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Smart Rooms Automation System by Thermal Sensing

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***Abstract*— Electricity, being one of the most indispensable forms of energy is wasted a lot just by not turning off appliances when not required. Research suggests that in the developing nations such as India, electrical consumption is more than the amount produced. Thus, creating a deficit of a resource. The objective of the current study is to analyse the amount of the electricity wasted in a college during a whole working day and implementing a system that automate the process of powering on/off of electrical devices in a room without any manual work. This is done by sensing emitted Infrared radiation from human body using a thermal sensor to determine the presence or absence of a human.**

Keywords*— Thermal sensor, automation, body heat, electricity consumption.

I. INTRODUCTION

Being an indispensable resource in developing nations, Electricity - lots of it is wasted on a daily basis by many just by not turning off appliances when not in use. Being a nation, whose electrical consumption is more than the production, a lot of electricity can be conserved just by using it only when it is absolutely necessary.

The goal of this study is to analyse how much electricity is wasted on a daily basis on a working day in a college. This paper also involves an experiment with the objective to reduce the unwanted consumption of electricity in the same college by turning off the electronic devices when not in use.

This paper is organized as follows. Section II discusses the literature review. Section III discusses the study conducted to analyse the unwanted electricity consumption in a college. Section IV discusses the solution proposed, and in Section V, the procedure of the experiment conducted is shown. In section VI the conclusion is given highlighting the amount of energy conserved.

II. LITERATURE REVIEW

A. Passive Infrared Sensor (PIR)

They are most often used in PIR-based motion detectors. The term *passive* in this instance refers to the fact that PIR devices do not generate or radiate energy for detection purposes [1]. They work entirely by detecting infrared radiation emitted by or reflected from objects. They do not detect or measure "heat". An individual PIR sensor detects changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor. When an object, such as a human, passes in front of the background, such as a wall, the temperature at that point in the sensor's field of view will rise from room temperature to body temperature, and then back again. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage, and this triggers the detection [2]. But the drawback with these types of sensors when it comes to energy conservation is that they can neither detect a stationary body nor can detect without a change in heat radiated. Thus, leaving this a partially satisfiable solution.

B. Bidirectional Visitor Counter

The Bidirectional Visitor Counter or the people counter is an electronic device that is used to measure the number of people traversing a certain passage or entrance [3]. Examples include simple manual clickers, infrared beams, thermal imaging systems, and video counters using advanced machine learning algorithms. But the biggest shortcoming when it comes to using this sensor technology to conserve energy is that it cannot take simultaneous entries into account. Thus, making this an incomplete solution to the problem at hand.

III. ANALYSIS OF UNWANTED ELECTRICAL CONSUMPTION

This study was conducted on a working day of the college to get more accurate results on the amount of electricity wasted. The study is conducted at three different places on the college campus.

A. In the classrooms - Department:

Ideally, all students are present in a classroom, and they turn off electrical appliances when they leave an area. But we observed that it is not the case in practical situations. Sometimes a fan might function in a place where the student might not even be there. And there were cases when the student doesn't turn off the lights and fans when he/she decides to leave. **From our keen observation, we landed on a conclusion that on an average two electric fans and four light bulbs were functioning unnecessarily per classroom. So,**

By considering a 75 watts Electric Fan running for 8 hours a day, the power consumed per month was

((75*8) * 30) = 18 Kwh (appx)

Now, considering 12 fans in minimum six classrooms got us to **216 Kwh (appx)** per month. And per year around **2500 Kwh**

(appx) is wasted. Likewise, considering a 45 watts tube light functioning for 8 hours straight, the power consumed per month would be around,

((45*8) * 30) = 11 Kwh (appx)

Now, considering 24 light bulbs in minimum six classrooms of the department we could find that **264 Kwh (appx)** is wasted per month. And per year around **3000 Kwh (appx)** is wasted.

Thus, from the calculations, we found out that by considering just two fans and four light bulbs for six classrooms, **5500 units of Electricity is consumed per academic year**. On a large scale, it can be seen that a huge amount of Electricity is wasted.

B. In the food court:

When the same analysis was conducted for the food court in the college we observed that the area of a food court is very large. Hence the food court alone wasted around **2500 units** per year.

C. In the Hostel rooms:

When the analysis was conducted for hostel rooms, we found out that the students usually turn off the light bulbs but not the fans. So, when we considered only ten rooms for the experiment, we observed that an electrical fan functioning for 8 hours in just ten rooms would consume **3500** units of electricity annually. On a large scale, it can be seen that a huge amount of electricity is wasted.

With all these data collected from this study, a graph was plotted to get a clearer picture where X axis represent the name of location and Y axis represent Power incremented in thousand.

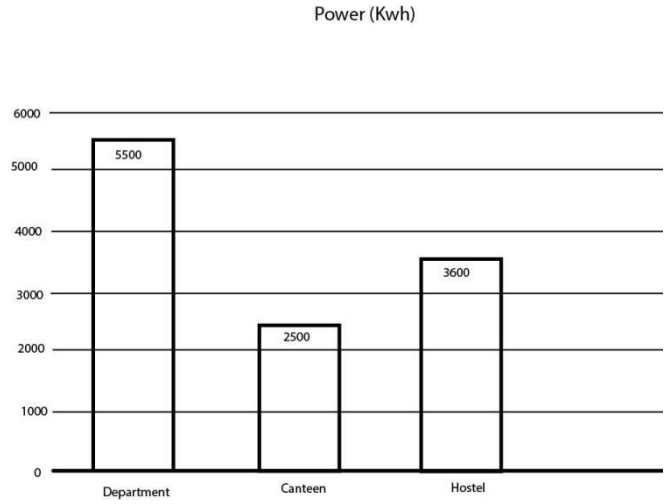

Fig 1.1 - Energy wasted

D. The conclusion of the study:

The results of the study indicated that a huge amount of electricity is wasted just by the carelessness of countless people. This helped us experiment further and helped us devise a system that would reduce the unwanted consumption of electricity.

IV. PROPOSED SOLUTION

Since the existing systems are found to have certain limitations in the process such as the inability to detect a stationary person, a better system that is capable of overcoming these above shown limitations with the facility to operate electronic appliances automatically at ease [4].

A. Proposed System:

The proposed system comprises of a **D6T-44L** thermal sensor as its key component [5]. Using this thermal sensor, the Infra-red rays radiated by the human body is detected and activates the electronic appliances around him. Likewise, if the Infra-red radiated is not detected, the sensor detects that the human is not there and deactivates the appliances again [6].

B. Operating Principle:

The operating principle through which the sensor works is,

- The Silicon Sensor which looks like in the Fig 1.2 receives Infrared Rays from the Object to the Thermopile Sensor [7].

Fig 1.2 - Sensor

- IR produces an Electromotive Force (Emf) on thermopile sensor.
- The Analog circuit calculates Temperature by using Emf value and reference temperature value inside the module [8].
- Measured value is outputted as Binary signals.

Once the binary signals are outputted, they are further analysed and checked to find whether there are any humans present in the given area.

C. Working - An illustration:

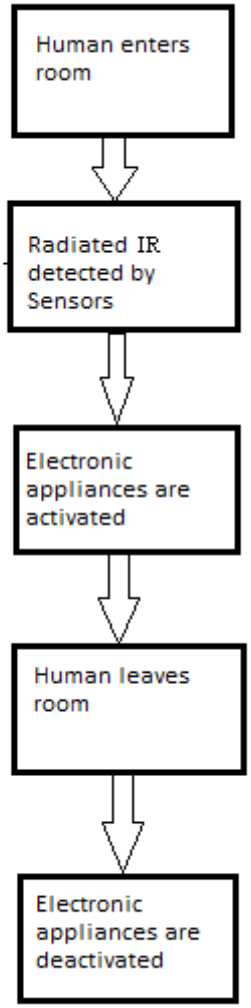

Fig 1.3 - Working of the proposed system

As explained in Fig 1.3, Once the human enters the room, the sensors fitted on the room detects the radiated Infra-red radiation from the body of the human being and passes the signals to the electronic appliances in the room to get activated [9]. Likewise, once the human leaves the room, due to the absence of the IR, the sensor deactivates all the electronic appliances.

V. EXPERIMENT CONDUCTED

The experiment was conducted in a room of area **8sq. Meters.** The number of sensors needed to experiment depends on the size of the room. In our experiment, two sensors were required.

A. The sensor setup:

We used a thermal sensor of the series D6T to experiment. The sensor which looks like in the Fig 1.4 is made up of a cap with silicon lens, MEMS tthermopile sensor chips [10], and a dedicated analog and logic circuit for converting to a digital temperature value on a single board with one connector.

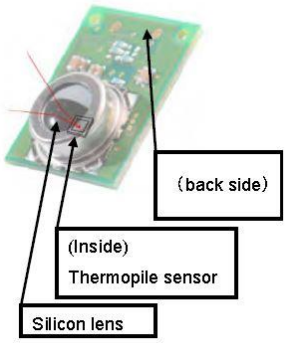

Fig 1.4 - Sensor (Parts labelled)

It is a non-contact temperature sensor that measures the surface temperature of an object and operates accordingly. The D6T-44L-06 unit has sensor chip arrays of 16 channels (4x4) that continuously detects far - infrared rays emitted from the body of an object [11]. The sensor corrects a temperature measurement value by using a reference heat source. The measurement value is influenced by the specific material of the object to be measured, and the surface shape of the occupant relative to the sensitivity area. The sensor achieves its sensitivity characteristics over an object view angle by using the silicon lens called the FOV(Field Of View) described in the Fig 1.5 is an indication of view angle that is generally specified as an area angle of 50% for maximum sensitivity.

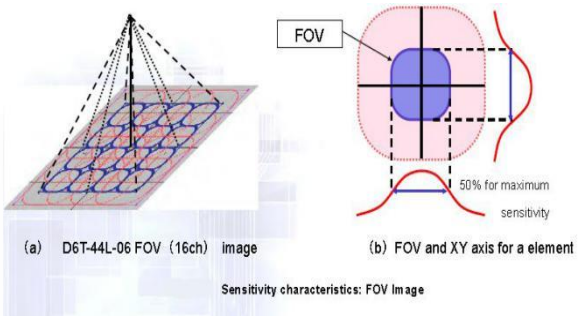

Fig 1.5 - FOV of sensor

As shown in the Fig 1.6 the sensor output four values namely,

- SCL - Serial Clock Line,
- SDA - Serial Data Line,
- VCC - Power source,
- GND - Ground.

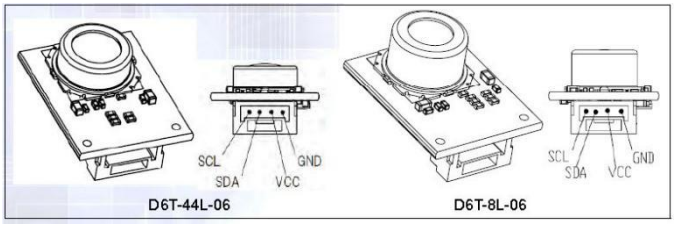

Fig 1.6 - Sensor & its components

B. The Connector:

The connector used is JST p/n SM04B-GHS-TB. A harness made using the above connector act as a bridge between Arduino and Sensor. The Arduino which draws power is further connected to a relay module as shown in the figures 1.7 & 1.8 below, helps us to control AC power supply to on/off the Electric Bulb connected.

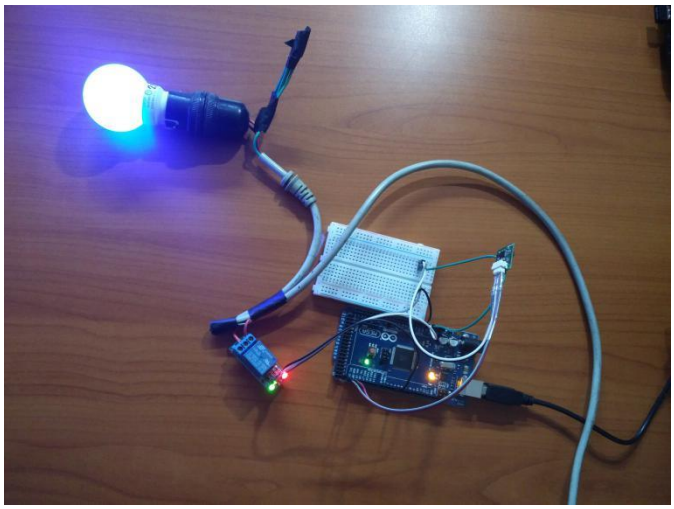

Fig 1.7 - Experimental setup

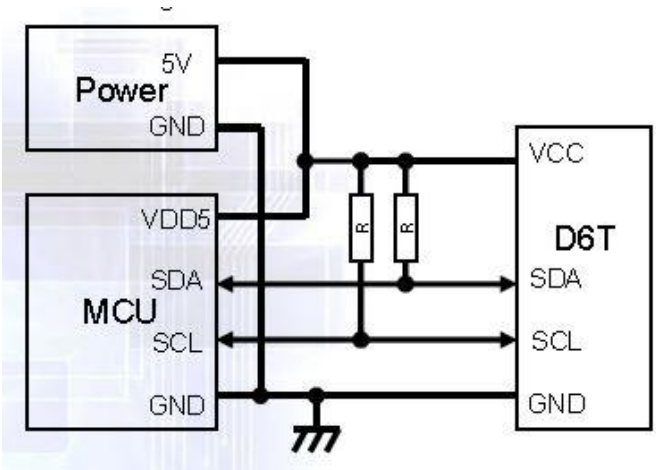

Fig 1.8 - Direct Connection

C. Working:

The sensor is set up and made ready which is shown in the Fig 1.7. Then according to the system workflow diagram as shown in the Fig 1.9, A person is now made to enter the room. Once the radiated IR is detected, the Silicon lens collects the radiated IR from the subject and passes it onto the thermopile sensor in the module. The radiated heat (far - infra-red ray) produces an electromotive force on the thermopile sensor. The Analog circuit calculates the temperature of an object by using the electromotive force value and a measured temperature value inside the module [12]. Once the temperatures are recorded, the Measured value is outputted as Binary Signals through a Serial Transmission port. The Arduino board with the threshold value already programmed into it receives the digital input from the sensor connected to it. Since there are arrays of 16 cells in the sensor which pass on the digital signals produced to the Arduino, an average of the values is calculated to arrive at the result. If the result is proven to be higher than that of the threshold value, then the Arduino closes the relay circuit, thus enabling the electricity (AC power supply) to flow through the Electric Bulb. If the person/group of persons leaves the room, then the sensor detects the reduction in the radiated heated in the room and thus average falls below the threshold value which in turn allows the Arduino to open the relay circuit disabling the flow of electricity. Thus, failing to switch on the Electric Bulb.

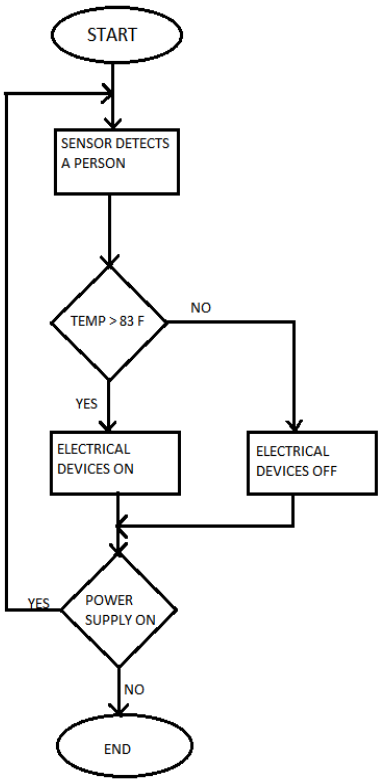

Fig 1.9 - System workflow

For experimental purposes, the threshold value to detect radiated heat from human body is set as any temperature greater than that of 83 F, and we found that the sensor was able to cover a range of 1.8 - meter distance(approximately). The reason for the low-temperature threshold is because the

radiated heat from the human body will always be lesser than that of the actual internal body temperature (98.4-98.6).

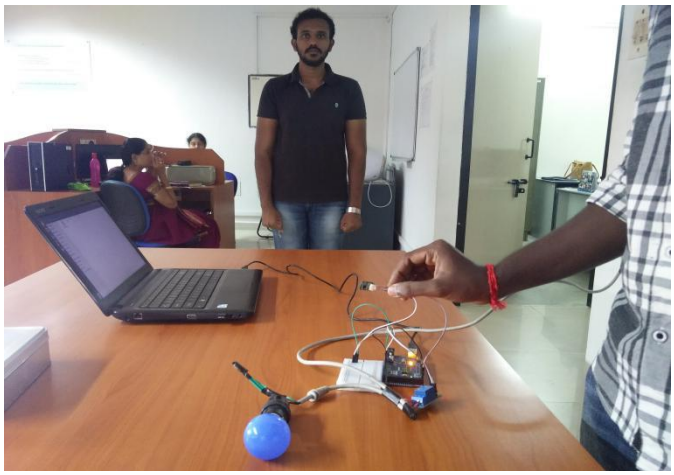

Fig 1.10 - Subject out of range

In the Fig 1.10 you can see that the subject is out of range, thus leaving the circuit open and no electricity flow into the electric bulb.

Fig 1.11 - Subject in Range

Whereas in the Fig 1.11, the subject is clearly into the range, thus closing the circuit and allowing electricity to flow into the electric bulb.

To extend the detection distance furthermore, improvements to the judgment accuracy can be made via software programming, considering time change, heat source location and the human being movement.

VI. CONCLUSION

As seen in the section III, on a yearly basis an educational institution like the one which we studied and analysed wastes around 14,500 units (Approximately). To fight with the rising costs of electricity bills and the scarcity of the resources, if the proposed system is implemented, then a great load of resources can be saved by all the institutions that implement our system.

Being a system that needs only a single investment for the implementation, this strives to save a lot of resources wasted regularly.

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