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Light Intensity Meter and Rear Position Lamp Height: Addition to Indonesian Road Safety Regulations

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Abstract

Forty-six percent of traffic accidents in Indonesia occur on the toll road, and 86 percent of road accidents are due to human error. The number of accidents on the toll road involving heavy vehicles is 33 percent, with the cause of the accident being hit by a vehicle from behind. This incident was caused by the driver's loss of visual perception of the presence of the vehicle in front of him, namely the driver was unable to estimate its existence with the distance of the vehicle in front, one of the reasons was that the driver did not clearly see the light emitted by the vehicle in front of him. Vehicle inspection to the vehicle class must be tested, necessary to do, which is to find out whether the vehicle is suitable for operation or not. Indonesia has not set rules that limit the light intensity and height of rear-light vehicles. From these problems, research was conducted on the design of measuring devices for measuring light intensity and height of the rear light for road safety regulations in Indonesia. The Research and Development (R&D) method is used in this study. This research is a development of previous research in designing a measuring device. Based on the design, manufacture, and testing results, this device can function according to the program design. The device design has been tested and validated, and it is hoped it can be in government policy and be applied to Vehicle Inspection Stations (UPUBKB) throughout Indonesia.

Keywords: *light intensity, the height of rear-light vehicles, vehicle inspection stations/UPUBKB*

INTRODUCTION

In the technical inspection of the vehicle, the lamp is one of the vehicle's main components that must be tested, both on the headlights and the rear lights of the vehicle. Lights in good condition can help the driver and other road users while driving, especially at night. The Indonesian government has set a threshold for light intensity, but only for the headlights of vehicles. The technical requirements for rear lights vehicles only state that the position of the rear lights is installed at a height not exceeding 2,100 (two thousand one hundred) millimeters to the left and right of the rear of the vehicle and must be visible at night, and not dazzle other road users. This is stated in (Government Regulation No. 55 of 2012, n.d.) concerning vehicles article 23 letter f. In the same regulation, article 98 states that the intensity of the rear light vehicles must be visible at night, with a minimum distance of at least 300 meters, and the light does not dazzle other road users. Until now, it has not been clearly stated what the threshold of light intensity is required for the rear light of vehicles to be visible at a distance of at least 300 meters and not dazzle other road users.

The United Nations has issued vehicle regulation No. 7 regarding regulations position, stop light and end-outline lamps. These rules include the rules for the position of vehicles' front and rear

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lights. It also explains the technical inspection of the rear lights that must be carried out to measure the intensity of light on each lamp. The intensity of the lights is not allowed to be less than the minimum intensity and not to exceed the maximum intensity specified so as not to dazzle other road users (UN/ECE Regulation No. 7, 2020). Countries that have implemented this rule include China, Russia, and Australia. (Department of Infrastructure and Transport (Australia), n.d.; National Standard of the People's Republic of China, n.d.)

Traffic accidents in Indonesia show a relatively large number. The number of accidents on the highway involving heavy vehicles is 33 percent, with the cause of the accident being hit by a vehicle from behind. This incident was caused by the driver's loss of visual perception of the presence of the vehicle in front of him, namely the driver was unable to estimate its existence with the distance of the vehicle in front, one of the reasons was that the driver did not clearly see the light emitted by the vehicle in front of him. From these problems, research was conducted on the design of light intensity meters and the rear position lamp height for Indonesian road safety regulations.

LITERATURE REVIEW

Several studies related to the design of similar devices have been carried out, and previous research related to the rear light (Schoon and Roszbach, 2001). This report also draws up a test framework based on a theoretical approach and a judgment of recent provisions for enhancing the rear light vehicle configuration. Those provisions include regulation of light intensity; rear fog lighting fixtures; braking-dependant lights; early-warning brake lighting fixtures; lighting fixtures activated with the aid of emergency prevention; and answers decreasing the carrying out of lamps. The check framework makes it possible to judge innovations on their necessity, functioning, and optical features.

Schefenacker plc renamed Visiocorp plc in 2007, a leading manufacturer of car and light truck mirrors, has developed a system to improve the visibility of signal lamps by adapting the lighting levels to the environmental conditions. A detector system, which includes a Lidar sensor and a mixed brightness/dust sensor, detects environmental situations. (Luce, 2005), a researcher on intelligent rear lights pressured that a concept for an adaptive rear light is predicted to be adopted soon because he thinks the system also offers the possibility to get an automatically operating fog lamp. Research on the Design of Low-Glared LED Rear lights according to European standards conducted by (Le et al., 2020) found that new LED rear light for automobiles is proposed and demonstrated for UN/ECE R07 regulation. The full rear light is an aggregate of a position lamp and a braking lamp, and LED light bars and micro-prisms are worried as their vital components. The micro-prisms are implemented to homogenize the rear mild to lower glare output and accomplish UN/ECE regulation. Through experiments, it miles showed that UN/ECE R07 regulation might be met in the proposed rear light, and 12% position lamps and 26.5% braking lamps with higher candela can be improved after the optimization of micro-prisms.

In other research about light intensity, (Pamungkas et al., 2015) designed a device to measure a room's light intensity. This device is claimed to have an accuracy of > 92% and is cheaper than similar devices that already exist. Another study by (Alawiah and al Tahtawi, 2017) designed a water level control and monitoring device on an ultrasonic sensor-based tank. The test results show that the ultrasonic sensor can measure the water level with an average measurement error of 4.93%. The water level monitoring system can be displayed in an interactive interface in the processing software.

RESEARCH METHOD

The Research and Development (R&D) method is used in this study. This research is a development of previous research in the form of designing a measuring instrument for light intensity and height of vehicle lights. This method is also based on the opinion of (Gall and Borg, 1989), who states, "In research and development, the stages are a cycle which includes a study of various field research findings related to the product to be developed". Before the design of this device was built, the software program development process was carried out through the prototype method.

The primary data used in the study were in the form of observation of the vehicle that became the object of research, distributing questionnaires to vehicle inspectors at one of the Vehicle Inspection Stations in Indonesia, and documenting the testing activities of the tools used to support the research data. Secondary data was taken from several related journals or research, vehicle inspection operational standards used as a reference in testing the rear lights of vehicles, as well as international regulations issued by the United Nations No. 7. This regulation contains the rules governing the size, position, lighting intensity, and color of the lights on vehicles.

The number of samples used is as much as the population of mandatory test motor vehicles tested in the survey period (1 week). The sample was selected purposively with the sample criteria: the type of goods vehicle with an allowed weight (JBB) above 7,500 kilograms. The device's credibility test is carried out to determine the durability of the device's performance during use. A validity test was conducted on vehicle inspectors to measure the device's effectiveness with six assessment aspects. The six aspects include the sensor's accuracy, ease of use, clarity of measurement results, effectiveness, clarity of measuring instrument, and safety.

FINDINGS AND DISCUSSION

The results of this device design are carried out in two stages, the first stage is a software design, and the second stage is hardware design. The software design stage begins with entering the light sensor library and ultrasonic sensor into the Arduino IDE software. The sensors are programmed into a unit so that they are interconnected, and the data captured by the sensor will be processed by Arduino Uno, which will appear on the LCD screen. Before the program is uploaded to the Arduino system, verification is carried out to discover possible errors in the program that was created.

The first step at the hardware design stage is to connect the power supply component with a series of tools and ensure the output/input power specifications on the Arduino Uno component are as needed because the suitability of the power supply cable has a significant impact on the overall performance of the tool *(See Figure 1)*.

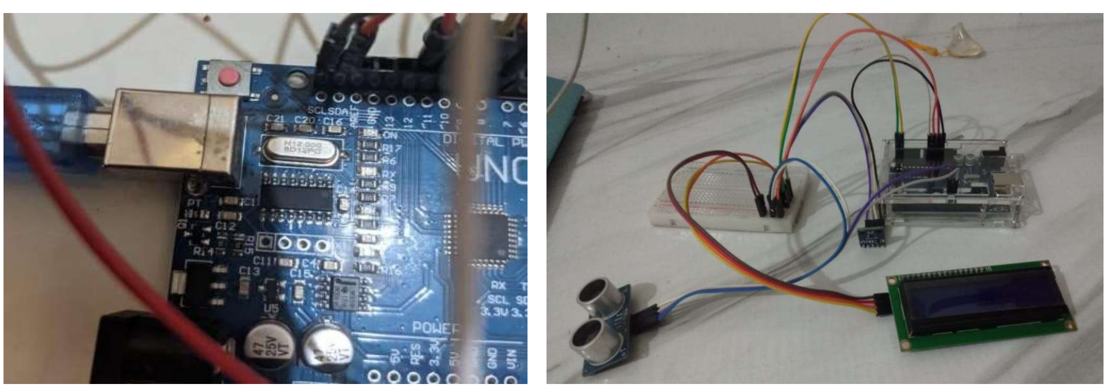

Figure 1. Power supply and set of device design

The second step *(See Figure 2)* is assembling the light intensity sensor component (BH1750). The installation of this sensor is adjusted to the available ports on the Arduino Uno component so that it can work according to the commands run by the Arduino Uno system so that it becomes a system circuit for measuring the light intensity of vehicle lights. The order of installing the port on the sensor to the Arduino Uno component includes: VCC pin with 5V port; GND pin with GND port; SDA pin with A5 port; SCL pin with A4 port.

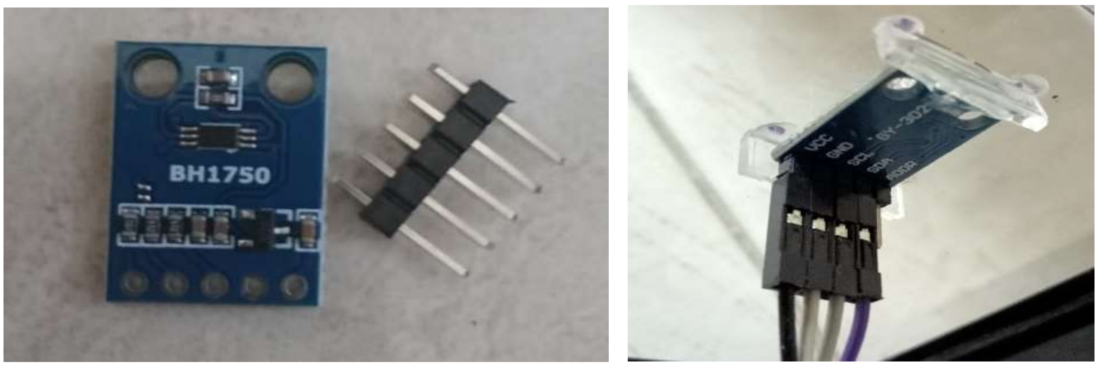

Figure 2. Set the light intensity sensor (BH 1750)

The next step *(See Figure 3)* is to assemble the ultrasonic sensor components that are used to measure the distance to the height of the rear lights of a vehicle. The installation of this port on the sensor to the Arduino Uno with the arrangement: GND pin with GND port; ECHO pin with port 5; TRIG pin with port 6; VCC pin with 5V port.

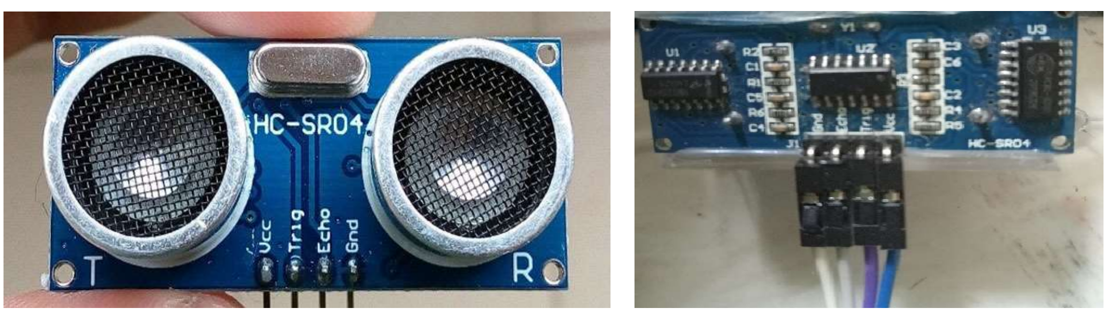

Figure 3. Set the ultrasonic sensor to the Arduino Uno board

The LCD is installed on the Arduino Uno component after all the sensors are installed *(See Figure 4)*. This is to display the measurement results from the light intensity sensor measurement (BH1750) and measurements on the ultrasonic sensor. The arrangement of the LCD ports to Arduino Uno includes: VCC pin with 5V port; GND pin with GND port; SDA pin with A4 port; SCL pin with A5 port. The last step of the hardware design is assembling the device series of tools into the box/body device that has been designed. This box serves to protect the components of the tool circuit and to make it easier to apply.

Figure 4. Set the device to the body device

Device Credibility Test

The device credibility test is carried out for one week to determine the consistency of the tool in running programming. The experimental results of operating the device for eight hours per day for seven full days concluded that the device worked well without experiencing errors. Standard operating procedures for device operations must be carried out to get optimal results on measurements. A number of the procedures that need to be accomplished consist of the following:

1. The officer/vehicle inspector directs the driver to place the vehicle on a flat surface;
2. The vehicle inspector is behind the vehicle at a distance of 1 m;
3. The test equipment is aligned with the position of the rear position lamp of the motor vehicle;
4. The tool will automatically measure the intensity issued by the rear position light while measuring the height displayed on the LCD screen, pay attention and record the measurement results

The optimal distance for using the tool with the most optimal vehicle rear light is one meter. If measured at a longer distance, the measurement is not optimal, influenced by outside light. The following are the results of measurements during the data collection period.

Table 1. Measurement results in light intensity

Sample	Type of Vehicle	Light Intensity Measurement Results			Measurement Deviation
		1st test	2nd test	3rd test	
Sample 1	Wooden Box Truck	128,58	127,27	128,18	1,31%
Sample 2	Wooden Box Truck	156,57	155,58	156,17	0,99%
Sample 3	Wooden Box Truck	117,27	117,14	118,17	0,13%
Sample 4	Wooden Box Truck	110,68	110,68	110,58	0,10%
Sample 5	Dump Truck	113,14	113,58	114,54	2,14%
Sample 6	Dump Truck	90	92,14	90,17	2,14%
Sample 7	Wooden Box Truck	205,83	204,13	205,23	1,70%
Sample 8	Dump Truck	98,58	98,38	97,28	0,20%
Sample 9	Dump Truck	100,03	100,13	100,53	0,50%
Sample 10	Dump Truck	93,27	93,27	93,57	0,30%
Sample 11	Dump Truck	93,27	93,37	93,27	0,10%

Sample	Type of Vehicle	Light Intensity Measurement Results			Measurement Deviation
		1st test	2nd test	3rd test	
Sample 12	Dump Truck	110,13	110,83	110,23	0,70%
Sample 13	Wooden Box Truck	127,67	126,17	127,17	1,50%
Sample 14	Wooden Box Truck	160,14	160,54	160,54	0,40%
Sample 15	Wooden Box Truck	101,67	101,27	100,58	1,09%
Sample 16	Wooden Box Truck	180	179,83	180,27	0,44%
Sample 17	Wooden Box Truck	231,67	229,17	230,67	2,50%
Sample 18	Wooden Box Truck	159,17	157,87	158,58	1,31%
Average		**132,09**	**131,74**	**131,99**	**0,97%**
Overall Average			**131,94**		

Table 2. Measurement results height rear-light

Sample	Type of Vehicle	Height Measurement Results			Measurement Deviation
		1st test	2nd test	3rd test	
Sample 1	Wooden Box Truck	1	1	1	1%
Sample 2	Wooden Box Truck	1	1	1	1%
Sample 3	Wooden Box Truck	2	2	2	2%
Sample 4	Wooden Box Truck	2	2	2	2%
Sample 5	Dump Truck	2	2	2	2%
Sample 6	Dump Truck	2	2	2	2%
Sample 7	Wooden Box Truck	2	2	2	2%
Sample 8	Dump Truck	2	2	2	2%
Sample 9	Dump Truck	0	0	0	0%
Sample 10	Dump Truck	2	2	2	2%
Sample 11	Dump Truck	1	1	1	1%
Sample 12	Dump Truck	1	1	1	1%
Sample 13	Wooden Box Truck	2	2	2	2%
Sample 14	Wooden Box Truck	0	0	0	0%
Sample 15	Wooden Box Truck	1	1	1	1%
Sample 16	Wooden Box Truck	2	2	2	2%
Sample 17	Wooden Box Truck	1	1	1	1%
Sample 18	Wooden Box Truck	1	1	1	1%
Average		**132,09**	**69,83**	**70,11**	**70,00**
Overall Average			**69,98**		

From three trials, the average deviation light intensity is only 0.9, and the deviation on height measurement is 1,39%. It can be concluded that this device is quite consistent in measuring.

The measurement of the light intensity of the vehicle's taillights is influenced by the distance and area of the irradiation. This is in accordance with the results of research conducted by (Pamungkas et al., 2015), who found that the distance of the light source is inversely proportional to the amount of light intensity, meaning that the closer the sensor is to the light source, the greater the light intensity. Experiments were conducted to measure the intensity at night with various measurement distances.

Table 3. Result of measuring light intensity from several distances

Sample	Type of Vehicle	Light Intensity (lx)				
		1 m	3 m	5 m	7 m	10 m
Sample 1	*Truck*	120,00	10,00	2,50	1,67	0,83
Sample 2	*Truck*	128,00	10,23	2,83	1,67	0,83
Sample 3	*Bus*	35,00	5,83	2,50	1,67	0,83
Sample 4	*Bus*	34,83	5,23	ins	1,67	0,83

The measurement results show that at a measurement distance of > 1 m, the sensor of this device does not have the ability to work optimally.

Device Validity Test

Table 4. Results of device validity by respondents

Respondent	Question					
	1	2	3	4	5	6
1	4	4	4	4	3	4
2	3	4	4	4	3	4
3	4	4	4	4	3	4
4	4	4	4	3	4	4
5	4	4	4	3	4	4
Average	**3,8**	**4**	**4**	**3,6**	**3,4**	**4**
Status	**Effective**	**Effective**	**Effective**	**Effective**	**Ineffective**	**Effective**

From these data, the following results 5 out of 6 respondents who tested the device answered that this tool effectively tests the light intensity and height of vehicle lights.

$$Effective = \frac{5}{6} x\ 100\% = 83{,}33\%$$
$$Ineffective = \frac{1}{6} x 100\% = 16{,}66\%$$

Figure 5: Device validity test by Vehicle Inspectors

CONCLUSION

The results of the prototype test, the percentage of measurement deviations generated in the measurement of light intensity is 0.97%, and the height of vehicle lights is 1.39%. The conclusion of the prototype test results is quite consistent in measuring both light intensity and vehicle light height. The results of testing the light intensity from several distances also concluded that the intensity of the light was affected by the distance and the area of the vehicle's light beam. Validation of the effectiveness of the prototype was obtained from respondents' answers. 83.33% of respondents stated that this prototype was "EFFECTIVE" to test the light intensity and height of vehicle lights.

This prototype has the opportunity to be mass-produced. The cost of prototyping is very low, with a fast assembly period. The prototype needs to be calibrated with an existing headlight tester so that the deviation results on this prototype can be used as a benchmark to determine the accuracy of the measurement. The addition of a tripod is also needed so that the prototype results are more consistent and safer when used. From the results of this design, the Government of Indonesia is expected to be able to apply a minimum and maximum threshold for the intensity of rear-light vehicles according to existing international regulations. With this regulation, the vehicle's rear lights can be seen clearly from a certain distance and not dazzle other road users, which can cause accidents.

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