Energy Efficiency of Internet of Things for Indoor Illumination systems

Jayashri A. Bangali
Kaveri College of Arts, Science and Commerce, near CDSS, Erandwane, Pune, Maharashtra, India

Corresponding Author E-mail- jayashri789@yahoo.com

Abstract

Today, "Internet of Things" (IoT) has become a ubiquitous term. The IoT is a common concept of "anytime" and "anyplace" to the connectivity for "anything". This anything could be a sensor or actuator or any electronic equipment. The connectivity can be via a network of LAN, PAN or body area network. The use of IoT for smart lighting is increasing day by day. However, there are few issues related to energy efficiency of IoT. Illumination system or smart lighting is one of the parts of IoT. Enormous energy savings are possible using energy efficient equipments, effective proper selection of light sources.

This paper presents the details of developed microcontroller based lighting control system for a corridor of a building. It gives the comparison of energy saving due to developed lighting control system and IoT. Further it discusses the issues of IoT related to energy efficiency.

KEYWORDS: Internet of things (IoT), Lighting control system, Energy Efficiency.

Introduction

Internet of Things:

Over the last few years, IoT has become popular worldwide. The number of things/devices/objects availing internet services is increasing day by day. It was predicted that by 2020, 20 million "things" will be connected to the IoT. Through IoT everyone and everything can be connected to Internet (R.Khan et al., 2012). IoT is the approach of converging data obtained from various things/objects to any virtual platform on existing internet infrastructure (Ling-yuanZeng 2012). IoT includes hardware (things) and embedded software which will connect the objects via network. Basically, the IoT implies physical objects being able to utilize the Internet backbone to communicate their output, location and other attributes (J. Eckenrode 2013). Different technologies are used in IoT such as RFID (Radio Frequency Identification), WSN (Wireless Sensor Network), Wi-Fi, Bluetooth, Zigbee, Near Field Communication (NFC), cloud computing etc. Usually, 3G or 4G networking technology is used in IoT. However, because of heavy mobile traffic, fifth generation is used in IoT nowadays.

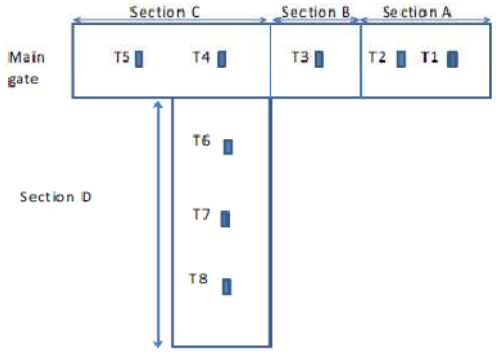
Energy Efficient Indoor Illumination systems:

Energy efficiency 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. There is much scope of energy saving in indoor illumination systems. It has been reported that 30-40 percent energy is consumed in illumination systems of buildings. People spend about 80% lives inside buildings. So, achieving lighting comfort conditions in a building is very important and has direct implications to the energy efficiency of the building

(Alexandridis K 2007). 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 not exist. Energy savings using energy efficient lighting technology have not been fully explored. 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. These types of technologies are well suited for retrofit projects, where it is useful to minimize rewiring (Ryckaert W.R et al., 2010; Roisin B et al., 2008).

Development of microcontroller based energy efficient illumination system for corridor of a building:

The lighting control system for corridors uses daylight and electric lighting jointly to provide task, background or general luminance. The design of control system depends upon sky condition and solar location. In order to establish the lighting controls, luminance measurements are needed for a minimum of three different seasons representing winter, rainy and summer. Here, illuminated indoor environment is the Corridor of Electronic Science Department, University of Pune. The area is first studied for deciding the optimum illumination level. For this study, the corridor in which the light control system has to be installed is divided into four sections A, B, C and D as shown in figure 1.



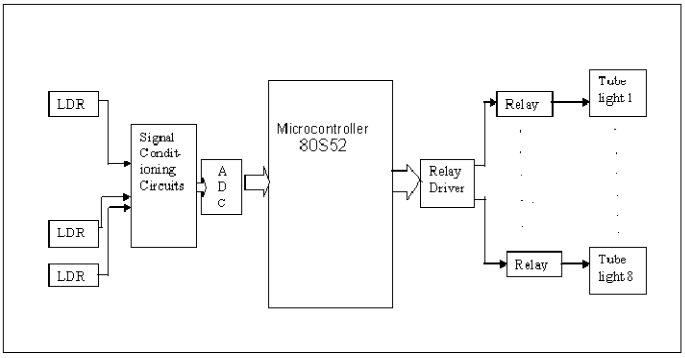


Figure 1.Design of Corridor Figure 2. Block diagram of developed lighting control system.

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 (T8) of 40 W. The block diagram of the developed lighting control system is shown in figure 2 which uses 80S52/80C52 microcontroller. 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 turned ON or OFF. In mode 2, different options of patterning of tubes are given to user. User can 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.

Impact of IoT in Energy Efficiency:

The Internet of Things can be considered as a global network which allows the communication between human-to-human, human-to-things and things-to-things, which is anything in the world by providing unique identity to each and every object (Aggarwal, R et al., 2012). The Internet is a network of networks that consists of millions of private, public, academic, business, and government networks of local to global scope that are linked by a broad array of electronic, wireless and optical networking technologies (Nunberg, G 2012). The IoT is not just the network of number of things/objects which can be remotely controlled; it is a major disruption for energy efficiency applications by many aspects: The number of connected objects, the nature of objects, the business opportunity, the sensors revolution, the "Big Data" disruption, Smart-phones and apps as a main user interface to IoT etc. (F. Jammes 2016). The proliferation of IoT offers opportunities in almost all the fields; however, there are some challenges of IoT. It is possible to increase power consumption in IoT applications, as IoT devices are expected to be reachable by other devices at all the times. This implies that the device itself or at least its communication module is consuming electrical energy even when it is not in use for its primary function. According to the report (Technology and Energy Assessment Report, 2016), smart LED tube (highest standby power 1/A) consumes 1W average energy when it is in standby mode. If Wi-fi technology is used, its standby energy consumption is up to 3W. The standby energy consumption varies with the technology used for IoT. Most appropriate technology regarding standby power is Bluetooth as it has low standby power and gateway is not needed. It has direct communication from mobile to device. Most of the IoT devices are battery operated and there is one battery per device which has to be replaced by every second year. To charge these batteries, again it consumes energy.

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 60 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 LED tubes is 70%. Energy saving due to developed Lighting Control System 84% (J. Bangali et al., 2012). Consider the luminaire pattern as shown in table 1 for the calculations of energy consumption and energy saving.

Table 1.Pattern of luminaires in four sections.

Zone timing /Section	**8a.m.-10a.m.**	**10a.m.-6p.m.**	**6p.m.-8p.m.**	**8 p.m.-8a.m. (next morning)**	**Total no of hrs in a day**
Sec	T1:	T1:	T1:	T1:	T1:O
Sec	T3:	T3:	T3:	T3:	T3:O
Sec	T4:	T4:	T4:	T4:	T4:O
Sec	T6:	T6:	T6:	T6:	T6:O

Table 2. Energy consumed by tube per day or per 24 hours for above pattern.

LED tube	Energy consumed per day or per 24 hours (kW-Hrs)
T1	0.240
T2	0.144
T3	0.288
T4	0.000
T5	0.168
T6	O.144
T7	0.288
T8	0.096

Total energy consumption of all LED tubes for the pattern given in table 1 is 1.368 units per day. For one year or for 365 days, it will be 499.32 units. If lighting control systems was not installed in the corridor then total energy consumption will be 2.304 units per day and 840.96 per year. Therefore, total energy saving due to developed illumination system is 40.60 %.

The IoT can be used instead of microcontroller based illumination system. All LED tubes are connected through network which can be controlled remotely based on the data of photosensors. However, in IoT, LED tube will be in standby mode when it is in OFF condition. So, When LED tube is OFF according to the pattern, it will consume 1W energy as it is in standby mode.

For the pattern given in table 1, standby power consumption of LED tubes is 0.078 units. So, total energy consumption of IoT is 1.446 units (1.368+0.078) per day. Total energy consumed is 527.79 units per year if IoT is used. So, annual standby energy consumption IoT consumes 5.6% more energy than the developed system. It will increase if number of LED tubes goes on increasing.

Conclusions

This paper focuses on the standby power consumption of IoT. The energy consumption and energy saving of the developed microcontroller illumination system is calculated for a particular pattern of luminaires. The standby power consumption of IoT is calculated for the same pattern. From results, it is cleared that IoT consumes more power than stand alone illumination system. As the number of devices connected to IoT increases, standby power consumption will also increase. The network energy consumption is increasing rapidly due to increase in data rates and number of Internet-enabled devices and services. The future IoT will cause significant increase in the network energy consumption. Researchers are working on energy efficiency of IoT and trying to develop new technologies which consume less power.

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