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Implementation of a Smart Security Light Control System

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ABSTRACT

The conventional way of controlling the security light in a developing countries like Nigeria are offline by manually turning ON or turning OFF the lighting system by the home owner. This practice is ineffective as it frequently results in the wastage of energy if the user forget to turn it off. Due to this limitation, there is need to design a system of security lightning control system that will switch ON automatically during darkness while notifying the user through motion such as ultrasonic sensor. Hence this project concentrates on the design and putting in practice a smart security lightning control system for notifying the user through buzzer while minimizing the energy wastage. The project consists of a PIC16F877microcontroller, an ultrasonic sensor, relay and light dependent resistor (LDR). The PIC16F877 microcontroller is used for controlling and switching off the buzzer through a relay. The buzzer acts as a notification, relying on the signal from the ultrasonic sensor, and it employs the PIC16F877 microcontroller, into which the operation is programmed. The smart security lighting control system casing was locally fabricated having a dimension of (7 X 10 X 15) cm. Following the casing, the measured findings are as follows: light dependent resistor (LDR) is 1012 ohms, source voltage is 220V (A.C), while the Microcontroller voltage falling within the VCC and GND including the buzzer voltage between pin VCC (2) and GND (5) is 4.93V and 4.91V respectively. The distance of 100cm was set as the reference value to be captured by the ultrasonic sensor while sounding alarm for 60 seconds indicating the presence of an intruder. The device's ability to acts as smart security notification by home users has been proved in this project.

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INTRODUCTION

For quality of life and wellbeing, security is essential. It is necessary to maintain security to have complete relaxed attention, be it from your place of residence or others. Development of Controlling and security systems for lighting was considered in this work since we knew that it could be deployed as security units in places of residences, manufacturing environment and for different purposes be it for local and business purposes [1]. When elements for architecture both fixed and controlled are deployed; which include windows, skylights and blinds respectively daylight can be control but these also depends on its availability. Therefore, effects which could be visual or non-visual effects can be deduce when electric light sources are designed easily [2-4].

Lighting, computer gear, HVAC (heating, ventilation, and air conditioning) systems, and other commercial agency structures make substantial use of electricity. A recent survey on commercial buildings' energy use, which was conducted around the year 2012, found that lighting, as an illustration in US business build up environments, was credit to the 20% of energy expended.[5]. According to the US Energy Information Administration (EIA), lighting in public streets and on its highways accounts for 150

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billion kWh, or roughly 11%, of the electricity used in the business sector in 2016. This is because the US commercial US sector consists of businesses and established structures. About 11% of the electricity utilized in the business sector, or 150 billion kWh, was used for public illumination (such as street lighting and highway lighting). [6].

Currently, in Nigeria, the security lightning system is been controlled offline mainly by house owner or the security at the gate [7]. The practice is not effective, especially if the building has many levels that has light on each floor. The current method of manual turns ON and turn OFF the security lights in the home usually results in waste of energy if the lights are forgot to turn OFF [8]. In view of the aforementioned limitation of the conventional switching of the security lightning, there is need to automate the system smartly in order to avert the problems by using the current advancement of technologies especially in the field of electronics to control the security lightning system in a real-time basis using any of the available technologies to control the security lightning system smartly. Hence, this project designed and implemented a smart security light control system using light dependent resistor (LDR), ultrasonic sensor, PIC16F877A microcontroller, step-down AC transformer, a bridge rectifier, a voltage regulator and power electronic components including a locally manufactured casing.

LITERATURE REVIEW

Some research relevant to the study are reviewed and presented in this section. These literatures include the previous works on smart security light control system. [8] demonstrates a smart home prototype with better-quality security characteristics for lighting. In order to implement daylight harvesting, a cutting-edge closed-loop feedback algorithm was used in conjunction with the onboard ambient light sensor and a specially developed Android mobile application. The prototype was tested to determine its performance before the developed system was put into use. The prototype's results showed that the system setup's cost analysis was marginally less expensive than products meant for commercial purposes and, because of its daylight garnering abilities, has the possibility to save money in the long-term performance that surpasses that of competing products. However, there is a need to implement improvements to this work by incorporating LDR to increase efficiency.

[9] For the effective use of energy in classroom settings, a lighting and control system that is programmed and built on Arduino was developed. Grids were created by the authors to represent the proposed piece in the classroom. The only way a grid's lights will turn on without the aid of relays is if it detects the presence of students. The system's mobility and remote command execution via Bluetooth-enabled mobile apps were included by the authors so that voice commands could control lighting. They believe that even though their work was successful, it could still be enhanced by using a PIC16F44 microcontroller, which is less expensive than an Arduino.

[10] demonstrates WinLight, a security-driven system for regulating lighting that reduces energy depletion without compromising comfort for residents. This technique predicts precise occupancy data from Wi-Fi configuration without being intrusive. An algorithm developed by Win Light used the collected information to compute appropriate dimming commands for each lamp. It was possible to activate the brightness adjusting with a local controller integrated into each lamp to implement occupancy-driven lighting control. These instructions are given to a zonal gateway by a centralized lighting control system. The implemented was evaluated and the results revealed shows its performance satisfactorily. However, one of the limitations of this work is that, it is restricted to the presence of WIFI. Hence, the need to make the system smart by incorporating the LDR.

In [11] the authors "An energy-efficient smart lighting control system using mobile light sensors for sensing local illuminance and aiding smart light bulbs to coordinate the brightness adjustments while matching users' heterogeneous lighting preferences" has been presented". The work was implemented and performance evaluation was carried out in order to determine it

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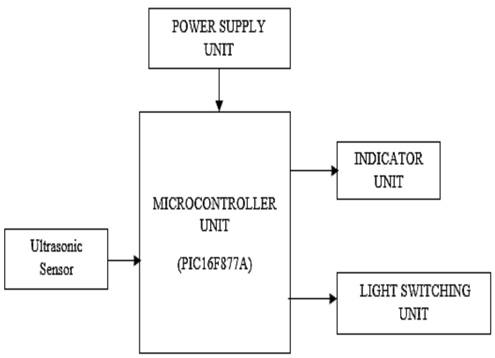
efficiency. Despite the results from the implemented prototype, it has shortcoming of capturing all other objects apart from human as an intruder.

MATERIALS AND METHODS

Adopted Methodology

A power supply unit makes up a smart light control system, LDR unit, indicator unit, outdoor light switching unit and microcontroller device and ultrasonic unit; the sensing unit is connected to the microcontroller that control the entire lightning control system. Presented is the design's block diagram. in Figure 1



. Figure 1: A Simple Block Diagram of the System

Power Supply Unit Selection

Figure 2 shows the power supply unit of the circuit.

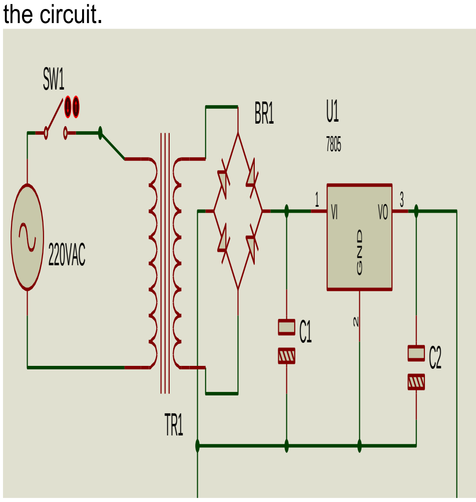


Figure 2: Power Supply Circuit

From Figure 2, the stepdown transformer converts 220Vac from utility power to 5Vdc. The voltage rectifier converts the step-down ac voltage to dc, the capacitor filtered any ac ripples in the supply, while regulator maintains the voltage to constant 5Vdc which is used for the entire circuit operation.

Since the AC power supply rating used in Nigeria is 220–240V. A step-down transformer with a secondary current rating of 500 mA, a primary voltage of 220 V, and a rectified voltage of 12 V is used for 50 Hz applications. The transformer is assumed to have a unity power factor (i.e. ideal situation).

The transformer primary voltage $(V_1) = 240V$
The transformer secondary voltage $(V_2) = 9V$
AC $(I_{AC}) = 500mA$

The transformer ratio M is given as:

$$M = \frac{N_1}{N_2} = \frac{V_1}{V_2} \quad (1)$$

Where: N_1 is the number turns in the primary winding, N_2 is the number turns in the secondary winding.

The relationship between the voltage and the turn ratio is given by:

$$M = \frac{V_1}{V_2} \quad (2)$$

$$M = \frac{V_1}{V_2} = \frac{240}{9} = 26.67 \approx 27$$

The Maximum secondary current is given by:

$$I_{DC} = \frac{2 \times I_{rms} \times \sqrt{2}}{\pi} \quad (3)$$

$$I_{DC} = \frac{2 \times \sqrt{2} \times 500 \times 10^{-3}}{3.142} =$$

The voltage across the bridge rectifier is given by:

$$V_{DC} = \frac{2\sqrt{2}V_{rms}}{\pi} \quad (4)$$

$$V_{DC} = \frac{2 \times 9 \times \sqrt{2}}{\pi} = 8.27V$$

The diode peak inverse voltage (PIV) is obtained as:

$$PIV = 2 \times V_{DC} \quad (5)$$

PIV=2× 13=26V

Therefore, IN4001 diode is used as a rectifier.

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Filter Capacitor Selection

The output of the rectified wave structure has some AC Ripples which should be wiped out. The filter plays this role. The Capacitor C_1 ought to have the ability to filter all ripple voltages. The ripple voltage ($V_{r.}$) is given by:

$$V_{r.} = V_{pp.} - V_{rms} \quad (6)$$

Where: $V_{pp.}$ = peak voltage of the secondary, V_{rms}. =root means square voltage.

Also, $$V_{r.} = \frac{I_{dc}}{2FC_1} \quad (7)$$

Where F is the frequency of the power supply in Hertz, C_1 is the capacitance in farad and I_{dc} is the dc current in Ampere (A).

By equating equation (6) and (7), we obtained

$$V_{pp}\text{-}V_{rms} = \frac{I_{dc}}{2fC_1} \quad (8)$$

Where: I_{dc} = 450 mA, F = 50Hz, V_{pp} =17V, V_{rms}=12V

C_1= 0.45/ (2×50(17-12))

C_1=900μF

$$V_{cap} = 2V_{max} - V_d \quad (9)$$

Where: V_{cap}= Voltage across the electrolytic capacitor, V_d= voltage across the diode.

Therefore, $V_{cap} = (2 \times 9\sqrt{2}) - 1.4 = 24.05V$

Hence, an electrolytic capacitor above a value of 900μF (i.e. 2200μF, 25V) was chosen for better 'filtration', remembering that the more highly the capacitor is rated.

Voltage Regulator Selection

It was essential to have a well-regulated voltage for the circuit to operate as efficiently as possible. Due to the high precision of the +5V regulator IC (7805) that was selected for this purpose. The regulated voltage (V_{rv}) is given by:

$$V_{rv} = V_{dc} - 2(V_{ac}) \quad (10)$$

Also, $$V_{dc} = 2\sqrt{2}\frac{V_{rms}}{\pi} \quad (11)$$

Where: $V_{rms} = 9v$ and V_{ac} =0.7V

By substituting equation 7 and the give values into equation 6, the resulting value of V_{rv} can be obtained

V_{rv}= $2\sqrt{2}\frac{9}{\pi}$ – 2(0.7)

V_{rv}= 6.095 – 1.

V_{rv} =5.067V

Therefore 7805 was chosen to provide regulated 5V as V_{cc} at minimum current of 1A.

Microcontroller Selection

The PIC16F877 microcontroller embedded device was used in this project to manage the system. There are interrupts, counters, timers, I/O ports, RAM, and ROM/EPROM in addition to the central processing unit

Diagram and its Operation Principle

In Figure 3 below, the broad circuit diagram of the project is illustrated.

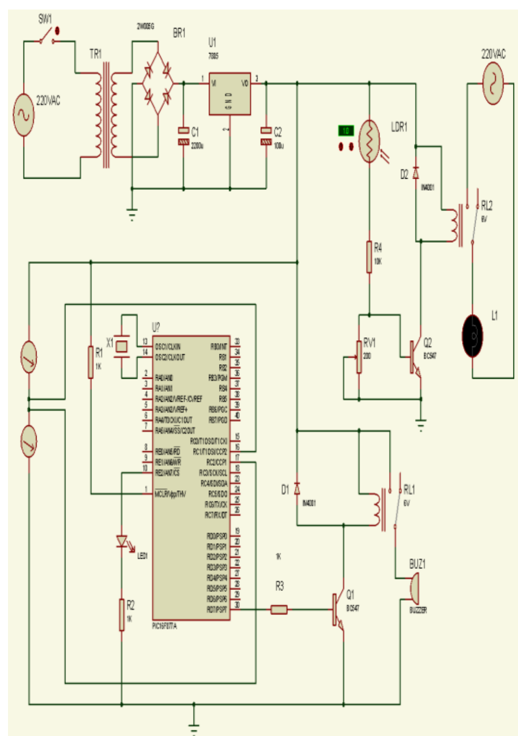

Figure 3: Complete Circuit Diagram of the Project

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A 5V dc regulated power circuit is used to power the entire circuit; the transformer does the transformation from 220Vac to $12V_{aC}$ the bridge rectifier does the rectification and capacitor C_1 2200µf does the filtration and the regulator IC 7805 regulate the output voltage to 5V dc and is use for circuit operation.

Any intruder can be found using the ultrasonic sensor. It uses a 5V power supply to function. The ultrasonic sensor serves as an input to the microcontroller 16F877A because its purpose is to detect any intruder and deliver a signal to it. The ultrasonic sensor which is used to always sending a signal to the echo 16. The microcontroller through pin 16 enable the ultrasonic sensor to generate a continuous pulse signal. However, if an intruder is detected, the trigger of the ultrasonic sensor connected to pin15 send a signal to the microcontroller immediately enable via pin 30 to go high and bias of transistor Q1 BC547 via resistor R3 which now energies the relay R_{L1} and enable the buzzer to sound an alarm the duration of 10 seconds .

The security system is designed to operate the security light automatically. That is, LDR_1 uses light and darkness. Whenever, there is light the LDR_1 resistance will be very low and allowing conduction to the base of transistor Q2 BC547 which in turn will bias the base of Q2 BC547 allowing conduction from collector of Q2 BC547 to the emitter and this will energies relay RL_2 and this will disconnect the security lamp L_1 to go OFF. However, when it is dark especially in the night, the LDR_1 resistance will be high and this will not bias the base of transistor Q1 BC547. Hence, the relay RL_2 will not be energized so the security lamp L_1 will be ON.

RESULTS AND DISCUSSIONS

This section describe the results obtained and the finding after testing the devices.

Temporary Construction

Breadboard was used as a temporary circuit to detect any possible error associated with the construction. In addition, the breadboard provides an avenue for temporary construction and testing. The components were tested on a breadboard, as shown in Figure 4.

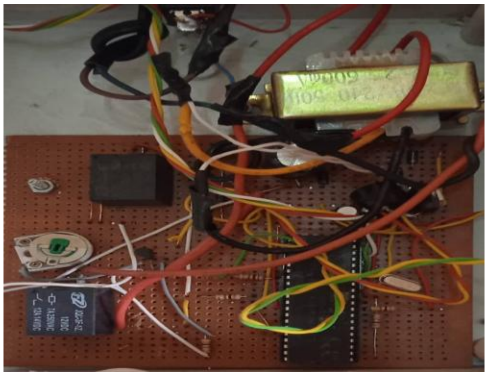

Figure 4: Temporary Construction

Permanent Construction

This is assembling all the components on the circuit board after testing it on a breadboard. Before constructing the whole system, the components were tested separately and were in good condition. This was intended at helping to identify faulty components. Finally, the whole system was constructed and permanently soldered on a Vero board using a soldering iron and soldering lead. Figure 5 shows a permanent connection of the system.

Figure 5: Permanent Construction

RESULTS AND DISCUSSIONS

From the results obtained after the casing, the smart security light control circuit could switch ON and OFF the buzzer at night when there is a present of an intruder within the specified

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range of distance by the ultrasonic sensor. The LDR component is to switch ON the security when it is dark. The buzzer alarm to indicate when there is a present of an intruder worked satisfactorily. When the system was connected to the supply, the following was observed. An LDR recorded the value of 1012 ohms, 220V (A.C) from input, Microcontroller power rating determined amongst VCC and GND to delivered a voltage of 4.93V. When the ultrasonic sensor capture the first distance at 10m, the buzzer sound an alarm for 9 seconds. Also, when the distance of an intruder from the ultrasonic sensor was varied to 8m, the buzzer also sound an alarm for the same duration. The switching ON and OFF of the smart security light time of the system when there is no intruder as shown in the Table.

Table 4.1: Results obtained from testing the prototype

S/NO	POWER	Distance (cm)	LED 1
1	OFF	0	OFF
2	ON	100	ON
3	ON	100	ON

CONCLUSION AND RECOMMENDATION

In the end, the aim of this project was attained. The smart security control system will always be a referral for generations in future who will want to undertake the design and implementation of aiding instruments to provide security to an environ while saving cost of energy. After design and implementation, the smart security control system gave a good account of its operation during switching. The device is cost-effective, dependable, and portable and uses limited power with the robust ability to provide lightning as means of security to it home users against conventional security control system.

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