Content lists available at PublikasiPolije

International Journal of Technology, Food and Agriculture (TEFA)

journal homepage : https://publikasi.polije.ac.id/index.php/tefa

Article

Design and Development of a Motorcycle Brake Fluid Temperature Monitoring System to Prevent The Vapor Lock Conditions

Alex Taufiqurrohman Zain [1,*], Dwi Djoko Suranto [2], Cahyaning Nur Karimah [3], Ahmad Fahriannur [4], and Ahmad Yusuf Adi Chandra [5]

[1] Engineering Department, Politeknik Negeri Jember; alextaufiqurrohman@polije.ac.id
[2] Engineering Department, Politeknik Negeri Jember; dwi_joko@polije.ac.id
[3] Engineering Department, Politeknik Negeri Jember; cn.karimah@polije.ac.id
[4] Engineering Department, Politeknik Negeri Jember; ahmad_fahriannur@polije.ac.id
[5] Engineering Department, Politeknik Negeri Jember; yusufadichandra8@gmail.com

*Correspondence: alextaufiqurrohman@polije.ac.id

Citation: A. T. Zain, D. D. Suranto, C. N. Karimah, A. Fahriannur, and A. Y. A. Chandra, "Design and Development of a Motorcycle Brake Fluid Temperature Monitoring System to Prevent The Vapor Lock Conditions", *TEFA*, vol. 3, no. 1, pp. 7–15, Jan. 2026.

Received: 18-11-2025
Accepted: 08-01-2026
Published: 10-01-2026

Abstract: One of the braking system problems in a motorcycle is a vapor lock. Vapor lock can occur when brake fluid, the fluid that helps the brake piston movement, experiences increased heat until it evaporates. Vapor lock can occur when the vehicle has been used due to the high-performance load of the braking system. This research aims to create a brake fluid temperature measuring and monitoring tool. By monitoring the brake fluid temperature, vapor lock conditions can be anticipated. To conduct this research, several materials are required, including K-type thermocouple sensor, Arduino Mega module, RGB bright LED, buzzer, and LCD. The accuracy value of the sensor will be calculated. The results showed that under all conditions, the sensor accuracy had a good value, above 98%. When implemented on a motorcycle, brake fluid temperature conditions are divided into four ranges: 29 °C to 124 °C; 125 °C to 134 °C; 135 °C to 145 °C; and above 145 °C. The results of the implementation on the motorcycle were successful overall, where the condition of each actuator changed when the temperature range of the motorcycle's brake fluid also changed. For example, at the highest temperature, the RGB bright LED lights up Red, the buzzer sounds continuously, and the status message on the LCD is "Bahaya!".

Keywords: Arduino Mega; K-type thermocouple sensor; RGB bright LED; Vapor lock condition

1. Introduction

The braking system is one of the most important systems in a vehicle [1]. The braking system functions to reduce speed or stop a vehicle safely and effectively. This system consists of several main components, including the brake lever, brake cable or hose, caliper, brake pads, and either a disc or drum. The reliability of the braking system significantly affects rider safety, especially in emergencies or on difficult terrain [1], [2].

In recent years, motorcycle braking technology has evolved, with both drum and disc brakes being introduced. Technologies that have begun to develop include Anti-lock Braking System (ABS), Electronic Brake-Force Distribution, and Brake Assist (BA) [3], [4], [5]. However, many drivers still use vehicles with conventional braking systems that are susceptible to decreased performance due to component wear, lack of maintenance, or improper use.

One of the most common problems encountered in vehicle braking systems, especially motorcycles, is vapor lock. Vapour lock is a condition where the brake pistons stop moving because the oil, the fluid that supports the movement mechanism, evaporates. This evaporation occurs because the brake fluid receives excessive heat as a result of continuous friction between the brake pads and the brake disc [6], [7]. Brake fluids actually have a variety of boiling point ranges. For example, DOT 3 is one of the most common brake fluid standards used in motorcycles, with a boiling point of ± 205 ^{o}C. In addition, there are DOT 4, DOT 5, and DOT 5.1. The fundamental differences between these four types of brake fluid are based on their boiling points and material content, so each type has its own specific uses.

Previous studies have focused more on the friction mechanism between the disc brake and the brake pad [2]; Distribution of braking load on each wheel [5]; Braking automation [3], [4]; As well as optimization of the braking system in various track conditions [8], [9]. In addition, the effect of heat on the performance of the vehicle's braking system has also been studied [6], [7], [10]. However, brake fluid, as one of the important fluids in the braking mechanism, has not been widely studied, especially regarding monitoring its temperature when the vehicle is in use.

However, brake fluid, as one of the important fluids in the braking mechanism, has not been widely studied, especially regarding monitoring its temperature when the vehicle is in use. Currently, brake fluid testers are available on the market for measuring brake fluid quality. However, these devices are used when the vehicle is not in use.

This research will design and develop a prototype system for monitoring the brake fluid temperature on a motorcycle in real time during use. It is hoped that a vapour lock can be prevented when the motorcycle is used under excessive braking load. The addition of a buzzer actuator and bright RGB LEDs is expected to increase rider awareness.

2. Methods

2.1. Assembly of temperature measuring and monitoring systems

Several materials and tools used include: a K-type thermocouple sensor used as a brake fluid temperature sensor. The K-type thermocouple sensor was chosen because it has several advantages, including its waterproof properties, high accuracy, and measurement range[11], [12].

Table 1. Arduino ATmega 2560 Specifications

Parameters	Specifications
Microcontroller	ATmega2560
RAM	8 KB of SRAM
Flash Memory	256 KB (8 KB used by bootloader)
EEPROM	4 KB
Clock speed	16 MHz
Operating Voltage	5 V
Input Voltage (recommended)	7-12 V

The MAX6675 module was used as an amplifier, timer, and analog-to-digital converter of the K-type thermocouple sensor [12]. The Arduino Mega microcontroller module was used as a data processing module. This module is used because it can handle complex programming with a large number of input/output pins, PWM outputs, and higher memory than other Arduino modules [13]. Figure 1 shows the flowchart of systems in this study.

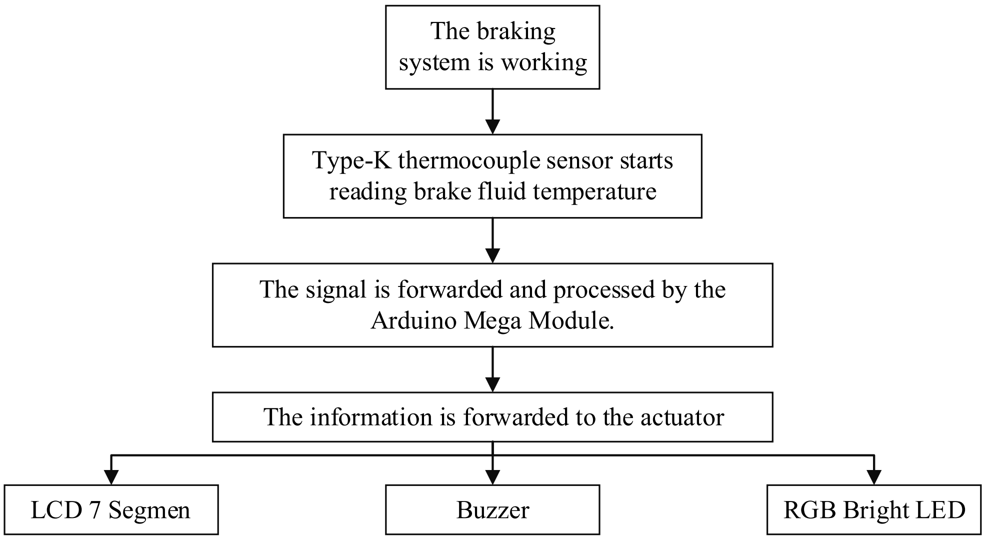


Figure 1. The Flowchart of the System

After being processed by the microcontroller, the data is received by the LCD screen to display the measurement results. In addition, other indicators such as RGB bright LED colors and the number of tones on the buzzer will also work. The wiring diagram of the system is shown in Figure 2 below.

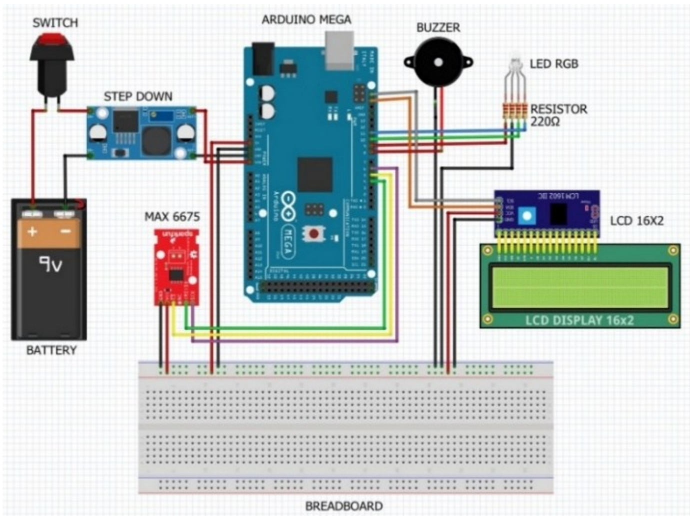


Figure 2. The Wiring Diagram of the System

2.2. Sensor calibration

One essential step in assembling a sensor-based measurement and monitoring system is calibration. This refers to the process of adjusting or correcting the sensor to ensure it delivers reliable and precise readings. Calibration is performed by comparing the sensor's output against a recognized reference or standard, then making the necessary adjustments to minimize errors. To preserve measurement accuracy—particularly in applications demanding high precision—calibration must be conducted regularly. [14], [15].

Accuracy plays a crucial role in data measurement and analysis. Although the terms accuracy and precision are sometimes used interchangeably, they carry distinct meanings. Accuracy refers to the closeness of a measurement or obtained data to the true value or a recognized reference standard (such as those from calibrated instruments). To evaluate error, as well as the levels of accuracy (expressed in %), the following equations are applied [13]:

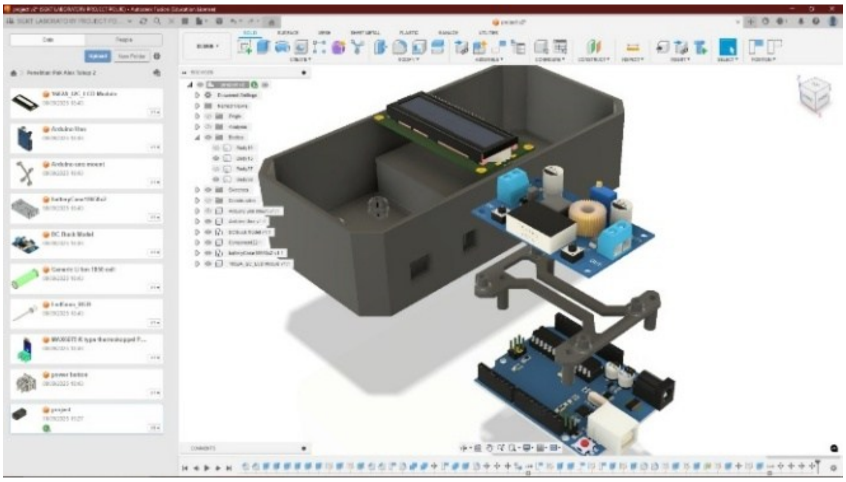
$$error(\%) = \left(\left| \frac{Y - X_n}{Y} \right| \right) \cdot 100\% \quad (1)$$

$$accuracy(\%) = \left(1 - \left| \frac{Y - X_n}{Y} \right| \right) \cdot 100\% \quad (2)$$

Where Y is for reference parameter value (measurement results using standard measuring instruments); X_n is for the n-th measured parameter value using the developed system [13]. For each of the same conditions, data collection was repeated three times. The standard measuring instrument used is the TP 101 digital thermometer.

2.3. Packaging System

To minimize external interference, including heat, liquids, dust and short-circuiting, the assembled device is placed in a box. The box was custom-designed using Autodesk Fusion, as seen in Figure 1 (a), and the design was realized using 3D printing, as shown in Figure 3 (b). Polylactic Acid (PLA) is used for 3D printing material in this study.



(a)

(b)

Figure 3. The Packaging Box **(a)** Design Using Autodesk Fusion and **(b)** Realization Using 3D Printing

2.4. Application of temperature measurement and monitoring systems

The final stage of this research involves applying the developed system to a motorcycle.

Figure 4. Application of Temperature Measurement And Monitoring Systems In A Motorcycle

A K-type thermocouple sensor is placed inside the motorcycle's disc brake caliper. To minimize reading errors, the sensor is secured with a nut and the connection is thermally insulated.

3. Results and Discussion

3.1. Calibration results

The system has good measurement results. This is proven by the error results, which are not more than 2% for all conditions.

Table 2. Temperature Calibration Test Results of K-Type Thermocouple Sensor

Temperature (°C)				Error (%)	Accuracy (%)
TP 101 Digital Thermometer	**Average**	**K-Type Sensor**	**Average**		
29.20	29.17	30.75	29.62	1.54	98.46
28.90		28.60			
29.40		29.50			
78.10	78.63	80.50	80.00	1.74	98.26
79.30		79.90			
78.50		79.60			
99.00	99.73	101.00	100.80	1.07	98.93
100.40		101.10			
99.80		100.30			
121.30	120.70	122.60	122.20	1.24	98.76
120.50		122.70			
120.30		121.30			
152.40	152.67	152.20	151.83	0.55	99.45
152.90		151.80			
152.70		151.50			

The average accuracy value of over 98% indicates that the test results have a high level of agreement compared to standard measuring instruments. The test results of this K-type thermocouple sensor show that the error percentage is below 2%, which means this device still has a high level of accuracy [13]. Thus, the K-type thermocouple sensor can be applied to digital current measurements using a microcontroller.

3.2. Actuator Setting

This study used three actuators. The actuators in this study served as the primary indicators when the maximum brake fluid temperature limit was reached. The actuators used included an RGB bright LED, a buzzer, and a 7-segment LCD. The set point value used was the brake fluid temperature measured by a K-type thermocouple sensor. The following are the actuator settings used in this study.

RGB bright LEDs are a common type of LED used in electronic devices. This type of LED has the advantage of changing colors according to the bit values assigned to each of its base color components. In this study, the colors used were green, yellow, and red. The bit value combinations used to produce these colors can be seen in Table 3 below.

Table 3. RGB Bright LED Color Setting

RGB Bright LED Color Used	The Bit Value of Each Primary Color Component (bit)		
	Red	Green	Blue
Green	0	255	0
Yellow	255	155	0
Red	255	0	0

Another actuator used is a buzzer. The buzzer must be adjusted to produce the desired sound. Combining it with an RGB bright LED is necessary to produce an indicator that can provide accurate information to the user. Table 4 below shows the buzzer sound settings combined with the RGB bright LED color setting.

Table 4. Buzzer Sound Setting

RGB Bright LED Color Setting	Buzzer Sound Setting
Green	Sound on with intensity 30 times per minute
Yellow	Sound on with intensity 60 times per minute
Red	Sound on continuously

After successfully adjusting the RGB bright LED and buzzer, the next step is to adjust the 7-segment LCD. The 7-segment LCD is expected to provide information regarding the actual condition and temperature status of the brake fluid. Four statuses in this study are "Aman" for safe conditions; "Siaga" in standby conditions; "Waspada" for alert conditions; and "Bahaya!" for danger conditions. The brake fluid status and temperature parameters used are as shown in Table 5 below.

Table 5. 7 Segment LCD Status Display Settings

Brake Fluid Temperature (°C)	Status
29 °C to 124 °C	Aman
125 °C to 134 °C	Siaga
°C to 145 °C	Waspada
>145 °C	Bahaya!

The temperature range classification is based on initial testing, where DOT 3 Brake Fluid begins to boil at a temperature of 205 °C to 250 °C. Anticipation is needed so that the hydraulic mechanism in the braking system does not completely fail, so in this study, the final temperature limit used is 145 °C [3] [16], [17].

3.3. Implementation of Brake Fluid Temperature Monitoring System on A Motorcycle

After the sensor was successfully calibrated and the actuator parameters and set points were determined, the next step was implementation on a motor vehicle. The system was installed on the rear disc brake caliper. Testing was then conducted with the motorcycle stationary. This was done to anticipate system failures and prevent endangering the safety of the user and the vehicle. The motorbike is started at high speed, between 120 km/hour to 150 km/hour then braked suddenly and repeated several times until the brakes heat up. Table 6 below shows the test results when the system was implemented on a motorcycle.

Table 6. Implementation of Brake Fluid Temperature Monitoring System on Motorcycles

Brake Fluid Temperature (^oC)	RGB Bright LED Color Conditions			Buzzer Sound Conditions	LCD Status	Test Description
	Green	Yellow	Red			
100	Off	Off	Off	Off	Aman	Succeed
110	Off	Off	Off	Off	Aman	Succeed
115	Off	Off	Off	Off	Aman	Succeed
125	On	Off	Off	Sound on 30 times per minute	Siaga	Succeed
135	Off	On	Off	Sound on 60 times per minute	Waspada	Succeed
147	Off	Off	On	Sound on continuously	Bahaya!	Succeed

The system's implementation on motorcycles has proven successful. The system can display temperature and security status via a 7-segment LCD. Furthermore, the bright RGB LED and buzzer provide additional user indicators.

4. Conclusions

A brake fluid temperature monitoring system for motorcycles has been successfully developed and tested. Calibration results for the K-type thermocouple sensor showed that the error value for all test conditions was below 2%. The results of the settings on the actuator were also successfully implemented. When implemented on a motorcycle, brake fluid temperature conditions are divided into four ranges: 29 ^oC to 124 ^oC; 125 ^oC to 134 ^oC; 135 ^oC to 145 ^oC; and above 145 ^oC. The results of the implementation of the system on the motorcycle were successful overall, where the condition of each actuator changed when the temperature range of the motorcycle's brake fluid also changed. For example, at the highest temperature during testing, 147 ^oC, the RGB bright LED lights up Red, the buzzer sounds continuously, and the status message on the 7-segment LCD is "Bahaya!". Thus, the system created in this research is very possible to be applied to motorbikes to prevent vapor lock conditions.

Supplementary Materials: -

Author Contributions: "Conceptualization, 1st. and 3rd; methodology, 2nd; software, 5th; validation, 1st, 3rd. and 4th; formal analysis, 4th.; investigation, 1st; resources, 2nd; data curation, 5th; writing—original draft preparation, 1st; writing—review and editing, 3rd; visualization, 2nd; supervision, 4th; project administration, 3rd; funding acquisition, 1st.

Funding: This research was funded by Central Unit of Research and Community Service (P3M) Politeknik Negeri Jember

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Not Applicable

Data Availability Statement: -

Acknowledgments: The entire research team would like to thank Politeknik Negeri Jember through the Central Unit of Research and Community Service (P3M) for the financial and technical support in carrying out all research activities.

Conflicts of Interest: "The authors declare no conflict of interest." "The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results".

References

1 F. Irvan Saputro and H. Pranoto, "Analisis Daya Pengereman pada Rem Cakram Roda Depan Kendaraan Motor Listrik E-Niaga," *Journal of New Energies and Manufacturing (JONEM)*, vol. 1, no. 2, pp. 82–93, May 2022, doi: http://dx.doi.org/10.22441/jonem.v1i2.16500.

2 M. F. Popa, D. M. S. Capătă, and N. Burnete, "Aspects Of Wear Braking Process On Brake Discs And Brake Pads In The Construction Of Commercial Vehicles," in *IOP Conference Series: Materials Science and Engineering*, Cluj Napoca: Institute of Physics Publishing, Sep. 2019, pp. 1–8. doi: 10.1088/1757-899X/568/1/012093.

3 M. Kowalski, "The Effect of Automotive Vehicle Braking System Failure on Driving Safety," *Journal of KONES Powertrain and Transport*, vol. 20, no. 1, pp. 147–53, Jun. 2013.

4 Z. Xu, "Talking about the Automobile Braking System," in *IOP Conference Series: Materials Science and Engineering*, Dongguan: Institute of Physics Publishing, Dec. 2017, p. 1. doi: 10.1088/1757-899X/274/1/012141.

5 Y. Yang, S. you YANG, L. jie YANG, and Y. Liu, "A New ABS Control Strategy Designed for Electric Vehicle Independently Driven by Four Wheel Motors," in *2nd International Conference on Computer Science and Electronics Engineering (ICCSEE)*, Paris: Atlantis Press, Mar. 2013, pp. 1264–1267. doi: 10.2991/iccsee.2013.317.

6 J. Dewanto and A. Wijaya, "Sistem Pendingin Paksa Anti Panas Lebih (Over Heating) pada Rem Cakram (Disk Brake) Kendaraan," *Jurnal Teknik Mesin*, vol. 12, no. 2, pp. 97–101, Jun. 2011.

7 Jusnita, D. Annisa Fitry, and V. Selviyanty, "Sistem Pengendalian Panas Rem Tromol dengan Water Cooller sebagai Solusi Losse Brake pada Truck," *Surya Teknika*, vol. 9, no. 2, pp. 511–515, Dec. 2022.

8 S. S. Joshi, Vi. S. Jadhav, D. P. Bhosale, and Malave, "Design Of Automatic Braking System For Vehicles In Hill Station," *International Journal Of Innovations In Engineering Research And Technology*, no. 4, pp. 6–9, Apr. 2017.

9 P. D. Pangestu, I. M. Arsana, I. Nurjannah, H. Arizal, and M. A. Irfa'i, "Performance Analysis of Automotive Brakin System in Various Road Conditions," in *Proceedings of the International Joint Conference on Science and Engineering 2022 (IJCSE 2022)*, Jakarta: Atlantis Press International BV, Nov. 2022, pp. 145–154. doi: 10.2991/978-94-6463-100-5_15.

10 P. Aleksandrowicz, "The Effect of Automotive Vehicle Braking System Failure on Driving Safety," in *MATEC Web of Conferences*, Bydgoszcz: EDP Sciences, Jul. 2018, pp. 1–6. doi: 10.1051/matecconf/201818201025.

11 S. Hatmoko *et al.*, "Karakterisasi Termokopel Tipe K pada Fasilitas Simulasi Sistem FASSIP-02," *Poros*, vol. 16, no. 2, pp. 127–37, Nov. 2018, doi: 10.24912/poros.v16i2.11651.

12 A. Riantono and R. A. Koestoer, "Kalibrasi Sensor Temperatur Termokopel Tipe K dan DS18B20 Pada Temperatur Es Mencair dan Air Mendidih Sistem Dengan Akuisisi Data (DAQ) Berbasis Arduino," in *Prosiding Seminar Nasional Tahunan Teknik Mesin (SNTTM)*, Kupang: Universitas Nusa Cendana, Oct. 2019, pp. 1–6. [Online]. Available: https://www.researchgate.net/publication/363053101

13 A. T. Zain, D. D. Suranto, A. Budiprasojo, C. N. Karimah, F. A. Azhar, and M. D. Haryanto, "Applications of 18650 lithium-ion batteries pack in 3 kw electric vehicles," in *IOP Conference Series: Earth and Environmental Science*, Banyuwangi: Institute of Physics Publishing, Oct. 2024, pp. 1–9. doi: 10.1088/1755-1315/1446/1/012056.

14 P. M. Ramos, N. B. Bras, and A. C. Serra, "A New Calibration Method for Current and Voltage Sensors Used in Power Quality Measurements," Sorrenti: Institute of Electrical and Electronics Engineers (IEEE), Mar. 2007, pp. 2283–2288. doi: 10.1109/imtc.2006.328579.

15 J. Lu, Y. Hu, G. Chen, Z. Wang, and J. Liu, "Mutual calibration of multiple current sensors with accuracy uncertainties in IPMSM drives for electric vehicles," *IEEE Transactions on Industrial Electronics*, vol. 67, no. 1, pp. 69–79, Jan. 2020, doi: 10.1109/TIE.2019.2896320.

16 J. Caban *et al.*, "The Research on Ageing of Glycol-Based Brake Fluids of Vehicles in Operation," *Advances in Science and Technology Research Journal*, vol. 10, no. 32, pp. 9–16, Dec. 2016, doi: 10.12913/22998624/65113.

17 C. C. Eze, “Formulation and Production of Bio-Hydraulic Fluid as an Alternative to Mineralfluids for Automobiles,” *American Journal of Engineering Research*, vol. 5, no. 10, pp. 147–51, Oct. 2016, [Online]. Available: www.ajer.org