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Effect of PWM Duty Cycle and Frequency of Power Supply to the LED Bulb Efficacy

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ABSTRACT

In this paper described the effect of frequency and duty cycle of the PWM power supply LED bulb light efficacy. Efficacy LED bulb is measured by measuring the light flux and power consumed at standard conditions, the bulb is supplied directly from the network. Then efficacy, the luminous flux and power the bulb is also measured under the conditions given PWM power supply at some frequency and duty cycle value. In the same light flux levels between the two treatments, the use of PWM power supply can increase the efficacy of the light bulb up to 66.2%, with a value of 117.52 light efficacy lumen / Watt. At the level of light flux which is slightly lower, the use of PWM power supply to the LED bulb with a specific frequency and power supply can achieve the efficacy of 397.14 lumens / Watt.

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1. INTRODUCTION

More than 50 percent of the electrical energy to the light emitting diode (LED) is converted into light. It makes LEDs more efficient than fluorescent bulb, moreover incandescent bulb. Every 1 watt of electricity produces light berfluks 70-100 lumen. Longer service life can be up to 50,000 hours. In addition, the power consumption of incandescent or fluorescent bulb types larger than lumen LED bulb for the same amount. With so many advantages of LED bulb types than other bulb types, use less power again can make it very right bulb is used to reduce the waste of the power consumption of the lighting system.

Currently one of the controlling power is the widely used technology of Pulse Width Modulation (PWM) or a way of manipulating the width of the signal represented by pulses in a period where periodanya repeatedly between high and low that width ratio can be set. PWM widely applied to telecommunications, power control or the incoming voltage to the load, a voltage regulator, audio effects, and strengthening, as well as other applications. Applications typically a microcontroller based PWM DC motor speed control, servo motor control, ignition settings and other sebagainya.Penggunaan bright LED PWM for controlling power more efficiently when compared to the control of power in a conventional manner.

As it is known that the light flux on a bulb is generally seen constant despite the fact that the resources of the bulb through a cycle of life and death at a certain frequency and duty cycle. The higher the frequency of the light will be more constant, and vice versa low frequencies will menyebahkan flickering bulb. Although it is not certain frequency continuous boundary between lit and lights flashing. Similarly, duty cycle, the higher the duty cycle, the light will be more constant, and vice versa at a low duty cycle light bulb will tend to blink. Power consumed bulb duty cycle is directly proportional to its power supply. Need observation to determine the frequency and duty cycle that can produce maximum efficacy, ie the maximum value of the ratio of lumens of light bulb to power consumed. Observations can be done by using a PWM power supply that can be set frequency and duty cyclenya.

Effect of PWM power supply to the bulb, LED bulb terhadapa particularly value the efficacy of the bulb has not been known. The frequency and duty cycle power supply will greatly affect the flux of light produced and power consumed. Need dikethaui frequency and duty cycle which produces the most optimum efficacy bulb.

2. RESEARCH METHOD

In this study, an LED bulb that can be easily found on the market, supplied from the power supply PWM. Duty cycle and frequency of the PWM power supply output varied at some certain values and its influence on the observed flux (lumens) produced and power consumed by the bulb, or often called efficacy. To find out how much influence the use of the power supply at any frequency and PWM duty cycle tested, we used the power, illumination (lumen), and the efficacy of standard bulb as a reference. Standard values obtained by measuring the light flux and power consumption to the use of a standard bulb bulb is linked directly to the network without using PWM.

Measurement of luminous flux of the bulb, performed in an enclosed space measuring 1 x 1 x 1 m3 with black walls (black box). LED bulb is tested Philips 14 W LED bulb, the bulb is placed on the upper side of the mid point lumen meter box and a detector placed at the midpoint of the lower side. To facilitate reading, the display lumen meter is placed outside the box.

2.1. Efficacy Measurements Standard

As a reference to assess the effect of using the PWM power supply LED bulb, note the value of the object bulb efficacy trials on condition connected directly to the network (DOL). Standard efficacy measurements carried out in accordance schematic drawing 1, and the measurement results as shown in Table 1.

Figure 1. Schematic measurement of the efficacy of the LED bulb is connected directly to the network

Table 1. Consumption of power and luminous flux (lumen) LED bulb standard

No.	V (volt)	I (Ampere)	Cos phi	P (Watt)	Fluks Cahaya (Lumen)
1	223.7	0.1	0.564	12.62	501
2	223.3	0.1	0.564	12.59	501
3	223.5	0.1	0.564	12.61	501
4	223.0	0.1	0.564	12.58	500
5	223.1	0.1	0.564	12.58	500

2.2. Efficacy Testing Bulb With PWM Power Supply

Testing the efficacy of the LED bulb with the power supply PWM sperti do with the scheme of Figure 2. Source AC network first rectified and filtered and then converted into a PWM voltage variable frequency and variable duty cycle. The setting frequency and duty cylcle done using arduino. Frequency is set at 30 Hz, 61 Hz, 122 Hz, 244 Hz, and 488 Hz. Duty cyle at each frequency is set to 10%, 20% to 100% with a scale of 10. Data test results shown in Table 2.

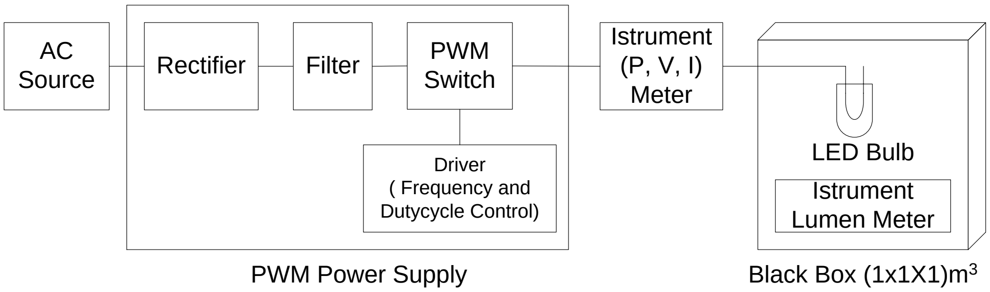

Figure 2. Schematic measurement of efficacy with PWM power supply

Table 2. Data efficacy test results illumination LED bulb uses PWM power supply

Duty cycle (%)	Frekuensi 30 Hz		Frekuensi 61 Hz		Frekuensi 122 Hz		Frekuensi 244 Hz		Frekuensi 488 Hz	
	P (Watt)	lm (Lumen)	P (Watt)	lm (Lumen)	P (Watt)	lm (Lumen)	P (Watt)	lm (Lumen)	P (Watt)	lm (Lumen)
10	0.42	326*	0.64*	411	1.2	476	1.48	490	1.73	494
20	1.07	365*	1.43*	431	2.24	485	3.42	498	4.25	500
30	2	415*	2.51*	457	3.52	489	4.76	503	6.52	503
40	3.11	439*	3.84	470	4.86	493	6.2	506	7.75	506
50	4.39	461*	5.36	483	6.38	497	7.56	508	8.95	508
60	5.87	486*	6.96	492	7.94	501	8.95	509	10.23	509
70	7.72	498*	8.64	498	9.5	504	10.27	510	11.4	510
80	9.47	507*	10.35	503	10.9	509	11.51	511	12.7	509
90	11.39	511	11.85	507	12.69	510	12.73	513	12.75	512
100	12.64	512	12.8	509	12.8	512	12.79	515	12.8	512

Caption .: * The lights blink

3. RESULTS AND ANALYSIS

From Table 1, it appears that at standard conditions in which the LED bulb linked directly to the network without going through a PWM power supply, the luminous flux obtained an average of 500.6 lumens with an average power consumption of 12.6 watts. Thus it can be seen efficacy illumination LED bulb at 39.76 Lumen / Watt can know the average efficacy LED bulb.

From the test results as shown in Table 2, it can be graphed influence of duty cyle and the frequency of the light flux produced by the LED bulb, see Figure 3. Each variation frequency of the light flux values obtained are increasing due to higher duty cycle. On the condition of duty cycle of 90% and 100% the power consumption of LED bulb is almost equal to the power consumption under standard conditions where the bulb is supplied directly from the network. The luminous flux (lumens) produced under these conditions exceeds the luminous flux at standard conditions.

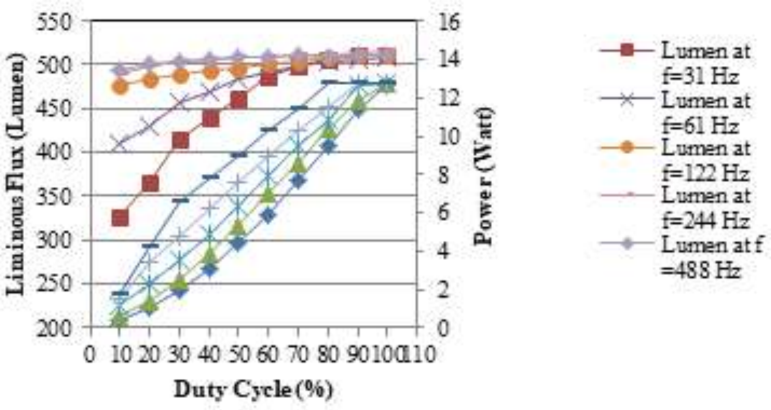

Figure 3. Graph influence the duty cycle of the light flux and power LED bulb at any frequency PWM power supply

As seen in Figure 3, at a frequency of 30 Hz with a duty cycle of 80%, the luminous flux has reached 507 lumens of power of 9.4 Watt. The flux value is already more than a standard light flux amounted 500.6 12.6 Watts of power. However, at a frequency of 30 Hz and a duty cycle of 80%, the bulb is still blinking light conditions, and stabilizes at a duty cycle ranging from 90%.

At 61 Hz frequency of the light bulb is still visible flashes at 20% duty cycle. Start a duty cycle of 30% to 100% of the light bulb does not blink anymore. On duty cycle of 80%, the luminous flux has reached 503 lumens with a power of 10.3 Watts. At higher frequencies, the luminous flux standard duty cycle can be achieved on a smaller and less power as well, such as the frequency of 122 Hz, the luminous flux standard achieved on a duty cycle of 60% with a power of 7.9 Watt.

At a frequency of 244 Hz with a duty cycle of 30% and a power of 4.7 Watt already generated luminous flux of 503 lumens, and at a frequency of 488 Hz with a duty cycle of 20% and a power of 4.2 Watt already generated luminous flux of 500 lumen. Frequency is one factor which the reduction in power consumption can be achieved to produce the same light flux with standard conditions.

From Figure 3 can be identified value of the minimum duty cycle and power consumption minimum bulb at any frequency, which can produce a luminous flux equal to or more than a standard bulb cayaha flux, which is about 500 lumens. From these values, it can also be calculated the percentage of reduction in power consumption of the bulb, as shown in Table 3 below. The greater the frequency of the PWM power supply given to the bulb, the smaller the power needed to generate trust flux standards, in line with this, the greater the reduction in power consumption.

Table 3. The percentage reduction in power on the condition of the luminous flux reaching the light flux at standard conditions

Frequency (Hz)	Luminous Flux (lumen)	Duty Cycle (%)	Power (Watt)	Power Reduction (%)
30	511.00	90	11.39	9.57
61	503.00	80	10.35	17.86
122	501.00	60	7.94	37.01
244	503.00	30	4.76	62.25
488	500.00	20	4.25	66.23

In Table 3 shows that in order to achieve the level of luminous flux of more than 500 lumens, the necessary power supply PWM frequency of 488 Hz, 20% duty cycle, and power Watt 4:25. This means that the efficacy of LED bulb can be increased from 39.76 lumen / Watt at standard conditions become 117.52 lumen/Watt, an increase of 66.2%. For the light bulb flux levels less than 500 lumens, the value of the efficacy of the bulb can be even greater. From Table 2, for normal light conditions (not blinking) produced the highest efficacy bulb diperloeh value of 397.14 lumens / Watt at a frequency of 122 Hz, dutycycle 10%, with a luminous flux of 476 lumen power consumed at 1:20 Watt bulb. For more efficacy values can be seen in Figure 4 the following graph, the graph of the value of the efficacy of the light bulb berkedif conditions are ignored.

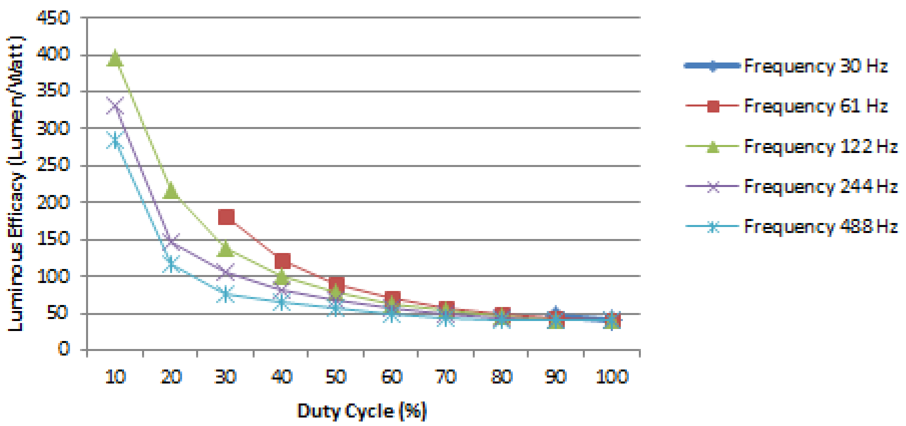

Figure 4. Graph influence the frequency and duty cycle of the PWM power supply efficacy LED light bulb

4. CONCLUSION

In the same light flux levels between the two treatment, the use of PWM power supply can increase the efficacy of the light bulb up to 66.2%, with a value of 117.52 light efficacy lumen / Watt. At the level of light flux which is slightly lower, the use of PWM power supply to the LED bulb with a specific frequency and power supply can achieve the efficacy of 397.14 lumens / Watt.

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