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Energy Saving System using a PIR Sensor for Classroom Monitoring System

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Abstract: ***The work gives a report about the design of an energy saving system using a Passive Infrared Radio sensor to switch 'off' fan and light circuits in the classroom in the absence of students. When a student enters the classroom, the Infrared energy emitted from the living body is focused by the Fresnel lens segment and the PIR sensors activate and give to the microcontroller which acts as power saving device according to the relay. When motion is detected the relays trigger and switch the fan and light 'on' and after ten minutes to switch 'off' the fan and light when motion has not been detected. The fan only switches 'on' when the room attains a temperature of 250 C-300 C.***
Keywords: Energy saving System, PIR Sensor, embedded systems

I. INTRODUCTION

In the beginning of electrification, switching electrical devices has been done by means of connecting or disconnecting them to the power grid. In recent year disconnecting a device from its energy source has become less popular. Instead, switching is done electronically (automatically). This means that the inner device is separated from the switching circuit. As a consequence, the device can be powered 'on' or 'off' by a remote control unit or by an automated switching circuit based on occupancy. Some computer main boards may even allow reaction to power network events, It was then argued in [1] that the downside of the switching unit keeps consuming energy as long as it stays on. In [2] , a system was designed and built to control the intensity/speed of electrical lights and fans using a TV remote control in the infrared (IR) set range of frequency The PIR (Passive Infra-Red) Sensor is a device that detects motion by measuring changes in the infrared (heat) levels emitted by surrounding objects. When motion is detected the PIR Sensor outputs a high signal on its output pin. This logic signal can be read by a microcontroller or trigger a transistor which could switch high voltage devices. This is a good sensor for monitoring an area for motion in [1] This sensor has two revisions: Revision A and Revision B. Both revisions of this sensor use the same Fresnel lens, and basic functionality remains the same between the two. However, there were a number of improvements and updates made to Revision B in [3] The control of light intensity and fan speed was successfully achieved through microcontroller. The system followed a linear profile and provided regulation against power supply voltage. It supplied voltage frequency independent. This could be also used to cater for output power of high consuming power loads like fridge. Meanwhile, a mathematical model was simulated in [3] to control air conditioning system using Matlab/Simulink based on adaptive fuzzy and analyzed the performance of that controller. Matlab Simulink tools were used to evaluate the physical application, through simulation. Authors in [4] proposed a light dependent resistor (LDR) that included a circuit to turn off the lamp when there was a good luminance and vice versa. The design by [5] focused in places where the security was paramount. An alarm system was designed to alert when someone was passing by. The significance of the design, was that it turned the appliances 'on' and 'off' automatically. In this scope, more power could be conserved. This could be improved by adding a timing system that would delay the operation for some time before applying the principles when a person is detected. In [6], the study investigated electronic circuit that made use of a Passive Infra-Red (PIR) sensor module to develop a motion sensor alarm detector. A message showing 'motion detected' would be displayed on a PC whenever the sensor detected a motion with the aid of AT89S51 microcontroller. The system could also be applicable to various loads like pressure, force etc, when the number of ports of the microcontroller were increased. This could be developed without wires such that different sensors in different places would be put in place. The proposal could also be used to reduce power consumption in electricity. The application could be extended to indoor lamps and fans with a delayed timer. It was investigated in [7], the daily electricity consumption by using LCD which used GSM to alert consumption. Home utility signals, customer preference and presence were taken into account in case of an emergency. Keil (μ vision IDE) and Micro Flash were the software's used to achieve the dimming of light intensity according to user preference and thus energy management. The PIR sensors and the Advanced RISC (reduced instructions set computer) Machines (ARM) Processor remote control were used to provide a comfortable home management.

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This has shown an efficient energy management and reduces wastage of electricity in the absence of people in a room. This could also detect appliances that are faulty and as a result could consume more power. A remote control for a fan regulator was designed and implemented in [8], Infrared (IR) remote control signal decoder was implemented using a decade counter and TRIAC software. The control system was reliable and easy to operate. This could also control the intensity of light. In [9], a Comparative study on the energy consumption for wireless sensor networks that was based on random and grid deployment strategies was reported. The relationship between energy consumption and the deployment strategy was underlined. The rest of the paper is structured as follows. The next section of the paper, section II, depicts the design methodology. Section III presents the testing and the device calibration. The conclusion, is given in Section IV, which closes the paper by suggesting future research directions.

II. DESIGN METHODOLOGY

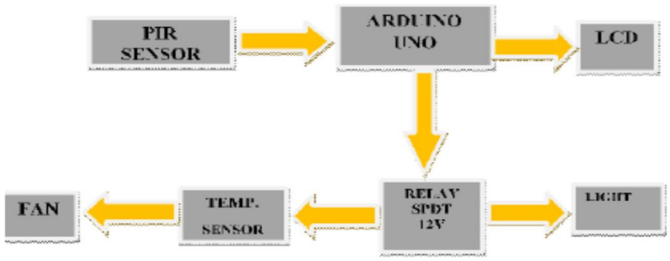


Figure 1 : Block diagram of the circuit

It comprises of the various components used in the construction of the device. The pins (Output, Input and Gnd) of the PIR sensor are connected to the arduino uno [10] through the bread board. The load (fan and lamp) is also connected to the bread board, the Temperature sensor is connected to the fan. A sensor was positioned in the classroom to cover the entire area.

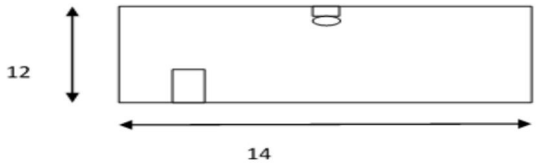


Figure2 : Schematic diagram of the study area

The second consideration was based on Fresnel zone thus the sensors were placed above the fan and the lamp so that the clearance is met, in such that the sensors can detect every motion in the classroom to switch fan or lam off automatically. The study area is a classroom of an area 12m by 14m, the view of the study area and Positioning of the PIR sensor are depicted in Figure 2. For the implementations of the design, the following software were used Windows operating system (windows 7) and EGLE cadsoftware. The Arduino hardware has the following specification given in the Table 1.

DISCRIPTION	SPECIFICATION
Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output
PWM Digital I/O Pin	6
Analog Input Pins	6
DC Current per I/O Pin	20mA
DC Current for 3.3V Pin	50mA
Flash Memory	32Kb (ATmega32P) of which 0.5kB used by bootloader
SRAM	2Kb (ATmega328P)
EEPROM	1Kb (ATmega328P)
Clock Speed	16MHz
Length	68.6mm
Width	53.4mm
Weight	25g

Table 1: Specifications of Arduino Uno

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Whenever the rooms are occupied the fan and lamp are automatically switched 'on' and are put 'off' when there is no occupant in the room. The fan switches 'on' only when the temperature of the room is in the range of 25OC- 30OC. The coding is given as:

A. Code

```
#include <Arduino.h>
#include <Adafruit_Sensor.h>
#include <SoftwareSerial.h>
#include "DHT.h"
#define DHTPIN 8   // Digital pin connected to the DHT sensor
#define DHTTYPE DHT11   // DHT 11
DHT dht(DHTPIN, DHTTYPE);
#define RX 2
#define TX 3
String AP = "Light";       // AP NAME
String PASS = "Light1234"; // AP PASSWORD
String API = "0JEDOSKGP3QGTPIX";   // Write API KEY
String HOST = "api.thingspeak.com";
String PORT = "80";
int countTrueCommand;
int countTimeCommand;
boolean found = false;
int valSensor = 1;
int H=0;
SoftwareSerial esp8266(RX,TX);
uint32_t delayMS;
const int LED = 13;
const int relay_Fan =12;
const int relay_Lamp =11;
const int PIRsensor =7;
int Mstatec = 0;
int Hstatec = 0;

void setup() {
  Serial.begin(9600);
    pinMode(LED, OUTPUT);
   digitalWrite(LED, LOW);
   delay(1000);
  esp8266.begin(115200);
  sendCommand("AT",5,"OK");
  sendCommand("AT+CWMODE=1",5,"OK");
  sendCommand("AT+CWJAP=\""+ AP +"\",\""+ PASS +"\"",20,"OK");
     digitalWrite(LED, HIGH);
        delay(1000);
     dht.begin();
   pinMode(relay_Fan, OUTPUT);
   digitalWrite(relay_Fan, HIGH);
   pinMode(relay_Lamp, OUTPUT);
   digitalWrite(relay_Lamp, HIGH);
    pinMode(PIRsensor,INPUT);
   delay(1000);
```

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```
 }
void loop() {
   float h = dht.readHumidity();
   int val =getValue();
  delay(100);
  if(val==HIGH) { Serial.println("Motion detect");     digitalWrite(relay_Lamp, LOW); delay(1000);  Mstatec = 1;}
  if(val==LOW)  { Serial.println("Motion not detect");      digitalWrite(relay_Lamp, HIGH);  delay(500);  Mstatec = 0;}
  String getData = "GET /update?api_key="+ API +"&field1="+getMValue()+"&field2="+getHValue();
 sendCommand("AT+CIPMUX=1",5,"OK");
 sendCommand("AT+CIPSTART=0,\"TCP\",\""+ HOST +"\","+ PORT,15,"OK");
 sendCommand("AT+CIPSEND=0," +String(getData.length()+4),4,">");
 esp8266.println(getData);delay(1500);countTrueCommand++;
 sendCommand("AT+CIPCLOSE=0",5,"OK");
}
int getValue()
{
     int motion = digitalRead(PIRsensor);
   //  Serial.println("Motion");
  return motion;
}
String getMValue()
{
     int motion = digitalRead(PIRsensor);
   //  Serial.println("Motion");
  return String(motion);
}
String getHValue()
{
       float h = dht.readHumidity();
   if(h>=30)     { Serial.println("Humidity is good");     digitalWrite(relay_Fan, HIGH); delay(1000);  Hstatec = 1;}
  if(h<30)      { Serial.println("Humidity is dry");      digitalWrite(relay_Fan, LOW);  delay(1000);  Hstatec = 0;}

  return String(h);
}
void sendCommand(String command, int maxTime, char readReplay[]) {
  Serial.print(countTrueCommand);
  Serial.print(". at command => ");
  Serial.print(command);
  Serial.print(" ");
  while(countTimeCommand < (maxTime*1))
  {
    esp8266.println(command);//at+cipsend
    if(esp8266.find(readReplay))//ok
    {
      found = true;
      break;
    }
    countTimeCommand++;
  }
  if(found == true)
```

```
{
  Serial.println("OK");
  countTrueCommand++;
  countTimeCommand = 0;
}
if(found == false)
{
  Serial.println("Fail");
  countTrueCommand = 0;
  countTimeCommand = 0;
}
found = false;
}
```

In this phase of the testing and calibration, the device was hooked up to a voltmeter and Ammeter. The circuit was then powered by a bench AC power supply. The following circuit parameters were tested: The total power of the circuit is the product of the voltage and current. The minimum and maximum voltage and current were recorded and the power consumption calculated as follows:

Voltage (V)	Current (mA)	Power (mW)
7	87	609
9	100	900
12	120	1440

Table 2. Measured Values From The Research Conducted

The device was quite unstable and caused the microcontroller to restart when it was powered with the 7 V power supply. The 9 V power supply run the device smoothly without any glitches. And the current at which the device operated was efficient. The 12 V caused the arduino micro-controller to heat up. This was because the arduino has on it a 5 V voltage regulator that operates at an optimum voltage of 7V. Although the technical a specification says it can handle up to a maximum of 18 V, heating will cause inefficient use of power. Therefore, after considering the voltage range, the 9V power supply was selected for its availability and less heating. The view angle and range test was to measure the view area of the device. The device was once again mounted on the ceiling of a room of dimensions 10 m x 5 m x 4.5 m. The device was able to detect the presence of a human being right at the entrance and also at the end of the room. This made it possible for the device to keep the light ‘on’ so far as the person was in the room and the fan ‘on’ when the temperature of the room was at 300 C.



Figure 3: View angle and range test result

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For the device sensitivity test, the device was mounted in a room and three people engaged in an abstract activity in the room. The device maintained the 'on' state of the lamp as far as the people were in the room. After exit of the three people, the device switched off the lamp after 10 seconds, exactly as it was programmed. The temperature test was quite challenging. To measure this, the device was stationed close to an incandescent bulb mounted in the room. The threshold temperature was set between 25o C- 30o C and a standing fan was connected to the device's fan output. The fan was started automatically by the device when the temperature rose to 25o C. The fan continued working until the room temperature cooled to 20o C that was the minimum temperature set in the device's programming.



Figure4. Device before test



Figure 5: Device during Test(onlu lamp is 'on')

III. CONCLUSION

The paper reports an energy saving system using a Passive Infrared Radio sensor to switch 'off' fan and light circuits in the classroom in the absence of students. The built device was placed at the main entrance. It was realized that its sensitivity limit was low. As a result of this a second one was placed at the far end diagonally to improve the sensitivity limit. The design system comprises a motion detector and temperature sensing component. The motion detector is meant to detect any human being displaced through the infrared (IR) heat generated by human body. The temperature detector operates when the room temperature is above a given threshold. For this project the room temperature is summed to be in the range of 25OC to 30OC in other to meet the weather condition experienced in Ghana. Two sensors were used and placed diagonally in other to cover the entire classroom. The future should include a shorter recovery time for the device to switch off the lamp and fan in a span time of 60 seconds when there is no occupancy.

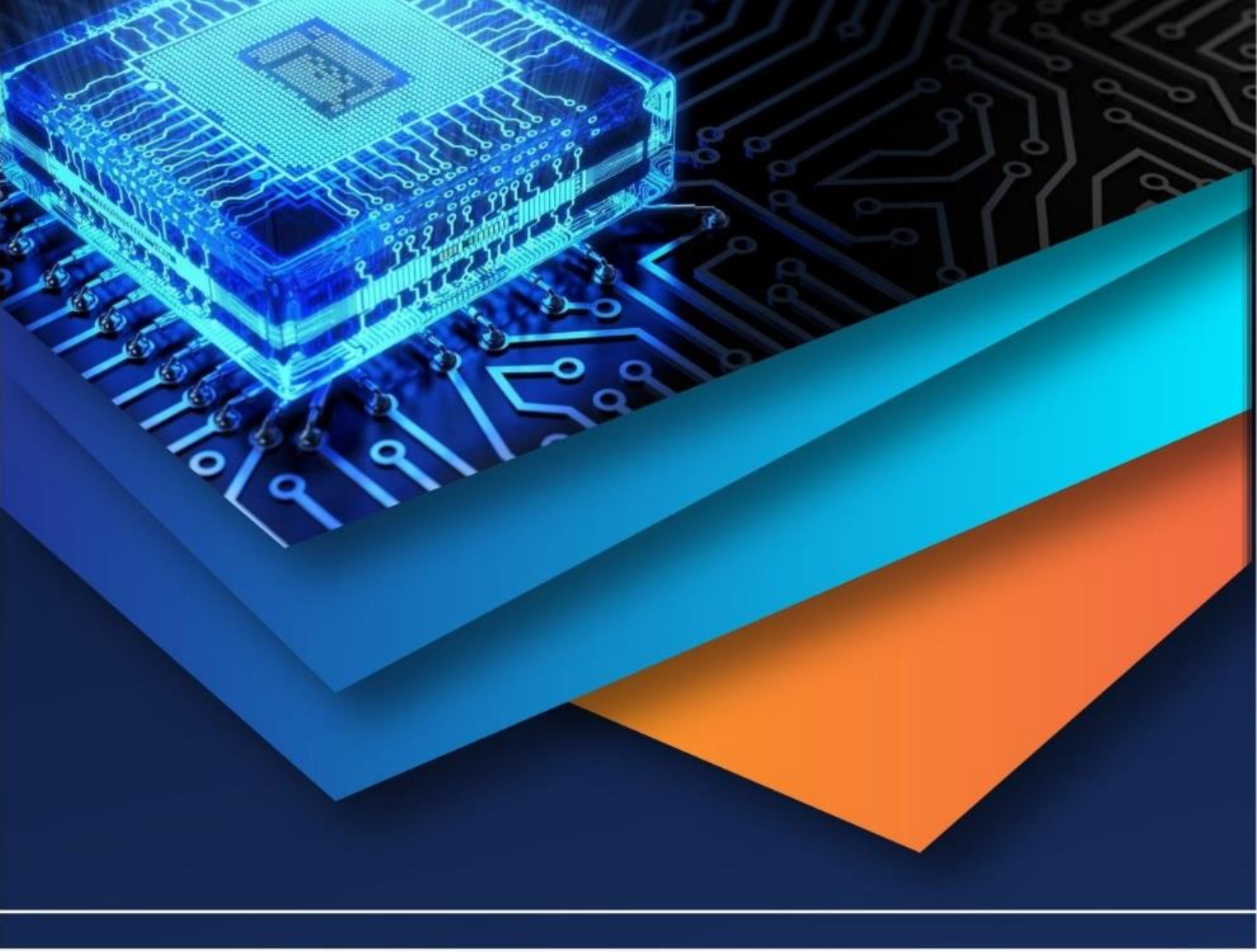
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