An Implementation of Illuminance Meter Using Light Dependent Resistor Integrated with Labview Program

Jassada Sarasook[1*] and Chaiyapon Thongchaisuratkrul[2]
[1*,2]Department of Teacher Training in Electrical Engineering, Faculty of Technical Education
King Mongkut's University of Technology North Bangkok, Bangkok, 10800 E-mail : jassadat77@gmail.com

Abstract

This research presents design of illuminance meter by applying light. This research presents the design of an illuminance meter by applying a light dependent resistor (LDR) for light distribution testing. The luminance value is displayed on the Labview program. In order to calibrate the proposed illuminance meter, seven types of lamp were examined. A black testing room measuring 1.5m x 1.5m x 1.5m in size was constructed with steel structure and plywood. A stepping motor was used to rotate the light from -90 to +90 degrees in order to investigate the light distribution. The driver of the motor was controlled through the Labview program. The LDR was applied to measure the illuminance and the Labview program was used to display the value. The proposed illuminance meter was calibrated with a standard digital illuminance meter. The test was done five times for each type of lamp. According to the experiment, results showed that the proposed illuminance meter could measure at the range of 0- 900 lux. The average error was 4.42% with a standard deviation of 4.85. A high error occurred at low luminosity and it decreased when luminosity levels increased.

Keywords : Lighting system, Light distribution, Illuminance meter, LDR, Labview

1. Introduction

As we recognize that the lighting system is very important on living thing dairy life activities. Hence it is necessary that how to use and design lighting system is suitable for each activity. Lighting not only needs for working but also leads to efficient work. The productive design of light system affects to see clearly, rapidly, correctly and work effectively (Thongchaisuratkrul, C., 2011). According to research in a factory shows that increasing the luminance level leads to higher production while the loss of that becomes lower. Besides this, the rate of accidence is reduced occur (Ministry of Energy, 2010). In Thailand, employer needs to provide suitable illuminance on condition and work feature (Ministry of Labour, 2011). The illuminance level has been assigned for different work. Therefore suitable intensity of light should be considered before engineer will design lighting system.

Thailand has declared Energy Conservation Act since 1992. Designed building and factory needs do energy conservation (Ministry of Energy, 2010). The personnel responsible for energy are appointed for energy conservation. They need understand characteristics of lamps. One of important characteristics is light distribution. It is important factor for designing because it influences on user. For example, light distribution for street effects on safety feeling in people (Haans, A. & Kort, Y.A.W., 2012). It is not easy to study light distribution by only visual without supporting instrument. Simulation program is a tool such as Matlab application to analysis lighting distribution (Pornpojratanakul, V. 2006). But it is easier if the demonstration set is used for observing phenomenon.

To determine light distribution, illuminance meter is important device. In the past, it was expensive meter. Presently, very cheap and high efficient portable sensors are available also light dependent resistor (LDR). LDR is variable resistor which inverses with the light intensity. Therefore LDR is implemented for detecting the intensity of light. For example, LDR was used for conserving energy in lighting system (Radhakrishnan, A. & Anand, V., 2013). Because of accurate sensor, LDR has been used for measuring the light luminance (Hussein, E.A.R., 2008).

Therefore this research attempts to implement the simple illuminance meter using LDR sensor which it is low cost tool for detecting light quantity. Labview program, which is widely and simple to be used, is performed to display the illuminance. The voltage divider principle is used for detecting voltage. The voltage would vary by illuminance. The voltage signal would be changed to illuminance value by Labview program.

2. Research Proposes

2.1 To design and construct illuminance meter using light dependent resistor (LDR) for measuring the light distribution.

2.2 The constructed illuminance meter is able to display the illuminance value on computer screen and can be controlled by Labview program.

3. Relevant Principles

3.1 Circuit diagram

LDR is variable resistor which inverse with the light intensity as shown in equation (1) (Kumar, N.P. & Jatoth, R.K., 2015; Kulkarni, M.V. & Kulkarni, S.R., 2016).

$$R_{LDR} = \frac{k}{L} \qquad (1)$$

which, R_{LDR} is resistance of LDR (ohm), L is illuminance (lux), k is constant.

It is applied for measuring light using voltage divider as shown in **Figure 1.** V_{output}, is output voltage of voltage divider. It is sent into interface card. After that it is changed to illuminance value by Labview program as gotten by equation (2) and 3 respectively.

$$V_{output} = \frac{R_L x V_S}{R_{LDR} + R_L} \qquad (2)$$

$$L = \frac{k x V_{output}}{R_L V_S + R_L V_{output}} \qquad (3)$$

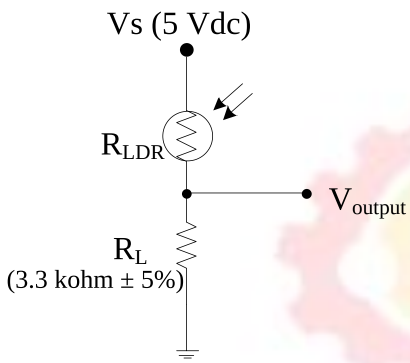

Figure 1 Voltage divider circuit.

From equation (3), the relation of L and V_{output} is plotted in **Figure 2**. It is investigated that the curve is exponential function as shown in equation (4).

$$L = k_1 e^{k_2 V_{output}} \qquad (4)$$

which, k_1 and k_2 are constants.

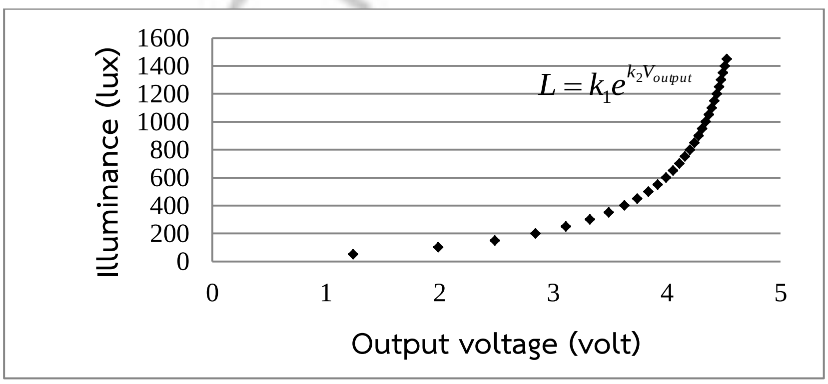

Figure 2 Relation of output voltage and illuminance.

4. Research methodology

The research procedure consisted of LDR circuit designing, construction of the testing room, creation of software to control and display using Labview program, calibration of proposed meter with standard meter and testing.

4.1 LDR illuminance meter

The proposed illuminance meter was implemented by principle of light dependent resistor (LDR) and voltage divider. LDR resistance would vary by light intensity. To implement illuminance meter, voltage divider circuit was used for detecting voltage. The voltage divider circuit consisted of 200 mW LDR resistor connected with 3.3 kΩ as shown in **Figure 1**. The voltage of 3.3 kΩ resistor was voltage signal. It would vary by LDR resistance. The voltage signal would be changed to illuminance value by Labview program.

4.2 The design of black testing room

The closed black testing room was 1.5x1.5x1.5 m in size. It was constructed from plywood and steel as shown in **Figure 3**. The center of floor was installed by proposed LDR illuminance meter. It was placed on black plastics box. The lamp was set above 1 m from illuminance meter. The lamp was hung at the steel shaft. It could rotate by stepping motor. Power supply, interface card and motor driver were contained in the insulation box besides testing room. Computer and Labview program were used to control motor and display the illuminance value.

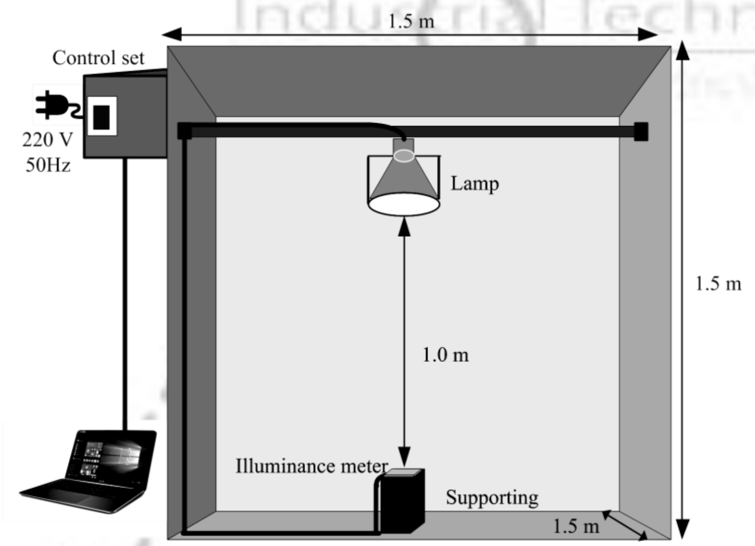

Figure 3 Construction of testing room.

4.3 Experimental diagram

The test diagram composed of 2 parts; power supply and control part as shown in **Figure 4**. Power supply consisted of $220V_{ac}/15V_{dc}$ for motor. Furthermore, AC 220 volt was distributed to the lamp. For the control part, computer linked with motor and LDR illuminance meter by interface card through USB port. Labview program was used to command rotation of stepper motor. The DC 5 volt from computer was the source for interface card. It was paralleled with voltage divider circuit. The voltage signal showed on computer screen. It was changed to illuminance value by Labview program. The testing diagram is shown in **Figure 4**. The configuration of program by Labview is shown in **Figure 5**.

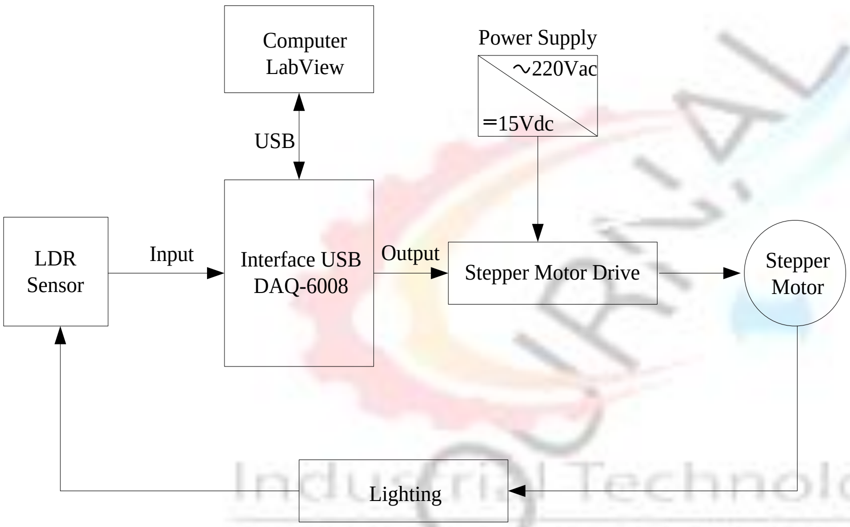

Figure 4 Testing diagram.

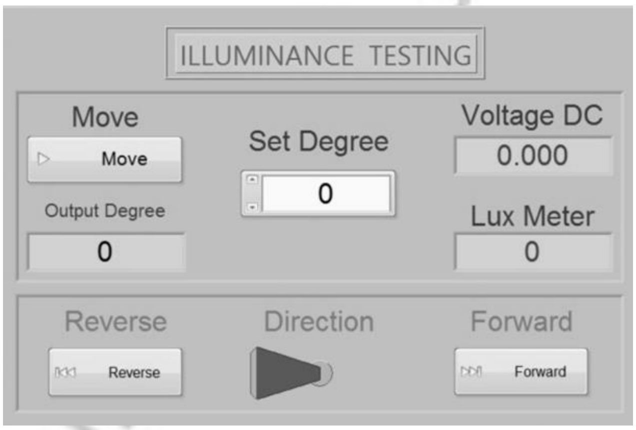

Figure 5 Configuration of program for testing.

4.4 Testing procedure

For testing meter, procedure was conveyed for calibrating the proposed LDR illuminance meter with standard digital meter in model LX1010B. The seven types of lamp; 14 watt daylight complex fluorescent (CFL) with both down light and high bay luminaire, 60 watt daylight incandescent with both down light and high bay luminaire, 7 watt daylight LED (Light Emitting Diode) with both down light and high bay luminaire, and finally 36 watt daylight fluorescent (FL) with flex were used. The angle of lamp was set from -90 to 90 degree. It was increased 5 degree a step. The test was made five times a lamp. The illuminance value was measured by standard meter. The voltage of proposed LDR illuminance meter was recorded. The value from standard illuminance meter and voltage from proposed LDR would be calibrated to find relationship functions. After that, the obtained relation functions were programed in Labview for displaying value in form of illuminance. Finally the test was done again to find error.

5. Results

5.1 The calibration

As **Figure 6**, the finding shows relationship curve between voltage and illuminance. The voltage was voltage of 3.3 kΩ resistor obtained from voltage divider (**Figure 1**). The illuminance was obtained from standard illuminance meter. The relation between voltage and illuminance is exponential function as shown in **Figure 6**. Because of being exponential function, it is observed that LDR illuminance value is not zero. From the experiment, if the voltage is less than 0.150 volt, the illuminance from standard meter is zero. Hence the first function is gotten as equation (5). Moreover, if the voltage is 0.150-1.051 volt, it shows accurate so the second function is gotten as equation (6). Additionally, if voltage is more than 1.051 volt, the illuminance value more deviates from trend line than another as shown in **Figure 6**. Therefore, function is found again at this range. Plotting curve between LDR illuminance value and standard illuminance is plotted as shown in **Figure 7**. The third function is gotten as equation (7).

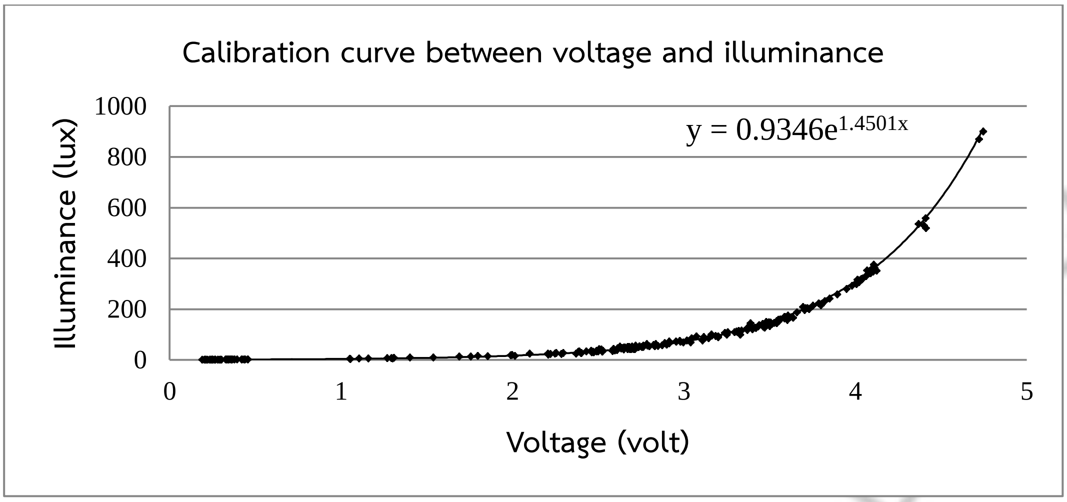

Figure 6 The calibration curve between voltage and illuminance

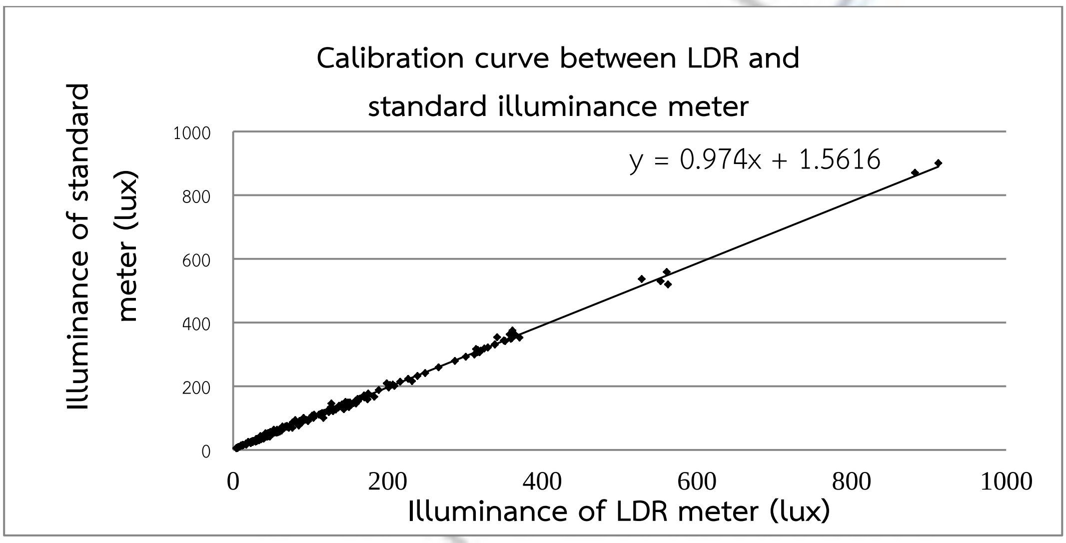

Figure 7 The calibration curve between LDR and standard illuminance meter

These equations are used for programing by Labview.

$$Lux = 0; v \le 0.015 \quad (5)$$

$$Lux = 0.9346e^{1.4501v}; 0.015 < v \le 1.051 \quad (6)$$

$$Lux = 0.974(0.9346e^{1.4501v}) + 1.5616; v > 1.051 \quad (7)$$

5.2 The testing of fluorescent lamp with flex

From **Figure 8**, it is found that at 69-171 lux the percent of error is 0.00-6.33%. Average is 2.65% with 2.03 SD. The illuminance at about 205-350 lux, the error is about

0-2.53%. Average is 0.80% with 0.68 SD. The error and SD. are lower. To sum up, all average error is 1.72% with 1.77 SD.

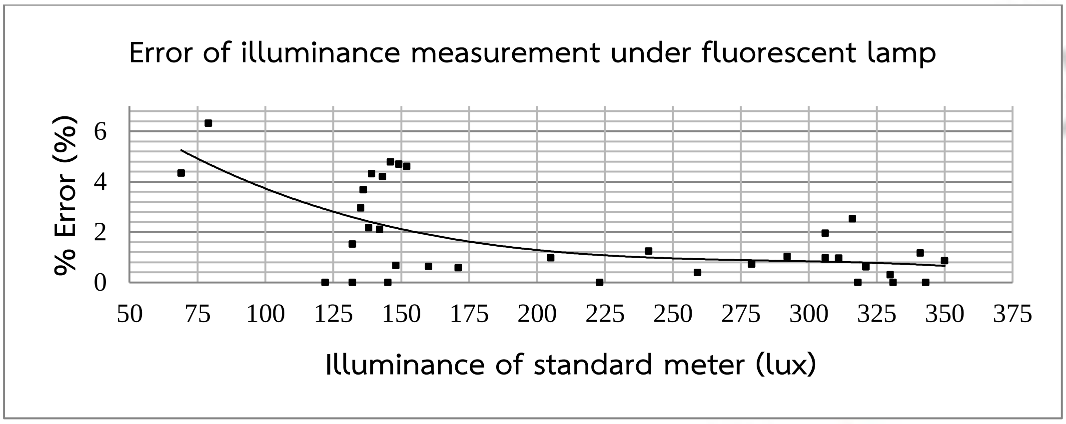

Figure 8 Error of illuminance measurement under fluorescent lamp

The light distribution of fluorescent lamp is shown in **Figure 9**. It is comparison between illuminance values obtained from proposed LDR and standard illuminance meter. It shows feature is the same. Therefore, it is said that the LDR illuminance meter can measure accurately and the experiment set can use for studying.

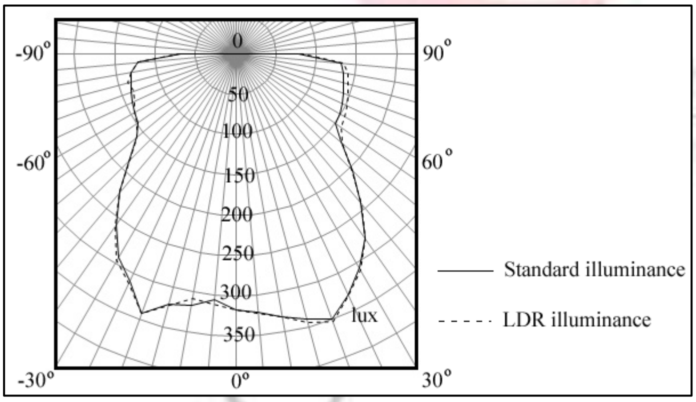

Figure 9 Light distribution of fluorescent lamp comparing between proposed LDR illuminance and standard meter

5.3 The percent of error

From **Table 1** shows the error percent of LDR illuminance meter comparing with standard meter. The error is gotten by equation (8).

$$\%error = \left| \frac{Real - Test}{Real} x100 \right| \quad (8)$$

Considering **Table 1**, the average error is about 4.42% with 4.85 SD. at its range of 0-900 lux. It can clearly find that the maximum error is 26.26% at the range of 0-100 lux. The minimum error is 0.00%. Moreover, if illuminance is increased, the error is decreased. At the range of 200-900 lux, average error is just 1.87% with 1.75 SD. It is lower than error of 0-100 lux and 100-200 lux.

Table 1 The error percent of proposed illuminance meter

Illuminance (lux)	Percent of Error (%)			
	Max	Min	Average	SD.
0-100	26.26	0.00	5.38	5.52
100-200	13.37	0.00	3.34	3.04
200-900	6.61	0.01	1.87	1.75
All	**26.26**	**0.00**	**4.42**	**4.85**

The error is high at low illuminance level (0-100 lux) because LDR resistor less responded. Considering **Figure 6**, the voltage depends on LDR resistance. The voltage very less increases at low illuminance but it more increases at high illuminance. Because LDR resistor well responds at high illuminance. Therefore the error is low at high illuminance.

6. Conclusions and discussion

6.1 Conclusions

According to experimental results, the research findings can be summarized that the proposed LDR illuminance meter is able to use really for the range of illuminance at 1-900 lux with average error of 4.42% and standard deviation (SD.) of 4.85. The maximum error is 26.26% occurred at the range of 0-100 lux but the average error in this range is just 5.38% with 5.52 SD. The minimum error is 0.00%. The high error occurs at low illuminance and it decreases when illuminance level increases. The proposed illuminance meter in experimental set of light distribution is correspondent to standard meter.

6.2 Discussion

From the result as shown in **Table 1**, it can investigate that the average error is approximately 5.38% at range of 0-100 lux but if light intensity is higher at 100-200 lux and 200-300 lux, the error is lower at 3.34% and 1.87% respectively.

It can be concluded that if the intensity increases, the average error would decrease. This result is correspondent to Batsungnoen, K. et al.'s research (2011). Although the maximum error is 26.26% at 6 lux, the illuminance level in working and activity area are more than 200 lux (Ministry of Labour, 2011). Therefore, it can say that the proposed meter can use for pre-checking. From the **Figure 9**, it shows the light distribution obtained by standard and proposed meter. It is observed that the both of curve intend the same. Therefore the proposed meter can use for studying light distribution. Moreover the program designed by Labview is easy for using. For example, if users want the light intensity at 45 degree, they just fill it in the angel box and select direction. After that clicks the move button. The value would show in the lux meter box. Another last interesting point is the display on computer screen. Nowadays a computer is used widely so this reason why research displays on computer. It is correspondent to Batsungnoen, K. et al (2011), Kumar, N.P. et al (2015) and Kulkarni, M.V. et al (2016). They used computer also. This research displays through Labview while Batsungnoen, K. used Microsoft Visual C#. Kumar, N.P. used HTML (HypertText Markup Language) and PHP scripting languages. These types of software are the form of code while Labview is the form of block function. Kulkarni, M.V.'s research, the value displayed on computer through serial monitor of microcontroller.

7. References

Batsungnoen, K. and Kulworawanichpong, T. (2011). Implementation of Illuminance Meter by Light-Dependent Resistors (LDR). **The 25th Thailand National Safety Week Conference on Occupational Health and Safety;** July 7-9, 2011, Bangkok, Thailand. (in Thai)

Haans, A. and Kort, Y.A.W. (2012). Light Distribution in Dynamic Street Lighting : Two Experimental Studies on Its Effects on Perceived Safety, Prospect, Concealment, and Escape. **Journal of Environmental Psychology**, 32, 342-352.

Hussein, E.A.R. (2013). Design and implementation of digital light meter. **Journal of Babylon University,** 21(1), 263-272.

Kulkarni, M.V. and Kulkarni, S.R. (2016). Measurement of light luminance and temperature monitoring for real time energy saving applications using Arduino Uno Atmega328. **Bonfring International Journal of Research in Communication Engineering,** 6(special), 34-37.

Kumar, N.P. and Jatoth, R.K. (2015). Development of cloud based light intensity monitoring system using raspberry Pi. **International Conference on Industrial Instrumentation and Control (ICIC);** May 28-30, 2015, Pune, India.

Ministry of Energy. (2010). **Handbook of Personnel Responsible for Energy in Electrical Section.** Bangkok: Ministry of Energy. (in Thai)

Ministry of Labour. (2011). **Occupational Safety, Health and Environment Act A.D. 2011.** Bangkok: Ministry of Labour. (in Thai)

Pornpojratanakul, V. (2006). **Matlab Application for Lighting Distribution Analysis**, M.S. Thesis, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand.

Radhakrishnan, A. and Anand, V. (2013). Design of an intelligent and efficient light control system. **International Journal of Computer Applications Technology and Research,** *2*(2), 117-120.

Thongchaisuratkrul, C. (2011). **Energy Management in Buildings.** Bangkok: King Mongkut's University of Technology North Bangkok. (in Thai)