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Research Article

Construction of An Automatic Power Switch using Infrared Motion Sensor

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Abstract. In public and private institutions the problem of switching off light and other appliances wherever it is not needed is a concern. In Covenant University, the issue led to various rules that try to limit the way light is being used in the halls of residence, classrooms and other buildings. The main aim of this project is to conserve energy. This project presents the construction of a power control system which can detect the approach of a person, and then turn the power of a room on. The project involves four stages: the power supply stage, the sensor stage, the arduino stage and the switching mechanism stage. The power supply stage involves the supply of power to the arduino and the sensor. The sensor stage consist the passive infrared sensor which is the core part of the project. It detects the radiated heat energy from a person and converts the energy to an electrical signal which is sent to the arduino for processing. The arduino then processes the signal and sends a specific voltage to the relay that actuates the power switch to on. When nobody is detected the power is turned off. Conclusively, the constructed energy control system prevents energy wastage in the lecture halls, classrooms and other buildings.

Keywords. Light; Power switch; Energy conservation; Sensor; Arduino

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1. Introduction

Energy efficient buildings not only save money, but are also comfortable and can have an abundance of natural light. In a university, these features contribute to a more conducive learning environment. Mechanical switches have made the human comfort much tougher and has increased negligence, maximum power loss has been observed for such cases which in turn add a great shortage to productivity and development. An effort towards the automation of power control is a one stop solution towards such negligence. It has been observed that most lighting systems and air conditioners are left unattended to after lectures by students or lecturers, this has led to waste in electricity in the university [1]. The need of building an automation system for an office or home is increasing daily because of its numerous benefits. Industrialists and researchers are working to build efficient and affordable automatic systems to monitor and control different devices like lights, fans, air conditioners, etc. Automation ensures efficient use and minimal loss of electricity.

The rise in energy costs urged the need in minimizing its consumption. Significant amount of energy is used for illumination and cooling in educational buildings such as lecture halls/rooms. Therefore, improvements are needed to avoid energy waste during unoccupied hours. The lighting and cooling will be controlled based on demand to save costs. The energy control system can be applied in lecture halls, classrooms, laboratories and halls of residence. Nowadays, electricity is one of the important energy in human life. Due to increasing cost of production and distribution of electricity coupled with increasing consumption, there is a need to invest in managing and conserving this resource as most consumers are not aware of the importance of reducing its cost. As a result of this need, this energy saving project was constructed with Covenant University in focus using an arduino board and a motion sensor to detect the body heat of humans. When the sensor detects nobody is in any of the classrooms or lecture halls, the arduino will calculate to a preset time, say 10 minutes. If within this time there are students coming into the lecture hall, the air-conditioner and lighting system will reset as programmed but if the hall stays empty the lighting system and air conditioner will turn OFF automatically.

2. Type and Applications of Passive Infrared Sensor

IR sensors are widely known in the arts of intrusion, fire or smoke detections. The IR sensors have basically two forms: active and passive. An active IR detector has a radiation source and an IR sensor which is sensitive to interruptions in the radiation sensed from the source. A passive IR (PIR), has no IR source, motion detector detects heat energy radiated by an object, such as an animal or a person, moving across the field of view of the heat sensor of the motion detection system. It generally uses an optical collection system and multiple sensing elements of alternating polarity to create a detection pattern in the volume of interest. The PIR sensors have a lot of advantages compared with other sensors: simple, reliable, and low price [2]. Shown

below in Figure 1 [3] and Figure 2 [4] are schematic diagrams of a PIR sensor and its operation respectively. The two types of motion sensing are: local and area. Local sensing implies sensing of a motion at designated locations while area sensing implies sensing of a motion in a specific 'Field of View'.

The built lighting control system includes hardware and software parts. The software that was used is the Arduino Uno IDE (Integrated Development Environment), while the hardware part involved: PIR sensor, relay, power supply, LCD display and the Arduino board. The PIR sensor is the most important element in this project as it was used to detect the human presence in a room. As a person walks into the detector's field of view, the detector senses a sharp increase in IR energy as seen in the output signals in Figures 1 and 2. In order to achieve a wide field of view, motion detectors generally require complicated optical arrangements for directing the infrared radiation from the outlying reaches of the desired field of view into the significantly narrower angular reach of the sensor. A few motion detectors achieved wider fields of view by compounding a plurality of integrated-circuit sensor packages; each having its own limited field of view, with optical arrangements that bring the incident radiation to the proper sensor at the proper angle to be perceived. Motion detectors with wide fields of view have generally involved a trade-off among increases in cost, complexity, and the physical size of the motion detector unit, and a compromise in performance. For motion detectors approaching a full 360° field of view the trade-off is all the more stringent. The block diagram of the built energy control system is shown below in Figure 3.

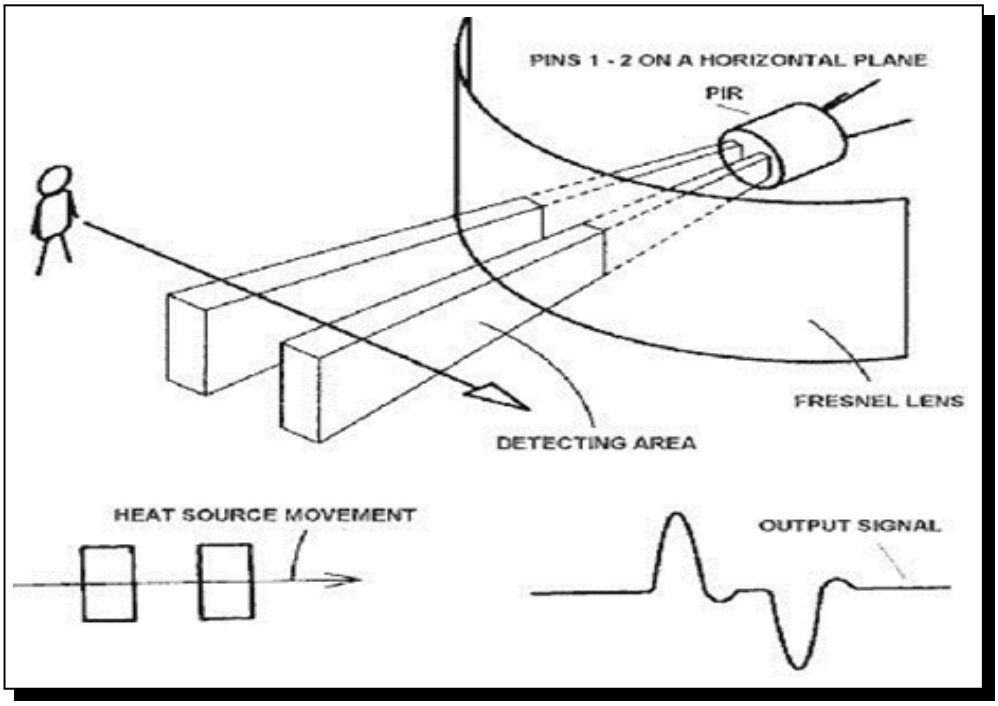

Figure 1. Schematic diagram of a Passive infrared (PIR) sensor
(Source: `http://www.instructables.com/file/FXWS6GHFYNTA23Z/`, 2017)

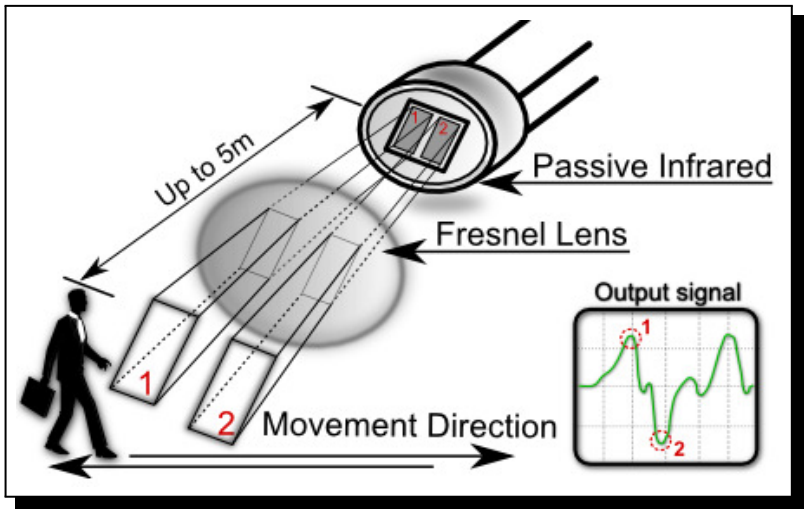

Figure 2. PIR motion sensor operation
(Source: `http://www.ledwatcher.com/motion-detectors-explained/?doing_wp_cron=1500397241.0596170425415039062500`, 2017)

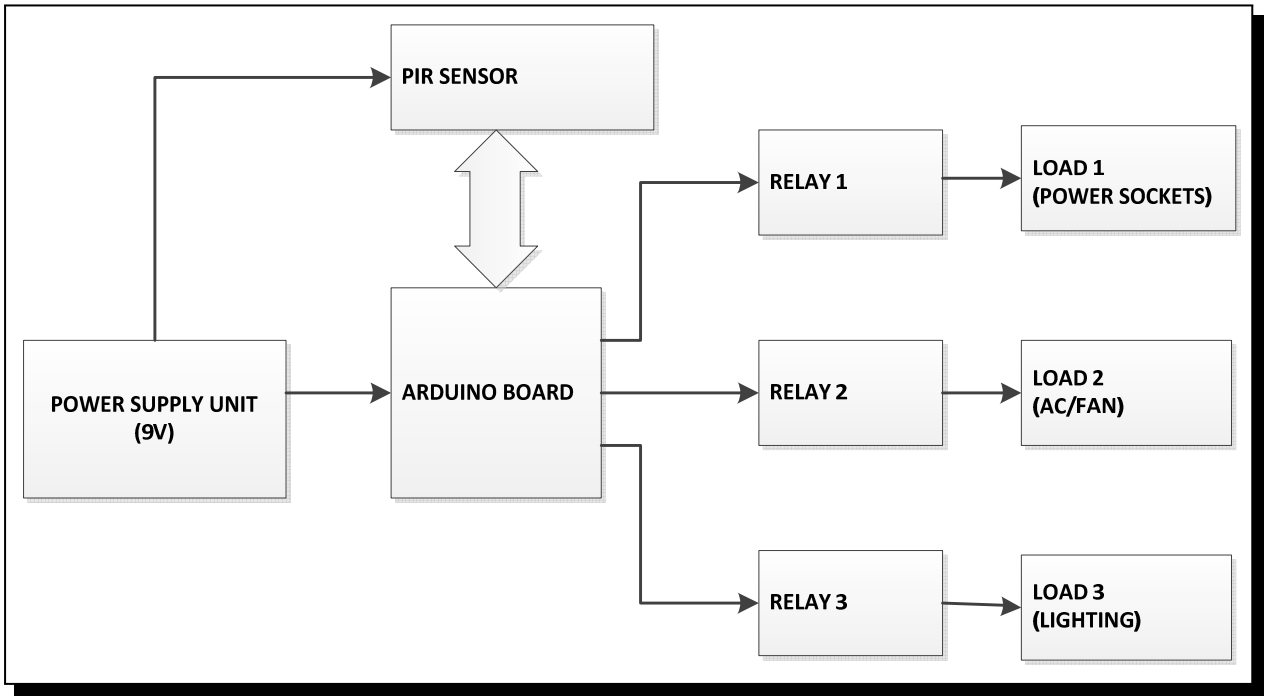

Figure 3. Block diagram of energy control system

3. Operation and Results

The energy control system consists: power supply, Arduino, PIR sensor and switching stages. A 9V DC regulated power supply to the Arduino and the PIR sensor was implemented using circuit built using an LM7809 Voltage Regulator.

The coding sequences of the Arduino is of two parts: the first part is about the initial process of the circuit (Figure 4), from the detection signal that is sent to the arduino, it processes it and then sends an output through the ports 8 and 9 which are connected to the relays.

```
#include<LiquidCrystal.h>
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
int relay[2]={8,9};
int pir[2]={12,11};
boolean currentstate[2]={LOW,LOW};
int relaytotal=2;

void setup()
{
Serial.begin(9600);
Serial.println("Ready");
lcd.begin(16, 2);
pinMode (12,  INPUT);
pinMode (11, INPUT);
pinMode (8, OUTPUT);
pinMode (9, OUTPUT);
digitalWrite(8,LOW);
digitalWrite(9,LOW);
}

void loop()
{
  for(int i=0; i<=1;i++){
    currentstate[i]=digitalRead(pir[i]);;
    delay(200);
    if(currentstate[i]==HIGH){
      delay(100);
      if(currentstate[i]==HIGH){
        digitalWrite(relay[i],HIGH);
      }
    }
    else{
```

Figure 4. The coding sequence that sends detected signal to the arduino

The second part is about what happens after the sensor detects presence of people in the room (Figure 5). The second coding sequence is repeated every 500 milliseconds as it detects a presence; when is does not detect a presence it repeats the sequence for a certain amount of time until it turns off the power if the output from the PIR sensor is still zero. As soon as the PIR sensor detects someone, it sends a minimum electrical voltage of 3.3V and a maximum of 5V to the arduino, which reads signals in terms of 0s (for absence) and 1s (presence). The arduino then processes the presence as a high signal then sends a 5V to the relays as a control voltage. The relays are then triggered by principle of induction and their poles are attracted from normally closed contact to normally open contact. Thus power then flows from the source through the relays to the load. The mains power is connected to the commons of the relays while the load is connected to the open contact of the relay. The PIR Sensor V_{CC} pin is connected to the output of the arduino in other to power the PIR Sensor and the output pin of the PIR Sensor is connected to the Input Pin of the arduino, so that when motion is detected the electrical

signal is sent to the input pin of the arduino. The relays, induction pins are connected to another output port of the arduino, where the latter sends 5V to the ports that the relays were connected to whenever motion is detected. The circuit was firstly carefully tested on a breadboard before being assembled on a Vero board and carefully packaged for wall/ceiling mounting.

In order to test the constructed circuit a person was made to enter the detection range of the PIR sensor; the relays got switched ON as the PIR sensor was activated and its generated output that was sent to the arduino which then actuated the relays. As soon as the person left the detection range of PIR sensor, the relays got turned OFF. The PIR sensor goes to idle mode. It was observed that the relays got turned ON as soon as the power is given to the circuit without even having an intruder in the detection range of the sensor, this happened because the PIR sensor requires an initial stabilization period of 2 to 3 minutes in order to function properly. During this time, the sensor gets familiar with the environment. After 3 minutes, the relays get turned OFF as there was no person in the detection range of the system. The sensor uses approximately the same 3 minutes to get to its idle state when a person might have left the range of detection. Consequently, this keeps everything from being turned OFF for that particular amount of time. Both the initial stabilization and the idle times are functions of the sensitivity of the PIR Sensor; if the sensor sensitivity is not good, it would take an amount of time to get to its idle state, if the sensitivity is very good it would get to its idle state as soon as the person leaves the range of detection.

```
void loop()
{
  for(int i=0; i<=1;i++){
    currentstate[i]=digitalRead(pir[i]);;
    delay(200);
    if(currentstate[i]==HIGH){
      delay(100);
      if(currentstate[i]==HIGH){
        digitalWrite(relay[i],HIGH);
      }
    }
    else{
      delay(5000);
      digitalWrite(relay[i],LOW);
    }
    delay(500);
    Serial.print(digitalRead(pir[i]));
    Serial.print(" ");
    Serial.println(digitalRead(relay[i]));

  }
  delay(500);
}
```

Figure 5. The coding sequence of arduino action when it senses the presence of someone

4. Recommendations

The circuit can still be improved upon with collaborative efforts of relevant departments and the prototype can be replicated and deployed as a pilot scheme on the campus to save energy cost. More functionality can be added to the design, like the system can be remote controlled with a smartphone, and an alarm system can be incorporated in the circuit to detect an intruder in the homes.

5. Conclusion

In building energy, power control system can play an important role by continuously and seamlessly monitoring the building energy use, which lays the foundation of energy efficiency in the school buildings. The project constructed and implemented with a lighting module. It can detect motion and then let the relay circuit actuate the lighting to work to maximum intensity. The results show that the implemented module is functional and the proposed system can be useful for energy saving purpose.

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Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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