Optimal Light Power Consumption Using LDR Sensor

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***Abstract*— High demand of electrical power receives challenging feedback due to the lack of natural resources and high impact of the global warming. This paper describes one applicable method to optimize the electrical power consumption using Light Dependent Resistor (LDR) sensor. A simple adjuster based on the sensor reading was developed and tested to one small room with two Light Emitting Diode (LED). Two LDR sensors to measure and analyze the surroundings light intensity were allocated for one LED bulb. The LDR sensors interface with each other, and the necessary intensity required by the bulb will be calculated and the bulbs will provide the required lumen for the surrounding/workspace. This system is tested during the day time. The output would affected by surroundings light sources. Hence, the LED bulbs light intensity will be reduced causing a directly proportional effect to the power consumption. This system can provide optimized light intensity for the surrounding and reduces the electrical power consumption during daytime.**

Keywords*— *LED Power consumption; optimized light intensity; LDR Sensor;

I. INTRODUCTION

In most public indoor areas and offices, the light is used during the day time, but most of the times the amount of light intensity needed is almost half of the amount of power consumed for the lights, so by being able to control the suitable light intensity on various times, the consumed power will be reduced. For example, at 10 o'clock in the morning, rooms with windows will be bright and might only need a slight amount of light which only consumes around 10% of the normal light source with no power consumption control. A survey was done by earth policy Institute from International Energy Agency (IEA) on the lighting consumption percentage in a country and it is found out that the residential and offices consume around 20% of the electrical power generated [1].

There are many actions that have yet to be taken in order to reduce the energy consumption. The most important step is consumer's awareness on the problem. Besides that, the lighting system itself must work smartly. The objectives of this project are, to design and develop an optimal power usage for lighting system that will vary the power consumption depending on the surrounding's light intensity, to reduce electrical power consumption by reducing the light source intensity when necessary.

This study is based on several previous works as present in [2] and [3]. There was also a similar system released by Murata Manufacturing [4] that also aimed on optimizing the electrical power consumption for indoor usage. But it was applied with LED type of light emitter only, due to that, the device can only provide a DC power supply for the light emitter and it was not compatible with tungsten bulb or fluorescent bulb. The device was controlled wirelessly, the variation of the light intensity of the light emitter occurs by varying the pulse width of the transmitted signal from the device. The picture of the device was as shown in Fig. 1.

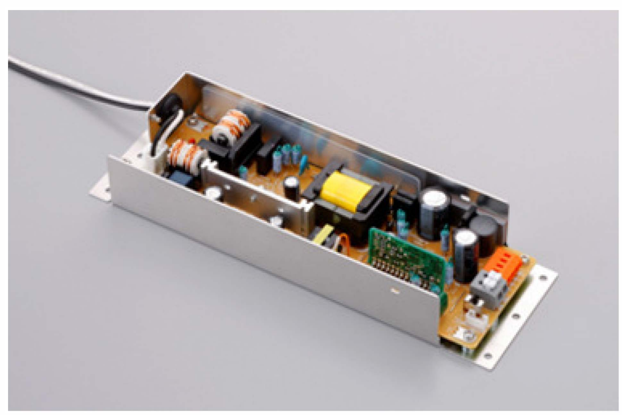

Fig. 1. Optimal Lighting Control Device by Murata Manufacturing

There is another research prepared by the California Statewide Utility Codes and Standards team [5]. The studies aimed on the indoor lighting control, the intention was to reduce the lighting energy used in offices. A detailed studies was carried out on three different offices of different areas (125sf, 250sf, and 500sf), the workstation of the research is as shown in Fig. 2.

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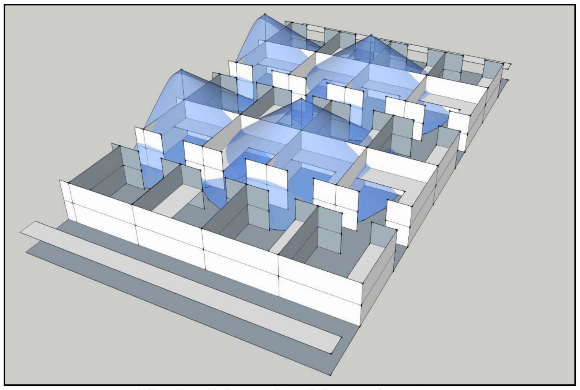

Fig. 2. Schematic of the workstation

Musa et al. [6] studied the Intelligent and Energy conserving Living Environment. The research aimed to reduce electrical power consumption by applying the system for fan control and lighting control. LDR sensors were applied in the system. When the LDR sensor senses a sufficient light intensity from the surrounding, the light bulb will be turned Off, whereas when surroundings light intensity is insufficient, the light bulbs will be turned On. The difference of this research compared to this project that this proposed system is upgraded with the ability to vary the lighting intensity and provide the best lighting for the surrounding instead of only On and Off functions.

F. Kaku et al. [7] designed an intelligent lighting system that it can provide desired illuminance distributions in actual office environment. The system provides desired illuminance distributions at minimum electrical power and this was constructed in the actual office environment. Illuminance sensors were installed on the offices desks to sense the surroundings light intensity and accordingly. The system provided suitable lumen by controlling the lighting for suitable office environment by controlling the lighting color, and optimizes the power consumption. Operation of the proposed system is as follows, after the LDR sensor measures the surrounding's light intensity, the signal will be in the analog form, hence it will be converted to digital and sent to the microcontroller, the second step is the microcontroller analyzes the signal received and accordingly sends a PWM signal that causes variation in the LED bulb light intensity. The system algorithm undergo looping every instant insuring the surrounding's light intensity is satisfying, hence, lumen provided by the LED light bulb will always vary according and provide us with the best light intensity for the workspace. The lighting control system was applied to the three workstations named 1, 2, and 4 respectively and their results were as shown in the table 1.

TABLE I. SAVINGS PERCENTAGE IN OPEN OFFICES.

Workstations per occupancy sensor	**1**	**2**	**4**
Approx. area per occupancy sensor (sf)	125	250	500
Calculated lighting energy savings	52%	40%	23%
PAFs (tuned down from savings)	0.40	0.30	0.20

A similar research also carried out by Seyed and Hamed [6]. Their aim was to achieve a high reliability in electrical power consumption by applying an automatic lighting control system. It is stated in their research that recent studies have shown that about 14% of the electric usage in residential buildings and also about 35% of the electric usage in commercial buildings is for lighting purposes. In particular, it was estimated that an annual total of 499 billion kilowatt-hours (kWh). So by applying this automatic system, instead of letting the bulb consumes the maximum amount of its power, the bulb only consumes the sufficient amount of power to lit the surrounding depending on the surroundings light intensity, as shown in Fig. 3.

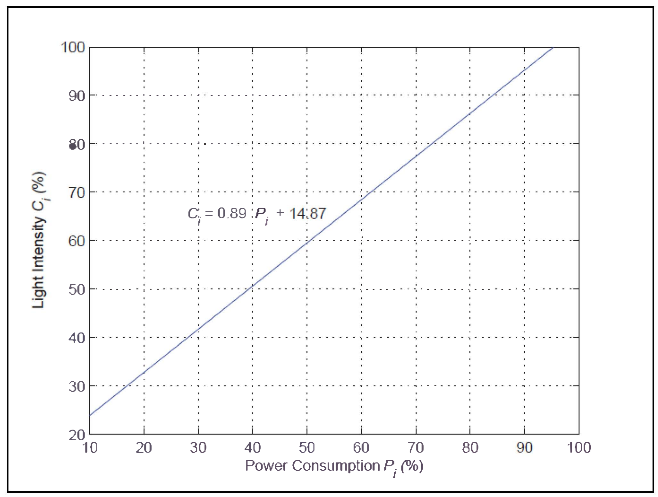

Fig. 3. Light intensity versus power consumption

II. SYSTEM SETUP

Initially, the LDR sensor of the system will measure the light intensity of the room, and accordingly a calculation will be done in the microcontroller according to an algorithm implemented to it using C language to calculate the suitable light intensity for the room. Then, the amount of electrical power delivered to the light emitter will be varied to vary the amount of light intensity emitted by the light emitter. The variation of the emitter's light intensity is directly proportional to the variation of the electrical power delivered to the light emitter. The system operation is shown in Fig.3.

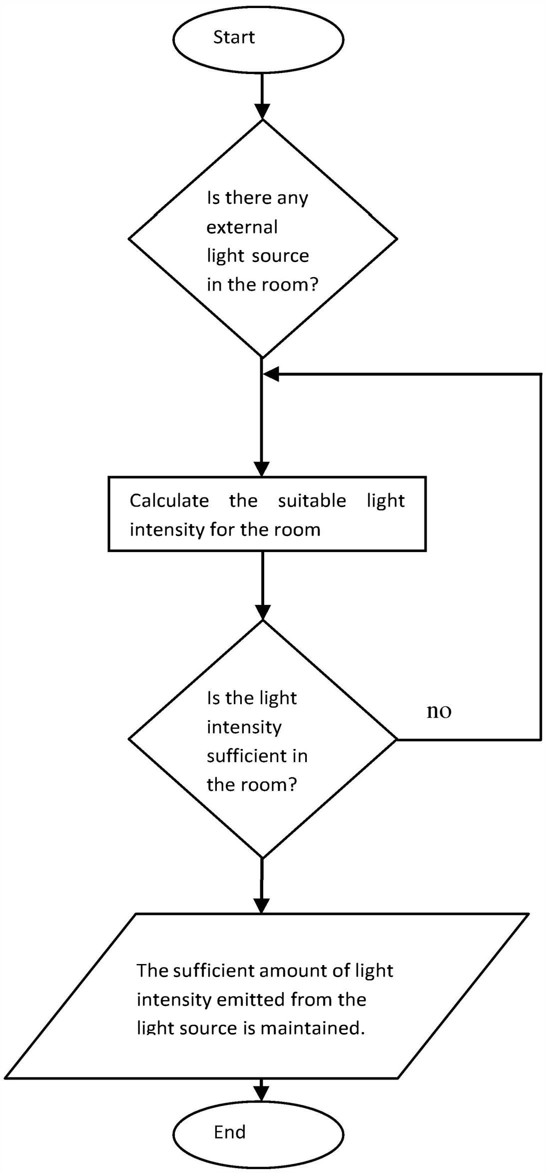

Fig. 3. Operation flowchart

Once calculations were done of the light spread and the suitable distances between the light bulbs were determined. A small room model was built to apply and test the system. The real system plant is shown in the Fig. 4.

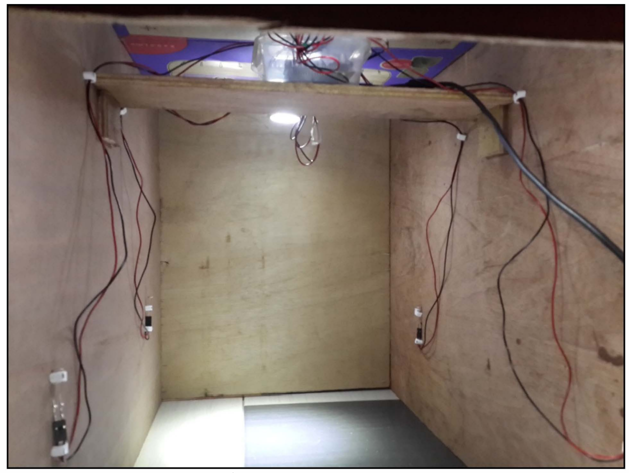

Fig. 4. Experimental Prototype

The controlled device is located in the top as if it can be fixed on the ceiling of the room. The sensors are positioned at the sides, every two sensors works together according to the algorithm of the system to measure the most suitable light intensity required by the surroundings. A window was also made for the room to measure how external factors can affect the light intensity and how it effects on the electrical power consumption. The external shape of the prototype and the window is shown in Fig. 5.

Fig. 5. External design of the prototype

III. Results and Discussions

The results were obtained in term of voltage variation within time, there were two led light bulb named bulb A and bulb B. The one beside the window was bulb A, the results are shown in the tables below.

TABLE II. BULB A POWER AGAINST TIME

Bulb A				
Time(h)	**Voltage (V)**	**Current, I(mA)**	**Power(W)**	**Power Consumed per hour (W/h)**
8.00 am	7.75	40.00	0.31	1,116
9.00 am	5.70	15.40	0.08778	316
10.00 am	5.47	14.86	0.0812842	293
11.00 am	5.22	17.07	0.0891054	321
12.00 pm	4.75	9.70	0.046075	166
1.00 am	4.86	14.46	0.0702756	253
2.00 pm	4.67	8.12	0.0379204	137
3.00 pm	5.21	18.30	0.095343	343
4.00 pm	5.17	18.45	0.0953865	343
5.00 pm	6.40	23.40	0.14976	539
6.00 pm	8.15	52.40	0.42706	1,537
7.00 pm	11.33	62.50	0.708125	2,549
8.00 pm	12.00	64.50	0.774	2,786
				10,700

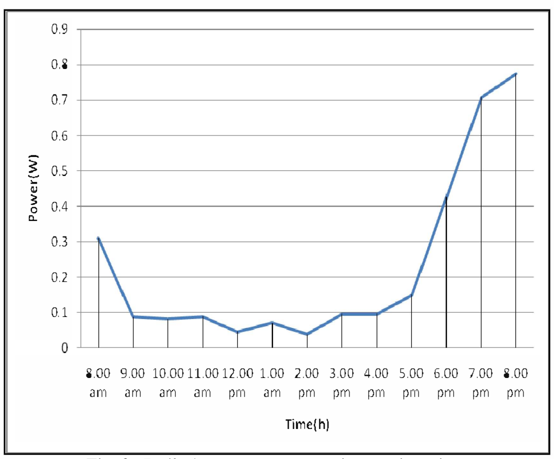

Fig.6. Bulb A power consumption against time

The prototype room was placed in a way that its window was facing the sunrise to obtain the maximum external light source which is the sun. As it is observed in the graph in Fig. 7, at 8.00am the external light source is slightly low, so the power consumption is a bit high, but within that time the sun starts to rise and a sufficient amount of light passes through the window, the system to reduce the light intensity. Thus, power consumption will be reduced. Then the graph will maintain until 2.00pm and the consumption starts to increase, this is because the position of the sun was vertical above the room, only slight amount sunlight passed through the window. The more the sun moves toward sunset, the darker it gets, the power consumption will be higher. At 5.00pm the power consumption increases rapidly due to the absence of external light sources. It can be noticed that at 7.00pm the incremental rapidity reduces, this is because the street lights were turned on, hence, street light can be considered as external light sources that helps to reduce the power consumption.

TABLE III. BULB B POWER AGAINST TIME

Bulb B				
Time	**Voltage (v)**	**Current, I(mA)**	**Power(W)**	**Power Consumed per hour (W/h)**
8.00am	9.37	48.3	0.452571	1,629
9.00am	6.16	27.5	0.1694	610
10.00am	6.04	18.33	0.1107132	399
11.00am	5.95	28.66	0.170527	614
12.00pm	5.46	21.8	0.119028	429
1.00 am	5.55	17.45	0.0968475	349
2.00 pm	5.12	13.73	0.0702976	253
3.00 pm	6.44	20.25	0.13041	469
4.00 pm	6.15	25.45	0.1565175	563
5.00 pm	8.93	53	0.47329	1,704
6.00 pm	10.46	54.3	0.567978	2,045
7.00 pm	12.13	57.3	0.695049	2,502
8.00 pm	12.06	56.5	0.68139	2,453
				14,018

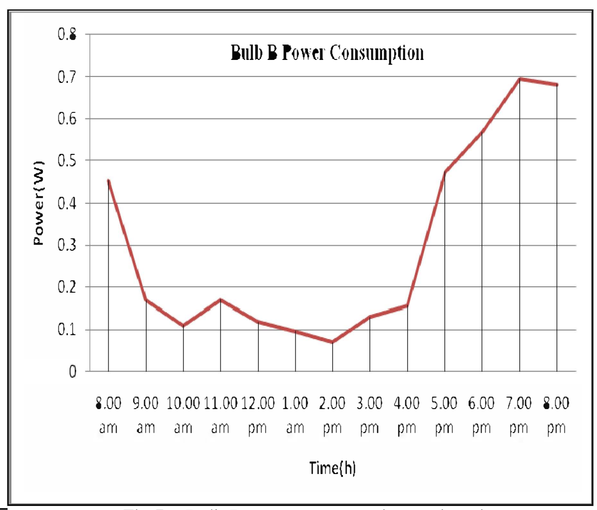

Fig.7. Bulb B power consumption against time

The shape of graph in Fig.7 is similar to the shape of the graph of bulb A in Fig. 6, except that the power consumption of bulb B is slightly higher, this is because the bulb B is further from the window compared to bulb A, the external light source does not reach it's lighting spread area as much as it reaches the lighting spread area of bulb A.

For comparison purpose a test of bulb power consumption of the bulb without applying the system was also carried out. The result for this is described in the graph shown in Fig 8.

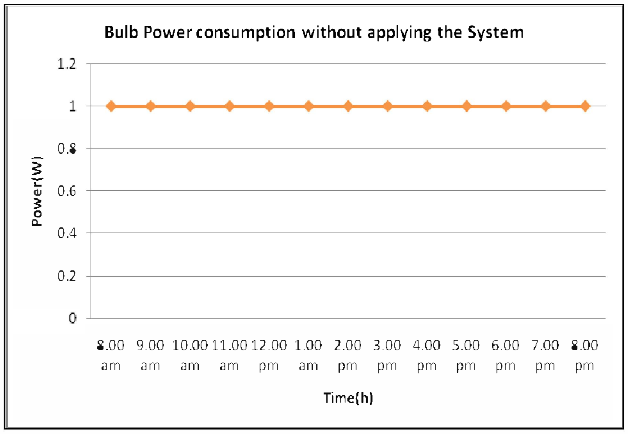

Fig.8 Bulb's power consumption without applying the system

Power consumed at each instant is one watt when the system is not applied, this is the reason the graph is horizontal without any fluctuation.

Applying the optimal light power consumption system does saves a lot of power and the graphs obtained does shows some fluctuations at certain times during the day which proves the system's ability to react to external environmental changes. Whereas when the system is not applied the power consumed by the bulb is always at its peak point and consumes the maximum energy at each instant even when it is not required to consume that much. It can be further described through the graphs shown in Fig.9.

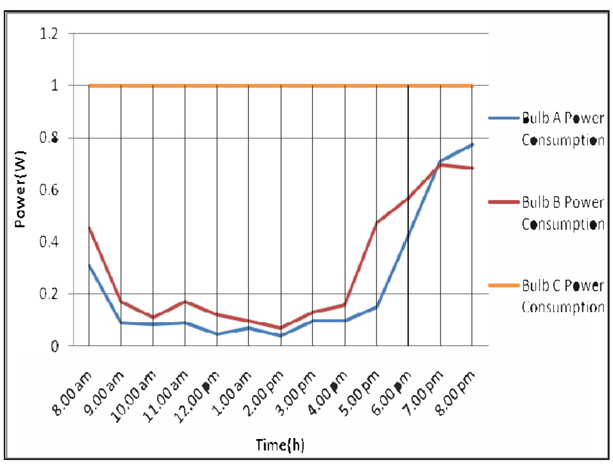

Fig.9. Power consumption comparison graphs with and without applying the system

From Fig. 9, it can be observed that there is a big gap between the power consumption when the system was applied compared to when it was not. During working hours which is from 9.00am until 4.00pm, the power consumed is very low and some of the times it can reach almost zero, that means at those hours only a very slight amount of light is required. When night reaches and it gets darker, the power consumed still does not reach its maximum, this is due to the external light sources effects such as road light or moon light. The system could save electrical power consumption up to 71.39%.

IV. CONCLUSIONS

Based on the experimental results, it can be observed that the system had saved a lot of electrical power consumption throughout the day. The bulb consumption which was affected directly by the external light sources was reduced by 75.23%, whereas for the bulb which is far from the external /environmental light source, the power consumption was reduced by 67.55%. The average percentage of power consumption saving reached by the system is 71.39%. It is also shown that the bulb's light intensity varies according to the external light source intensity as well.

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