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A LOW-COST COMPACT ELECTRICAL ENERGY SAVING SYSTEM INTEGRATED WITH PIR MOTION DETECTOR

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ABSTRACT

In the present modern society, where electricity is necessary for the lightening of homes and public buildings, the major problem in our localities is power wastes. To some extent electrical appliances such as lighting systems were left ON even in the absence of people in both private and public places. This is because traditional manual switching system is still employed in almost every building where one has to switch the room lights ON or OFF. Thus, a large amount of energy is being wasted if lights are left ON in the absence of people in those places. This work presents an intelligent energy saving system that can automatically power ON/OFF our lightening systems. The heart of this project is Passive Infrared (PIR) motion detector that can detects the radiated heat of a person and converts it to electrical signals, which is sent to switching circuit for processing. A low-cost fully automated energy saving system was designed and tested in physics laboratory of Umaru Musa Yar'adua University, Katsina, Nigeria. The system was able to detect movement of objects/humans within range of 6 meters in the lab to switch ON the light and also switch it OFF in their absence. Therefore, the designed system if explored will have the potentials of reducing energy waste and at the same time reducing one's energy bills.

Keywords: Low-cost, Electrical Energy, saving system, Integrated, PIR motion detector

INTRODUCTION

Self-sustenance in energy is a key factor for socioeconomic growth and development of every country (Choi et al., 2014). However, with the current period of energy crisis and high energy cost, energy management is seen as a fundamental task of ensuring significant reduction in energy loses (Arum et al., 2020; Qasim et al., 2020). Home power consumption being among the largest part of energy consumption, the power consumption of lamps in particular in a typical home is a factor which cannot be ignored (Bai & Ku, 2008).

For decades now, government's efforts are being made to overcome these challenges by exploring all kind of alternatives for power generation, such as, fossil fuels, hydropower, nuclear power, wind, solar etc. However, individuals are also expected to provide a significant contribution by turning off unwanted electrical appliances in their homes. In many cases, people forget to put off lights in their homes, offices, laboratories etc. before leaving (Syeda et al., 2015). Thus, home automation is seen as a key step in reducing these leakages and at the same time reducing one's electricity bill (Qasim et al., 2020).

Lighting system being an essential component of modern buildings that ensures the inhabitants are comfortable, productive and in a secure environment at night, has received serious technological transformation where lighting system is being automated (electronically) (Shao et al., 2023). This means that, light will become ON if there is any movement in the room and remains OFF as long as there is no movement in the room (Syeda et al., 2015). This can be achieved by incorporating additional electronic component "Passive Infrared (PIR) sensor" to our lighting systems.

The PIR Sensor is an electronic device that can detects movements by measuring changes in the infrared (heat) levels emitted by surrounding objects. When the movement is detected, the sensor outputs a high signal on its output pin that can be read by a microcontroller or a trigger transistor which could switch high voltage devices (Twumasi et al., 2017). In view of this, the current work explores the potentials of using PIR sensor for designing an intelligent and cost-effective power saving system capable of saving electricity in an efficient and automated manner.

Although, the first motion detector which employ ultrasonic waves to detect intruders and fire incidence was invented in the early 1950s by Samuel Bango, yet majority of the current motion detectors still employ the same principle. A good example is PIR sensor that measures infrared light emitted by objects in its field of view. To date, a lot of researches conducted by different researcher such as (Bae et al., 2003): Al-Ali & Al-Rousan, 2004); Ziya & Buhur, 2005) presented different techniques for human detection and power saving systems. However, a quite number of these systems are inefficient in terms of human detection. While others apart from having high production cost, their systems required high power for operation. Furthermore, some of the works available in the literature (Ha et al., 2006; Bai & Ku, 2008; Okinda et al., 2016; Harsha & Kumar, 2020; Htwe et al., 2020) presented a more complex power saving system which may be difficult to be installed in standalone system and open places like Streets.

MATERIALS AND METHOD

The designed System

The designed system consists of sensing module, amplifying circuit, DC regulating circuit, a rectifying circuit, energy saving bulb and a relay module as shown in the circuit diagram below:

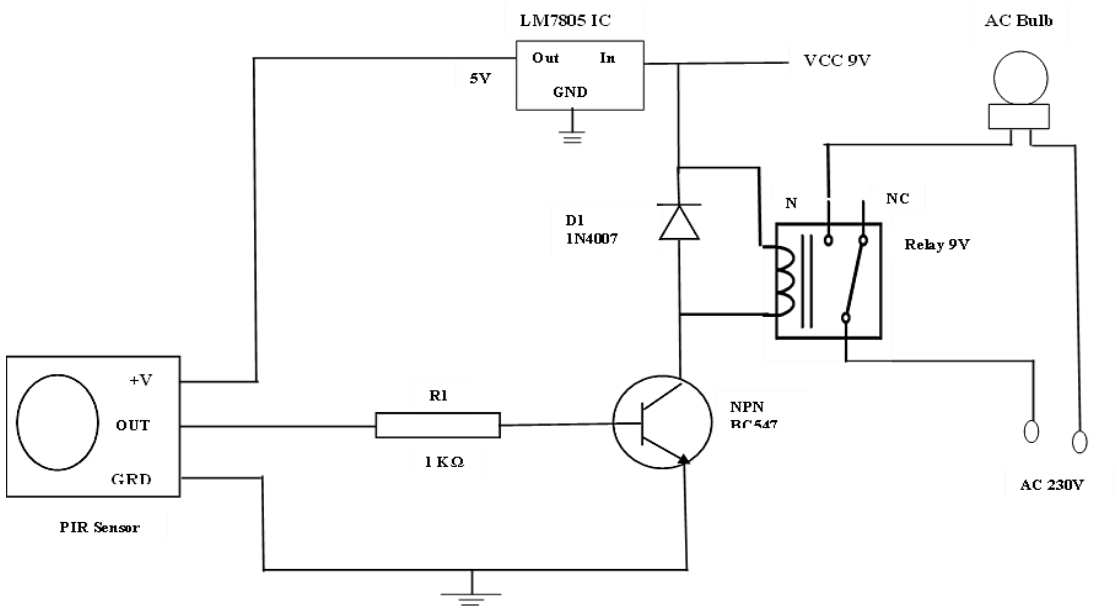

Figure 1: Circuit Diagram of the Designed System

In Figure 1, a single 9V battery was used to operate the circuit. The output terminal of LM7805 voltage regulator connected to the input terminal of the PIR module was to ensure 5V DC voltage supply to the sensor module. While the output terminal of the PIR sensor is connected to the base terminal of the switching BC547 transistor, the transistor collector terminal is connected to the relay terminal. With the presence of an object, human as a good example, the temperature in the PIR sensor field of view will increase from normal temperature to body temperature (Infrared radiation). These heat signals detected by the sensor triggers its output to a high state and hence the transistor gets high input at the base which turns the transistor ON. The output signals from the transistor, will then influence the activation of the relay circuit thereby switching the bulb ON. However, with no movement, the sensor gives low output, making the transistor OFF as well as the relay and the bulb.

The PIR Sensor Module

The name PIR (passive Infrared) is given to the sensor because it receives infrared rays passively and do not emit any infrared ray. The sensor just works by detecting infrared radiation (radiant heat) emitted by or reflected from objects. Therefore, with the presence of objects (Humans or Animal) the sensor detects infrared radiations emitted from the object which is then converted into electrical signals that can trigger the transistor into conduction state. The sensor has numerous configurations in various applications of uses, but the most widely recognized models have multiple mirrored lenses or Fresnel lenses, with a powerful scope of approximately 6 meters and a field of view of fewer than 180 degrees, see Figure 3:

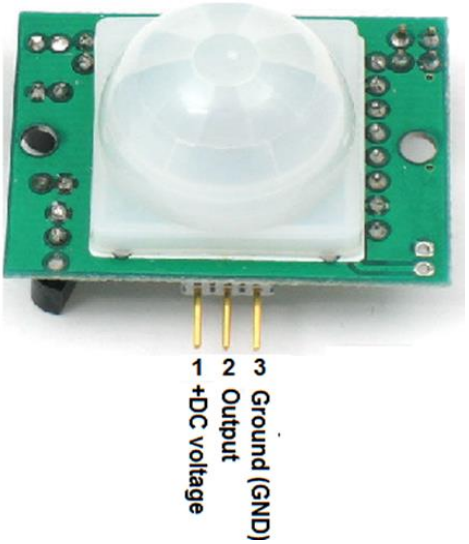

Figure. 3: PIR Sensor Module

In this work, the PIR sensor used has three terminals. The first terminal pin 1 receives 5V DC voltage from the LM7805 voltage regulator while pin 2 was grounded. The middle terminal "pin 3" which is the output of the sensor is connected the base terminal of the BC547-transistor.

The BC547 Transistor

This is a three terminal semiconductor device that regulates or controls current or voltage flow in addition to increasing signal strength by amplification. In this work, a NPN BC547 -transistor was used to serve as a switch and at the same time increasing the strength of signals receive from the PIR sensor module, see Figure 3 below:

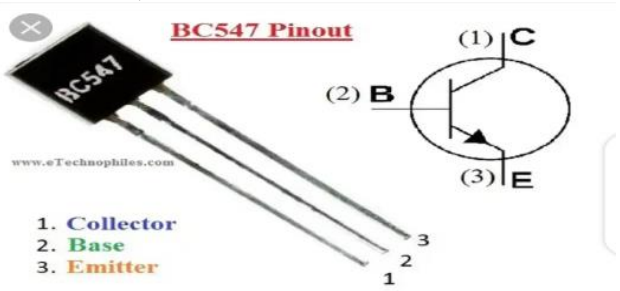

Figure. 3: The BC547-Transistor

LM7805 Regulator

The LM7805 voltage regulator used for this work is the commonly used voltage regulator that finds its application in most of the electronics projects (see Figure.4). In this case, it was used in the circuit to provide a constant +5V DC output voltage to the PIR sensor module.

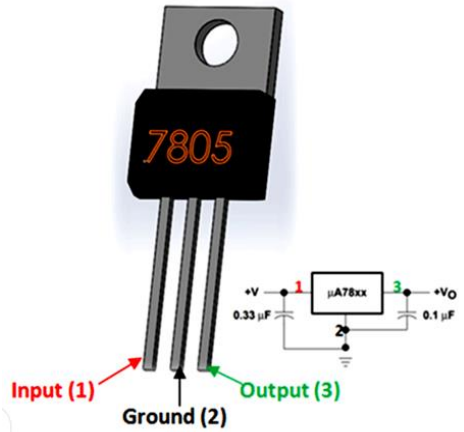

Figure 4: LM 7805 Voltage Regulator

The Relay Circuit

Normally relays are AC switches that open and close circuit electromechanically or electronically. Thus, they control one electrical circuit by opening and closing contacts in another circuit.

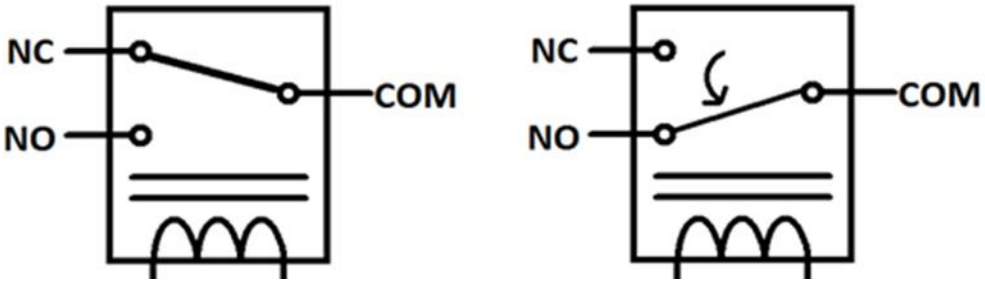

Figure.5: Relay circuit operations

When voltage is applied to the coil, the electromagnetic field produced attract the Armature (lever connected to spring), and COM and NO (normally open contact) gets connected, which allow larger current to flow. However, with no voltage applied to the coil, COM (common) is connected to NC (normally closed contact). Although, relays are available in many ratings, here a 9V operating voltage relay that can allow 20A/10A-230VAC/28VDC current to flow was used.

1N4007 Diode

This is a simplest semiconductor device with the characteristics of passing current in only one direction (i.e., rectification). Likewise, in this work 1N40007 diode (see Figure. 6) was used in the circuit to prevent reverse current flow to the switching transistor. Again, the relay has inductor coil and every inductor coil produces equal and opposite emf when switched off suddenly, this may damage the components. Thus, a diode must be used to prevent these reverse currents.

Figure. 6: The 1N4007 Diode

RESULTS AND DISCUSSION

Implementation/Packaging

The designed system was first implemented on a breadboard before being transferred onto a Vero board. All the components were soldered onto the Board and there after a distribution box was obtained so as to mount the entire circuit, see Figures 7 below:

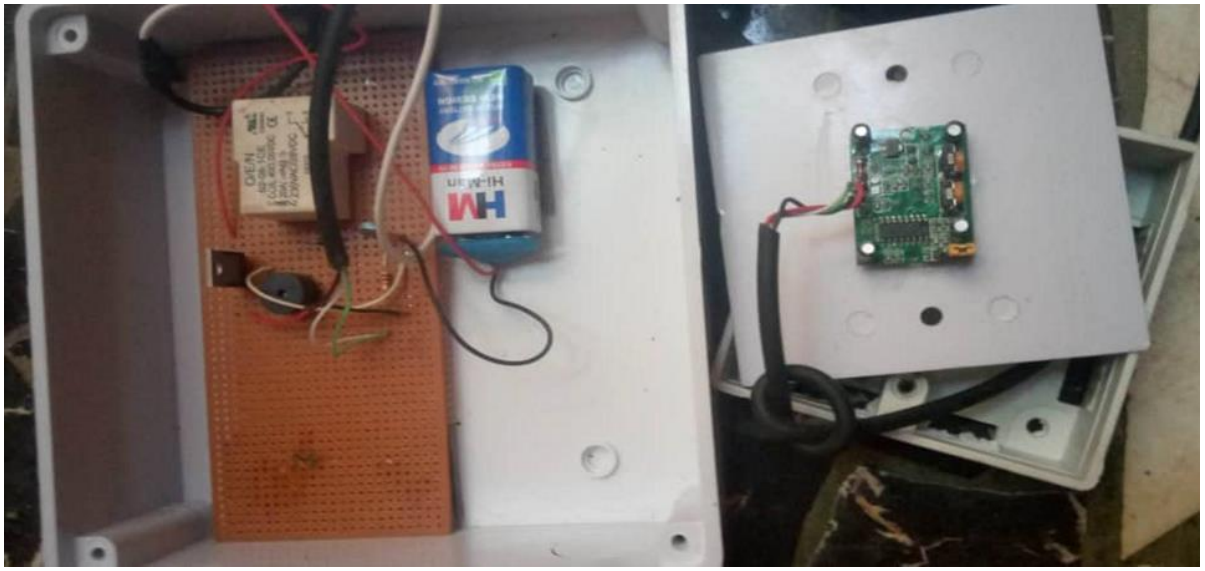

Figure. 7: The Inner View of the Constructed System

Finally, the switch and PIR sensor were carefully brought out from the internal part of the casing through the holes made on the body of the casing, see Figure 8 below:

Figure. 8: The Constructed Energy saving system

Test Set-up

The designed system was deployed and tested in the physics laboratory of Umaru Musa Yar'adua University, Katsina, Nigeria. When a person was made to enter the detection range of the sensor, the infrared radiations from the person were converted to electrical pulses which triggers the transistor. Then relay is energized and switched ON the bulb. As soon as the person left the detection range of PIR sensor, the relay make turned OFF and hence the bulb. It was noticed that bulb takes approximately 5 minutes to go OFF even after the person must have left the detection range. This because the PIR sensor initializes its stabilization within the delay period of 3 to 5 minutes even when there was no person in the detection range of the system. Thus, the relay also automatically turned OFF after taking the same delay time of 3 to 5 minute. Consequently, apart from eliminating the need for manual switching ON/OFF of our lightening systems, the constructed system can automatically save electricity wastages, especially in the public places.

CONCLUSIONS

The present work presented a designed, constructed and tested energy saving system using a PIR sensor that can switch ON light circuits in the presence of students or persons and OFF the light circuit in the absence any. The device was temporarily placed at the main entrance of the physics laboratory, Umaru Musa Yar'dua University, Nigeria. Although, it was realized that the motion sending range was low, the system detect any movement of up to 6 meters. In addition, at initial stage, the PIR sensor may take 10 – 15 seconds to stabilize before working properly. Thus, this work suggest that the system could be employed in our campus laboratories, lecture theaters, offices etc. to cut down energy loses and at the same reducing energy bills.

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