IMPLEMENTATION OF TRANSISTOR 2N2222 AND L298 MODULE AS DC MOTOR DRIVERS IN LINE FOLLOWER ROBOTS

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ABSTRACT - A line follower robot is a type of robot that is designed to follow a specific path by using sensors and a motor control system. The proper use of motor drivers is essential to ensure the stability and efficiency of the robot's performance. The two commonly used components for DC motor drivers are the 2N2222 transistor and the L298 module, each of which has different characteristics in terms of motor control and power consumption. This study aims to evaluate the performance of the two motorcycle drivers on the line follower robot without using a microcontroller. This study aims to analyze and compare the performance of the 2N2222 transistor and the L298 module as DC motor drivers in the line follower robot, focusing on the speed, power consumption, and stability of the robot's motion in following an oval-shaped path. The method used is a quantitative experiment in the laboratory, by conducting direct tests on the robot equipped with the 2N2222 transistor motor driver and the L298 module. Data was collected based on the robot's average speed, current consumption, and path error rate during experiments with a 4-meter-long oval-shaped path. The test results showed that the robot with the L298 module had an average speed of 0.42 m/s, while with the 2N2222 transistor it was only 0.31 m/s. The current consumption in a system with L298 is 480–520 mA, while with a 2N2222 transistor it is only 290–340 mA. Robots with L298 only experienced 1 path error out of 5 attempts, while robots with 2N2222 experienced 3 errors. The selection of motorcycle drivers greatly affects the performance of the line follower robot. The L298 module provides better stability in controlling the motor, albeit with higher power consumption. On the other hand, the 2N2222 transistor is more efficient in power usage, but it has less stable performance. Further research can study the combined use of both motor drivers to achieve a balance between power efficiency and control stability.

Keywords – robotic practice; robot line follower; DC motor; 2N2222 transistor; L298 module; motor driver

I. INTRODUCTION

The development of robotics today is accelerating, with many applications that can improve efficiency and automation in various fields. One of the commonly used robotics applications is the line follower robot, which is a robot that is designed to follow a certain path automatically. In its operation, this robot utilizes sensors to detect lines and motors to move the robot following the line. The control system used to drive the motor plays an important role in the performance of the line follower robot, as it will affect the speed, stability, and accuracy of the robot's movements (et al., 2019).

In this practicum, we studied the DC motor control system in a line follower robot, using two different types of motor drivers, namely the 2N2222 transistor and the L298 module. The use of these two components aims to analyze the difference in performance in driving a DC motor without using a microcontroller. In this practicum aims to find out the sensor response, compare the power consumption, speed, and path accuracy produced by the two motorcycle drivers (Herdianto, 2020).

The purpose of this practicum is to provide an understanding of how to control a DC motor in a line follower robot without a microcontroller. Specifically, this practicum aims to identify and compare the performance of the two motor drivers, as well as to evaluate their effect on the stability and efficiency of the robot in following the path.

1. Understand the working principle of IR sensors in detecting lines based on infrared light reflections.
2. Implement the 2N2222 transistor as a switch to control the DC motor based on the output signal from the IR sensor.
3. Analyze the response of IR sensors to the color of the path surface in an automation system.
4. Understand the use of resistors in circuits to control current and prevent damage to electronic components.

II. RESEARCH METHODS

2.1 Materials and Tools Used

1. Sensor IR/TCRT5000
2. LED Lights
3. Transistor 2N2222
4. Diode IN4007
5. Breadboard/PCB bolong dan kabel jumper
6. Resistor:
   a. 150 Ω (to limit the current to the transistor base)
   b. 1 KΩ (to adjust the sensitivity of the IR sensor)
7. Lippo 3 Cell Battery (11.5 V DC)
8. Regulator Module (Step Dwon)

9. Switch
10. Color board (black and white) as a line detection medium
11. DC Motor and Gearbox
12. Module Driver L298

2.2 Experimental Design

The purpose of this practicum is to compare two configurations of line follower robots that use different motor drivers, namely the 2N2222 transistor and the L298 module. Before assembling the actual kit, the research practice began by creating a series of simulations on the proteus 8.12 application.

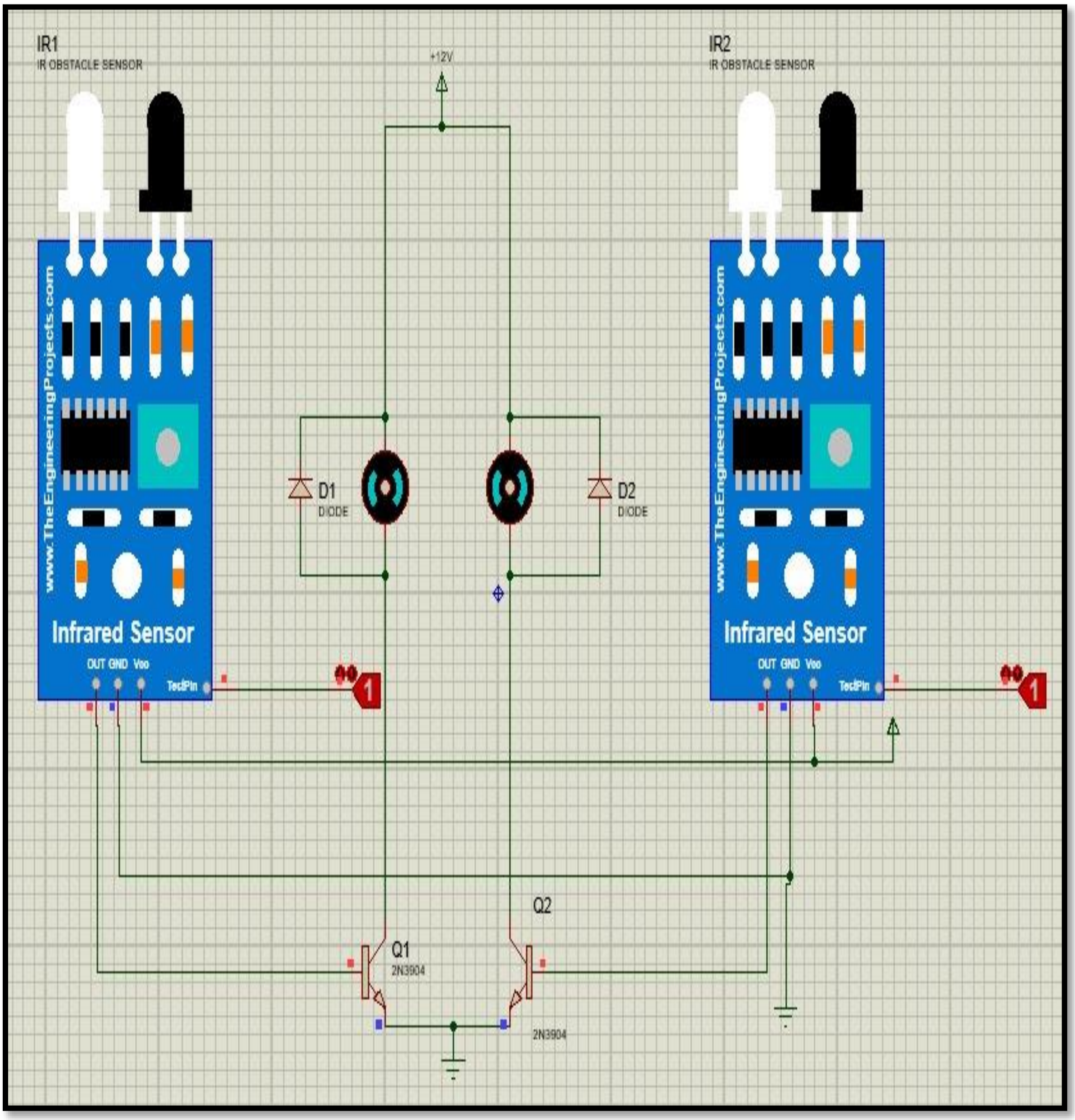
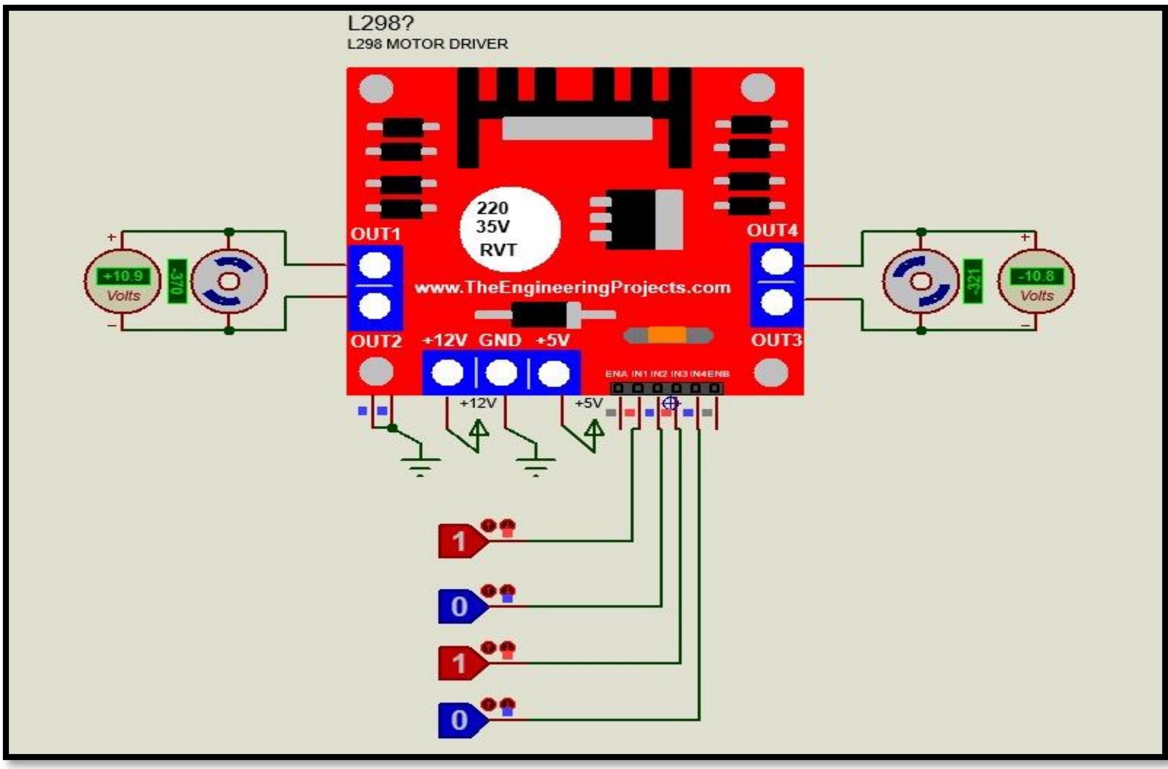


Figure 2.2.a Analog Line Follower Circuit With 2N222 Transistor Driver



on the path.

2. Testing:

   a. The robot is run on a 4-meter-long oval strip.

   b. Each experiment was carried out 9 times to measure the sensor's response and 5 times to test the robot's stability in following the path.

3. Observation:

   a. Sensor response, robot average speed, power consumption, and path accuracy are observed and recorded.

   b. Speed is measured by calculating the time it takes the robot to complete the oval path, while power consumption is measured by using a multimeter.

   c. Path accuracy is measured by recording the number of errors or deviations from the path that occur in each experiment.

4. Data Logging:

a. The average speed of the time it takes the robot to complete the path is 4 meters.

b. The current power consumption used by the robot during operation, is measured using a multimeter.

c. Path error: the number of deviations or errors that occurred during the experiment.

d. Measure and observe changes in the IR sensor TCRT5000.

2.4 Data Collection and Analysis Techniques

The data obtained from each experiment were in the form of TCRT5000 IR sensor response, travel time, current consumption, and the number of path errors. The data was analyzed descriptively to obtain a comparison between the two motorcycle drivers used. The test results will be compared to see the influence of the driver on the TCRT5000 sensor response, speed, power consumption, and the precision of the robot's movement. To analyze the results of the experiment, the technique used is comparative analysis. Data from both types of motor drivers will be compared based on average speed, power consumption, and lane error rate (Sukamta et al., 2024).

2.5 Basic Theory

2.5.1. Robot Line Follower

A line follower robot is a type of robot that is designed to follow a certain predetermined path, usually in the form of a black line on a white surface. The robot is equipped with a sensor that detects lines, and based on the input from the sensor, the robot will control the motor to follow the path. The control system on the line follower robot can use various types of sensors such as infrared (IR) sensors or optical sensors, as well as different types of motor drivers to drive the robot's wheels (Junita et al., 2023).

2.5.2. Motor DC

A DC (Direct Current) motor is a motor that works on the basis of direct current. This motor has two main components, namely the stator and rotor. DC motors are widely used in robotic applications due to their ability to generate easily controllable torque at appropriate angles (et al., 2021). DC motors require a uniform voltage supply to the field coil to be converted into mechanical energy. In a DC motor, there are two coils, namely a field coil that functions to produce magnetic megans and an anchor coil that functions as a place where electric motion forces (ggl E) are formed. If the current in the anchor coil interacts with turning the motor (Agustina & Nugroho, 2015).

2.5.3. Driver Motor

A motor driver is an electronic component that functions to control the motor by receiving a control signal and providing the power required for the motor to operate. This motor driver plays a role in regulating the speed, direction of rotation, and torque on the motor used in the robot. There are several types of motor drivers, one of which is the L298 module and the 2N2222 transistor, each of which has specific characteristics and applications (Sudimanto & Kevin, 2020).

2.5.4. Module L298

The L298 module is an IC (Integrated Circuit) designed to control two DC motors or stepper motors independently. This IC uses the H-Bridge principle to regulate the direction of rotation of the motor, thus allowing bi-directional control. The L298 module can provide stable speed and torque with more power, but higher power consumption compared to other components. The use of L298 modules is generally more efficient in applications that require more precise and stable motor control (Listiana et al., 2021).

2.5.5. Transistor 2N2222

The 2N2222 transistor is an NPN-type transistor that is commonly used as an electronic switch to control DC motors (Vietnam, 2023). Although the

2N2222 transistor has a lower power capacity than the L298 module, it is more efficient in power usage for applications that do not require highly precise motor control. These transistors work by regulating the flow of current through collectors and emitters to control the motor, but their performance can be limited to smaller loads or simple applications. Equations used in network analysis:

1. Arus Basis Transistor ():I_B

$$I_B = \frac{V_{out} - V_{BE}}{R_B}$$

2. Collector Current (Ic) with Transistor Gain:

$$I_c = h_{FE} x I_B$$

3. LED Resistors (220Ω) for Limiting Current:

$$R = \frac{V_{sumber} - V_{LED}}{I_{LED}}$$

2.5.6. Motor Speed and Direction Control

The speed and direction of the motor can be controlled by using two main methods: changing the voltage applied to the motor or using the Pulse Width Modulation (PWM) technique. PWM allows the motor speed to be adjusted by changing the duty cycle of the control signal, so that the motor receives the average power according to the desired speed. This PWM is usually applied to motor drivers to achieve more efficient and smooth speed control (Hanifah & Yuhendri, 2023).

2.5.7. Working Principle of Line Follower Robot

The line follower robot operates by utilizing sensors to detect lines on the floor and transmit that information to a microcontroller, which then processes that information and gives commands to the motor driver to change the direction or speed of the motor. In order for the robot to stay on track, the control system must be responsive to changes in track conditions. Therefore, the selection of

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an efficient and reliable motor driver is essential to improve the performance of the robot in following the path (Panji Anom Respati et al., 2023).

III. RESULTS AND DISCUSSION

3.1 Experimental Results

The results of the experiment were obtained by testing a line follower robot using two types of motor drivers, namely transistor 2N2222 and module L298, on a 4-meter oval circle shaped path. Each experiment was conducted 9 times, with data recorded by the sensor's response, for average speed, power consumption, and number of path errors.

3.1.1 Sensor Test Results Using 2N2222 Transistor Driver

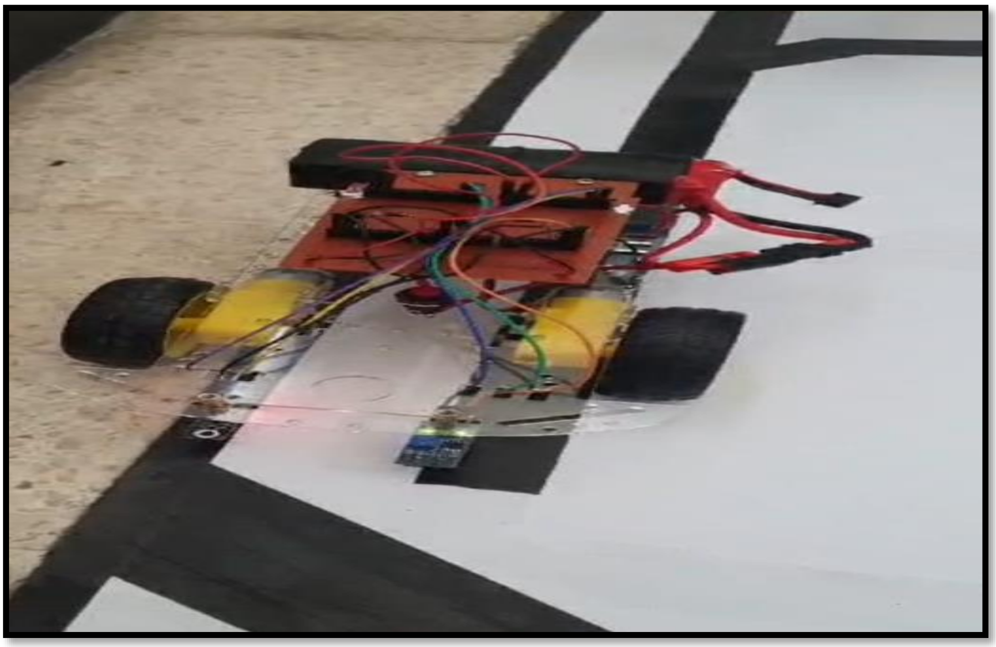

Figure 3.1.1a Testing Sensors with Transistor Driver 2N2222

The test results as shown in Figure 3.1.1 show that the IR sensor successfully distinguishes the color of the surface based on the intensity of the infrared light reflection. When the sensor is above the black surface, the transistor is active, allowing the LED to illuminate. Instead, when the sensor is above the white surface, the transistor is inactive, and the LED turns off.

Table of White Path Object Detection Experiment Results:

WHITE OBJECT DETECTION								
No	DISTANCE Cm	VOUT AND (Was)	IB (mA)	IC (mA)	IE (mA)	STATUS TR	STATUS MOTOR	LED
1	0	4,97	0,0284	28,4	0,806	ON	ON	0N
2	0,5	0,50	0,0013	0,13	0,000160	OFF	ON	ON
3	1	0,50	0,0013	0,13	0,000169	OFF	ON	ON
4	1,5	0,49	0,0014	0,14	0,000196	OFF	ON	ON
5	2	0,49	0,0014	0,14	0,000196	OFF	OFF	ON
6	2,5	0,50	0,0013	0,13	0,000169	OFF	OFF	ON
7	3	0,48	0,00146	0,146	0,000213	OFF	OFF	ON
8	3,5	0,49	0,0014	0,14	0,000196	OFF	OFF	ON
9	4	4,98	0,0285	2,85	0,081	OFF	OFF	OFF

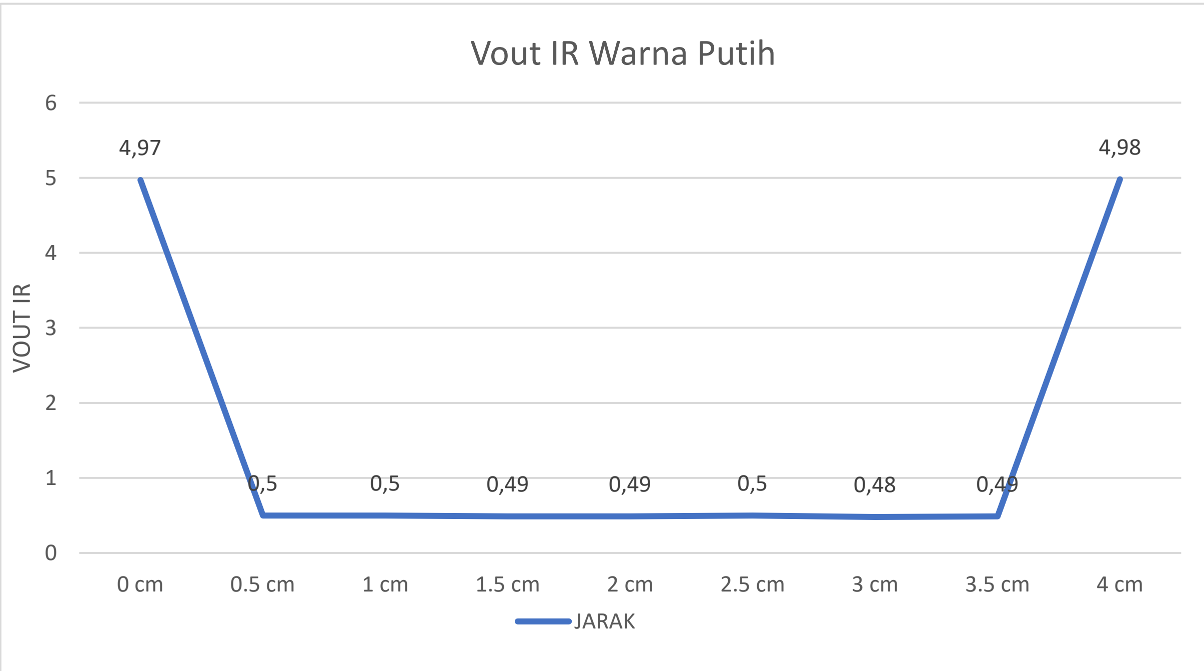

Figure 3.1.1b Voltage Graph of White Object Detection IR Sensor Output

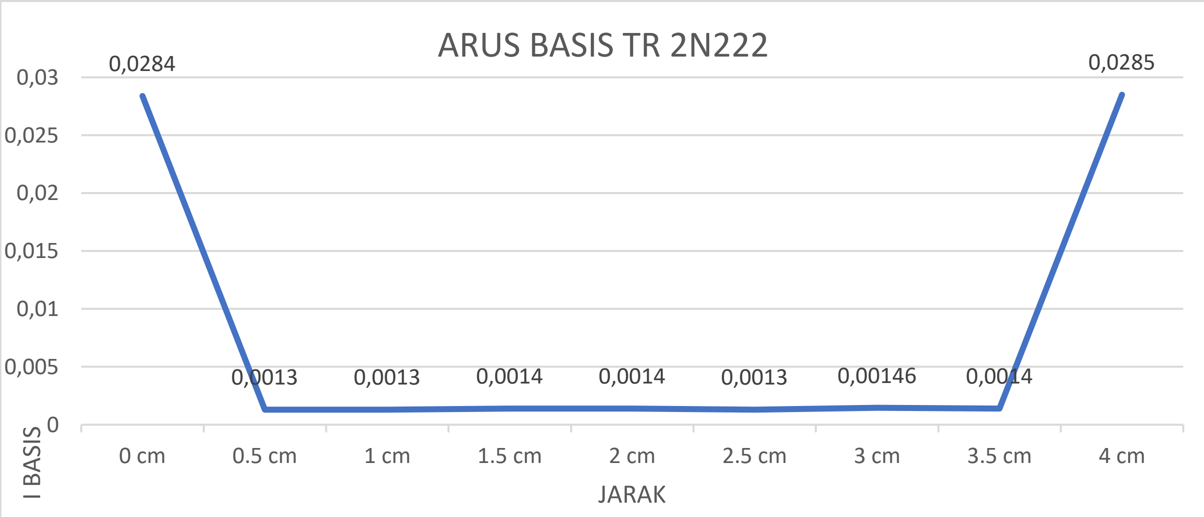

Figure 3.1.1c Tr Base Current Graph of White Object Detection IR Sensor Output

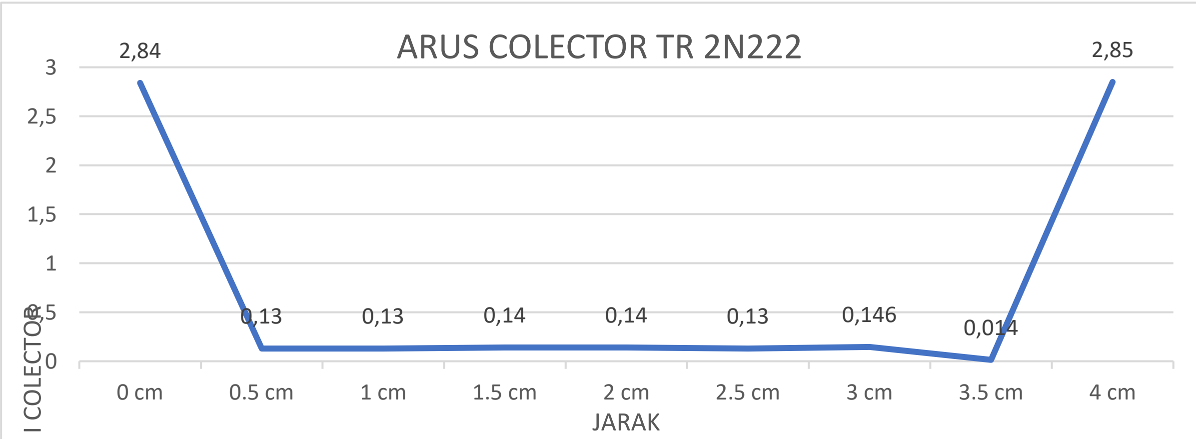

Figure 3.1.1d Tr Colector Current Graph of White Object Detection IR Sensor Output

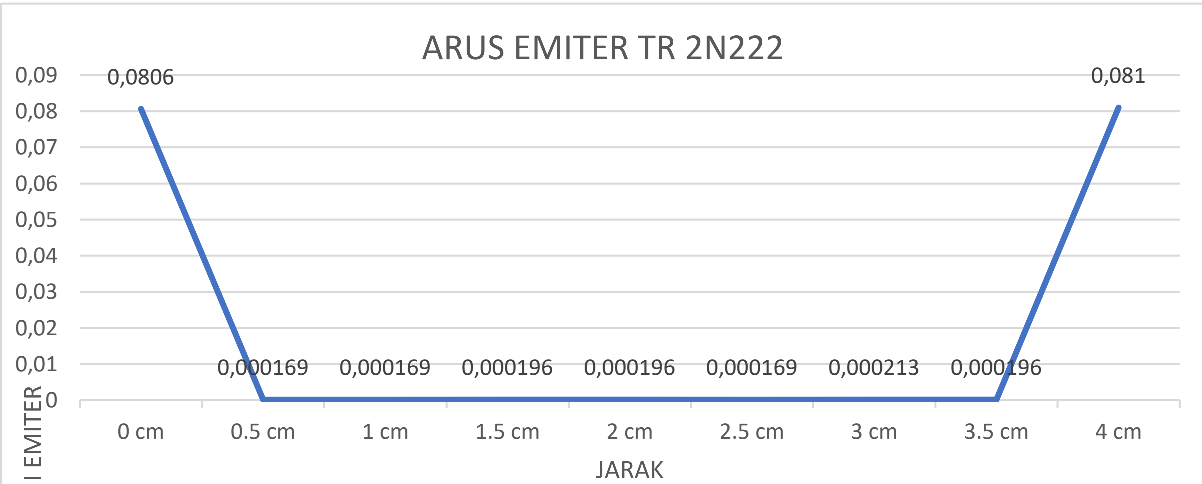

Figure 3.1.1e Tr Emitter Current Graph of White Object Detection IR Sensor Output

Table of Black Path Object Detection Experiment Results:

BLACK OBJECT DETECTION								
No	DISTANCE Cm	VOUT AND (Was)	IB (mA)	IC (mA)	IE (mA)	STATUS TR	STATUS MOTOR	LED
1	0	4,91	0,028	2,8	0,0784	ON	ON	OFF
2	0,5	4,94	0,0282	2,82	0,0795	ON	ON	OFF
3	1	4,97	0,0284	2,84	0,0806	ON	ON	OFF
4	1,5	4,97	0,0284	2,84	0,0806	ON	ON	OFF
5	2	4,97	0,0284	2,84	0,0806	ON	ON	OFF
6	2,5	4,98	0,0285	2,85	0,081	ON	ON	OFF
7	3	4,97	0,0284	2,84	0,0806	ON	ON	OFF
8	3,5	4,97	0,0284	2,84	0,0806	ON	ON	OFF
9	4	4,98	0,0285	2,85	0,081	ON	ON	OFF

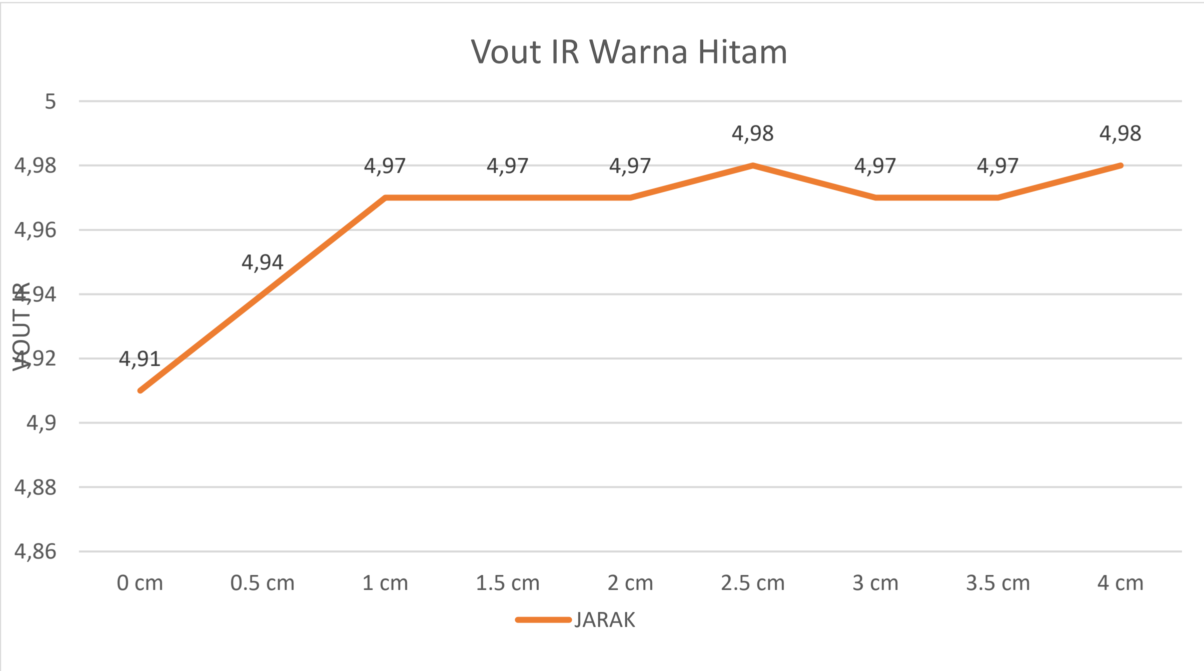

Figure 3.1.1f Voltage Graph of Output IR Sensor Black Object Detection

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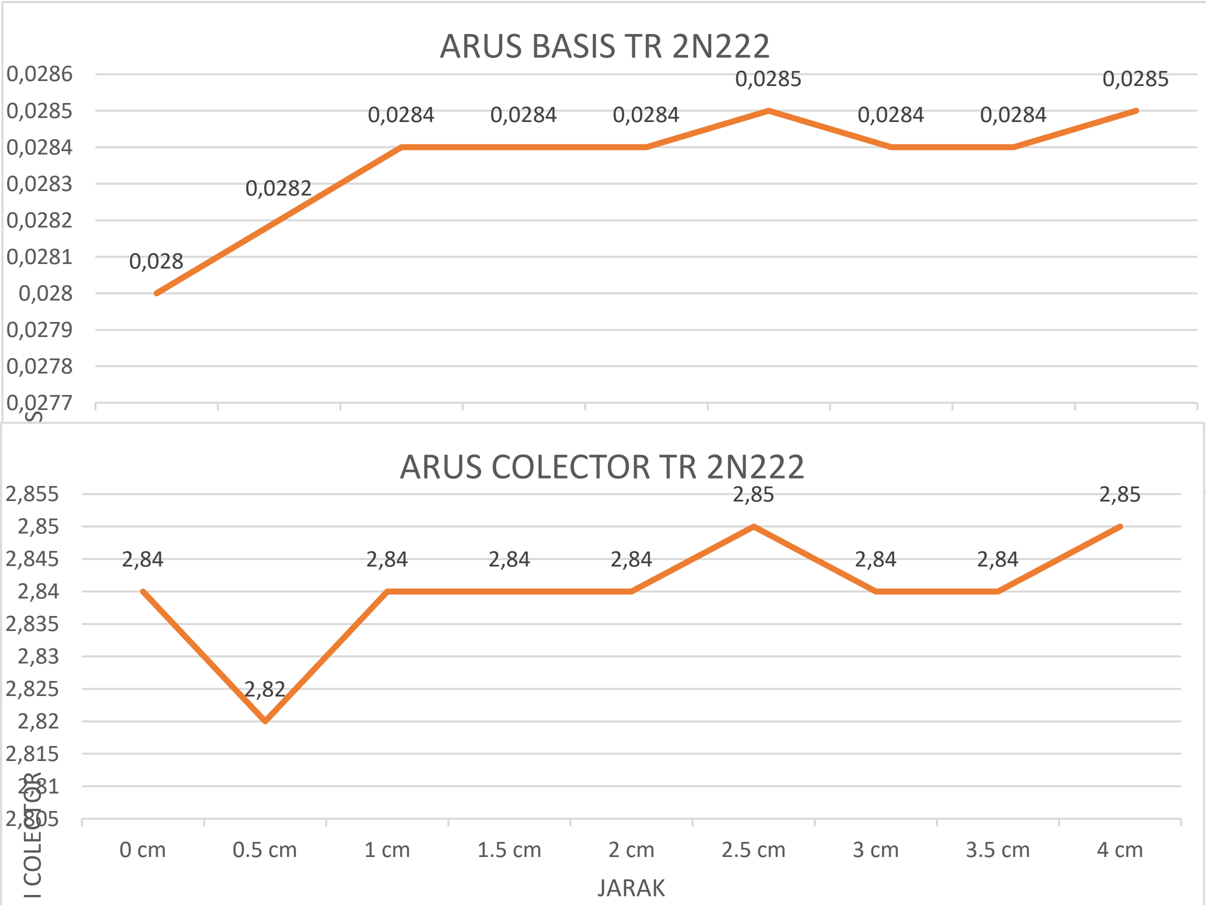

Figure 3.1.1h Tr Collector Current Graph of Black Object IR Sensor Output

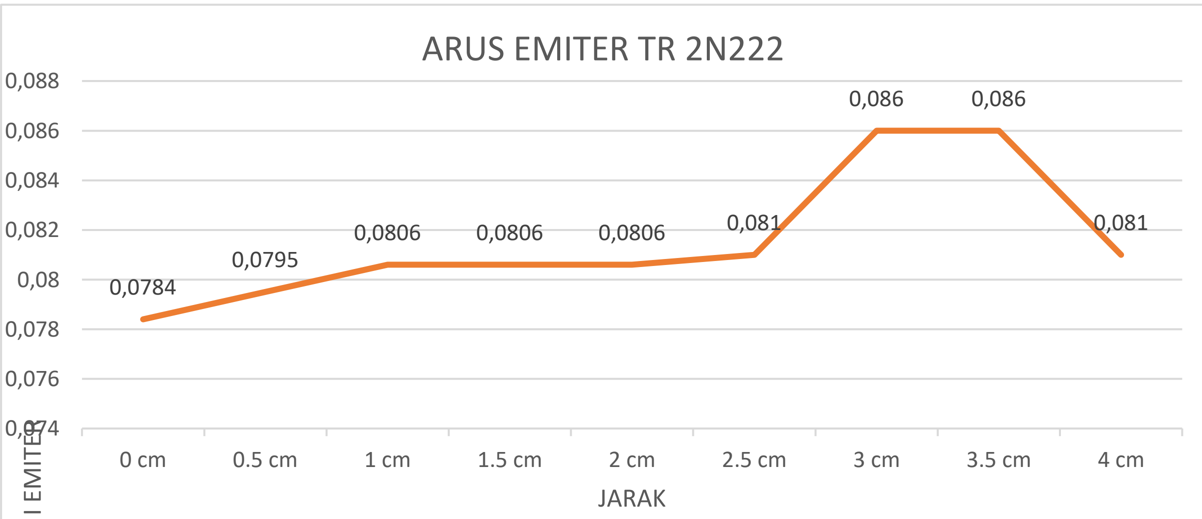

Figure 3.1.1i Tr Emitter Current Graph of the IR Sensor Output of a Black Object

3.1.2 L298 Driver Test Results

Average Speed The robot using the L298 module has an average speed of 0.42 m/s. These results show that the L298 module is capable of delivering higher speeds, which is due to more stable and more efficient control compared to the 2N2222 transistor. Power consumption with the L298 module ranges from 480–520 mA. Although the L298 module provides better performance in terms of speed, the higher power consumption is a major drawback compared to the use of the 2N2222 transistor, which is more efficient in power usage. The robot with the L298 module only experienced 1 path error out of 5 attempts. The L298 module exhibits more stable and accurate performance in following the path compared to the 2N2222 transistors.

Table of Results of L298 Driver Experiments

NO	Travel Time(s)	Speed (m/s)	Current Usage (mA)	Strip Allergy (Offset)
1	9.5	0.42	510	0
2	9.7	0.41	500	0
3	9.6	0.42	520	1
4	9.4	0.43	480	0
5	9.5	0.42	490	0
Average	9.54	0.42	500	0.2

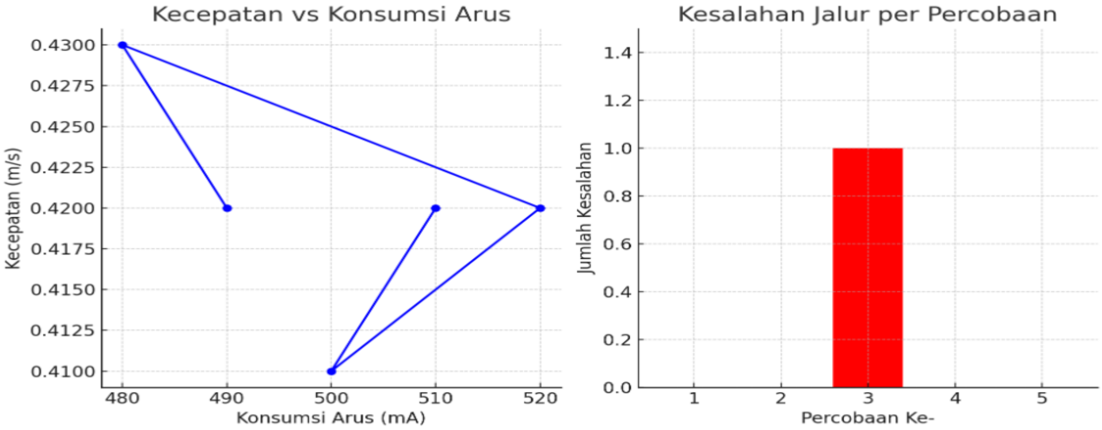

Figure 3.1.2 Speed-Consumption Graph of Aurs and Lane Error

IV. CONCLUSION

Based on the results of the experiment, it can be concluded that the selection of the right motorcycle driver greatly affects the performance of the line follower robot. The L298 module provides better performance in terms of motor control speed and stability, despite having a higher power consumption than the 2N2222 transistor. Robots with the L298 module show higher speeds, fewer path errors, and better motion stability. Meanwhile, the 2N2222 transistor is more efficient in terms of power consumption, but it cannot provide the same stability as the L298 module. Therefore, in line follower robot applications that require stability and speed, the L298 module is more recommended.

For further research, trials can be conducted with other motor drivers that may offer a balance between speed, stability, and power efficiency. In addition, further research may also involve the use of microcontrollers to improve control of the motor, which can improve the robot's performance in terms of path accuracy and more dynamic speed regulation.

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