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ASLA INTELLIGENT SENSOR IN ENERGY-SAVING AND ENVIRONMENTALLY FRIENDLY DIRECTIONAL LIGHTING SETTINGS

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ABSTRACT

This research develops and tests an innovative tool called ASLA (Automated Signal Light Brightness Adjustment) designed to automatically adjust the brightness of train signal lights based on environmental conditions such as light intensity, rain, and fog. The main purpose of this tool is to reduce the waste of electrical energy caused by using lights with constant brightness intensity all the time. An experimental method is used in this research, where tests are conducted by measuring important variables such as light intensity, current, voltage, and LED brightness. It uses sensor fusion techniques to combine data from various sensors, such as LDRs, rain sensors, and gas sensors, to obtain accurate environmental information. The test results showed that the ASLA tool successfully reduced power consumption from 2.37W to 2.24W, contributing to electricity savings. In addition, the variation of LED power decreased to less than 0.2W under certain weather conditions. This research proves

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1. INTRODUCTION

A langsir lamp is a lighting system installed along the railway track to provide good visibility and assist in train operations, especially at night or in bad weather conditions (Priambudi et al., 2023). The langsir signal is a signal that serves to give instructions through signals in the form of color or light that may or may not perform the langsir movement (Ruswantara, 2024). Basically, langsir lights are applied at every station and are specialized in switching lines when the train is about to change lines. Lane lights utilize electrical energy as the main energy source to run the components. The langsir lights will be red when on an empty line in the sense that there is no train traffic, and will turn white if the sensor detects train facilities. Electricity is the main source of energy to run components on the directional lights. However, the problem is that the energy for the langsir signal is used continuously with the same intensity all the time, this is a waste considering the strong current produced is 24 volts and the light produced is 0.109 candela all the time (Istiadji, 2010).

Based on the current strength and light used, it can be adjusted to the surrounding environmental conditions to reduce power waste. Energy consumption that is higher than necessary to perform a particular task is usually caused by inefficient equipment, poor usage habits, or poorly regulated systems (Arifianto et al., 2020). Based on these problems, the energy used in the langsir lamp should be adjusted to the surrounding environmental conditions. For example, during the day the level of brightness intensity can be increased and when approaching the night the brightness level can be lowered. In this way, the intensity of electrical energy can be reduced so that electrical energy consumption can be controlled and limited.

This phenomenon has led to an innovation in the form of a train signaling lamp that is able to adjust the brightness of its light automatically. This innovation aims to reduce the waste of electrical energy while ensuring that machinists can still monitor signals reliably in various conditions. The strength of the electric current produced by ASLA is relatively lower with a voltage difference of 12VDC with the usual langsir lamp (Moch. Alif Afdilah Saldi, 2021). The automatic system called ASLA (*Automated Signal Light Brightness Adjustment*) will adjust the brightness of the signal lights by adjusting the surrounding environmental conditions with indicators of brightness, rainfall and fog.

The ASLA work system is designed when the brightness of the sun's rays is too high, then the tool will automatically increase the brightness of the lights, as well as during nighttime conditions to save electrical energy by adjusting the brightness of the lights adjusted to the conditions of the surrounding environment. With this breakthrough, the waste of electrical energy caused by the consumption of the same quantity of energy continuously to produce the same lamp brightness all the time can be limited and managed properly with the application of ASLA (*Automated Signal Light Brightness Adjustment*).

2. RESEARCH METHOD (10 PT)

2.1 Research Methods

This research uses an experimental method, which is an approach to reveal the causal relationship of two or more variables by controlling the influence of the two or more variables. Other variables (Sahara Munte et al., 2023). The experimental method was chosen because it allows direct measurements to be obtained with a wide variety of important variables, such as light intensity, current, voltage, and LED brightness. Under controlled and varied environmental conditions, various output results of the device will be obtained including reliability, electrical energy consumption and the strength of the light produced (Setiaji et al., 2022). With this method, the device is tested in a real situation, where the resulting data is analyzed to ascertain whether the device is functioning according to the predetermined objectives. This experimental approach is important to ensure the validity and accuracy of the research results, as well as to effectively evaluate and optimize the tool design (Setra & Sopian, 2022).

Tool design is a process of sensor selection, sensor placement and equipment system integration. The purpose of this tool design is to measure the success of the tool manufacturing process and to monitor and evaluate the performance of the tool after the construction of the equipment and its working system, including ensuring what processes are carried out to assemble the tool according to the appropriate theoretical concept. In the concept of designing this tool starts from the tool block diagram, sensor selection, sensor placement to the design of the tool prototype. Figure 1 will explain how the tool works. When the device is turned on, the Arduino will initialize all previously configured sensors. Then the sensors will read the conditions around the device according to their respective uses. The rain sensor is used to read the thickness of the raindrops that hit the sensor (Laili Mufidah, 2018). The MQ-5 type gas sensor is used to detect fog around the device (Vrushali Bagade et al., 2016). The L298N module is used to regulate the light intensity of LED lights through PWM techniques (Turesna & Zulkarnain, 2015). PWM (*Pulse Width Modulation*) is a technique used to control the power sent to electronic devices by changing the pulse *width of* a digital signal (Supardi et al., 2022). LDR sensor to read the intensity of light received (Alamsyah et al., 2022). The following is a power supply distribution system as a result of processing all system workflow processes.

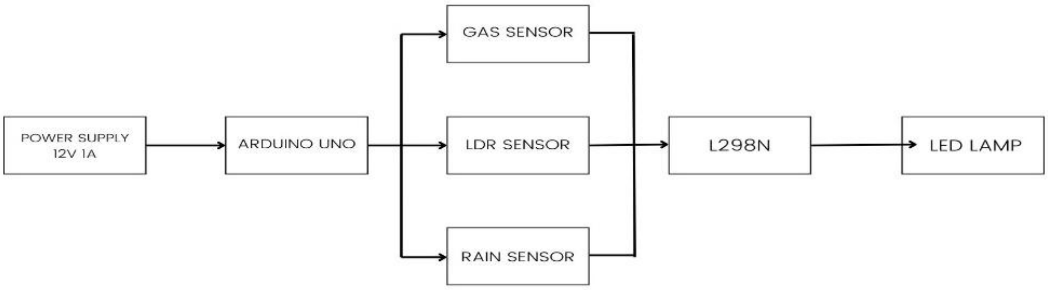

Figure 1 Power supply distribution system

The tool design in Figure 2 involves the pin configuration used on the Arduino Uno to ensure sensor communication runs according to the software that has been created. The Arduino Uno can be operated with an external supply between 6 VDC to 20 VDC, but the recommended range is between 7 VDC to 12 VDC to avoid stability issues and overheating (Dwiyanto et al., 2015).

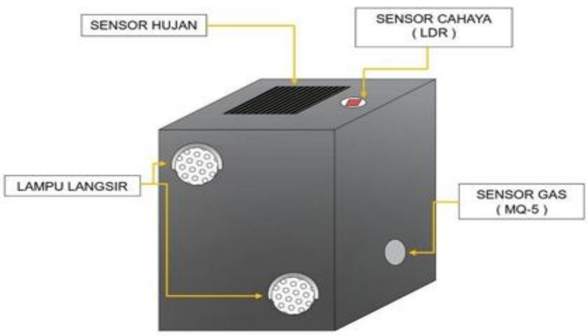

Figure 2 External design of the tool

2.2 Measurement Method

Measurements are made using sensor fusion techniques, which combine data from various sensors to produce more accurate and reliable information (Khaleghi et al., 2013). This process involves measuring light intensity, environmental parameters such as temperature and humidity, and cleaning data from noise (Friadi, 2019). In this experiment, researchers conducted experimental trials with the aim of knowing the characteristics and brightness (lumen) of the LEDs used in the signal trainer lights. By taking variables of current (I), Voltage (V), and Brightness (lux). According to (Yasu & Hadi, 2021) to determine the power (watts) used, it is calculated by the formula:

$$P = V \ x \ I$$

where :

P = Electrical Power

V = Electrical Voltage

I = Electrical Current

To analyze the data, the author uses a direct testing method on the experimental results. After the test is carried out, the data obtained will be analyzed. This tool is considered successful if the data generated is in accordance with the expected function. Conversely, if the data obtained does not reflect the desired function, then this tool is considered unsuccessful.

2.3 Programming method

In the software design in this study using the Arduino Uno ATMEGA328P microcontroller in the sensor data retrieval section is intended to read the output data from the sensor which will be processed into a database (Irana et al., 2021), because basically the microcontroller will read the sensor value continuously (Amani et al., 2017). Therefore, it is necessary to design software so that the tool works as needed. The first step in creating a program from the required tool is the initial design. The Arduino program design is made so that it can work properly. And correct. The manufacturing process is in accordance with the Arduino software design above. Making the Arduino program was made up to 65 revisions, due to the process of simplifying the program so that it can work as quickly as possible (Abdai Rathomy, 2021).

3. RESULTS AND DISCUSSION

The test results of the device aim to determine the decrease in power consumed at a certain time, in order to save the use of electricity consumed. This tool is made to reduce the performance of the lamp under certain conditions, by changing the power consumption supplied to the signal lamp. The following is the power consumption data before adjusting the brightness level.

Table 1 Power consumption of each component

Component	Voltage (V)	Current (mA)	Power (W)
Arduino Uno	12V	50mA	0.6
MQ-5 Gas Sensor	5V	150mA	0.75
L298N	12V	60mA	0.72
LDR Sensor	5V	<1mA	0.005
Rain Sensor	5V	20mA	0.1
5mm LED (series)	10V	20mA	0.2
Tool power			2.375

Source: Researcher documents, 2024

Table 1 shows the power consumption before the tool works at 2.375 W. This tool was tested 40 times with 10 different weather conditions. Measurement data consists of sensor values, lamp power consumption, total power consumption of the tool, and lamp brightness (Lux). The lux figure is based on the assumption that each 5mm LED at maximum current (20mA) provides about 15 lux at a distance of 1 meter. The lux value is adjusted to the brightness value relative to the current. The following is the measurement data in 10 different weather conditions.

Table 2 Data of Trial Results

No	LDR Value	Rain Value	Gas Value	Produced Weather Conditions	Rated Lamp (Brightness)	LED Power	Total Power	Lamp Brightness
1	900	600	100	Daytime with clear weather	50	0.039	2.214	2
2	150	650	120	Night time without rain or gas	255	0.20	2.375	15
3	300	400	600	Heavy foggy conditions	200	0.157	2.332	12
4	250	200	50	Evening with heavy rain	255	0.20	2.375	15
5	700	300	700	Evening with light fog	200	0.157	2.332	12
6	500	700	100	Cloudy weather in the afternoon without gas	153	0.12	2.295	9
7	820	450	400	Afternoon with light rain and fog	85	0.067	2.242	5
8	680	450	400	Morning with light rain and fog	200	0.157	2.332	12
9	240	700	800	Evening with heavy fog without rain	200	0.157	2.332	12
10	950	1000	100	Daytime without rain or gas	50	0.039	2.214	2

Source: Research data, 2024

The experimental results presented in Table 2 show how different weather conditions affect the brightness of LED lights controlled by Arduino Uno through various sensors, such as LDR, rain sensor, and gas sensor. In sunny weather conditions during the day, a high LDR value causes the lamp brightness to be low, around 50, with a brightness value of only 2 lux, which reflects the minimum requirement for lighting. In contrast, at night without rain or gas, the lamp is set at maximum brightness (255), resulting in a brightness of 15 lux to provide optimal illumination at a distance of 1 meter.

When heavy fog conditions are detected, even in the daytime, the lights are set at brightness 200 to provide more intensive illumination, reaching 12 lux. This condition is similar to the setting in the afternoon with light fog, where the lamp brightness is also set at a fairly high level to ensure visibility. In the evening conditions with heavy rain, the lamp brightness was also maximized to overcome the lack of natural light. The average total power consumption obtained of 2.3W was less than 2.4W and the variation in LED power consumption achieved was between 0.039W to 0.20W depending on the weather conditions. The total power is between 2.21W to 2.38W which shows more energy savings especially in sunny conditions during daytime. The total power consumed by the system also varies, with the highest power consumption occurring when the lamp is operating at maximum brightness, indicating efficient power usage related to environmental conditions.

4. CONCLUSION

Based on the series of explanations above, the development and testing of a device called ASLA (*Automated Signal Light Brightness Adjustment*) serves to automatically adjust the brightness of train signal lights based on environmental conditions, such as light intensity, rain, and fog. In addition, this tool aims to reduce the waste of electrical energy caused by using lights with the same brightness intensity all the time. The innovative tool in this research uses sensor fusion techniques to combine data from various sensors to obtain accurate environmental information. The test results show that the device successfully detects changes in weather conditions and adjusts the brightness of LED lights according to these conditions, which has an impact on saving electricity. The average power consumption of the device is 2.3W, with variations in LED power between 0.039W to 0.20W, depending on the weather conditions. It is hoped that this tool functions as needed and successfully achieves its design goal, which is to reduce the waste of electrical energy.

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