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Design, Fabrication and Testing of Energy-Saving Power-Control System

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Abstract: *The designed and fabricated energy-saving power control system is very efficient in switching off power system if there is no somebody inside the classroom. In this feature of the device, it can minimize the waste of electricity when the classroom does not use. The device has three stages, the power supply stage, the sensor stage, and the switching relay stage. When the three stages are functional enough, it features detecting human body movement is the key to create an energy saving power control system. The gadget can carry a maximum load of 4400 watts. That capability of the gadgets is very efficient in controlling any appliance inside the classroom. In detecting human body movement in the classroom, the device detection range is 7 meters in 120 degrees' angle view. To improve the performance of the said gadget, the long-range sensor should be used.*

Keywords: *Energy-saving, development, PIR sensor, electricity, Power-Control System*

I. INTRODUCTION

Electricity is one of the most important energies in human life. It is the key component to modern technology. Without it, most of the things that we use every day simply could not work, and would never have been created. Our mobile phones, computers, internet, cooling systems, televisions, and light bulbs - nearly everything in the home and different establishments would be completely different. There would be completely different systems put in place in the home and establishment to ensure that we can remain comfortable, and to ensure that we can live properly every day.

However, electricity is a constantly developing technology, and the aspects one currently associates with electricity and electricity generation are nowhere close to the original features. The past century and a half, electricity has steadily evolved from a scientific curiosity, to a luxury of the affluent, to a modern need.

As we enjoy the luxurious benefits of electricity, the consumption of electricity in this world increases because we do not have the awareness on the importance of electricity. In our country today, we suffer from electric power shortage because the main source of electricity is now decreasing the capability to produce electricity. This unawareness in the importance of electricity is the reason of the increasing cost of managing, conserving and distributing.

In our homes we sometimes forget to close our gadgets if they are unattended. We are not aware that the level of our consumption is getting high. This problem also occurs in different institutions like in a State university.

The researcher work on this project development because of high electricity bills in the campus. The fact is that there were students and faculty members who do not mind the importance of saving and reducing the cost of electricity in the campus using any kind of electrical and electronics gadget. It was also an observation that, at the end of lecture sessions in the classrooms, the lighting systems and cooling system are left opened. Sometimes, faculty members and students forget to switch off the lighting systems and cooling systems inside the classrooms. This neglect or unawareness increases the waste of electricity in the campus. These reason motivated the researcher to research on such development of energy saving power control system in the classroom to help the campus reduce the high electricity bill. With this, through the use of Electronics Technology, we can create possible solutions into a certain problem by using its principles and disciplines.

Electronics Technology is the most influential industry in today's era. We could now achieve the better way of creating new gadgets. And as time passes by, many inventions and knowledge are born.

One of the most important gadgets created and developed in this world is the electronics transducers which implies with the use of detector and sensors. These two transducers are widely used in traffic and parking management, security surveillance, CCTV systems, sensors for robotic machine, signal detector such as to detect human body in a particular area.

These features and technology brought by Electronics technology is a lead to make a research and develop the said project. The researcher created solution to the said problem by using the technology of sensors, switching relays and different electronics components. In this project, the PIR sensor will be used to detect the human present in the classroom. A Passive Infrared sensor (PIR sensor) is an electronic device which measures infrared light radiating from objects in its field of view. Apparent motion is

detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a wall. (C. F. Tsai and M. S. Young December 2003)

PIRs come in many configurations for a wide variety of applications. The most common models have numerous Fresnel lenses or mirror segments, an effective range of about ten meters (thirty feet), and a field of view less than 180 degrees. Models with wider fields of view, including 360 degrees, are available—typically designed to mount on a ceiling. Some larger PIRs are made with single segment mirrors and can sense changes in infrared energy over one hundred feet away from the PIR. There are also PIRs designed with reversible orientation mirrors which allow either broad coverage (110° wide) or very narrow "curtain" coverage or with individually selectable segments to "shape" the coverage. (GloLab Corporation. Retrieved 2013-05-31.)

The PIR motion sensor is used to detect the human body and movements wherein the output of the sensor was transferred to switching relay stage. When sensor detects nobody is in the classroom the power system of the classroom, it automatically off depending on the time delay set in to shut OFF the power system. If there are students coming into the classroom and detected by the sensor, the power system will automatically switch ON. The PIR sensor is typically mounted on a printed circuit board containing the necessary electronics required to interpret the signals from the sensor itself. The complete assembly is usually contained within housing, mounted in a location where the sensor can cover area to be monitored. (Steve's Lock, Safe and Alarm. Retrieved 2012-06-24)

The housing will usually have a plastic "window" through which the infrared energy can enter. Despite often being only translucent to visible light, infrared energy is able to reach the sensor through the window because the plastic used is transparent to infrared radiation. The plastic window reduces the chance of foreign objects (dust, insects, etc.) from obscuring the sensor's field of view, damaging the mechanism, and/or causing false alarms. The window may be used as a filter, to limit the wavelengths to 8-14 micrometer, which is closest to the infrared radiation emitted by humans. It may also serve as a focusing mechanism. (Leviton. Retrieved 6 September 2014)

II. OBJECTIVES

A. Objectives of the Study

The general objective of the study is to develop an energy saving device to reduce wastage of electricity.

The specific objectives are:

- 1) To design an energy saving power control system for application in classroom.
- 2) To develop an energy saving power control system by using motion sensor
- 3) To test the energy saving power control system in a classroom

III. METHODOLOGY

A. Assembly Procedure

Assembly procedure presents the different schematic diagram of every stage of the energy saving power control system and the functions in each stage.

- 1) *Power Supply Stage*: The function of the power supply stage is used to designate exact voltage needed by the sensor stage and the switching relay stage.
- 2) *Electronics Component*
 - a) *Step-Down Transformer*: was used to reduce the high voltage to low voltage to the needed supply voltage of the main circuit with an alternating current output.
 - b) *Bridge Type Diode (D1-D4)* : was use to convert the alternating current to direct current to produced flow of the positive and negative voltages in only one direction
 - c) *Zener Diode (D5)* is to limit the voltage across its terminal in reverse bias and regulated the supply to maintain the constant output voltage
 - d) *Capacitor*-- act as a line filter to improve transient response.

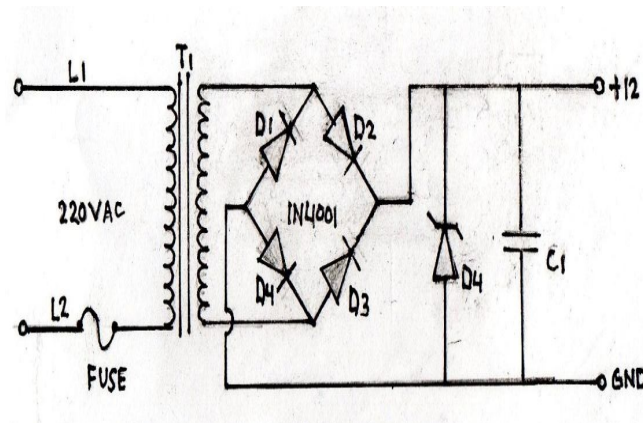


Figure # 1 represents the schematic diagram of the power supply stage.

3) *Sensor Stage*: The function of the sensor stage is to detect human movement. This movement was then converted into electrical pulse and that electrical pulse was use to trigger the switching relay stage.

a) *Electronics Component*

- i) *PIR (Passive Infrared) Sensor* – was used to detect human body movements and that movements is converted into electrical pulse that is use to trigger the switching relay stage.
- ii) *Fresnel lens* – was used to widen the sensitivity range of the PIR sensor.
- iii) *Delay to OFF Timer Trimmer*—was used to set the time to switch off the power system when the sensor did not detect anybody is in the classroom
- iv) *Sensitivity Range Adjustment Trimmer*—adjusts the sensitivity of the sensor to detect human movement and heat.

*GND— referred to us as the common ground.

*12VCC—served as the supply voltage of the sensor.

* Electrical Pulse Output—this electrical pulse is used to trigger the switching relay stage.

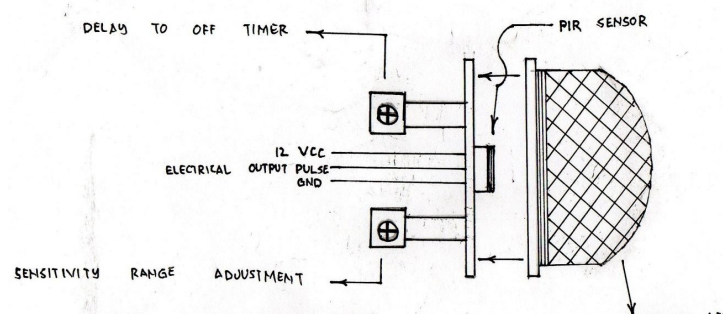


Figure # 2 represents the pictorial diagram of the sensor stage.

4) *Switching Relay Stage*

The function of this stage is to switch ON/OFF the power electric system. The ON/OFF of the switching relay stage is dependent on the output of the sensor stage.

a) *Electronics Component*

- i) *Relay (10A DPDT)* -- is the main component on this stage; it serves as the switch on the high voltage of the power system of the classroom
- ii) *Switching Transistor (Q1)*—is used to switch the negative polarity that needed by the relay to switc
- iii) *Resistors (R1, R2)* -- served as the voltage divider of the circuit
- iv) *Capacitor (C1, C2)* – it is used to improve the transient response
- v) *Diode (D1 & D2)*— use to regulate the voltage in the circuit.

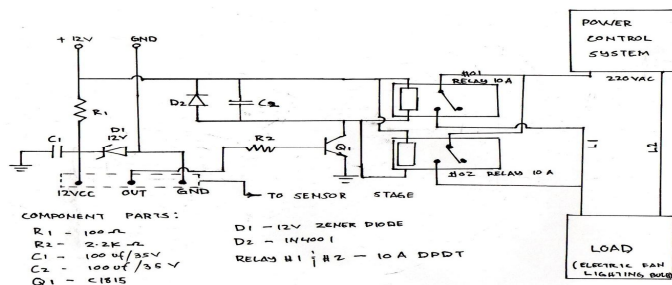


Figure #3 represents the schematic diagram of the Switching Relay Stage

B. Testing Procedure

In the testing of the project adjusting sensitivity range and time delay to OFF timer was considered.

The procedures that was done in testing were as follows:

- 1) **Power Supply:** The voltage output was measured using a multi tester for the exact voltage supply of the sensor and switching relay stage.
- 2) **Sensor:** The sensor was tested if it is capable in detecting human movements in a certain distance and if it will automatically ON the power system if it detects somebody is inside the classroom. It also tested the sensitivity range
- 3) **Switching Relay Stage:** Switching relay stage also tested if it is capable of switching the high voltage of the power system of a classroom and also to receive the electrical pulses from the sensor.

C. Data Gathering Procedure

The model of the Energy Saving Power Control System was developed through consideration of different function Electronics components. While the data for testing the sensitivity range and time to power off the electric power system when no one is somebody inside the classroom will be gathered using:

- 1) The distance of sensitivity ranges in meter
- 2) Timer clock start when the sensor did not detect human movement inside the classroom.

IV. RESULTS AND DISCUSSIONS

A. Description of fabricated Prototype Model of Energy Saving Power Control System

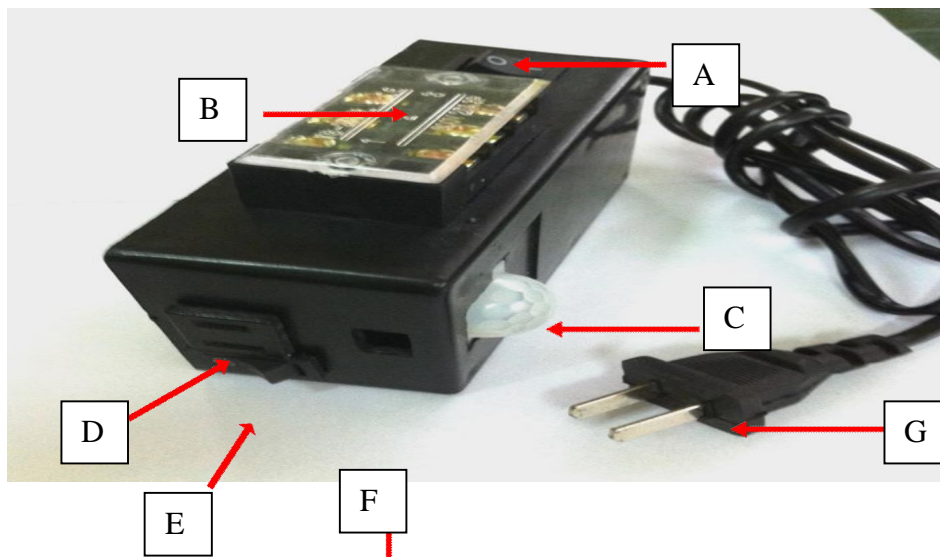


Figure #4 represents the main parts of the prototype of Energy Saving Power Control System

The following are the main parts of proto-type of Energy Saving Power Control System.

- 1) Main Power Switch-use to power "ON/OFF" the gadget.
- 2) HEAVY DUTY LINE 1 PORT- where the cut line1 from the circuit breaker is connected.
- 3) PIR SENSOR- used to detect human movement.
- 4) DIRECT APPLIANCE PORT-used to connect direct appliances that you want to control
- 5) SELECTOR SWITC- used to select direct appliance outlet or heavy duty line 1 port were used
- 6) SENSITIVITY AND TIMER ADJUSTMENT-used to adjust sensitivity range and time of the gadget to switch off the power system when it did not detect somebody in a classroom
- 7) AC PLUG-provides a passage of voltage from the source to the power supply circuit of the gadget.

B. Description for Sensor Stage.

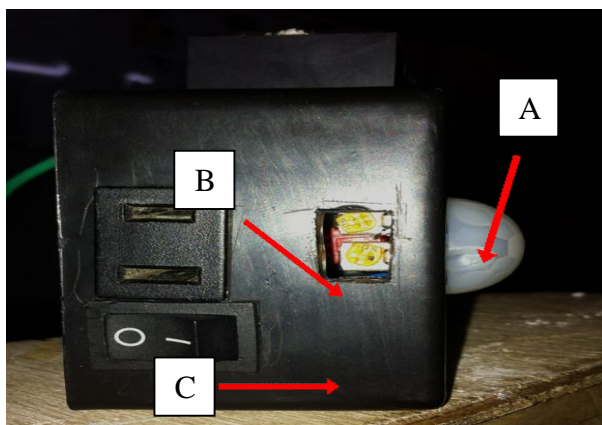


Figure #5 represents the main parts of the sensor stage

The following are the main parts of the sensor stage.

- 1) *Pir Sensor*-used to detect human movement.
- 2) *Timer adjustment*-used to adjust the time to switch off the power system was it did not detect somebody in a classroom
- 3) *Sensitivity Adjustment*-used to adjust the sensitivity range of the gadget.

C. Description of the Power Supply Stage.

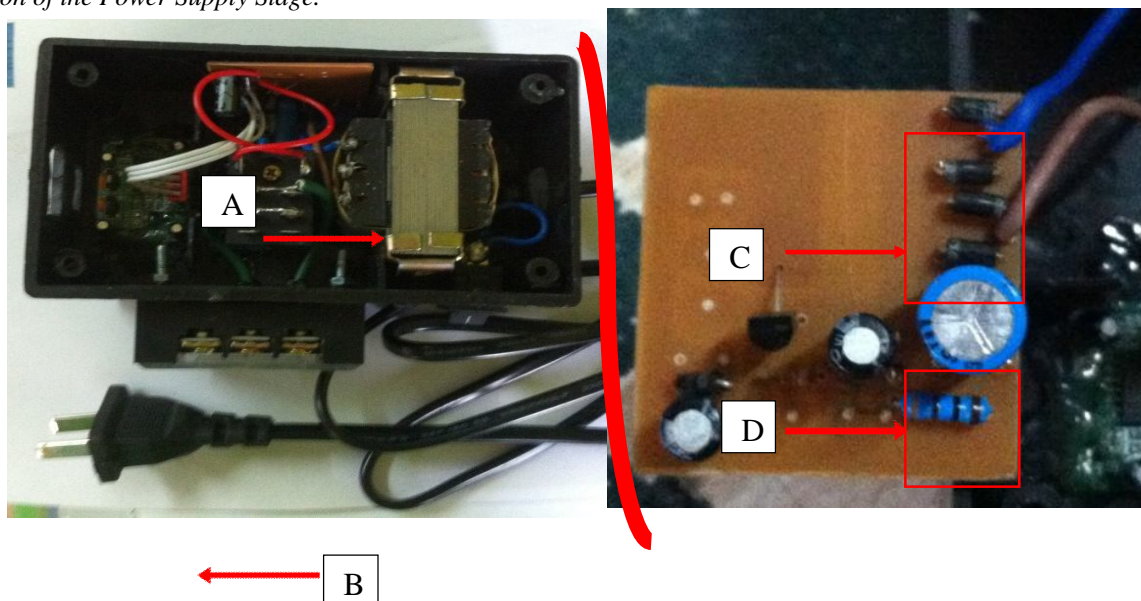


Figure #6 represents the main parts of the power supply stage

D. Description of Switching relay Stage

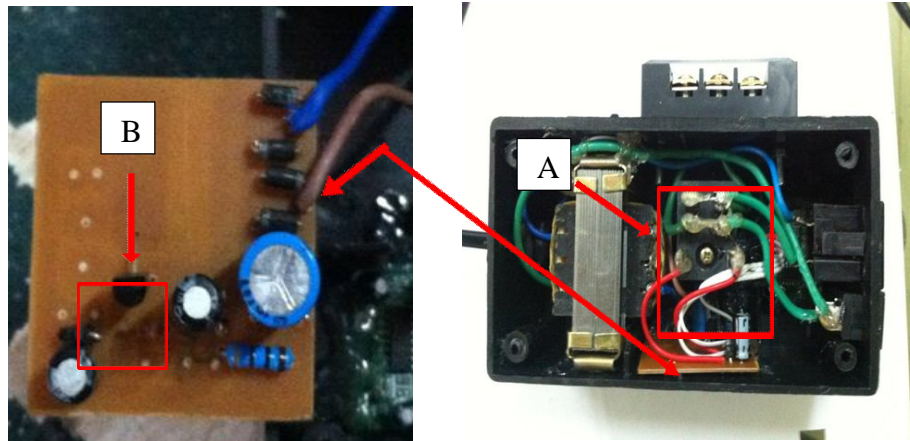


Figure #7 represents the main parts of the switching relay stage

The following are the main parts of the switching relay stage.

- 1) *Relay Switch*-used as switch of the line 1 of the circuit breaker
- 2) *Switching Transistor*-used to receive the pulse from the PIR sensor that is used to trigger the relay

E. Procedure For Assembling The Proto-Type Model Of Energy Saving Power Control System

The following materials were bought from Electronics Shop in Sanchez Mira

- 1) Transformer 250Ma 12V
- 2) Relay Switch DPDT
- 3) Rectifier Diode 1N4001
- 4) Zener Diode 12v
- 5) Resistors 100,2.2 k ohms
- 6) Capacitors 100uf/35v, 1000uf/50v
- 7) Lead
- 8) Regular Convenience Outlet
- 9) Heavy duty connector
- 10) Rectangular box
- 11) Stranded Wire
- 12) Male Plug

Special Material:

PIR SENSOR

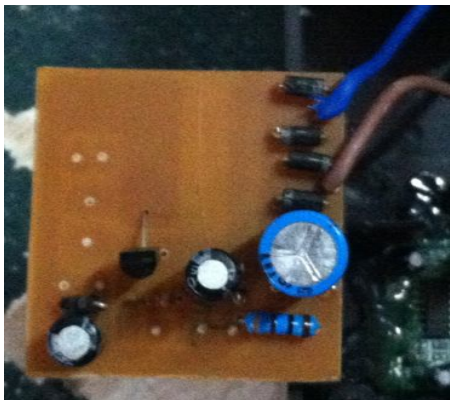
Recycled Material:

Heavy duty Wires

Steps in designing and assembling the gadgets as follows;



1.Design the Printed Circuit Board based on the schematic diagram. Printed Circuit Board is where the electronics component is mounted.



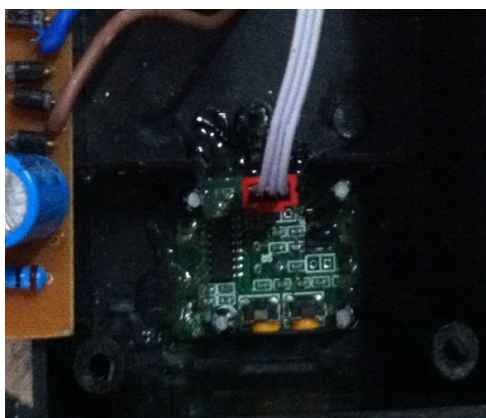
2. All electronics components were mounted in the PCB based on the schematic diagram of the gadget.



3. The casing was designed to the size of the components, better design of the casing make the paths of wire safe. The size of the casing is 13cm*7cm*5cm



4. Extract holes to the casing according to the size of the components to be mounted. Proper Extraction of the casing provides good insulation of the gadget.



5. The components were mounted into the casing and was locked to avoid short circuit inside the gadget.



6. All wires were connected in their proper terminal based on the schematic diagram and were made sure that all wires were properly insulated to avoid short circuit.

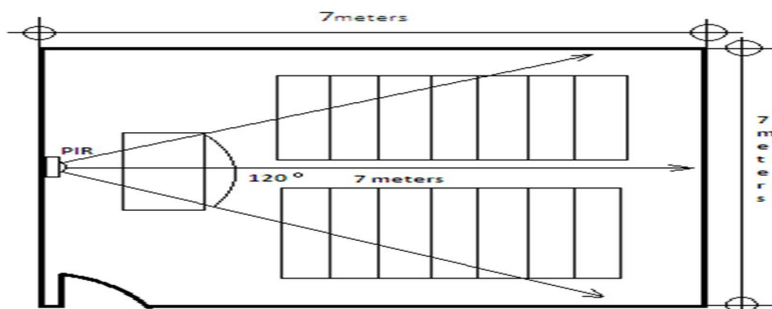
7. The proto-type model

D. Power Supply Stage

The output voltage of the power supply was measured by using Multi Tester DCV 50 range. And the measured output voltage is 12DC volt that is enough to operate the main circuit of the gadget.

F. Sensor Stage

- 1) **Sensitivity Range:** The gadget is capable of detecting human body movement in a maximum distance of 7 meters in a 120-degree angle where the sensor is facing. And it easily power “On” the power control system. The sensitivity of the gadget is adjustable for a certain purpose
- 2) **Timer:** The time of the gadget to Switch off the power system when it did not detect human body movement is 3 seconds up to 6 minutes. Use the timer to adjust the time to switch off the power system if the gadget is not detecting human body movement inside the classroom.



Figure#8 represents the sensitivity range

- 3) **Switching relay Stage;** When the gadget automatically detects human body movement inside the classroom, the power system automatically switch “ON” within 2 seconds. Switching relay stage can switch the load of 20 amperes load of 1 classroom. It is tested in 4 lamps and for ceiling fan. The gadget switches “ON/OFF” the power system smoothly.

- 4) *Life Span of the Gadget*; The lifespan of the gadget depends on the quality of the materials used and how strong the joints of the wire are connected to the PCB. In constructing the gadget, it uses cheap but quality electronics part. And the joining is properly soldered.

G. Testing The Gadget In The Classroom

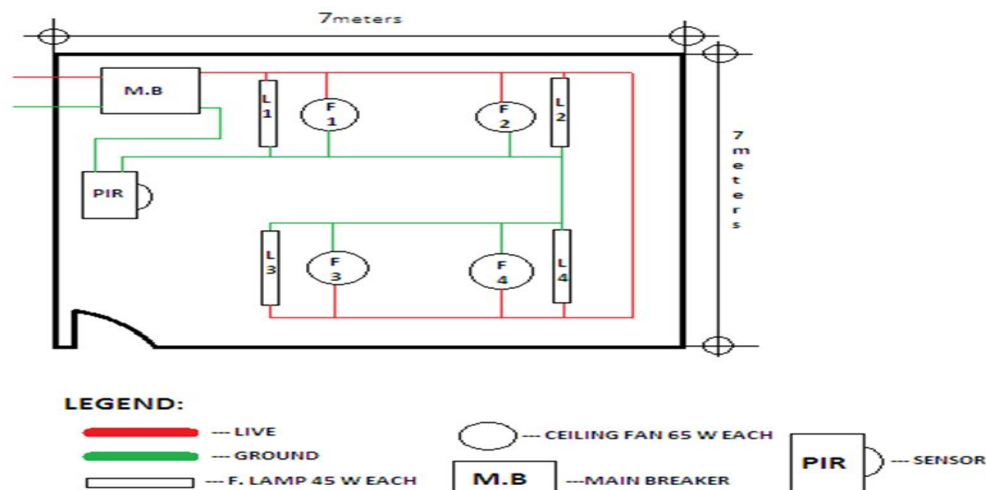


FIGURE #9 represents the sample connection of energy saving power control in a classroom.

The gadget is tested in a classroom which have loads of 4 fluorescent lamp rated in 45 watts each and 4 ceiling fan rated in 65 watts. And the gadget switches off the main breaker if it did not detect somebody in the classroom.

H. Maximum Total Wattage Load Of The Gadget

The maximum load of the gadget is 4400 watts.

Switching relay is rated in 20amperes/220volts. So, the maximum wattage of the gadget computed this way:

$$P = E * I$$

P – power (WATTS)

E – voltage (V)

I – ampere (A)

GIVEN:

$$P = ?$$

$$E = 220V$$

$$I = 20 A$$

SOLUTION:

$$P = E * I$$

$$P = 220V * 20 A$$

$$P = \boxed{4400 \text{ WATTS}} \Rightarrow \text{MAXIMUM LOAD}$$

I. Cost Of The Gadget

BILL OF MATERIALS		
ELECTRONICS COMPONENT	QUANTITY	PRICE
PIR SENSOR	1 pc.	300
RELAY SWITCH 10 A	1 pc.	75
AC PLUG 220V	1 pc.	25
SWITCH	2 pcs.	10
TRANSFORMER 250mA	1 pc.	100
TRANSISTOR C1815	1 pc.	5
RECTANGULAR BOX	1 pc.	25
RESISTOR	2 pcs.	2
CAPACITOR 1000uf/50V	1pc	20
100uf/35v	2 pcs	2
DIODE 1N4001	4pcs.	8
ZENER DIODE	1 pc.	5
BOLT & KNOTS	2 pcs.	2
STRANDED WIRE #18	1 METER	15
LEAD	2 METERS	10
HEAVY DUTY PORT	1 pc.	15
FEMALE OUTLET	1 pc.	15
TOTAL	= P 634	

SELLING PRICE (PROPOSED)	P1000
TOTAL EXPENSES	P634
LABOR	P150
NET INCOME (SP –(TE +L)	P216

J. Safety Precautions On The Use Of The Fabricated Proto-Type Model Of Energy Saving Power Control System

When using this electrical appliance, basic safety precautions should be observed including the following:

- 1) Read all instructions before using the gadget.
- 2) Do not immerse main power switch, or plug in water or other liquid to avoid electric shock.
- 3) Close supervision is necessary when this appliance is used by or near children.
- 4) Unplug the appliance when not in use.
- 5) Avoid contact with live ports.
- 6) Do not operate this appliance with a damaged cord or plug.

K. For Best Result

- 1) Put the sensor where it is free from obstacles to sense human body movement
- 2) Do not install the sensor near air conditioned to avoid moist inside the gadget.

V. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

A. Summary of Findings

The real objective of the experiment is to look into the efficiency of an energy saving power control system in terms of its capability to detect human body movement inside the classroom, and time for the power control system to switch off if the gadget does not detect human body movement inside the classroom.



The gadget has three stages; the power supply to energize the main circuit, the switching relay stage and the last is the sensor stage which detects human body movement inside the classroom.

VI. CONCLUSIONS

Based from the discussion of findings, the gadget is very efficient and useful because of its characteristic to switch off appliance when the gadget senses that there is no person in the area of its sensitivity range.

A. Recommendations

Based on the findings and conclusions, the following recommendations are offered.

- 1) The Proto-type model of Energy Saving Power Control System should be used to households and business establishments.
- 2) Parallel studies should be conducted to improve the said gadget and to innovate other gadgets that would function the same or better.

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