Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 02, February-2016

# Illumination Control using MEMS based Detection

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***Abstract*-In this paper we propose a design using both a microprocessor and light sensors for automatic room light detection and control. Our design, the LIC (light intensity controller) which will be installed in every light fixture of a family, is made up of three: Omron d6t thermal sensor, Luxmeter, 8051 microprocessor and Omron thermal sensor is used as a detector of human presence under the field of view (FOV). Luxmeter is used as an intensity monitor so as to regulate the illumination at the desired level. The illumination in the region of interest/room is proportional to the power consumption in lamps. The idea is to reduce the illumination level depending on the environmental conditions and occupancy in the home so as to minimize the power consumption.**

***Keyword: Light Intensity Controller (LIC), Microcontroller Unit (MCU), Energy Management System, Home Power Saving.***

## I. INTRODUCTION

In recent years the energy crisis has become one problem which the whole world must confront. Home power consumption makes up the largest part of energy consumption in the world. In the particular, the power consumption of lamp in a typical home is a factor which can't be ignored. The typical user needs different light intensities in different places. Sometimes the light intensities from outside is sufficient for the user, and thus we don't need to turn on any light. But sometimes the user leaves and forgot to turn off the light. These factors cause energy waste. Therefore some power management of light control in a home is necessary in order to save energy.

Lights are usually controlled by On\Off switches. Of course, the user can switch a light on or off remotely by connecting a specific device to a PC, but there has to be at least a PC, for the control mechanism. Moreover, this inconvenient practice comes at a high cost for users. In some design one must install specific hardware and software to control the lights, resulting in unacceptable cost. Furthermore this type of system cannot detect either the temperature of human body or the room light intensity.

In this paper we purpose a design for automatic room light detection and control. We install a low power light intensity controller (LIC) in every setup area of a home. The design detects the person presence in the detection area by means of MEMS based Omron Thermal Sensor (d6t) in the LIC unit. The unit also detects and controls the variation of the light intensity in a room from the desired level.

The paper is organized as follow. Section I comprises of a complete introduction and scope of the proposed work. Section II covers the description of the proposed work area describing the illumination requirement according to the room dimensions. Light Illumination Control Unit (LIC) is described in section III. Outcomes and achievements are discussed in section IV. Section V covers the conclusion and future scope of work.

## II. PROPOSED WORK AREA

The proposed energy management system can be applied to any building type, including offices, shopping malls, homes, shops, dining halls, conference rooms, etc. In our problem, we have worked on home power management. For this we have considered a house of basically three sections including bedroom, living room, dining area, study table. Each section is measured and the system is applied as follows:

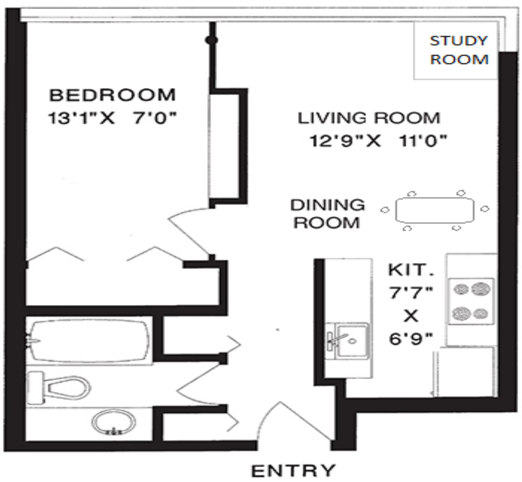


Fig 1: Proposed Area of Work

| Area | Watts | No of Bulbs | Total Wattage |
|---|---|---|---|
| Bedroom | 12 | 4 | 48 |
| Kitchen | 12 | 2 | 24 |
| Sitting Area | 12 | 2 | 24 |
| | 12 | 1 | 12 |
| Dining Area | 12 | 2 | 24 |
| Study Room | 12 | 1 | 12 |
| | 12 | 4 | 48 |
| Total Wattage | | | 192 |

Table 1: Illumination Load of the Proposed Area

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ISSN: 2278-0181
Vol. 5 Issue 02, February-2016

A bedroom of 13’ 1” x 7’ is considered and four lights are considered across each corner of the room of 60 W each. A 7’ 7” x 6’ 9” wide kitchen is taken with two lamps of 60 W each. Similarly, living room of 12’ 9” x 11’ is taken to be comprised of a dining area, study room and sitting area. Four Lamps are used in the sitting area of 60W each with a central designer light of 100W. Dining area is taken to be illuminated by two lamps of 40W each covering 3 persons each on a dining table. A study room is also considered with a 40W lamp light and 100W room light. The total illumination load of the house is 920 Watts if all the lights are switched ON after the sunset.
This causes large power consumption during the day.

The proposed power management system is capable of power saving by monitoring the illumination level in each area. The system calculates the illumination level as per the requirement in each sub area and adjusts the illumination level as per requirement. Various cases/conditions have been taken as per living conditions.

## III. LIGHT INTENSITY CONTROL UNIT

The proposed LIC is designed to minimize the daily illumination load by adjusting the illumination level as per the requirement and working conditions. The system is made up of the presence sensor, occupancy sensor, light sensor circuit, light controller unit, and the low power MCU. We also provide a DC power supply from AC power to every component.

Omron Thermal Sensor is used as an occupancy sensor to detect the presence of a person in the working sub-area.

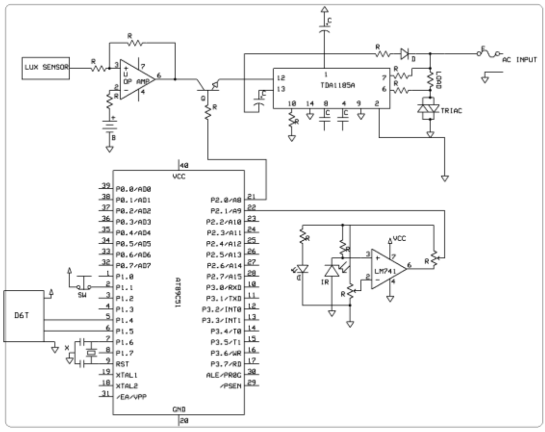


Fig 2: Circuit Diagram of LIC

The proposed work area is a home with living room and bedroom. We have considered three sub-work areas in living room including dining table area, television area and study table area.

| Time Slot | Day/Night Activity | Area of Illumination | Power Consumption without LIC | | | Power consumption with LIC | | | Power Saving |
|---|---|---|---|---|---|---|---|---|---|
| | | | No of Lamps | Watt | Total Watt | No of Lamps | Watt | Total Watt | (Watts) |
| 6am-7am | Reading Newspaper | Sitting Area | 2 | 12 | 24 | 2 | 3 | 6 | 18 |
| 6am-7am | Study | Study Area | 2 | 12 | 24 | 2 | 6 | 12 | 12 |
| 7am-8am | Breakfast Preparation | Kitchen | 2 | 12 | 24 | 2 | 3 | 6 | 18 |
| 7 am -8 am | Breakfast | Dining Area | 3 | 12 | 36 | 3 | 8 | 24 | 12 |
| 8 am -11 am | Household Work | Living Area | 1 | 12 | 36 | 1 | 3 | 9 | 27 |
| 11am-12pm | Watching TV | Living Area | 1 | 12 | 24 | 1 | 3 | 6 | 18 |
| 12 pm-1 pm | Lunch Preparation | Kitchen | 2 | 12 | 24 | 2 | 3 | 6 | 18 |
| 1pm-2pm | Lunch | Dining area | 3 | 12 | 36 | 3 | 6 | 18 | 18 |
| 2pm-3pm | Entertainment | Living Area | 1 | 12 | 12 | 2 | 3 | 6 | 6 |
| 3pm-5pm | Evening Rest | Bedroom | 2 | 12 | 48 | 2 | 6 | 24 | 24 |
| 5pm-6pm | Refreshment | Living Area | 2 | 12 | 24 | 2 | 4 | 8 | 16 |
| 6pm-7pm | Study | Study Room | 2 | 12 | 24 | 2 | 6 | 12 | 12 |
| 7pm-8pm | Dinner Preparation | Kitchen | 2 | 12 | 24 | 2 | 6 | 12 | 12 |
| 8pm-8.30pm | Dinner | Dining area | 3 | 12 | 18 | 3 | 8 | 12 | 6 |
| 8.30pm-10.00pm | Watching TV | Living Area | 2 | 12 | 36 | 2 | 8 | 24 | 12 |
| 10pm-11pm | Study | Study Room | 4 | 12 | 96 | 4 | 6 | 48 | 48 |
| 11pm-6am | Sleep | Bedroom | 1 | 12 | 84 | 1 | 6 | 42 | 42 |
| | Average Saving in a day | | | | 594 | | | 275 | 319 |
| | Average saving in a month | | | | 17820 | | | 8250 | 9570 |

Table 2: Average Load Chart

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ISSN: 2278-0181
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*a) Presence Detector*

We have taken much care for the power consumption even in the controller circuitry. An IR sensor circuit at the entrance is used to detect the presence of a person in the house. Thus, it will act as an enable signal for the LIC control circuitry. LIC put all the light OFF when there is no person in the house.

The moment person enters the house LIC gets triggered by presence detector and starts monitoring the illumination level of the house according to the designed requirements.

IR presence detector also acts as an automatic switching in case if the person leaves the area while keeping the lights ON.

The system is capable to turn it OFF automatically, thereby reducing the power consumption level in no requirement condition.

*b) Occupancy Detector*

The idea is to illuminate the area only when it senses the person under the sensor area. We have taken MEMS based thermal sensor as a presence detector.

Fig 3: Omron Thermal Sensor

Omron D6T-8L is made up of a cap with silicon lens, MEMS thermopile sensor chips, and dedicated analog circuit and a logic circuit for converting to a digital temperature value on a single board through one connector.

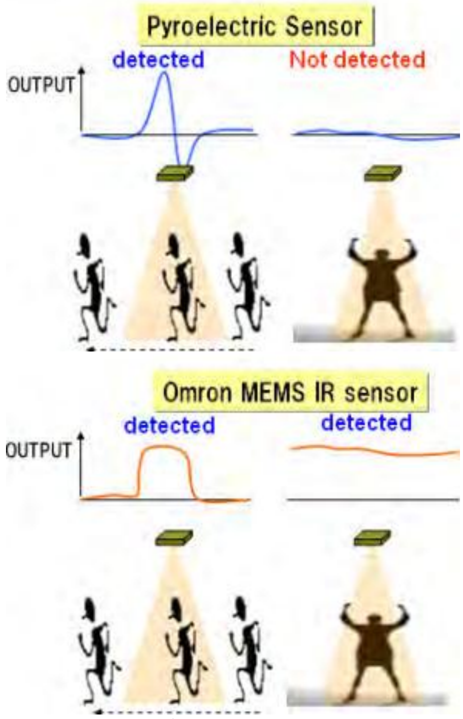


Fig 4: Detection of Poly-electric and Omron Sensor

Omron's non-contact temperature sensor can solve the shortcomings of a conventional pyroelectric sensor, which cannot catch the signal of a stationary person because the sensor detects the change of signal. Moreover, Omron's non-contact temperature sensor keeps detecting the far-infrared ray of an object, while the pyroelectric models do not.

The sensor is connected as per the connection shown in figure (5),

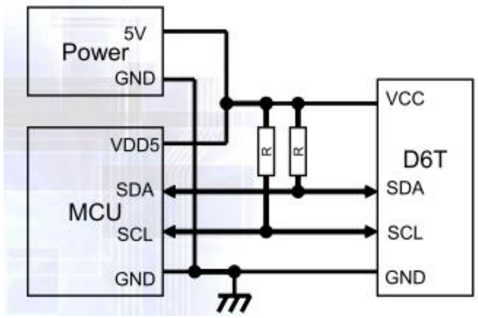


Fig 5: Interfacing of D6T with MUC

*c) Microcontroller Unit*

We have used 8051 microcontroller as a logic controller which regulates the condition of the system

| Working Area | Minimum Illumination (LUX) | Maximum Illumination (LUX) |
|---|---|---|
| Bedroom | 200 | 500 |
| Kitchen | 300 | 500 |
| Sitting Area | 150 | 300 |
| Dining Area | 150 | 300 |
| Study Room | 500 | 1000 |

Table 3: Illumination Range in each area

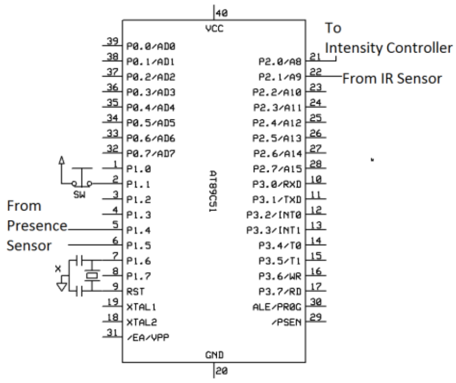


Figure 6 : PIN diagram of MCU

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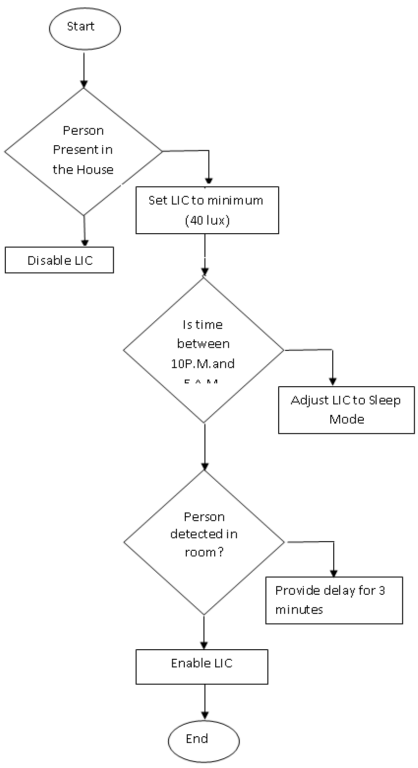


Fig 7: Flowchart of the Strategy

Large area is divided into sub areas. If the sensor does not find any person in the sub area for 5 minutes, then MCU sets the command for minimum illumination of 80 LUX.

Each work area is made to set for a reference illumination level. Various levels of illumination are taken in the proposed strategy for each sub-area of the house. Table x clearly define the reference illumination range for each sub-area.

The flowchart shown in Fig 7 clearly describes the assumed condition for our test area/ home.

The system is also made to set at sleep mode during 11pm - 6am. In this mode, all lights (except bedroom night lamp) are set to get turned off irrespective of any required reference illumination value. Manual switching is also possible as per convenience of the user.

*d) Intensity Detector*

In order to keep the illumination at the reference level, flux-meter constantly monitors the illumination in each area.

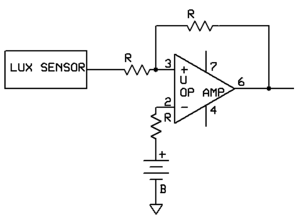


Fig 8: Circuit Diagram of Intensity Detector

Luxmeter implanted at the sub area detects the illumination level. The Luxmeter value is then compared with the reference value adjusted by a variable resistance (R) in figure 8 connected with the inverting terminal. The control signal is obtained at terminal 6 which is used to feed the intensity controller for illumination correction. The variable resistance (R) provided at the panel of the main unison that the user can adjust the required illumination as per his/her requirement. Thus, it makes it a generalized user friendly control circuit.

*e) Intensity Controller*

Intensity controller is that part of LIC which is responsible to provide variable power supply for to the load/lamp for illumination balance.

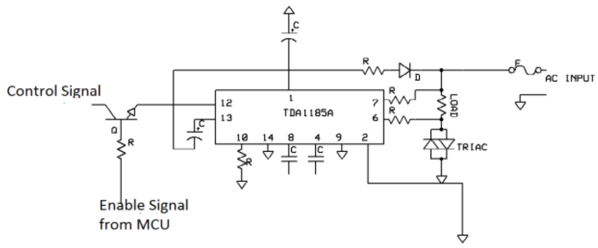


Fig 9: Circuit of Intensity Controller

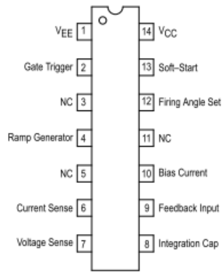


Fig 10: Pin Diagram of TRIAC voltage controller

It is provided with two input signal featuring control signal from intensity detector and enable signal from MCU. Both the signals are logically AND before feeding the phase controlled ac voltage controller.

Variable voltage supply at the load/lamp is provided with TRIAC phase angle controller. TDA1185A is used for the above requirement. It provides variable voltage for different value of control signal.

## IV. OUTCOMES

The proposed scheme find it useful in regulating the excessive power consumption. The scheme is tested with the simulation of the scheme setup. Luxmeter is installed in the house and its illumination values are measured in each target room. The average hourly data of complete one month is analysed initially. The hourly data is then passes to the signal conditioner so as to minimise the disturbances. We have then applied it to the LIC simlation and the power saving is calculated on hourly basis.

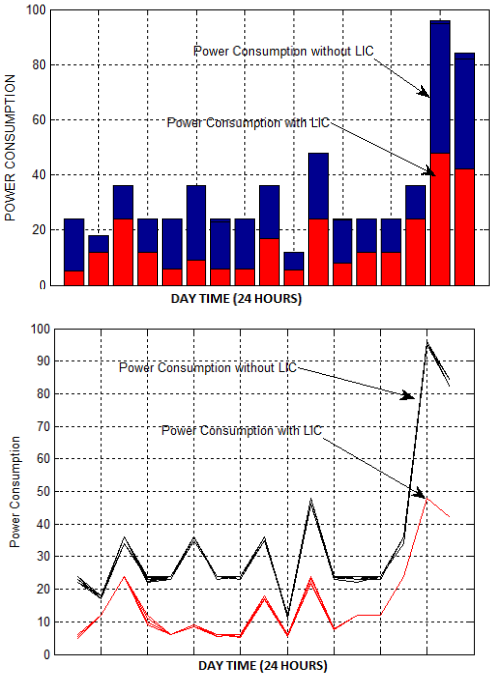


Fig 10: Average hourly plot for power consumption in light

It is to be noted from the plot that LIC is capable of saving the illumination power at each hour.
Various illumination controller is proposed by many researchers. The work finds it useful in detecting the stationary person which other strategy fails as it sense the person movement for illumination control.
The controller logic differ from other previous schemes as they worked on regulating the switching of lamps only. The proposed scheme provide fine illumiination control thereby varying the applied voltage. Thus, it is highly precise controller which constantly regulate the illumination level at each stage.

## V. CONCLUSION AND FUTURE SCOPE

The system seems to be quite beneficial for the minimization of power consumption. It can be installed not only in hose but also in the following places as stated in table 4. If universally adopted, such a system finds it extremely useful for the minimization of electric power consumption; thereby reducing the electricity bill up to 50%. The work can also be extended as a security system also. The presence sensor can detect the uninvited person in the area and can provide an alarming signal for unauthorized entry. A check can also be made for the fire. If the illumination and heat sensed by the Luxmeter and thermal sensor exceed the required level, the system can be used to provide alert for fire.

| | | |
|---|---|---|
| Office | Conference Reception room | 200-750 lux |
| | Clerical Work | 700-1500 lux |
| | Typing Drafting | 1000-2000 lux |
| Factory | Packing Place Entrance | 150-300 lux |
| | Visual Work at Production line | 300-750 lux |
| | Inspection Work | 750-1500 lux |
| | Electronic parts Assembly Line | 1500-3000 lux |
| Hotel | Public room, Cloak Room | 100-200 lux |
| | Reception , Cashier | 220-1000 lux |
| Store | Indoors Stairs Corridor | 150-200 lux |
| | Show window, Packing table | 750-1500 lux |
| | Forefront of Show Window | 1500-3000 lux |
| Hospital | Sick Room, Ware house | 100-200 lux |
| | Medical Examination Room | 300-750 lux |
| | Operation Room , Emergency | 750-1500 lux |
| School | Auditorium | 100-300 lux |
| | Classroom | 200-750 lux |
| | Laboratory, Library, Drafting Room | 500-1500 lux |

Table 4: Illumination Range in other areas

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