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Power Consumption Efficiency on LED Headlamp of Motorcycle

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***Abstract*— The use of LEDs as light sources has replaced many conventional lamps. One of the industries that utilize LED is automotive industry. LEDs are claimed to be more efficient and durable. On vehicles with LED as light sources are used for increasing the level of lighting and expand the radiation pattern. For efficiency, the radiation pattern of LED can be controlled based on the direction of the vehicle. In this research, LED lights are controlled based on vehicle direction. The main purpose of this research is the reduction of power consumption to support green technology application. The sensor on steer of the vehicle is used triggering to the main controller unit to make decisions in adjusting the LED intensity. The control algorithm based fuzzy logic was implemented on Altera DE-0 Nano FPGA. In this preliminary research, the power efficiency is up to 35% when compared with the condition without control.**

Keywords—LED, Vehicle, efficient, Fuzzy logic

I. INTRODUCTION

Efficiency is a simple concept that can be interpreted, "doing more with less" [1]. In the concept of energy efficiency also has the same principle that is using energy as small as possible to get the maximum performance. Research issues on energy efficiency has been widely improving such as in automotive industry. The use of LED as the main lighting source on the vehicle has been widely applied. The use of LED as a vehicle lamp replaces halogen has been started to be used by some vehicle manufacturers. The high efficiency of LEDs causes the power requirement to be smaller, thus becoming more energy efficient combined with an extended lifetime [2].

The number of vehicle users in Indonesia is increasing every year, automatically caused the growth of energy consumption. Based on data from the Statistic Central Bureau of the Republic of Indonesia, the growth rate of motorcycles user can reach 12% every year [3]. If we take a sample of active riders on daily by 85% with a long drive for 1 hour, it will get an increase in energy consumption every day by 2 billion watts if the lamps that used are 20 watts. This value can be decreased if the energy efficiency in power LED consumption can be applied but still have maximum performance which customized to the needs.

There are the weaknesses of LED technology such as expensive cost if comparing with other lamp and also has limitations of radiation pattern compared with halogen lamps. To overcome the problem of the radiation pattern, recently LED on the vehicle is arranged in an array so that the beam pattern becomes wide. However the problem comes when the usage of LED arrays initially to improve efficiency, but it becomes less efficient because it uses more LEDs.

Related research about the efficiency of LED is LED Light Dimming System using wall switch [4]. It implemented LED brightness control algorithm by using button this system does not work automatically. Design of energy saving for LED Lighting is also implemented by Chang [5] which implemented a Class-E resonant inverter as the main electrical circuit to improve efficiency.

Another research of LED control performed by Chilla, focus in the realization of an adaptive headlight based on LDR to control the intensity of headlight via PWM [6]. LED controls on the headlamp using PWM are also performed on [7], then comparing their performance with Halogen and HID lamps. However, in those studies are not discussed the efficiency of power consumption, so it has not seen how the influence of control on LED to support energy efficiency.

This research focuses on power efficiency by adjusting the LED intensity based on motorcycle direction using simple technique and low-cost component. Potentiometer which installed on the steer is used for direction sensor. Then read by the main controller to drive the LED according to the algorithm. For example, when the vehicle is going straight, the LEDs which light up is that have straight radiation pattern, while the light of side part LED is dimly lit, as well as when the motorcycle is turning right, the LED that lights optimally is LED right part.

This research presents a power efficiency by controlling LEDs radiation pattern of the vehicle. The system was analyzed through simulation then the concept calculated in the simulation will be realized on Altera DE-0 Nano FPGA device as the main controller unit and also used the direction sensor as the sensing module.

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II. Method and Design

A. Algorithm of Radiation Pattern Controlling

The main problem of this research is the efficiency of lighting based using effective lighting that describes on Fig. 1.

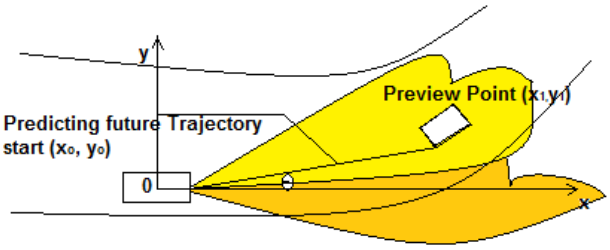

Fig. 1. Comparison of effective vehicle lighting and actual lighting [8]

To adjust the pattern of LED beams adaptively, previous research was done by providing additional control system using a mechanical system that changes the direction of the angle of light based on the direction of the vehicle. In another research, has successfully simulated an adaptive front-lighting system based on driver preview behavior and eye movement [8]. The main purpose is simulation a dynamic predictive algorithm of the vehicle's future track. The principle of this adaptive application can be used for power consumption efficiency applications by adjusting the LED intensity.

B. Beam Forming

Beamforming is a method to form a radiation pattern by arranging the sequence of certain direction radiation pattern. Beamforming is commonly implemented in the ultrasound transmission process. It has a narrow radiation pattern, to form a large radiation pattern the transducer will be formed into an array consist of several transducers. Then in order to obtain the required beam pattern, the radiation process is arranged with a different delay for each of the transducers.

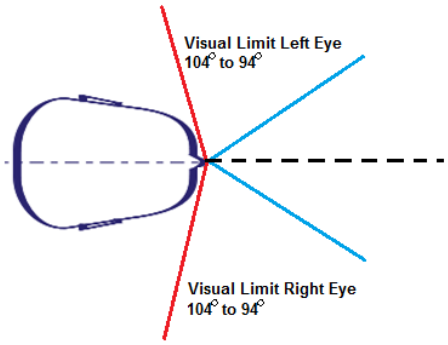

Fig. 2. Limitations view of human eye [9]

The same process will be adopted in this research to adjust the beamforming of the radiation pattern on the LED array. The Beamforming in LED system has reduced the intensity of the light by adjusting the output control of Pulse Width Modulation. This adjustment was also based on the effective view of the human eye that ranges from 94 to 104 degrees.

C. System Design

The whole design system of this research is shown in Fig. 3. There are four main modules which were realized in this research: sensing directions (angle sensors), decision making (as the main controller), light intensity controlling (dimmer) and LED lamp. Sensing directions consist of steer and an angle sensor that used a potentiometer then read by the analog-digital converter (ADC) as vehicle direction information. The decision component is used to synthesize information from angle sensor to determine the direction of the vehicle at this time. This decision module is implemented by Altera DE-0 Nano FPGA. The information of vehicle direction will be the reference for adjusting of PWM pulse. PWM pulse will drive the current to the LED that has three segments, representing the straight, right and left direction. Segment of LED is described in Fig. 4.

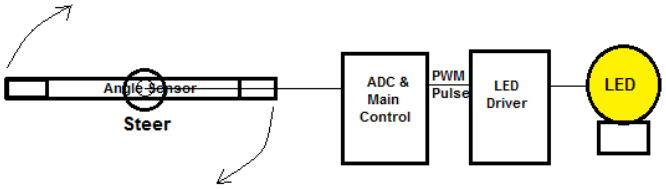

Fig. 3. Block of Design System

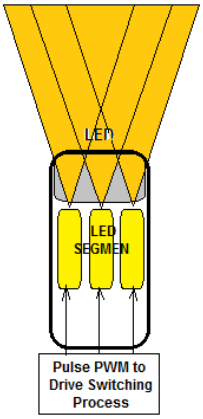

Fig. 4. Segments of LED

On decision-making process, divided into groups Based on vehicle steer direction. On this preliminary research, the direction of vehicle consisted of 3 directions such as straight, right and left.

Determining process of direction is using fuzzy logic algorithm for controlling. The first is determining the threshold for each direction. The major work of power consumption reduction in this research is by implementing dimming controls to the segment of LED which is not effective based on vehicle direction. The trade-off in this research is beamforming control of LEDs but still in a safe

condition which is also adapted to the limitation of human view.

In this work, the input was vehicle direction. Further for future works, additional input can implement to improve system efficiencies, such as vehicle acceleration and ambient light. Vehicle direction in this work was spread into a range of degree from -60 to 60, hence divided into three regions: left, center, and right. Left region is located in the area from -60 to -40 and then fading out as the transition region until reach 0% at -20 degree. The mirrored situation was implemented for the right area where the peak was located from 40 to 60 degree, and reach 0% at 20 degrees. The center area was slightly wider occupying -20 to 20 with 100%, with two transition regions that reach 0% at -40 degree and 40 degree consecutively. The complete fuzzy logic chart can be seen in Fig. 5.

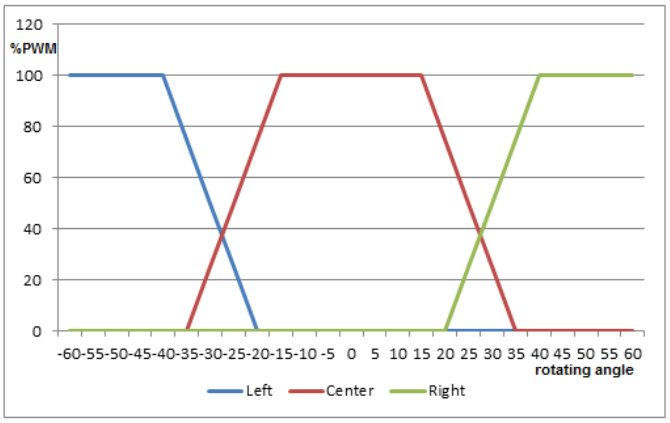

Fig. 5. Fuzzy Logic Graph for Area Separation.

D. The Composition of Light Intensity

We have determined the vehicle direction: straight, right and left direction, so the level of light intensity of each LED is described in Fig. 6.

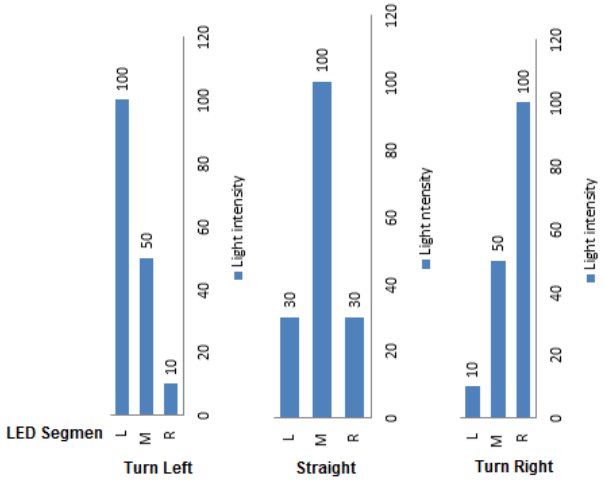

Fig. 6. Light Intensity

III. Result and Discussion

The first testing of the realized system is to analyze the correlation between level both of PWM pulse and LED intensity to determine the power consumption. Calculation of power consumption was done by providing a constant voltage of LED that is equal to 17.8 volts and then observed the change of current values by the PWM pulse which was given to the LED. The results show a linear relationship between the intensity of PWM and power consumption that can be seen in Fig. 7.

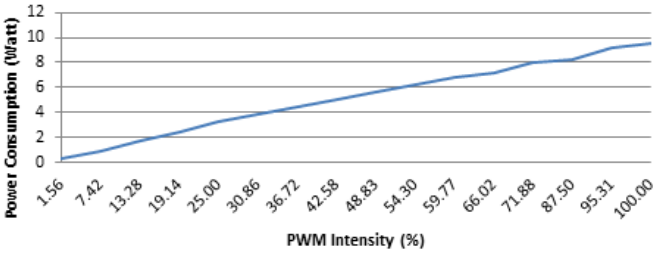

Fig. 7. Graph of the Relation between Power Consumption and PWM Intensity

From the Fig. 7, when the pulse condition of PWM is 100% power consumption on LED is 9.5 watt where the current value is 0.55 Ampere in 17.8 volts. The small current value in this experiment was caused by the using of 2 batteries with voltage 9 Volt. However, in this research focus on the linear relation between PWM and power consumption so that can be same relatively for other source voltage.

The result of the system test, illustration effect of setting PWM is showed at Fig. 8. For Straight condition, the light intensity is 30%-100%-30%. Then the light intensity is 100%-50%-10% for turn left condition and 10%-50%-100% for turn light condition.

Fig. 8. Illustration of Influence PWM to LED Intensity

Measurement resulted that the power consumption at straight, turn right and turn left are 6.5 watts. While in a condition where the lamp was full lights give 9.5 watts. It means power consumption decreased 35 %. The result of the implementation of the led control can be seen in Fig. 9.

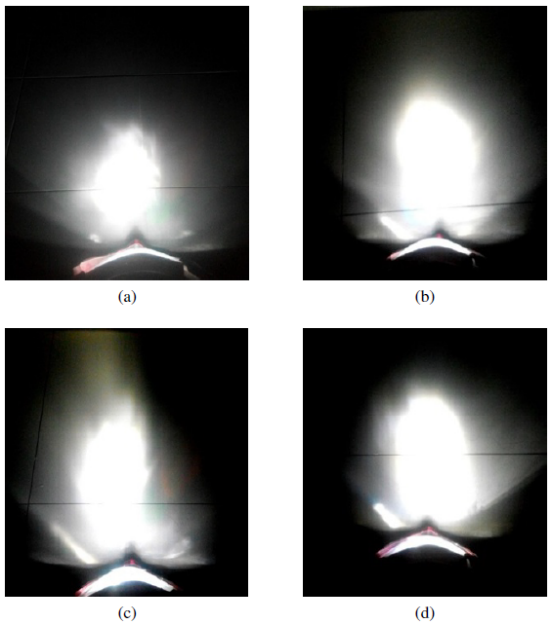

Fig. 9. Implementation Results (a) Straight direction without control, (b) Straight direction with adaptive system, (c) Left direction with adaptive system, (d) Right direction with adaptive system

IV. Conclusion

Based on the design and realization of the system, it can be concluded that it has been successfully implemented a low-cost prototype device that will be used for control the radiation pattern of LED. The results of this implementation can be used for power efficiency, especially the use of electrical energy on a motorcycle. The intensity level of each LED segment is adjusted to the vehicle's rotation angle with PWM control. The result of the system testing showed that the reduction of energy consumption up to 35%. For further research, will be analyzed and investigated in detail to become a System on Chip (SoC) and its the lumen measurement.

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