Automatization of fog lamp based on LED sensor and photo dioda

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Abstract. Accidents due to misuse of fog lamps are traffic violations. To help minimize the misuse of fog lamps, the automatic fog lamp design is indispensable for car drivers to be applied directly to vehicles that still use manual fog lamps. This study aims to produce the design / prototype automatic fog lights with control LED and photo diode sensors that can work effectively, efficiently and economically and is able to function when the fog began to emerge through the simulation of CO₂ solid (dry ice). This research method uses experiments with implementation stages including (1) designing an automatic fog lamp circuit, (2) simulating the validity of the design, (3) refining the design until the final design is obtained, (4) product manufacturing, (5) product testing, (6) automatic fog lamp prototype. Design media using PCB (Printed Circuit Board). While the main components needed are batteries, switches, resistors, LEDs, photo diodes, transistors, relays, fog lamps, and cables. From the test results, the automatic fog lamp circuit design with the substitution of the light sensor is able to turn the fog lamp on and off automatically. The efficient distance for placing the LED and photo diode is 4.5 cm. Thus, the LED-based automatic fog lamp and photo diode can be used as an alternative to support the safety factor for vehicle users.

1. Introduction

The lighting system in a car is divided into several parts, one of which is the headlamps. The headlights consist of head lamps and turn signal lights. The head lamp itself consists of near and long distance lights that serve to illuminate the road at night. To help improve visibility to the front when the vehicle's headlights are unable to penetrate the thick fog, the amount of dust or heavy rain, the yellow fog lamp or fog lamp is a solution to dealing with such situations and circumstances (Gan et al., 2013).
Fog lights are usually installed as additional lights that highlight yellow. Fog lights are installed on vehicles to overcome space limitations (Shim & Lee, 2016). Fog lights have two positions, some are installed as additional lights on the muzzle or also on the roof of the car. There are also those that are installed from the car factory, integrated with the vehicle body on the front bumper of the car. Some countries have strict regulations regarding the use of fog lamps. Use of fog lamps based on environmental conditions and temperature.

Judging from the mechanism, the fog lamps are connected together with the close range lamps (on the dimmer switch). LED fog lights are useful for safety, environment and health (OToole & Diamond, 2008). Fog lights are not turned on together with distance lights and are only turned on together with city lights. When the fog light is to be activated, the headlight switch must be at a short distance light position.

From the existing phenomena, there have been many accidents due to misuse of fog lamps. As reported by the British insurer Swiftcover, it was stated that due to the misuse of fog lamps, there were 300,000 accidents during 2011 (Luthfi, 2012). The use of LED fog lamps is found in newer model vehicles (Zadravec et al., 2017) (C. Series, 2020). In Indonesia, these accidents are often experienced by motorists in the highlands. Some of the contributing factors include: (1) manually turning on the fog lamps can reduce the driver's concentration, (2) in cornering road conditions / meandering like in the highlands with foggy weather, apart from turning on the fog lights the driver is also required to turn on the turn signal / hazard lights. This situation can endanger other motorists, for example the driver forgets to turn off the fog lights when the fog starts to thin. Development of LED sensors and photo diodes for fog lamps (Flores-Fuentes et al., 2018) (Qing-chuan, 2020). Other riders will have their eyesight impaired (glare) due to the fog lamps emitting from the previous rider.

Therefore, to reduce the number of accidents due to the misuse of manual fog lamps and make it easier for drivers to drive without reducing their concentration, the design with an automatic fog lamp design is needed. This design has the advantage that the lights are designed to turn on automatically based on foggy road conditions so as not to reduce the concentration of the driver. In addition to being designed for the comfort of the driver, the design must also pay attention to the comfort aspect for road users (Shah et al., 2018).

Development of fog lamp automation with various uses of sensors (Suntako, 2018) (Lin et al., 2019). Types of sensors developed for fog lamp automation include LED sensors, light sensors, working temperature sensors, and room temperature sensors. Furthermore, sensors that can be used for the development of fog lamp automation are photo diodes (Access, 2010) (C. Series, 2019). In this study, fog lamp automation uses LED sensors and photo diodes. The research objective is to produce a design / prototype of an automatic fog lamp with LED sensor and photo diode control that can work effectively, efficiently and economically. This research aims to produce the design / prototype automatic fog lights with control LED and photo diode sensors that can work effectively, efficiently and economically and is able to function when the fog began to emerge through the simulation of CO₂ solid (dry ice).

2. Research methods
This automatic fog lamp design research used experimental methods. The design method uses a PCB (Printed Circuit Board). While the main components needed are batteries, switches, resistors, LEDs, photo diodes, transistors, relays, fog lamps, and cables. The research stages began with (1) designing an automatic fog lamp circuit, (2) simulating the validity of the design, (3) refining the design until the final design was obtained, (4) manufacturing the
product, (5) testing the product, (6) prototyping the fog lamp. Furthermore, the research stages are shown through the flowchat in Figure 1 below.

![Figure 1: Flowchat of automatic fog lamp design](image)

3. Result and discussion

Design of the light sensor system circuit from the automatic ignition of the fog lamp is composed of several safety components or sensor components which include: (1) battery (12 Volt); (2) switch (Single Pole Double Throw) switch; (3) resistor, the resistor in this design circuit has a resistance value of 2200 Ω with a tolerance of 5%. (2200 x 5% = 110 Ω)

\[ R_{\text{Maximum}} = 2200 + 110 = 2310 \, \Omega = 2.31 \, \text{kΩ} \]  
\[ R_{\text{Minimum}} = 2200 - 110 = 2090 \, \Omega = 2.09 \, \text{kΩ} \]  

In this design, resistors are arranged in series; (4) LED (Light Emitting Diode) voltage is 1.6 V, the voltage size is not the same as a light bulb (Wang et al., 2012); (5) photo diode; (6) transistor (NPN type); (7) relay, the type of relay used is the Normally Open (NO) type; (8) the lamps, used are fog lamps with a voltage of 12 V and a power of 55 watts; (9) resistance (cable).

**Calculation of the Design of each Component**

Creating a design requires precise calculations to produce a perfect product. The things that need to be calculated in designing an automatic fog lamp design are as follows:

**Battery**

The voltage source for the automatic fog light ignition system circuit, adjusted for the car using a 12 V battery. In this circuit a 12V60Ah battery is selected. From these specifications it can be seen that:

\[ P_{\text{Battery}} = V \times I \]  
\[ = 12 \times 60 \]  
\[ = 720 \, \text{Watt/ hour} \]  

Meanwhile, the fog lamp used is 12V, 55W.

\[ \frac{720 \, W}{55} \times 1 = 13 \, \text{hours} \]

So, with a 12V60Ah battery, it can supply a current of 60 Amper / hour with a power of 720 W / h. so if used for a 12V55W lamp, the battery can last for 13 hours.

Resistance (R).
It is known that the LED voltage is usually from 1.6 V - 2.2 V. so it is planned that \( V_{\text{LED}} \) is 2 V and \( I_{\text{LED}} \) is 10 mA. The power supply voltage used is \( \pm 12 \) volts.

\[
\begin{align*}
V_{\text{CC}} &= V_R + V_{\text{LED}} \\
V_R &= V_{\text{CC}} - V_{\text{LED}} \\
V_R &= 12 \text{ V} - 2 \text{ V} \\
&= 10 \text{ Volt} \\
R_{\text{LED}} &= \frac{I_{\text{LED}}}{0.01} \\
&= 1000 \Omega = 1 \text{ k}\Omega (R1)
\end{align*}
\]

In this planning the transistor used NPN made from semiconductor silicon, then \( V_{BE} \) has been determined to be 0.6 V.

\[
R_2 = \frac{I_B}{V_{\text{BE}}} \\
= \frac{0.053}{0.6} \\
= 215.09 \Omega \\
= 220 \Omega \text{ (adjusted for values sold in the market)} \\
\]

\[
\begin{align*}
\frac{I_C}{I_B} &= \frac{4}{I_B} \\
75 &= \frac{I_C}{I_B} \\
I_B &= 0.053 \text{ A}
\end{align*}
\]

**Calculation of Voltage Loss and Cable Diameter**

The tension loss is the difference between the source voltage and the voltage that comes out after the load (Suyitno et al., 2020). In this plan the source voltage \( V_1 \) is a battery which has a voltage of 12V. While much voltage as the load of the measurement results \( V_2 \) of 11.6V, so the difference in voltage or voltage loss can be calculated:

\[
V_{\text{loss total}} = V_1 - V_2 \\
= 12 - 11.6 \\
= 0.4 \text{ V}
\]

**Automatic Design Circuit**

Circuit in a series of automatic fog lamps it is different from manual ones, because in an automatic circuit there are sensors that can control the lights on and off according to the condition of the road environment (foggy or not) The series of automatic fog lamps from this research can be seen in Figure 2.

![Figure 2. Automatic Fog Light Circuit](image-url)
Where:
- B is a 12 Volt 60 Ah battery, SW is a switch, $R_1$ is a 1000 Ω resistor,
- $R_2$ is a 220 Ω resistor, LED is an LED, PD is a photo diode,
- TIP 41 is a transistor TIP 41, RL is an 8 pin relay,
- FL_1 is the fog lamp 1, and FL_2 is the fog lamp 2.

How the automatic fog light circuit works:

Current from the battery enters through the switch (ON condition), then enters the resistor ($R_1$), photo diode, the positive terminal of the relay. The current from the battery that enters from $R_1$ is forwarded to the LED and to ground, so that the LED lights up (emits light). Then the current from the battery entering the photo diode cannot be forwarded to ground because the LED as the transmitter is still on and the light from the LED is still received by the photo diode as a receiver. When the fog (smoke) passes between the LED and the photo diode, the LED light emitting to the photo diode is blocked, so the photo diode works and damages the current to the transistor, to the resistor ($R_2$) and then to ground. Transistor TIP 41 receives current from the photo diode so that the current is forwarded to ground and relay, here its function is almost the same as a switch. Relay works because positive and negative currents meet so that the coil in the relay is energized so that it turns into a magnet and attracts the switch in the relay. At that time, the positive current is connected to the load (fog light) which is installed in parallel and turns on the fog light.

**Testing Results with Simulation Tool Fog**

To test this tool, the designer choose an alternative instead of the fog that CO$_2$ dense (dry ice). CO$_2$ Solid is compressed carbon dioxide. This material was chosen because after being reacted with water it will form a white fog which is almost the same as the fog created due to weather conditions. Dry ice operating characteristics have parameters of fast cooling with low electricity consumption. (Ilchi-Ghazaani & Parvin, 2011).

The chemical reaction formed is

$$\text{CO}_2(S) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{CO}_3(g) \rightarrow \text{H}^+ + \text{HCO}_3^-$$

CO$_2$ Solid is solidified carbon dioxide (dry ice), the nature of CO$_2$ it is very cold beyond icy cold temperatures (-78 °C). So if reacted with water the temperature will rise, much faster and will also release CO$_2$ gas whose temperature is still low enough to condense the surrounding water vapor. We usually call this condensed water vapor fog or the scientific term aerosol. Because this circuit is not equipped with a sensitivity regulator (potentiometer), to adjust the sensitivity of the sensor, the placement between the LED and the Photo diode needs to be adjusted. The closer the distance between the two sensor components, the less sensitive the light will turn on after a thick fog has passed. Vice versa, the further the placement of the LED and the photo diode, the higher the sensitivity in receiving stimuli. So that the lights are on even though the fog is not too thick. Based on test results, obtained from the data in Table 1 as follows:

| Experiment | Distance | Thickness mist | Results  |
|------------|----------|----------------|----------|
| 1          | 1.5 cm   | Medium         | No Lights|
| 2          | 2.5 cm   | Thickness      | No Lighted|
| 3          | 4.5 cm   | Thickness      | Lighted  |
The results of the test for the LED and photo diode distance fitting can be concluded that the fog thickness and distance (in cm) greatly affect the work of the sensor. If the installation distance between the LED and the photo diode is too close, the sensor is unable to work even though the fog passes through the sensor is thick, this is because the light from the LED emitting to the photo diode is too strong (Nessemon & Popov, 2018). Thus, the most efficient distance for sensor installation is 4.5 cm.

The design results of the automatic fog lamp design with light sensor substitution (LED and Photo diode) only require components that are cheap and easy to obtain (Gitelson & Gao, 2017) (IOPC Series & Science, 2019). However, the design of an automatic fog lamp is able to provide benefits for motorists, especially making it easier to turn on and turn off the fog lamp automatically so that it can minimize accidents due to the misuse of using the fog lamp (Yan et al., 2019) (Wijaya et al., 2019).

4. Conclusion
LED-based automatic fog lamps and photo diodes can be used as an alternative to support the safety factor for vehicle users. The efficient distance for placing the LED and photo diode is 4.5 cm. In order to make the use of this automatic fog lamp more effective and efficient, its use can be applied to all types of vehicles equipped with fog lamps.

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