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189. Building Energy Management System by Using Hybrid Technology Microcontroller Based Occupancy Sensor

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Abstract

The paper is about executing an energy management system in regard to building automation. The idea is to control the lighting and Heating, Ventilation and Air Conditioning (HVAC) parameter's for energy efficient operation of buildings. Arduino Mega Microcontroller has been used to interface Hybrid Sensing Technology. The primary objective is to develop a system, which could sense the occupants in the prescribed premises and control the lighting and HVAC accordingly. Passive Infrared sensor can detect the occupancy by the infrared rays emitted by the human body while Ultrasonic sensor detect the occupancy by the rate of change of frequency detected by the sensor. We can easily control the triggering level, detection area and frequency level through Arduino programming. This system is reliable, economical, less power consuming and has improved triggering speed.

Keywords: Energy Management System; Automation System; Passive Infrared Sensor; Ultrasonic Sensor; Arduino Mega Microcontroller; Building Automation.

1. Introduction

This paper enlightened the concept of building energy management and its control boundaries for all types of commercial buildings. This can save the considerable energy lost and benefit number of other applications. This system includes a various range of applications from a simple timer that turns off a lamp or bathroom fan, to centralized, computer-based systems that monitors, control and optimized building system.
Occupancy sensors commonly referred to as motion sensors or motion luminous sensors used for commercial, residential and office applications. These devices include passive infrared (P.I.R), ultrasonic (U.S) or a combined multi sensing technology (Hybrid sensors). Occupancy sensors for lighting will be installed in combination with the indoor environment quality sensor to reduce power consumption. The proper working of this technology will initiate to reduce the lighting that is not required at certain times. Different changes to remain under consideration using PIR, US and (dual technology) sensors including room layouts and the range of the sensors across the room. In addition to the responding occupancy sensor, they will be programmed through microcontroller or microprocessor to interface in hybrid sensor technology and to control the intensity of light.

2. Problem Statement

Over the last few years, power efficient equipment, advanced building materials and modern construction techniques have enabled more power efficient buildings. However, our working behaviour has a large effect on excess power consumption of each building. Systems capable of lowering down the rate of consumption by executing more correct behaviours, which may reduce the annual expenditures of any company and improving the environmental hazards. Here we are addressing the problems of extra energy consumption and in-efficient behaviour of people in office's buildings. We are focusing on decreasing global building power consumption without significantly affecting the occupants comfort zone. A method is used where the occupants are being maintained to their occupancy level and their requirements

based on their location. The developed system would be operational and being used as flexible and reliable device which can easily be programmed through microcontroller and in research methodologies [1].

3. Literature Review

An occupancy sensor is luminous control device that sense the occupancy of people and turns the lights on/off automatically, using passive infrared (PIR), ultrasonic (US) or microwave sensing technology. These sensors are used with a suitable assembly of circuit which provides the control over electrical equipment's such as lamps, heaters, air conditioner, HVAC system and other devices. The aim of using this device is to save energy, provide automation, and comply with building codes [1]. The work which is already done on this device the recent past years is given as follows:

3.1 Measuring Building Occupancy Using Existing Network Infrastructure

Green IT is focusing on the reduction of energy consumption in IT infrastructural buildings. Energy saving methods is applied in both IT and non-IT infrastructural buildings and results are obtained in saving energy. This technique is based on an idea of implicit occupancy sensing in buildings that are largely based on controlling, monitoring and directing MAC and IP addresses in routers and wireless access points, and then interfacing these addresses to the occupancy of a room, corridor, buildings, car parking, elevator zone and many other zones where occupancy is to be measured for some control purposes. This occupancy measurement data is then used for controlling lighting, heating, ventilation, elevator operation, AC controlling, HVAC, and other building equipment's, to improve building operations and to minimize power consumption. These control actions given a complete automatic and smart building concept. This also increases system working functionality in reliable manner. To assess the efficiency of implicit sensing and the feasibility of the dual-use of IT infrastructure, they practically analyse the data and their measurements [2].

3.2 POEM: Power-efficient Occupancy-based Energy Management System

To reduce the energy consumption an efficient way is used. As buildings are great consumer of electrical energy namely for heating, lighting, cooling, ventilation, elevators and in other equipment's, more energy efficient devices are used for reducing energy wastage, new building materials are used in construction and new technologies are adopted to use the nearby energy in efficient way. Energy saving problems needs a lot of attention so a system capable of reducing energy consumption and using the energy in a suitable way is achieved by a system. It is a complete feedback control system for handling HVAC systems that is being installed on existing occupancy levels in buildings. It consists of OPT Net (wireless network cameras) that operates as an optical turnstile to determine particular area occupancies. It also contains PIR sensor based wireless network cameras called BONet that functions alongside OPT Net [3].

3.3 An Integrated Approach to Occupancy Modelling and Estimation in Commercial Buildings

They had developed a model to analyze the activities of all the individuals of a building for measuring the occupancy in their predefined zone of detection in commercial buildings and to determine the low-ordered graphical models from Monte-Carlo simulations of the model. Building with such integrated approach to occupancy modelling achieves high energy efficiency through feedback control. This system is modified with sensing data especially for the case of one occupant and one room. With the help of graphical model predictions, noisy measurements are fused by using the classical LMV estimator. This device is used to estimate occupancy of a room in the building [4].

3.4 A Design Model for Building Occupancy Detection Using Sensor Fusion

Sensor fusion techniques are used to control and direct the occupancy, by using non-identical indoor climatic ranges of variables for useful energy consumption and to control the building services such as heating, lighting, air conditioning, ventilation and other equipment's by maintaining a comfort level. As complete reliable occupancy is difficult due to number of issues as unreliable data, maintaining privacy, change of use, sensor drift and other financial pressures such as quality and economy that's why fusion technique offers reliable occupancy measuring. In recent past years, artificial intelligence (AI) systems are used for control of buildings, and can also be adopted for occupancy analysis. This method for controlling and detecting the occupancy of buildings based on sensor fusion model through Adaptive

Neuro-Fuzzy Inference System (ANFIS) algorithm [5].

3.5 Occupancy Monitoring using Passive RFID Technology for Efficient Building Lighting Control

This method proposed a technique of controlling artificial lighting other parameters of buildings for saving energy and observing the occupancy, based on PIR and data fusion approach of passive RFID. This provides efficient need based control to user buildings parameters as lighting, heating, air conditioning and so many others. It gives an approximately of 13% of power energy savings for public building and also saves cost in office buildings. Practically, real-world occupancy profiling data to be utilized with PIR sensing which is reliable and a well-established approach, provide by RFID gateways for the analysis and enhancement of building lighting usage. This RFID provides better monitoring and helps in saving more energy. [6].

3.6 Dual-Input Dual-Output RF Sensor for Indoor Human Occupancy and Position Monitoring

This method is based on RF sensor proposed as concurrent dual band occupancy sensor, based on Doppler principle, for monitoring and controlling the occupancy of human in a room, corridor, car parking, or in any zone of building where this sensor is used. It operates simultaneously at 2.44-GHz and 5.25-GHz frequency bands. By using the sensor prototype and off-the-shelf laboratory equipment an estimating setup has been developed. From the analysis of signals correlation spectrum, received at individual frequency bands and from the estimated directed arrival of received signals, the human presence in a prescribed range can been predicted. This can benefit the proposed sensor lies in the reduction of the false alarms due to its well-designed operation, power consumption, and size [7].

3.7 Cost-effective Air Conditioning Control Considering Comfort Level and User Location

For the general purpose conventional control systems, use of expensive motion, temperature and humidity sensors to collect data of, both the area and the comfort of users and to provide area-based control to users but this will increase the system overall costs. In order to reduce cost of sensors, the proposed system use low-cost pressure sensors and provide energy efficient personal behaviour that will increase the efficiency of overall functions proving energy saving. To obtain occupancy data and its locations, low-cost pressure sensors and low-power communication nodes are used which are fixed to the chairs and they transmit seating data continuously to the database which store the information through PLC of a server in the database [8].

4. Methodology

This system is equipped with the Hybrid sensing technology based on Arduino mega microcontroller. This technology carries any two sensors that can interface each other to avoid false triggering. In this, we have used Passive Infrared and Ultra Sonic sensor. Ultra-Sonic sensor is dependent on Passive Infrared sensor detection. As Passive Infrared sensor detects any occupancy, it will trigger Ultra Sonic sensor to sense any motion detection. If there is any motion detection in that prescribed range, then it will trigger on the system load i.e. lighting and HVAC load. The load will remain triggered, until there is no occupancy remained in that range of detection.
The flow chart of the working of Arduino microcontroller is shown in figure 1. Initially, we have imposed the motion of an occupancy to Passive Infrared Sensor. Passive Infrared sensor work on the condition of window detection parameters. When there is a motion detection by Passive Infrared windows, then it will trigger else it will remain in sleep mode. It functions just like a window comparator. When there is a difference in inputs, the comparator generates output. In same sense, when there is a difference of motion detection on the windows of passive infrared sensor, it will trigger and generates a pulse. This sensor is interlinked with another motion sensor called Ultra Sonic Sensor. This sensor works on the phenomenon of radar. It emits out radiations in the direction of its prescribed range. If any object comes under its range, then radiation will hit that particular object and bounce back towards Ultra Sonic sensor. This gives the indication of motion detection and sensor will remain triggered until it doesn't find any detection in the prescribed range. If both the sensor doesn't find any motion detection, they remain in their initial mode of sleep. Otherwise both sensors work in hybrid format and will trigger one after another. When Ultra Sonic sensor detects any object, the system load i.e. lighting and H.V.A.C load will turn on. It will remain turn on until the occupancy detection remain within the prescribed limits of Ultra Sonic sensor.

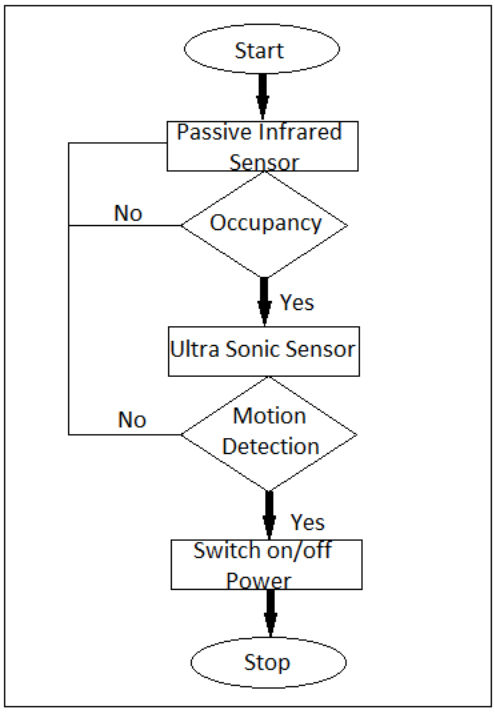

Fig (1) Flow chart of Microcontroller Program

4.1 Working of PIR sensor

The PIR sensor is made from pyroelectric medium, one property of pyroelectric medium is that it produces potential difference whenever there is temperature change detected. PIR sensor detect a person by comparing the infrared emission of the person and the background. PIR sensors have a direct line of sight therefore operators can easily define their limits. Normally PIR sensors have two or more input slots for absorbing infrared radiations and when there is change in the intensity of infrared radiation in any of the slot a minute voltage is developed which cause differential change between the slots and due to potential difference an electrical pulse is generated. . It is designed in such a way that it is most sensitive towards the wavelength which is emitted by the human body as infrared rays. Passive Infrared sensor module has been shown in fig 2.

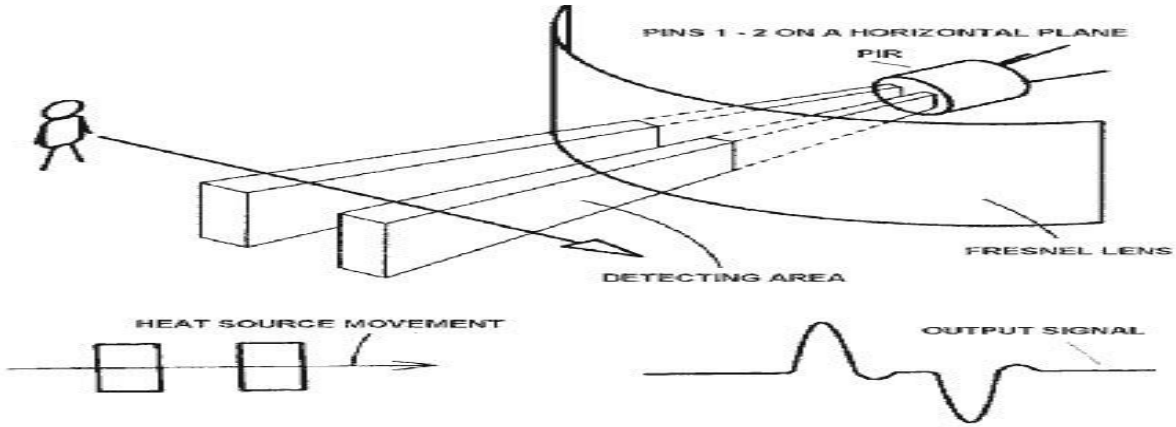

Fig.2. Working of PIR sensor

4.2 Working of Ultrasonic sensor

The Ultrasonic sensor emits ultrasonic sound waves and observed the change in frequency, also with the help of ultrasonic sensor we can also observe change in energy patterns. It works on the principal of change in frequency with respect the change in energy patterns as shown in figure 3. These signal can also be used be used for measuring the position and distance of the occupants therefore with the help of ultrasonic sensor not only motion of occupants can be detected, but also we can switch on the appropriate lighting load with respect to the position of the occupants We have integrated an ultrasonic sensor with

Arduino, it is used in coordination with passive Infrared sensor for detecting human in the prescribed area.

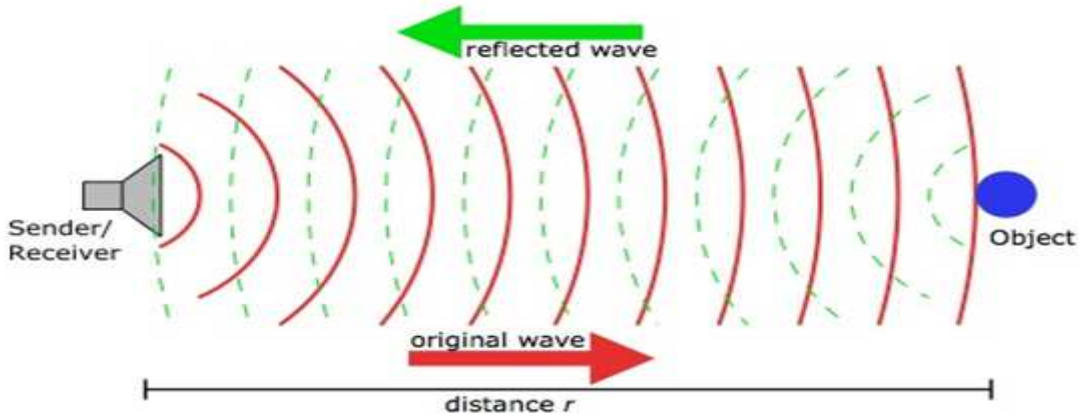

Fig.3. Working of Ultrasonic sensor

5. Results

For the analysis of the data an appropriate summary of the results from the test should be provided to the user to assist them in understanding the project were carried out to test the components, this chapter will explain end the results of the tests that were carried out to verify different component the project. We will discuss the result of each result in this chapter.

5.1 Results from microcontroller circuit

As this the heart of the whole project so this device is the most delicate part i.e. if this will work properly then the whole system will work satisfactorily otherwise there will be a mayhem. After the completion of microcontroller circuitry, it was tested but the result was not correct so we checked component s of the microcontroller's circuit, every component was perfect but the problem was of input current. It was not enough because for the power supply of microcontroller a 200mA 5volt charger was used. After troubleshooting charger was replaced with new 2A 12volt charger.

5.2 Result from connectivity test

As the electric components are fixed on the board with the help of soldering iron and wire, therefore after soldering it is very important to check soldering. As during soldering you might leave a component UN intentionally loose, so this will result in errors in the future tasks and also the joints must also be verified because sometimes two joints are joined and this result in short circuit and may destroy your circuit. This test s verified through multi-meter and every joint was checked and results were precise.

5.3 Results from interfaced system

This time the components were integrated for the verification of their result. A program was burnt into the microcontroller and then our system was switched on and all the results that achieved by the individual components were verified in integrated system and by the grace of God every result was absolutely precise. PIR sensor and ultrasonic was able to detect the occupants.

5.4 Result from survey regarding occupancy sensor system

Most of the load in the corridors, halls, auditorium, rooms, and shelter areas remain functioned when there is no occupancy in the prescribed range for a particular duration of time. This is completely a non-efficient behaviour of occupant's that made commercial building to be nominated as biggest source of greenhouse gas emissions. These facts made us to reconciled our priorities on reshaping a system that automatically turn on load, when there is a need otherwise load will remain turned off. This system will not only help in building energy management system but also will maintain equilibrium between generation and demand side.

The chart 1 describes the overall power consumption in watts against the time in which appliances are made to be used. A room has been chosen for the results of occupancy sensor.

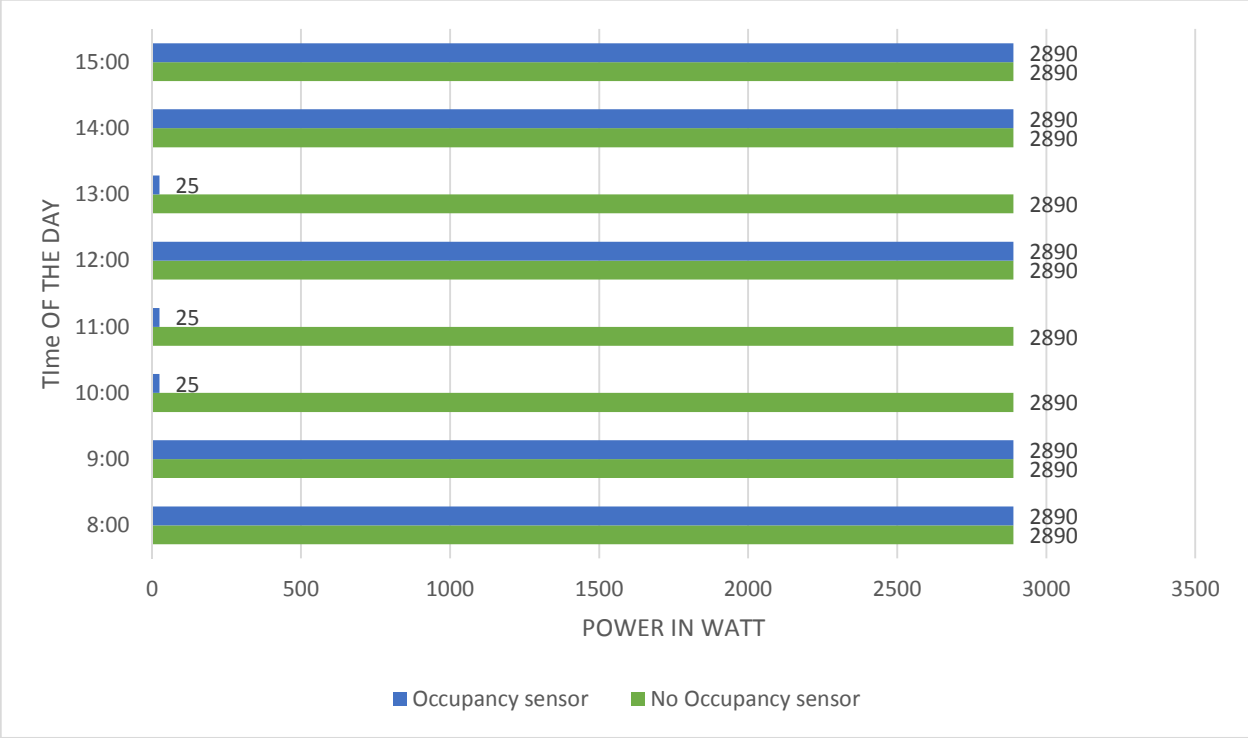

Chart.1. Comparison between Occupancy sensor and No Occupancy sensor.

HVAC Load	AC = 2400 Watt	Bracket Fans = 240 Watt	Total=2640 watt
Lighting Load	CFL = 50 Watt	Fluorescent Tube=280 Watt	Total=330 watt

The Room has 1 Air conditioned and 3 bracket fans of 80 watts. Out of 3, 2 are always in operating conditions. HVAC system of the room consumes about 2640 watt of energy. Lighting load of the room consist florescent lamp and compact florescent lamp. The lighting load has total has total wattage of 330. In normal operating condition, without using occupancy sensor, the power consumption rate is constant i.e. 2890 watts for a complete time duration. This depicts actual condition of our buildings and in our surroundings. By using occupancy sensor, we witness a dramatic reduce in power consumption from 2890 watts to 25 watts. This change has occurred, when occupancy sensor doesn't find any occupant in the prescribed range and will slowly turn off all the load that comes in that range. At last, the area is left with a 25-watt energy saver that only remained energized up to the requirement of the application. After some time, when sensor detects any motion of an occupant in the prescribed range, it will slowly turn on the loads that comes under the range of occupancy. This experiment when combined with overall data of occupancy sensing either when there is an occupant or not, we came up with a linear graph of energy saving. As time increases, power consumption decreases linearly. At the time of installation of occupancy sensor i.e. initial condition, the average power consumption was 2890 watts. After certain passage of time, the average power consumption is 1612 watts. It means, with the deployment of an occupancy sensor for a certain time, in the prescribed range will results in 1227 watts saving. This 42 % saving will definitely make a difference in reducing demand factor, carbon/greenhouse gas emissions and have a positive impact on the society.

6. Conclusion

Occupancy sensor system has diverse application at different work places. With little change in programming and parameters it can be used at almost every place. This concept not only insures that our work will be useable in the future but also provides the flexibility to adapt and extend, as needs change Though Occupancy sensor system is not much complicated but it will be very helpful for saving electricity by monitoring and controlling the unwanted flow of electricity. Usually in public places like hospitals, schools, colleges, hostels etc. the lights, fans and other appliances are still ON when they are not in use or the street lights are on even the day time, so we can save good amount of electricity by

avoiding this misuse.

In this project Arduino mega microcontroller has been implemented for occupancy sensor system, and different kinds of sensor has been integrated for getting better results regarding occupancy information. We have learned about different sensors and their interfacing with microcontroller and different signals flowing across circuit. There are different ways in which the Energy management system can be developed. For example, in case of university or college classes the timetable can be made. When the students are present in the class the appliances are on and when they go for attending the practical the appliances are off. Another application of occupancy sensor system in case of universities are personal offices and practical laboratories.

We have implemented the occupancy sensor system by employing Motion Detector Circuitry with the help of passive Infrared sensor as it will detect only humans, moreover motion and position of occupant is confirmed by ultrasonic sensor because there are problems that can occur in the occupancy sensor system if only one sensor is used.

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