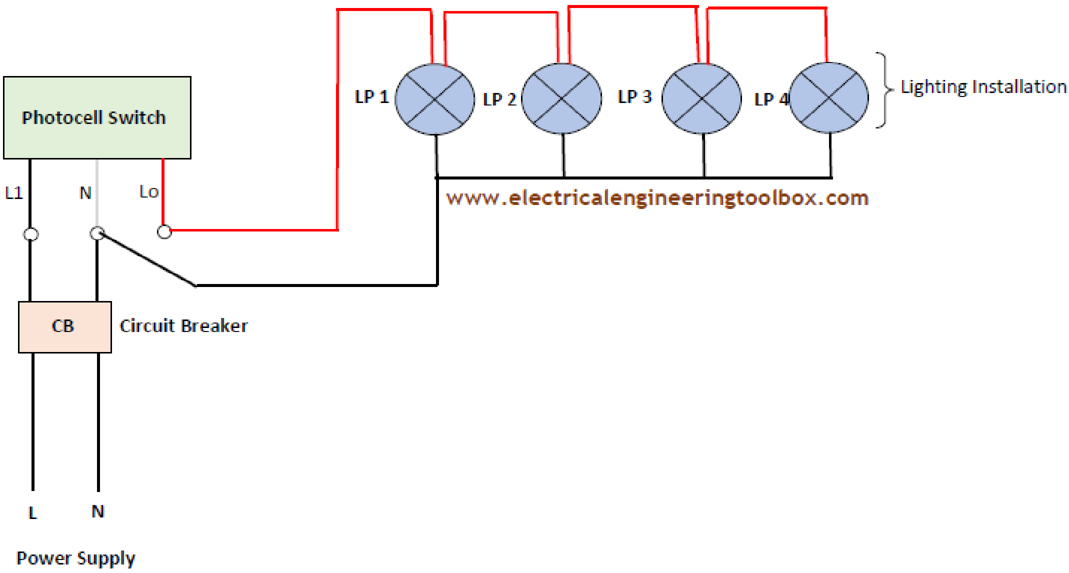

Figure 9: Wiring and installation circuit of photocell switch (Source: How to Install and Wire a Photocell Switch in a Lighting Installation, 2017)

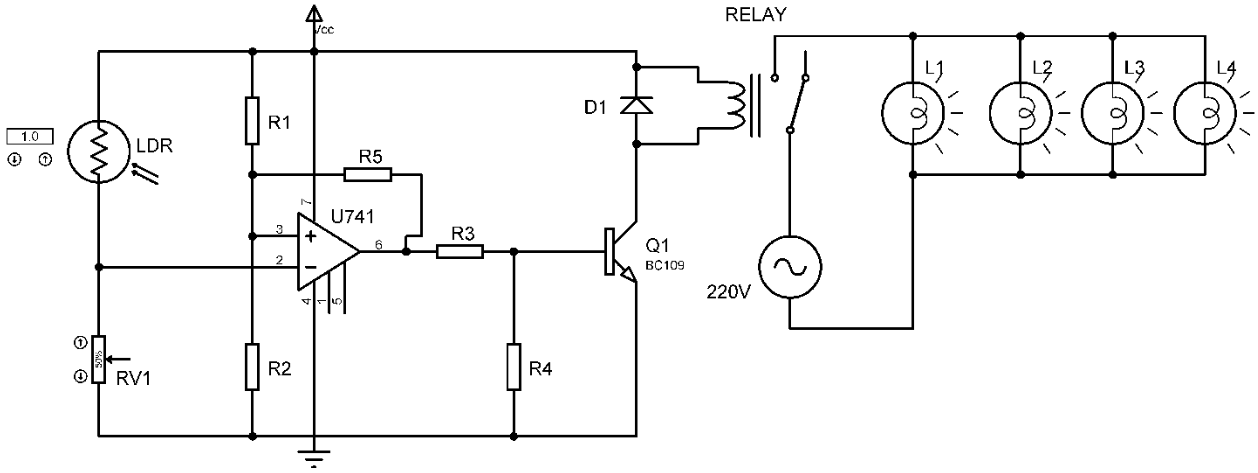

Figure 10: Circuit diagram of photocell switch

System Testing

Components to be used for the installation were ordered and bought from different shops and tested. Before and after the installation, testing and analysis were carried out. Components such as photocell switch, cables and the breaker were tested.

Before the installation:

The photocell switch was tested using the multimeter to check the output voltage from the fittings terminal of the device. This test was carried out under infinitesimal light intensity and high light intensity conditions. The test showed that the output voltage at the fittings terminal of the photocell was equivalent to the supply voltage (i.e 220/240V). This confirms that the device is working.

The cable was tested after laying to detect any bridge or short circuit along the line. This was done by joining the neutral and live terminal of the cable at the starting point and a multimeter was used to conduct continuity test at the terminals of the cable at the endpoint. There was a beeping sound from the multimeter. This confirms that the lamp holders were properly connected and there is no short circuit along the line.

The circuit breaker was tested using the multimeter to conduct continuity test at the live-in and live out terminals. There was a beeping sound which confirms that the device is working and not faulty.

After the installation:

Tests were run for 13 hours. It started at 06:20 PM and ended at 07:20 AM the next morning. This period was selected so that the state of light and darkness could be observed separately. It was observed that the photocell switch was triggered and the lights were turned ON at 06:50 PM at sunset. It was also observed that the lights were turned OFF at 06.59 AM at sunrise. The testing result is shown and highlighted in the plates and table 2 below.

Figure 11: Lighting condition of the walkway at 06:47PM

Figure 12: Lighting condition of the walkway at 06:50 PM

Figure 13: Lighting condition of the walkway at 06:59 AM

Table 2: Summary of System Response

TIME	OUTPUT	EXPECTED RESULT	TESTING RESULT
06:50 PM	Under low light intensity (i.e at dusk or when the photocell is covered)	Always switch ON with no delay	Delay for some time (≤5secs) before switching ON
06:59 AM	Under high light intensity (i.e during broad daylight or when the photocell is uncovered)	Always switch OFF with no delay	Delay for some time (≤1sec) before switching OFF

Generally, depending on the duration of day and night, the time for switching ON the light during sunset and switching OFF the light during sunrise may change. Especially, during rainy or very cloudy days and period of longer day and shorter nights. Hence, there is no actual or specific time for turn ON and turn OFF.

CONCLUSION

The installation of the walkway automated light system was carried out and tested successfully. The performance of the system as shown in figure 11 and figure 12 after testing met all the specifications and helped to save energy efficiently. Finally, the problem of putting ON or putting OFF the light manually by individuals was taken care of since the system operates automatically.

The effectiveness and reliability of the system are highly acceptable. The durability of the system, however, is dependent on the user who is prone to human error such as overloading the system and making wrong connections.

RECOMMENDATIONS

The following recommendations are suggested to enhance the efficient operation of the automated system:

- The total load to be connected to this device should not exceed 6A.
- The device should be connected to a 220V/240V,50Hz power supply.
- This system needs no intensive maintenance but for it to last long and work effectively, one needs to observe these few regulations:
- Photocell should be cleaned when dirty, for good and effective operation.
- Faulty breakers should be replaced as soon as possible for effective operation and durability.

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