International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 12 (December 2014) www.ijirae.com

Simulation and Development of Lighting Control System using daylight for Corridor of a Building

Jayashri A Bangali
Department of Electronics
Kaveri College of Science and Commerce
Pune, India

Arvind D Shaligram
Department of Electronic Science
Savitribai Phule Pune University
Pune, India

Abstract -- Due to the increase of environmental concerns, lighting control systems definitely will play an important role in the reduction of energy consumption of the lighting without impeding comfort goals in future. Energy efficient corridor illumination in commercial and residential buildings is becoming increasingly important in the energy conservation era since corridor is the area where maximum energy can be saved. The paper includes the study of workspace and daylight simulations of the corridor using DIALux lighting simulation software. Based on this study, it also presents the design and development of energy efficient lighting control system for corridor. Finally paper concludes the energy saving due to developed system.

Keywords: Lighting simulation, Lighting control system, DIALux, Energy efficiency

1. Introduction:

Energy efficiency basically refers to the use of less energy to provide the same level of energy service or to do more work with the same unit of energy. This objective can be achieved primarily by using a more efficient technology or process rather than by changes in individual behavior [1].

Lighting systems have the largest potential of any known appliance to reduce energy use. Lighting represents approximately one-third of electricity use in commercial buildings and more than one-half in lodging and retail [2]. Many studies have revealed that proper use of sustainable technology in lighting, such as the use of daylighting controls and low energy lighting, has a strong potential for reducing the demand for energy in commercial and industrial buildings and there is potential for improving the energy efficiency of lighting systems throughout the world. A recent survey of several companies has found that 23 per cent of all energy-saving opportunities could be achieved by improving the energy efficiency of lighting systems [3].

Lighting controls help conserve energy and make a lighting system more flexible. The most common light control is the on/off switch, Manual dimming, Photosensors, Occupancy sensors, Clock switches or timers and Centralized controls. Manual dimming controls allow occupants of a space to adjust the light output or illuminance. This can result in energy savings through reductions in input power, as well as reductions in peak power demand, and enhanced lighting flexibility. This type of technology is well suited for retrofit projects, where it is useful to minimize rewiring [4], [5]. Photosensors automatically adjust the light output of a lighting system based on detected illuminance. Occupancy sensors turn lights on and off based on their detection of motion within a space. Some sensors can be also be used in conjunction with dimming controls to keep the lights from turning completely off when a space is unoccupied. These sensors can also be used to enhance the efficiency of centralized controls by switching off lights in unoccupied areas during normal working hours as well as afterhours [5] [6].

2. Related work:

Researchers have been quantifying energy savings from lighting controls in commercial buildings for more than 30 years, but no comprehensive research review of controls studies has been done previously. This makes it difficult to understand the big picture of the opportunities of controls because the individual studies can have different goals, methods, coverage, and results.

National Research Council Canada and Florida Solar Energy Center has been working lighting system from many years and they have done lot research on lighting. A few papers have provided limited overviews of lighting controls studies. Three of these reviews focused solely on occupancy sensors; the number of reports or individual energy savings estimates referenced by these papers range from seven to 35. The paper [7] presented industry estimates of lighting energy savings for occupancy sensors by building space type, which ranged from five to 90 percent. The authors then presented results from their own study on 60 buildings with lighting savings ranging from 17 to 60 percent. The Lighting Research Center [8] compiled 26 case studies and claims by manufacturers to recommend energy saving estimates for occupancy sensors for the U.S. Department of Energy. The recommendations based on the data were 25 to 40 percent depending on the use of space. The authors of the paper [9] reviewed the performance of occupancy-based control systems from seven previous studies, with energy savings ranging from three to 86 percent.

The authors of paper [10] produced a report on the “Office of the Future,” which referenced studies that provided energy savings for daylighting, occupancy sensors, and personal controls in open offices; vacancy sensors in private offices; and occupancy sensors in corridors. The overall range of savings was six to 80 percent. The paper [11] presents a table of lighting energy savings by space type (private office, open office, and classroom) and controls type (multilevel switching, manual dimming, daylight harvesting, and occupancy sensors.

3. STUDY OF WORKSPACE AND OCCUPANTS

For this research work, the corridor of Department of Electronic Science, University of Pune, India is considered as a workspace or experimental area. Before designing the lighting control system, the workspace is studied. The study includes the types of occupants, their working timings and daylight distribution in the corridor.

The corridor is divided into four sections; section A, B, C and section D as shown in figure 1.

The corridor has one entrance door in section C and a window in section D. There are in total two cabins of teaching staff in section A and three in section D. There are three laboratories in section A, one in section B and three in section D.

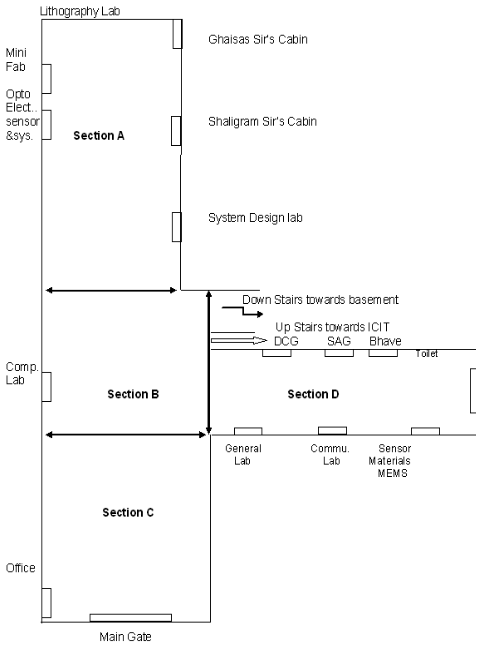


Figure 1 Design of a corridor

As an educational institute, a variety of people are using the corridor as per their requirements. The classification of the occupants is given in table 1.1

Type of Occupant	Category
Teaching Staff	Regular Staff and visiting staff
Non-teaching Staff	Office and laboratory staff
Post Graduation students	M.Sc. Part-I and Part-II
Research students	JRF, SRF, RA*, Mphil, Ph.D.
Miscellaneous	Teachers of other colleges/industry, people coming for enquiry, other staff to meet students or staff

Table 1.1 Classification of occupants

*JRF- Junior Research Fellow, SRF – Senior Research fellow, RA-Research Associate

As mentioned in table 1.1, various types of people are visiting the Department and use the corridor. The working and fringe hours along with the possible types of user is given in table 1.2.

Zone	Timings	Type of visitors
Fringe hours	8 a.m. to 10.a.m.	Students of M.Sc.
Working hours	10 a.m. to 6 p.m.	All (mentioned in table1.1)
Fringe hours	6 p.m. to 8 p.m.	Research students M.Phil., Ph.D.
Non-working hours	8 p.m. to 8 a.m.	-------

Table 1.2 Working timings of occupants

International Journal of Innovative Research in Advanced Engineering (IJIRAE) **ISSN: 2349-2163**
Volume 1 Issue 12 (December 2014) **www.ijirae.com**

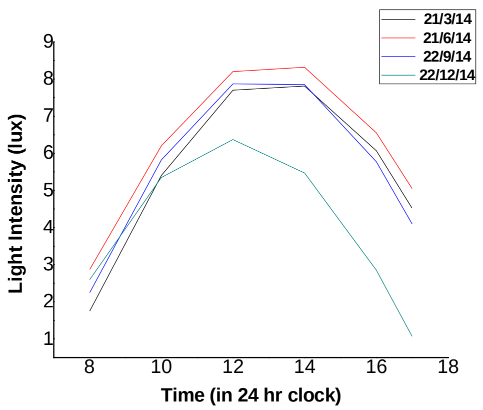
From above table, it is cleared that from 10 a.m. to 6 p.m. more number of people are using the corridor. So the requirement of light intensity is more during the working hours.

4. STUDY OF DAYLIGHT DISTRIBUTION IN THE CORRIDOR:

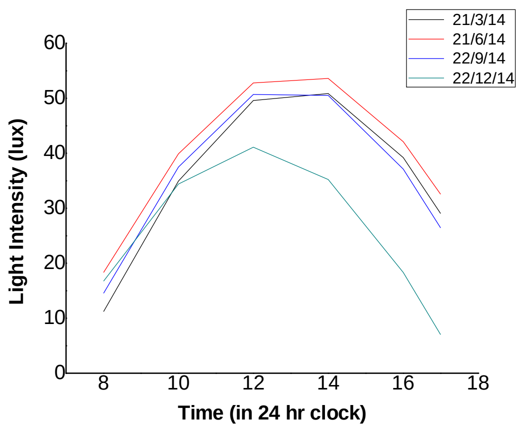
To design the energy efficient lighting control system, the daylight present in that area has to be considered. Depending on the location of the sun, daylight varies thorough-out the day. The north angle of the building also contributes in the daylight distribution inside any building. To study the daylight distribution in the corridor, DIALux lighting simulation software is used. The tool gives the estimation of energy demands in the lighting design phase, energetic optimization and tool helps in finding the best product. The software displays the calculated daylit area.
The design of the corridor is prepared using AUTOCAD and location of Pune (longitude:73.52^0 , latitude: 18.55^0) along with the north angle (40^0) is considered for the simulation. The daylight simulation on 21st March 2014 at 10a.m. is shown in figure 2. This simulation is done using daylight factor and it is the top view of the corridor. Daylight factor is defined as the percentage ratio of the instantaneous illumination level at a reference point inside a room to that occurring simultaneously outside in an unobstructed position. The daylight comes in to corridor from the entrance (in section C), a window (in section D) and from the roof (in section B).

Figure 2 Daylight simulation of the corridor on 21st March 2014 at 10a.m.

To get the accurate the results of daylight simulations, few points are inserted in each section. So, at every point, the software gives the light intensity in foot-candle (fc) which is noted and their graphs are plotted to get the exact picture of available daylight in that section. Considering the location of the workspace and weather conditions in Pune, four dates are identified which are important for the lighting simulation (21st March, 21st June, 22nd September and 22nd December). Since 21st March is the spring equinox (day and night are of the same length), 21st June is summer solstice (longest day of the year), 22nd September is autumn equinox and 22nd December is winter solstice (shortest day of the year), simulations are done on these days. As the daylight is considered in simulation, on 22nd December being a shortest day of the year very less daylight comes in the corridor. While designing the lighting control system, the daylight simulations of these days affects the designing parameters. The simulations are performed on these days and average energy is noted and also lighting simulations for each section at different times of a day are performed. The graphs of light intensities at various points of each section are given in figure 3.

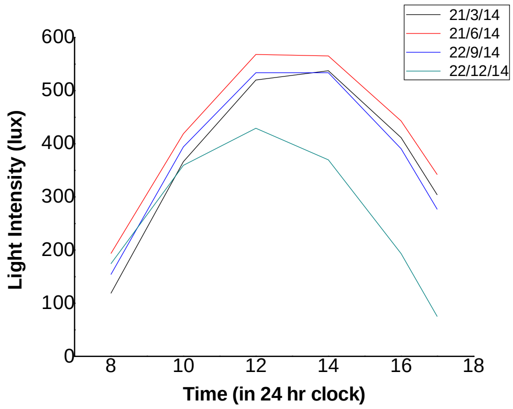


(Section A)

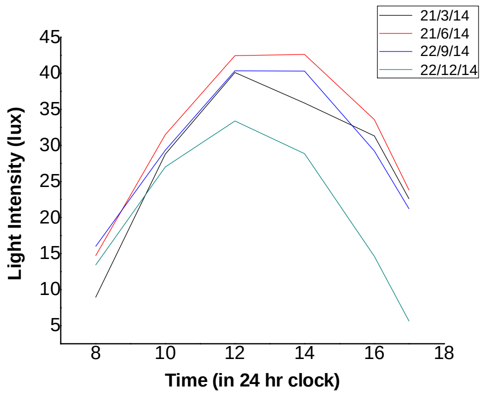


(Section B)

International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 12 (December 2014) www.ijirae.com



(Section C)



(Section D)

Figure 3 Simulation graphs of four sections

According to the standards of light intensities for specific areas, 60-70 lux is sufficient for the corridor illumination. Considering all above points, energy efficient lighting control system is designed and developed which is explained in next section.

5. Control System Design:

Lighting controls perform functions like on-off, time scheduling, dimming, and dimming due to presence of daylighting, lumen depreciation and demand control. Lighting controls is an integral part of a lighting system. These controls must be responsive to the functional and aesthetic requirements placed upon it, and should perform these duties in an energy efficient manner. In general, there are no general rules or guidelines that congenitally lead one to select specific controls. Energy savings due to daylight depends on climate conditions, building form and design and the activities within the building. Providing daylight in a building does not by itself lead to energy efficiency.

Before designing the lighting control system, the existing lighting system is studied. There are in total 8 fluorescent tubes of 40W each are installed as shown in figure 4.

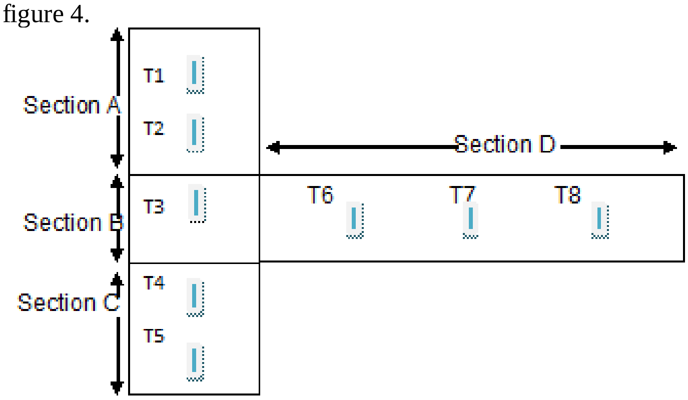


Figure 4 Design of corridor having 8 fluorescent tubes

Existing lighting system contains 2 tubes in section A, 1 in section B, 2 in section C and 3 in section D. The corridor has Conventional Fluorescent Lamps/tubes/tube lights (T8) of 40 W. Fluorescent lamps are categorized according to their diameter. The requirements of illumination levels at different times in the corridor depend on the people working in that area. So a survey about the working hours of the people in that building has done. The conclusions of the study is that maximum people are using the corridor in working hours (from 10 a.m. to 6 p.m.) and 60-70 lux light intensity is sufficient for the corridor.

In the working hours maximum daylight is available in the corridor which can be utilized or considered while designing the lighting control system. Considering all the above mentioned factors, the lighting control system is designed which is described in next section.

6. Description of Developed System:

The developed Lighting control system is basically based on energy efficiency of an indoor lighting installation for corridors which mainly includes use of daylight. The system is designed using 80S52 microcontroller. The block diagram of the developed control system is shown in figure 5.

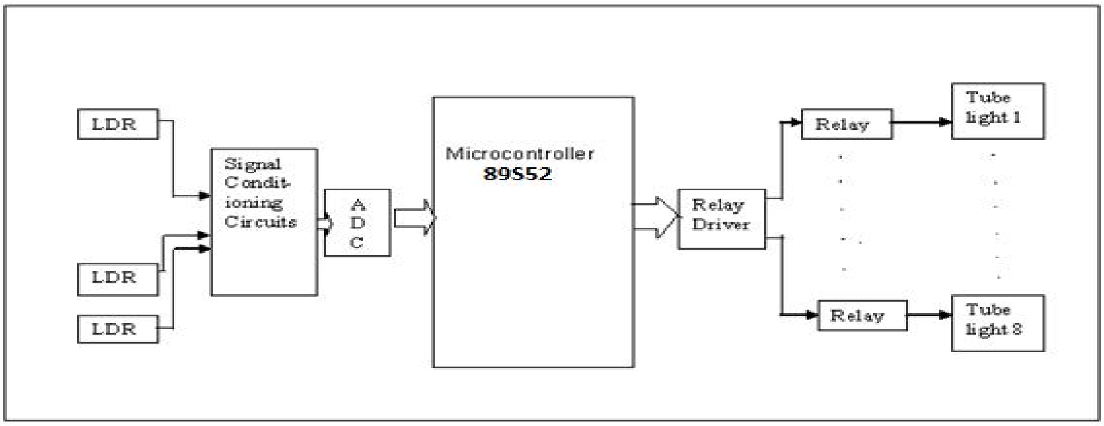


Fig 5 Block diagram of developed lighting control system

As shown in figure 2 .2, the lighting control system uses microcontroller 80S52/80C52. The system has two modes. In mode 1, the inputs from the LDRs are considered. The resistance of the LDR is varying according to the light intensity in the corridor. The signal conditioning circuit converts it into voltage which is given as an input to the ADC (Analog to digital Converter). The output of the ADC is given to the microcontroller and depending upon the light intensity, the tubes will be turn ON or OFF. In mode 2, different options of patterning of lights are given to user. User can select any one of them and then accordingly tubes will be On or OFF. User can also change or design the patterning of luminaires by making a particular tube on or off just by setting it to 1 to turn ON or 0 to off the tube. There are total five options are given in the system. However, they can be increased by changing the programming of microcontroller. The system uses relays which actually turn on or off the tubes.

To make the lighting control system more energy efficient, fluorescent tubes are replaced by LED tube which has the energy consumption as 18.25W.

7. RESULTS AND DISCUSSIONS

After studying the illumination levels in all sections of the corridor (section A, B, C and D) and considering the comfort level of the occupants, it was found that minimum light intensity requirement in the corridor is about 70 lux. In section A, B, and D very less daylight reaches as these sections are interior part of the building. However, in section C sufficient daylight is present because the main door of the department is open during the day time which is in section C. So, accordingly, the patterning of the luminaires in the corridor is designed.

Energy saving due to Lighting Control System:

To design the patterns of the luminaires, the graphs obtained from the lighting simulation software DIALux were studied. From the graph (figure 4), it is cleared that in section A, very less daylight is present through-out the day. So, in any pattern of lights, tubes T1 and T2 have to be kept ON. The availability of the daylight in section B and D is also very less. In winter season, the availability of daylight in all sections is very less.

The section C has maximum daylight through-out the day. So, in working hours (from 10 a.m. to 4 p.m.), the tubes of section C (T4 and T5) can be kept OFF. Considering these simulation results, patterns of luminaires are designed. Further, the energy consumption calculations using developed lighting control system were carried out. According to the daylight simulation, patterns are designed. Two patterns which are designed based on the 21st March and 22nd December daylight simulation are discussed here. On 21st March, in section A, the availability of daylight is very less through-out the day (from 10a.m. to 6p.m.). So T1 and T2 are ON. The minimum light intensity required in the corridor is 60lux. Assuming minimum light intensity, the patterns of lights are designed which is given in table 1.3. From 8p.m. to 8 a.m. in the next morning, four tubes are kept ON to prevent the entry of intruder in the building.

Zone timing /Section	8 a.m. -10 a.m.	10 a.m.- 6p.m.	6 p.m.-8p.m.	8 p.m.-8a.m. (next morning)
Section A	T1: OFF T2: ON	T1: ON T2: ON	T1: OFF T2: ON	T1: ON T2:OFF
Section B	T3:ON	T3:ON	T3:ON	T3:ON
Section C	T4:OFF T5:OFF	T4:OFF T5:OFF	T4:OFF T5:ON	T4:OFF T5:ON
Section D	T6:ON T7:ON T8:OFF	T6:ON T7:ON T8:ON	T6:ON T7:ON T8:OFF	T6:OFF T7:ON T8:OFF

Table 1.3 Pattern of lights designed according to the simulation results of 21st March

Energy consumption in each section for 24 hours is calculated. So, after installing LED tubes and the lighting control system, total energy consumed per day is 2.052 units. If lighting control system is not installed and fluorescent tubes are not replaced by the LED tubes then energy consumption is 9.216 units. Therefore, energy saving due to lighting control system and LED tubes is 77.7%.

8. CONCLUSIONS:

There are several instances in which lighting energy in the building has not been used efficiently. This could be because daylight is not efficiently integrated with the artificial lighting system, or in cases where integration does exist, energy savings using energy-efficient lighting technology have not been fully explored. The major issues of the owners for installing the lighting control system is the initial investment, visual comfort of the people and aesthetic requirement of the building. The main advantage of the developed lighting control system is that it can fitted in existing wiring setup and thus saved the initial installation cost of the system. The developed system is simple and cost effective as it is based on basic microcontroller. The daylight is integrated with the artificial light system which saves energy and LED tube gives the aesthetic look which is known as the "green light source", saves energy up to 65%. In addition to it, developed lighting control system based on the microcontroller is the "Secondary energy saving" on the basis of LED light source which again saves energy and suggests many patterning options to the user. The other way to design the lighting control system is based on the usage pattern of the occupants which is described in paper [12].
Considering the comfort of the people and reducing the installation cost of the system, the developed system gives the simple and good design of a lighting control system for energy saving.

REFERENCES:

[1].Alexandridis K., Dounis A. I., Supervisor of Digital PIlike Fuzzy Logic Controllers for Indoor Lighting Control in Buildings, eRA2, The Conference for the contribution of information Technology to Science, Economy, Society and Education, B.3.6. Greece, 2007, pp. 22-23.
[2]. DOE] U.S. Department of Energy. 2003 CBECS detailed tables. http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html#enduse03.
[3]. Slater A. “Lighting controls: an essential element of energy efficiency”, BRE Information Paper IP5/87, Garston, UK.
[4].Ryckaert W.R., Lootens C., Geldof J., Hanselaer P., Criteria for Energy Efficient Lighting in Buildings, Energy and Buildings, Vol. 42, 2010, pp.341-347.
[5]. Roisin B., Bodart M., Deneyer A., D’Herdt P.,Lighting Energy Savings in Offices Using Different Control Systems and Their Real Consumption, Energy and Buildings, Vol. 40, 2008, pp.514-523.
[6]. Lighting and Daylighting, http://www1.eere.energy.gov/buildings/commercial/lightin g.html
[7]. VonNeida B, Maniccia D, Tweed A. 2000. An analysis of the energy and cost savings potential of occupancy sensors for commercial lighting systems. Proceedings of the Illuminating Engineering Society of North America 2000 Annual Conference. p 433–459.
[8].[LRC] Lighting Research Center. 2003a. Integrated skylight luminaire. Field Test DELTA 1:1– 12. Troy (NY): Rensselaer Polytechnic Institute.
[9].Guo X, Tiller DK, Henze GP, Waters CE. 2010. The performance of occupancy-based lighting control systems: a review. Lighting Res Technol. 42:415–431.
[10].Southern California Edison. 2008. Office of the Future Phase II report: the 25% solution. The Office of the Future Consortium. ET 08.01. 72 p.
[11].New Buildings Institute. 2011. Advanced Lighting Guidelines. _http://algonline.org/index.php_. [August 2011].
[12].J.A.Bangali, A.D.Shaligram,“Energy Efficient Lighting Control system design for corridor illumination”, International Journal of Science and Engineering Research, Vol-3 Issue -4, April 2012, ISSN no: ISSN 2229-5518

