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Design and Construction of an AC Automatic Light Sensitive Switch System to Control Bulbs Inside Buildings

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Abstract

Electrical energy wastage remains a persistent challenge in modern buildings, particularly where lighting systems rely on manual switching that requires continuous human intervention and often results in bulbs being left on during the daytime or unavailable when needed at night. This study aimed to design and construct a prototype automatic light-sensitive switch system for controlling alternating-current lighting points in buildings such as lecture halls, classrooms, and offices in order to reduce unnecessary electricity consumption. The system was developed using a Light Dependent Resistor (LDR) as a photosensor and a relay-based switching mechanism to detect changes in environmental brightness and darkness and automatically switch bulbs on at sunset and off at sunrise. The methodological process was carried out in sequential stages comprising software simulation, component assembly and testing on a breadboard, soldering, final testing, and packaging of the prototype. The findings indicate that the developed system can automatically respond to ambient light conditions and control lighting operation without manual intervention. The prototype is projected to reduce building electricity costs by approximately 50% compared with a manual switching system, while

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also improving bulb lifespan and operational efficiency. The study concludes that an automatic light-sensitive switching system offers a practical and efficient solution for minimizing electrical energy wastage in residential and institutional settings. Its contribution lies in providing a simple, low-cost, and functional prototype that supports energy conservation and more efficient lighting management in buildings.

Keywords: Automatic Light Switch; Electrical Energy Conservation; Light-Dependent Resistor; Lighting Control; Prototype Design

INTRODUCTION

Human development is an ongoing process, and every human development in terms of infrastructure, such as building, will definitely need electricity. Electrical energy wastage is a common phenomenon in modern living. There has been a rapid increase in the usage of electrical energy as more buildings are constructed in most Nigerian Universities. Every development comes with its own challenges. Conservation of energy, such as light, sound, solar, etc. are considered a serious concern worldwide (Adewale et al., 2013). Electrical Bulbs in Lecture halls; Classes and offices are usually controlled by ON and OFF manual switches which are connected to 220-240 Volt A.C supply or others sources of voltage supply, this means that there is a possibility of a continuous lighting of Bulbs in an empty Lecture Halls; Classes; Rooms; Offices without any occupant, this will unnecessary leads to waste of Electrical Energy and hence have high financial implication. Particularly, continuous power consumption through lighting bulbs in a building is a factor that cannot be ignored. Every Building needs a different type of lighting at each location. Sometimes the light intensity from an outside source is considered sufficient, and a user inside a house does not need to turn ON the light source inside; these factors are considered one of the reasons that cause unnecessary energy wasting (Brown, 1998). Whenever Bulbs are ON at all times, it indirectly causes an increase in the utility Bill of the Building. An efficient lighting strategy provides a proper level of illumination and also reduces the cost of energy (Aniruddha et al., 2017; Nwoye et al., 2017). About thirty percent (30%) of European total energy consumption is on lighting only (European Commission, 2012). Therefore, some alternatives are needed to save energy and reduce the utility cost for homes, schools, and industries. Due to the rising energy costs in the world, negative energy usage and unawareness of optimizing energy usage at homes, schools, and industries, this problem

leads to the need to develop continuous energy-saving systems. Based on these facts, there are many lighting management systems that have been developed to reduce the energy wastage at homes, schools, and industries (Eldhose et al., 2007).

Automatic light switching system uses a light controlling mechanism which helps energy saving and security advantages. This system is designed to reduce the billing cost and indirectly increase the life span of bulbs. Electronic sensors and microprocessor-based energy controllers are used as inputs to the centralized system to detect darkness and for security purposes; a microprocessor is used to automatically control the lighting intensity during the respond to daylight (Yanev, et al., 2003). The most common applicable device is an automatic light sensor switch, which is a simple device that switches ON any lighting system in the evening and switches OFF in the morning during daylight (Aniruddha et al., 2017). The automatic switch system works based on a direct connection to the three electrical wires in the fluorescent light; this light sensor device is placed away from the light source to avoid the light from falling directly on the sensor photocell device (Denardin et al., 2011). The hindrance or slow rise in the development, especially in industrialization, may be hinged majorly on the wasteful attitude of individuals in energy management and consumption at home, especially in powering cooling and lighting systems in unoccupied places (Sambo, 2008). As a result of this, power cannot be diverted to industrial areas so as to foster production, thereby matching Electricity supply with demand in Nigeria (Sambo, 2008). There is an enormous energy need in Nigeria, and the national grid is insufficient, which leads to the use of generators. The use of generators is on the increase as a result of the demand for electric energy, which is insufficient (Oyedepo, 2012). This, however, impedes the economy of the Nation as it mounts pressure on the oil sector and reduces foreign exchange possibilities as a result of an increase in the consumption of oil products locally. There is a slight shift in the use of filament bulbs to energy-saving bulbs, which has spurred technology towards the production of low-wattage bulbs.

To avert this ill of energy wastage, this work presents a development of an automatic switch using LDR and relay for day and night detection as a means of energy conservation at home, school, and industries. Efforts to increase conservation attitudes among individuals towards energy have been ongoing for a long time. In recent years, LEDs have been used to produce electric bulbs because of their characteristics to give an appreciable output of lumens with less power. All these efforts only reduce power consumption and not the wastage. An energy-saving system is important to reduce unused

energy waste and to help utilize it and maximum energy used during peak demands. Furthermore, most energy system needs a consumer to help reduce the utility costs. Additionally, these systems could indirectly help to prolong the lamp's life span (Francis et al., 1990). An automatic lighting system also serves as a pre-secure system. As we know, users are often shocked by an electric shock when they try to switch ON or OFF the light. This reason leads to the development of an automatic light switching system, which is necessary for safety conditions, and at the same time, this system is capable of performing energy saving and efficient energy usage (Usikalu et al., 2011). The automation of light switches has a wide range of real-life applications, basically in automation, and can be used in surveillance systems if properly modified. Light switches have been constructed in many different ways, but this light-dependent resistor (LDR) type; it is more sensitive than inductive and capacitive sensors, which are rarely used in circuit designs. This is because it is a photocell that works on the principle of photoconductivity, whose resistance value decreases when the light intensity decreases. Light-dependent resistors are also called optoelectronic devices. When exposed to a source of light with high intensity will automatically lights ON LED by activating the circuit.

This research work seeks to find a more efficient way of controlling light points through automation of light switches, which will seek to eliminate the stress, time, and inconvenience associated with manual switching of lights at homes, schools, and industries, and to reduce the cost of electricity consumption. This research seeks to design and construct an A.C automatic light-sensitive switching system using a relay and Light Dependent Resistor (LDR). The key feature of this device is that its operation is light-dependent; that is, the device is activated only in a sufficiently dark environment, making it a light-dependent switching system. This system is designed to be placed in individual Lecture halls/Classroom/ Offices. Because sometimes these lecture halls, classrooms, and offices are unintentionally left switched ON for the whole day or even months. This will lead to unnecessary energy wastage and increase the utility bill in terms of energy consumption. Hence, when this automatic light switch is installed, it will provide a lasting solution to letting Bulbs ON at all times in buildings. This switching system is more convenient and efficient in reducing energy wastage in buildings. Automating a switch will also increase the efficiency of the bulbs, and to help increase the life span of the bulbs.

MATERIALS AND METHODS

The components used in this construction were locally sourced from Jos, Plateau State, Nigeria. These components are very common and available in the market. The list and specifications of the components used for the construction of a prototype A.C automatic light switch for this work are presented in Table 1, while Figure 1 shows some of the components used. The method used to carry out the design and construction of a prototype A.C automatic light-sensitive switch system includes: Using Livewire software to design and simulate the circuit diagram based on the components used, as shown in Table 1. Figures 2 and 3 show the test running the circuit to verify the functionality of the circuit. Figure 4 shows the second stage of assembling the components on a breadboard, which shows when the switch is OFF, i.e., when the day is bright, and when the switch is ON, i.e., at night time or when the weather is dark. The final stage involves the assembling, soldering, and packaging as shown in Figure 5, which shows the OFF and ON of an A.C automatic light switch. The Working Principle of an automatic light-sensitive switch system operates on the working principle of LDR using the intensity of light from the source, i.e., the higher the intensity lights the lower the resistance, and no light in the electrical bulbs (OFF), while the lower the intensity, the higher the resistance, and the electrical bulbs glow (ON). An automatic light-sensitive switch can be constructed using different components aside from the relay used in this work. A relay is used in this work because it is cheap, its availability, and it has a unique characteristic.

Table 1: List of materials used and their specifications.

S/no.	Components/Equipments	Quantities	Values/Specifications
1	Rectifier Diodes	4	1N4007
2	Zener Diode	1	12V/ 1WATT
3	Transistors	2	BC547
4	Capacitors	2	1µF/400V, 470µF/ 16V
5	Light bulb	1	220V
6	Relay	1	12V/ 1WATT
7	Resistors	5	1MΩ/1W, 100Ω/ 1W, 220Ω/ 1W, 1KΩ/ 0.5W, 100KΩ
8	Alternating power supply	2	220-240V
9	Breadboard	1	
10	LED	1	
11	Vero Board	1	
12	Jumper wire kit, male and female		



A B C

Figure 1. Components (A) Light Dependant Resistant (LDR) and (B/C) a relay

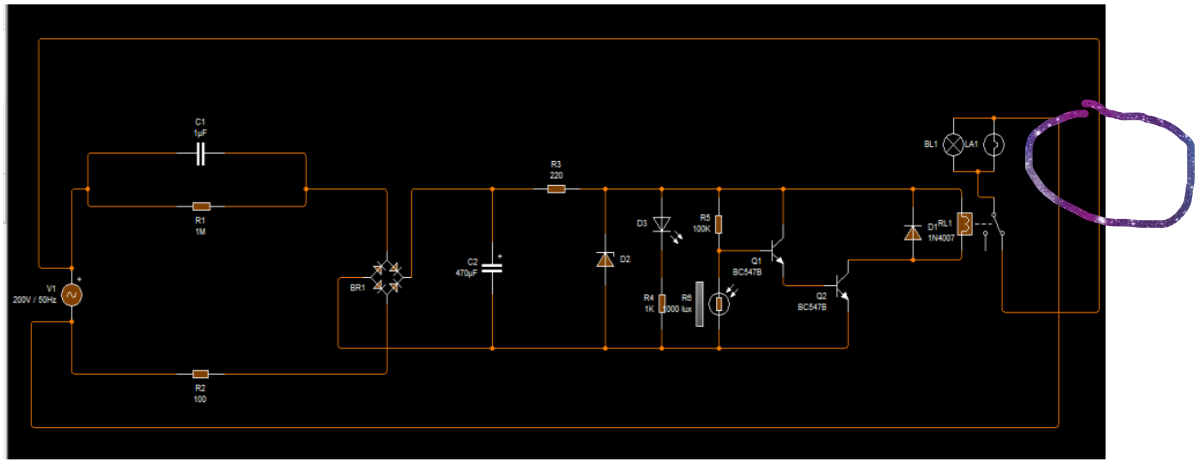


Figure 2: A circuit diagram of the automatic light switch when it is OFF during the day (the Bulbs are OFF).

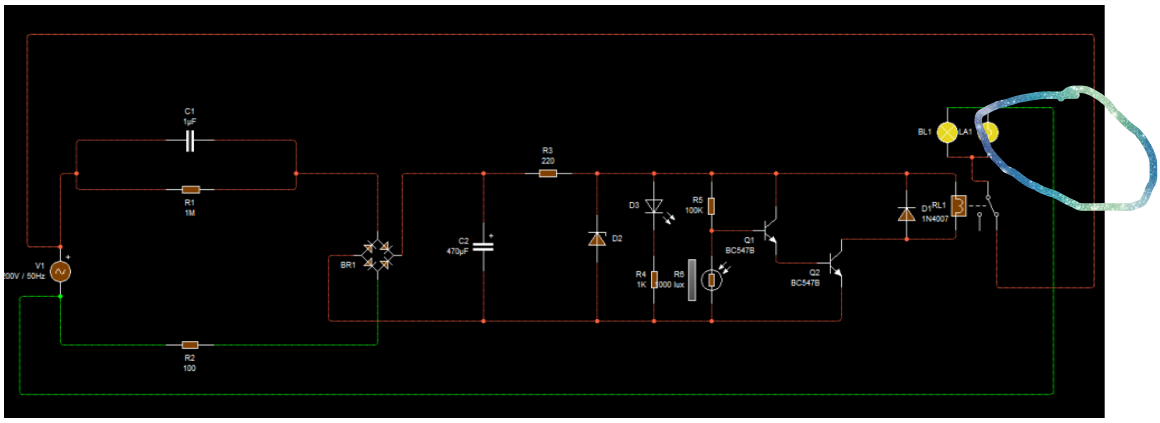
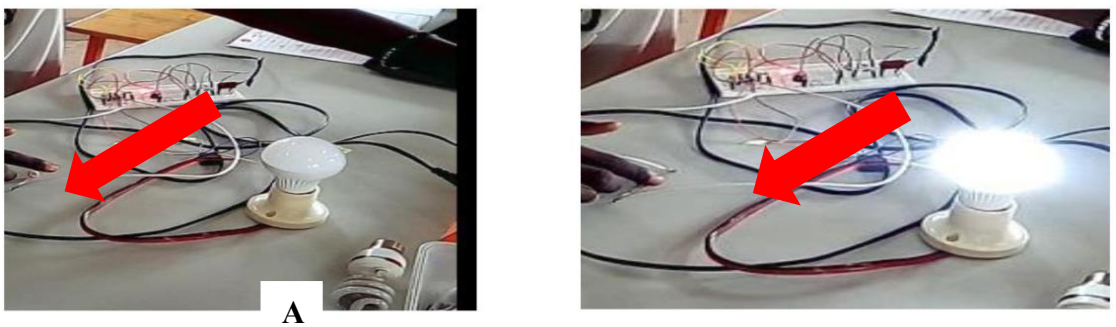


Figure 3: A schematic circuit diagram of the automatic light switch when it is ON at Night (bulb is yellow)



A **B**

A switch when it is OFF during the

A switch when it is ON at Night

Figure 4: An Automatic light switch on breadboard; (A) Bulb is OFF and (B) Bulb is ON

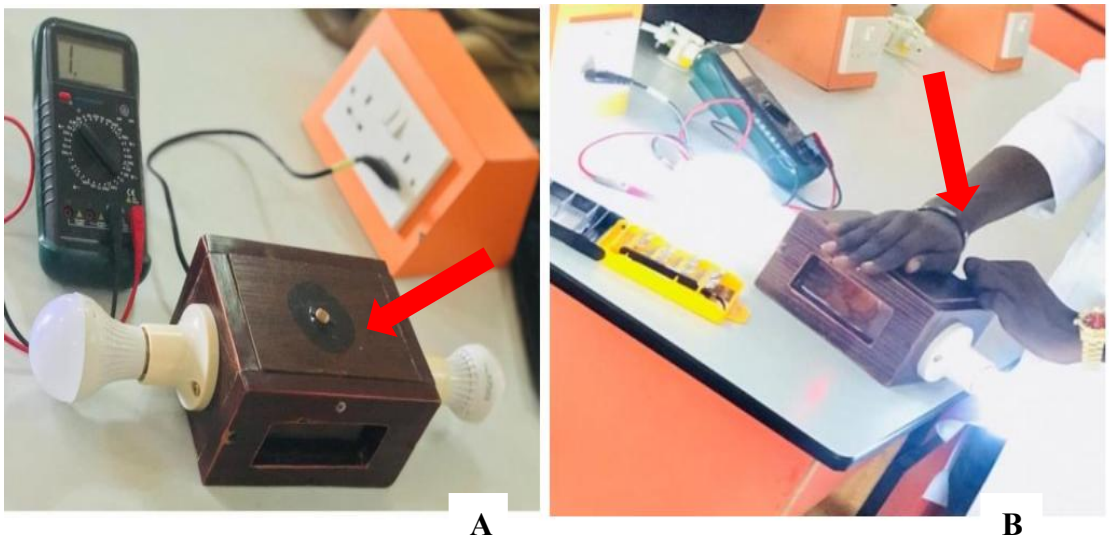


Figure 5: A Prototype A.C automatic light switch package: (A) when Bulb is OFF and (B) when Bulb is ON.

RESULTS AND DISCUSSIONS

From Figure 5, it can be seen that an A.C Automatic light switch is operational. When installed, it will ensure electrical energy conservation in Lecture Halls, labs, and other buildings. The mathematical expression to calculate the Energy consumption for a bulb is the product of the Power (watts) of the bulb to the total time (seconds) the bulb is in use, given as: -

$$\boldsymbol{Energy = Power\ rating\ of\ a\ bulb\ x\ total\ time\ the\ bulb\ is\ in\ use\ or\ (E = P \times T)}$$

The unit charge for electrical energy is KWH.

Considering the Physics Laboratory of Federal University Wukari as a sample point, the Laboratory has a total of 56 bulbs, each bulb is rated 60W, the total power for all the bulbs in the Physics laboratory is about 3360W or 3.36KW. Assuming all the bulbs are ON for 12 hours from 6 pm to 6 am, when using an A.C automatic light switch, it therefore means the total hours the bulbs will be ON for 365 days will be 4,380 hours. Then the total Electrical Energy Physics laboratory will be about 14716.8KWh. Based on Jos Electricity Distribution Company (JEDC) charges, the rate of ₦ 23.25 per KWH was the rate when this research was carried out. To calculate the total energy consumed, the following expression was used.

$$cost\ of\ energy\ comsumption = rate \times energy\ used\ (cost = R \times E)$$

Then the cost of Electrical energy consumed by the Physics Laboratory for 12 hours every day for 1 year (365days) is ₦ 342,165.60. Table 2 shows the assumed cost of electrical energy consumed by some selected halls in Federal University Wukari for 12 hours using A.C Automatic light switch and for 24hours when the switch is manual, assuming the light is constant all through for 365days (1year).

Table 2: Calculated summary of the energy consumption per Hall at Federal University Wukari

s/no.	Lecture halls	Number of Bulbs	Power Rate per bulb (KW)	Total Energy (KWh)	Cost of Electrical Energy for 12hrs in 365 days (₦)	Cost of Electrical Energy for 24hrs in 365 days (₦)
1	Physics Laboratory	56	3.36	14,716.80	342,165.60	684,331.20
2	Chemistry Laboratory	64	3.84	16,819.20	391,046.40	782,092.80
3	Biology Laboratory	56	3.36	14,716.80	342,165.60	684,331.20
4	MPB101	80	4.8	21,024.00	488,808.00	997,616.00
5	Multipurpose Hall 1	80	4.8	21,024.00	488,808.00	997,616.00
6	Multipurpose Hall 2	156	9.36	40,996.80	953,175.60	1,906,351.20
7	Pre-degree Hall	24	1.44	6,307.20	146,642.40	293,284.80
8	Lecture Theatre	212	12.72	55,713.60	1,295,341.20	2,590,682.40
9	Lecture Hall 1	48	2.88	12,614.40	293,284.80	586,569.60
10	Lecture Hall 2	40	2.4	10,512.00	244,404.00	488,808.00
	Total	**816**	**48.96**	**214,444.80**	**4,985,841.60**	**10,011,683.20**

CONCLUSION

In conclusion, the result from Table 2 above clearly shows that the cost of electricity energy used when the bulbs are ON for 24 hours is approximately ₦ 10 million, while it costs ₦ 5 million when the bulbs are ON for 12 hours. This shows a reduction of approximately 50% when using the A.C automatic light switch, which helps to reduce the cost by half and enhance this will increase the efficiency of the bulbs, and helps increase the life span of the bulbs in those Halls. Therefore, comparing the manual switch which are installed in all the Halls and needed human to switch it OFF and when an automatic light switch is used, it can be seen clearly that it will Cost (the sample locations Federal University Wukari) approximately less than 50% of the actual electrical energy which is supposed have been consumed when an A.C automatic Light sensitive switch when in use. When these systems are installed in a building such as lecture Halls/Classrooms/offices/others, the electrical energy cost will have been reduced by approximately 50%. This 50% approximate value reduction was also observed by other

research teams in other institutions. This reduction in the utility bill will then be channelled to other areas that require development in the Universities/colleges/etc.

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