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Construction Of Railway Door Automation Prototypes Using Arduino, Servo Motors and Ultrasonic Sensors

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Abstract

The Indonesian railway system is currently experiencing a lot of developments in terms of technology. The Indonesian railway system has been integrated with technology 4.0, where all transaction processes, whether payment, ordering tickets or monitoring trains, can be monitored via electronic media. Of course, this technology must be supported by adequate infrastructure, one of which is the railroad crossing. In Indonesia, several railroad lines have been constructed, and many portal or crossbar railroads have also been constructed. The railroad gate is part of the railway system which has a very important role, especially in regulating the safety of train travel. The rail gateway has been a problem and a source of accidents in recent years. This is because there are no security facilities at any rail portals, causing drivers to continue to break traffic laws. The making of this automatic railroad doorstop uses the Prototype method, namely a simulation that uses Arduino UNO R3, servo motors, HC-SR04 ultrasonic sensors and other components that can support the manufacture of this railroad doorstop prototype. The prototype of this automatic train doorstop is equipped with many sensors that works automatically according to what is ordered, so that its use can be easily controlled and implemented in real life. This automatic railroad crossing system is expected to optimize the task of the railroad crossing guard by providing automation for the process of opening and closing the railway door and providing additional warning information for the community around the railway door location so as to reduce the potential for accidents caused by drivers or people who break traffic laws.

Keywords: *Railway, Arduino, Motor servo, Sensor ultrasonic*

1. Introduction

The train is the mode of land transportation that is most in demand by all people, almost all over the world [1]. The train works with a timeliness level of almost 100% with a train speed of approximately 100 km/hour, and has fares or fees that are in accordance with the economic

conditions of the Indonesian people. According to research from [2] said that the choice of transportation depends on the type of transportation you use. The available transport types are: walk or use a vehicle, private vehicle (bicycle, motorcycle, car) or public transportation (bus, public transit, bicycle, train, etc.). Transportation choices are based on shortest route, fastest time, lowest cost, or a combination of the three. According to Tamin (2000) in [3], the factors that influence the rating of modes of transport can be divided into four characteristics: Characteristics of road users, characteristics of users, characteristics of means of transportation and facilities, characteristics of cities and built-up areas. The train is the best choice for traveling because it is effective and very efficient in the process of mobilizing from one place to another [4]. The speed of the train certainly has a very dangerous impact on the safety of many people, not only train passengers, there are many reports of accidents due to delays by train gate officers closing the train door (human error). There are four factors that cause accidents at railroadcrossings. First, road users are not trained in obeying traffic rules at railroad crossings. Second, road users can't stand long queues and traffic jams when driving past. Third, it still lacks safety features such as no door stopper Railroad crossings do not have signs, signs, signs or bumper strips (speed bumps). The 4th, Accidents also occurred among local residents due to lack of understanding of local conditions [5]. By automating the opening and closing of the railway door and providing more warning information to the neighborhood near the location of the railway door, this automatic railroad crossing system is expected to improve the job of the railroad crossing guard and lower the risk of accidents occurring when crossing the railway door. when an approaching train is.

The railroad doorstop system which is still manual, of course, can still work well and can still be used to close road access when there are trains. technology. Making this prototype utilizes Microcontroller technology, namely an Arduino UNO R3, SG90 Servo Motor, HC-SR04 Ultrasonic Sensor, LED Lights, Buzzer and LCD Screen, so that it can be operated to adjust the railway doorstop automatically according to what we want [6]. Making doorstop automation using a variety of sensors including Arduino devices, Piezeotronic sensors, and equipped with servo motors, Infrared, Buzzer, LEDs capable of detecting the arrival of a train The usage of the HC-SR04 ultrasonic sensor to detect the arrival of a train at a set distance and LED lights as an additional indicator when a train is approaching. This addition is a development of previous research [7]

From the research proposed [8], door control and monitoring prototype IoT-based railroad crossing MIT Inventor applications can work with sensors RFID travels at an average speed of 12.55 cm/s, also trigger the servo motor. The Inventor handled directly by Firebase as a real-time database, the it displays the status of the bar and crowd in gate area intersection.

The use of hardware in making this simulation functions as a physical implementation of the software that we process. The Arduino UNO R3 is a very popular and very smart microcontroller device that can be used in a wide variety of projects. The Arduino has a microcontroller board using ATmega328 technology [9] and can hold up to 32kb of data, making it useful for many electronics projects. The Arduino has 20 input/output pins that can be customized according to the sensor needs of each project.

Hilal, A., and Manan, S. in[10] SG90 said that a servo motor is a motor with a closed loop feedback system in which the position of the motor is fed back into the servo motor's control circuit. Servomotors support movement and display the response of each running program. In this automatic railroad doorstop prototype, this servo motor acts as an actuator or function to automatically raise and lower the train doorstop**.**

HC-SR04 ultrasonic sensor acts as a signal to other components this sensor provides a digital signal when the train leaves a certain distance detected [11], so the role of HC-SR04 ultrasonic sensor is very important in the production of this prototype railroad door stop. When signaled, other components react to information signals from this sensor.

LEDs (Light diodes) are small, bright, power capable lights commonly used in electronic commodities [12]. It is an additional component that is used to provide an indication when there

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is a signal from the Ultrasonic Sensor, the LED light will light up. The commonly used LED lights are Red, Yellow and Green. LCD screens and I2C modules are components designed to display information in text form on existing screens. The I2C module is a module that helps you install your LCD screen easily and efficiently. Using the I2C module reduces the number of cables used during installation, simplifying the LCD screen installation procedure and increasing efficiency. A buzzer is an electronic component that emits a sound when it receives a signal from an ultrasonic sensor [13]. There are two types of buzzers: active buzzers and passive buzzers. An active buzzer is a buzzer that can immediately sound a sound with a signal from an ultrasonic sensor, and a passive buzzer is a passive buzzer that cannot sound a sound immediately with a signal from an ultrasonic sensor. Installed to work out of the box sound.

In addition to the components above, there are several components that support the design of automatic railroad crossings, such as: Male to Female Jumper Cables, Male to Male Jumper Cable, Project board and 12 Volt Adapter.

2. Research Methodology

The making of this automatic railroad doorstop uses analysis research methods. The use of software that is used to run this automatic train doorstop prototype is Arduino IDE Software, Draw Io and Microsoft Excel. The Arduino IDE functions to enter, change each program that will be configured later. Draw Io functions to create diagrams and use cases, and Microsoft Excel functions to load numeric data in tabular form which will be processed later. There is a hardware design or scheme used, flow chart design method that will describe the sequence process of Railway Door Automation Prototypes, the cable design depicted on the wiring diagram. Making the prototype model in this study consisted of two prototyping stages, where there was additional equipment on the second prototype. The testing method used consists of software and hardware testing to analyze whether the device has functioned according to the expected scheme.

2.1 Diagram Block

The block diagram is a basic description of the system design. Each part of the system block has its own function [14]. The block diagram of railway door automation prototype shown in the Figure 1 below:

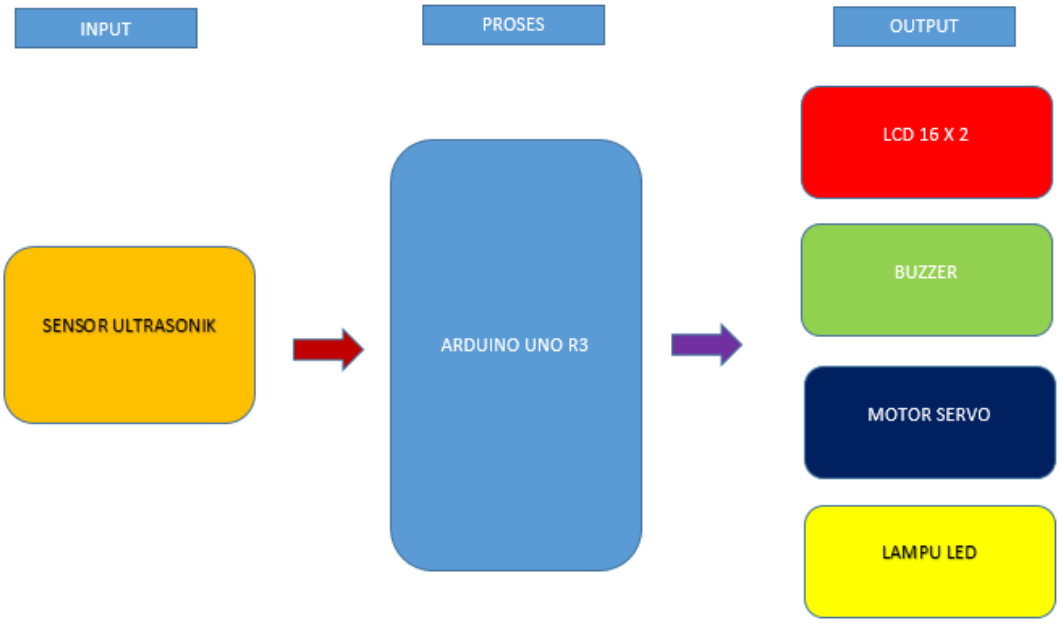

Figure 1. Diagram Block Railway Door Automation Prototype

From the results of Figure 1, the design consists of input, process data / program, and output. The input part is using Ultrasonic Sensor. The output consists of: motor servo, LCD for display alert, LED lights and buzzer. Arduino Uno R3 is used to process program data.

2.2 Flowchart

Design the flow chart of automatic railroad doorstops shown in the Figure 2 below

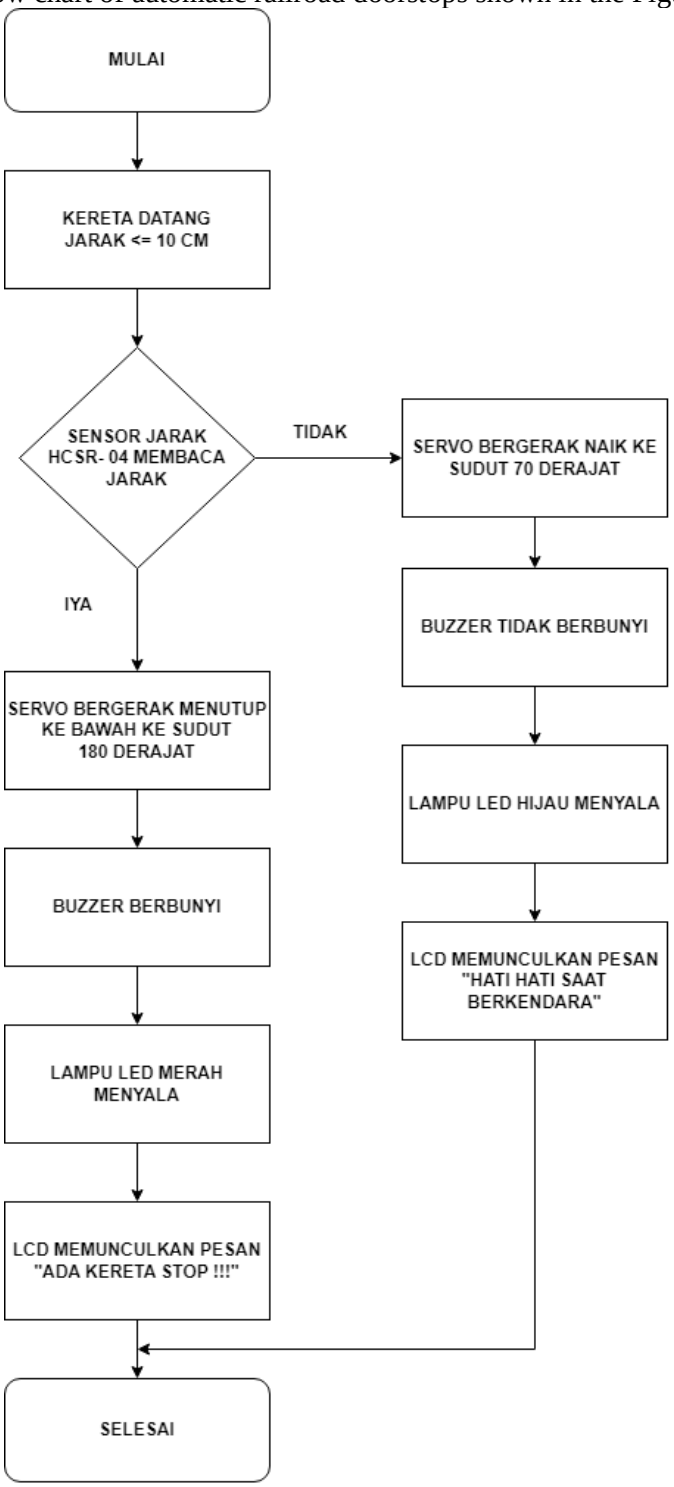

Figure 2. Flow Chart of Automatic Railway Doorstop

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The flow chart shown in Figure 2 can be explained as follows:

1. When there is an object (train) at a distance of <= 10 cm, the HC-SR 04 ultrasonic sensor will respond by giving a signal to all components that have been installed.
2. After that, if the signal is received by all components, all components will respond according to their respective functions, such as: The Servo Motor will move down 180 degrees, the Buzzer will sound, the LED light will turn red and the LCD screen will display the message " Ada Kereta Stop!!!".
3. Then if there is no object (train) at a distance of <= 10 cm, the HC-SR 04 ultrasonic sensor will not give any signal, thus indicating the absence of a train.
4. When there is no train, all components will be in their initial configuration positions such as; the LED indicator light will remain green, the servo motor remains in a position above 70 degrees, the buzzer does not sound and the LCD screen displays the message " Hati hati saat berkendara ".

2.3 Wiring Diagram

The schematic below serves as a visual reference for connecting the components [15]. Design and manufacture of wiring for railway door automation, including the principle of operation of tools for the communication system Arduino Uno R3, HC-SR04 ultrasonic sensor. The wiring for this system consists of a Arduino Uno R3, HC-SR04 ultrasonic sensor, SG90 servo motor, LCD for displays alert, LED lights, buzzer, male to male jumper cables, male to female jumper cables, project board and volt adapter. The diagram shown in Figure 3 below:

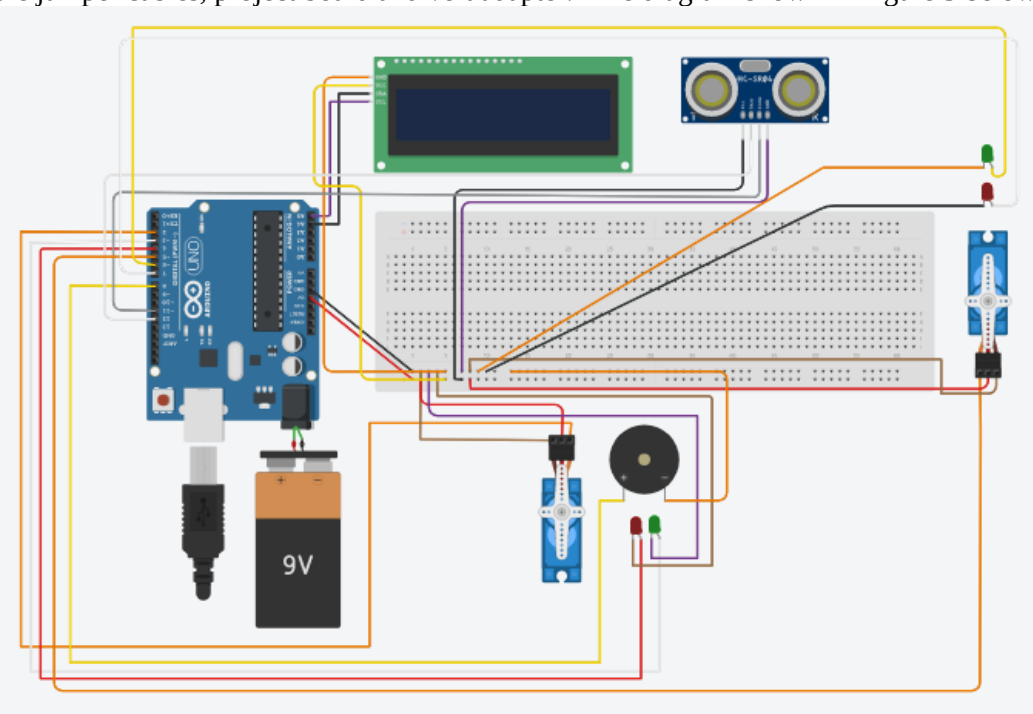

Figure 3. Schematic of Wiring Diagram

2.4 Prototype Model

The method for making Prototype 1 in the design of this automatic railroad crossing uses several sensors and components that function to run the program that has been designed. Results of first prototype shown in the Figure 4.

The method for making Prototype 1 in the design of this automatic railroad crossing uses several sensors and components that function to run the program that has been designed. Arduino UNO R3 is connected to all the components in the design of this automatic railroad crossing system. It gets a power supply from a 12-volt adapter then distributes electricity to the

Project board which is the place for all components to get electric voltage and can be configured as needed. When the Arduino has been successfully programmed properly, the Ultrasonic Sensor will become a reference for all components connected to the Arduino

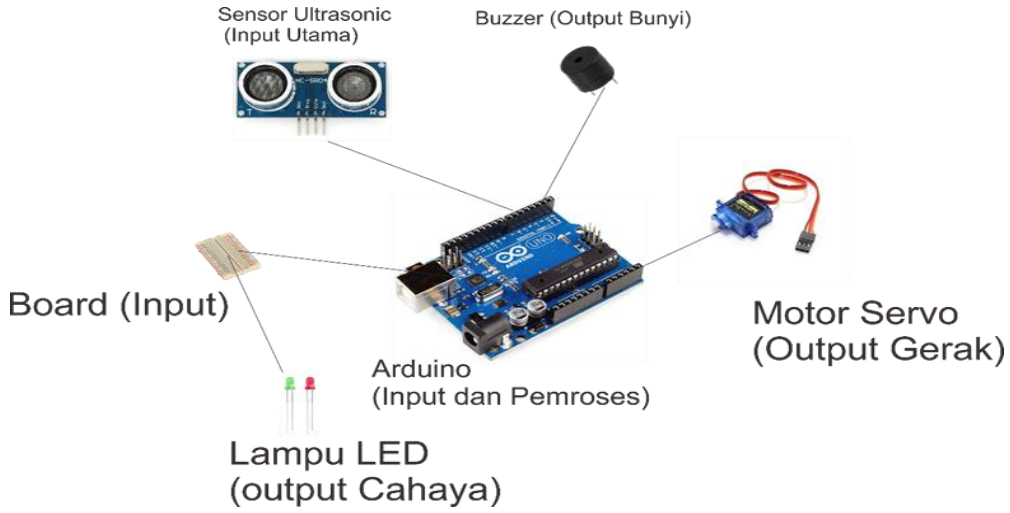

Figure 4 Railway Door Automation Prototypes 1

This Ultrasonic sensor is configured to be able to detect trains with a distance of approximately 10 cm, so that when there is a train this sensor will work and can provide signals for other components. After there is a signal from the Ultrasonic Sensor, all components that become the receiver will function properly automatically. The servo that is made for the doorstop will close the train's doorstop and the Buzzer, LCD and Indicator Light will simultaneously light up until the train passes the crossing and is no longer detected by the Ultrasonic Sensor.

The development of automatic rail doorstops for the prototype 2 model is a development of the prototype model 1. It is shown in the Figure 5

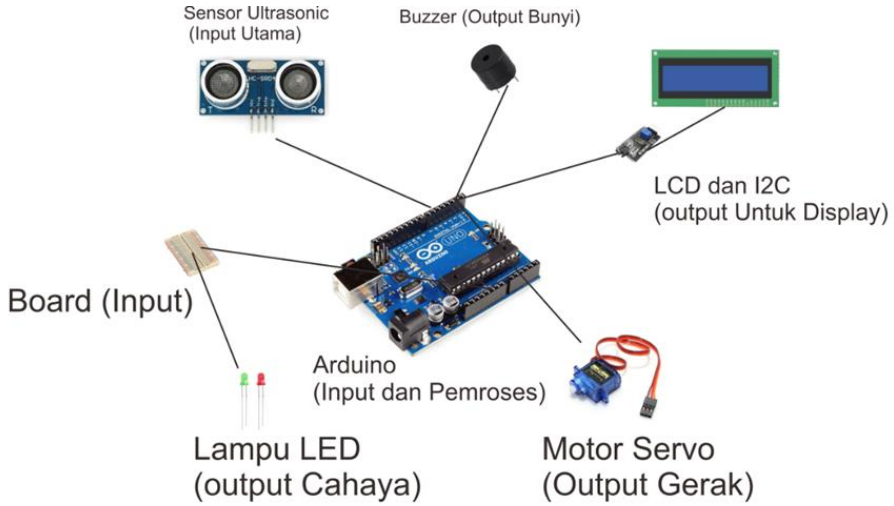

Figure 5 Railway Door Automation Prototypes 2

The making of the automatic railroad doorstop for the prototype 2 model is a development of the prototype model 1 model where in prototype model 1 there is no output in the form of writing on the LCD layer so that with the LCD the message displayed will certainly make road users aware of an object (train) at a predetermined distance, it will be visible to all road users when crossing the railroad crossing.

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2.4 Testing Scheme

Software testing is focused on using the Arduino IDE Software which will later be used as a place to enter the program. So, the test is to provide an indication that the program can run properly. Testing on the Arduino UNO is focused on whether each connected component can run properly. Tests on the HC-SR04 Ultrasonic Sensor were carried out in several distances (cm) and resulted in tests.

3. Result and Analysis

According to prototype 1 modeling, the design focuses on using sound sensors (buzzers) and LED lights as the main indicators to provide output when there are trains come. The result of prototype 1 is shown in the Figure 6

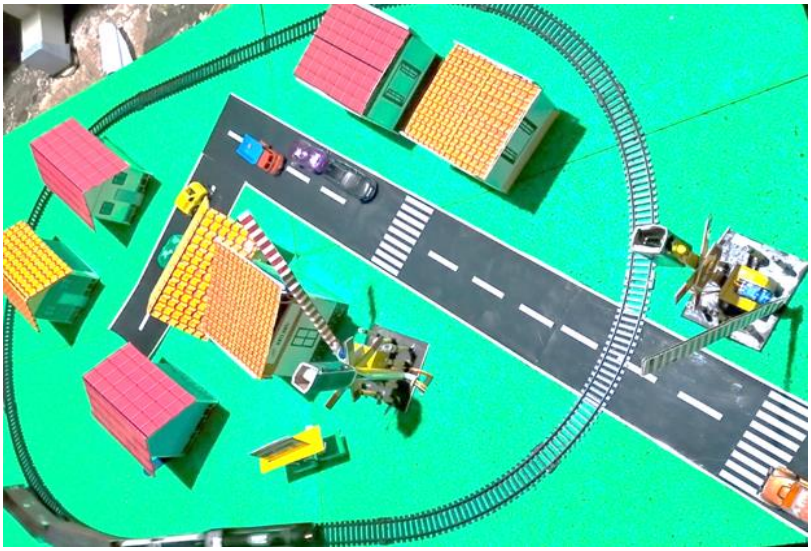


Figure 6. Prototype 1

The concept of the installation and flow of input and output components is no different from the prototype model 2 than the previous one. However, there is the addition of an LCD layer which functions to display messages in the form of writing on the LCD layer. It is shown in the Figure 7

Figure 7. Prototype 2

The LCD added in the model shown in the Figure 8 below:

Figure 8. LCD displays alert

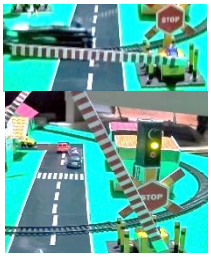
Testing on the Arduino IDE software consists of testing functions, configurations, features and tools. The test results are shown in Table 1 below:

Table 1. Arduino IDE software testing

Testing	Results
Function	Software Works and Turns On
Configuration	Software Can Configure and Make Programs
Fitur	Features Work Well
Tools	All Tools Can Run Well

Testing on all hardware is done by seeing all equipment in a condition that can be turned on. this is shown in Table 2 below:

Table 2. Testing on all hardware component

Equipment	**Description**	**Results**
Arduino UNO R3	On	
Sensor Ultrasonic HC-SR04	On	
Motor Servo SG90	On	

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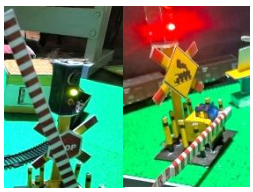
Equipment	Description	Results
LCD	On	
LED Lights	On	
Buzzer	On	

Testing on the Arduino UNO is focused on whether each connected component can run properly. Tests on the HC-SR04 Ultrasonic Sensor were carried out in several distances (cm) and resulted in the following tests shown in Table 3 below:

Table 3. Testing on Sensor Ultrasonic HC-SR04

Distance (Cm)	Results
7	Well Detected Objects and Distances
8	Well Detected Objects and Distances
9	Well Detected Objects and Distances
10	Well Detected Objects and Distances
21	Object and Distance Not Detected
22	Object and Distance Not Detected
23	Object and Distance Not Detected
24	Object and Distance Not Detected

The test results from the Ultrasonic Sensor show that objects are detected within a range <= 10cm, while objects are not detected above 10 cm, the results of distance measurements were not mentioned in research [7], while in previous research [1] there were similar results, namely objects would be detected at a distance of less than 10 cm.

Tests on the Servo Motor SG90 were carried out by looking at the movement and the opening and closing angles of the train door latch, shown in Table 4 below:

Table 4. Testing on Servo Motor SG90

Distance (Cm)	Results
7	Servo Move closes to a 180 Degree angle
8	Servo Move closes to a 180 Degree angle
9	Servo Move closes to a 180 Degree angle
10	Servo Move closes to a 180 Degree angle
21	Servo Moves up to a 70 Degree angle

Distance (Cm)	Results
22	Servo Moves up to a 70 Degree angle
23	Servo Moves up to a 70 Degree angle
24	Servo Moves up to a 70 Degree angle

The test results from the servo motor show that at a distance of <= 10cm where the train object is detected, the servo moves to close at an angle of 180 degrees, while the servo will open at an angle of 70 degrees if the object is outside the specified distance. The results of testing the servo motor by looking at the distance are not explained in the previous research [1].

Tests on the LCD displays has a correlation with the Sensor Ultrasonic HC-SR04. The LCD will display alert Ada kereta stop!!! when the Sensor Ultrasonic HC-SR04 detects the train object. It will display hati-hati dalam berkendara when object passes the distance limit, it is shown in Table 5 below:

Table 5. Testing on LCD Display

Distance (Cm)	Results
7	LCD displays the message Ada kereta stop !!!
8	LCD displays the message Ada kereta stop !!!
9	LCD displays the message Ada kereta stop !!!
10	LCD displays the message Ada kereta stop !!!
21	LCD displays the message hati – hati dalam berkendara
22	LCD displays the message hati – hati dalam berkendara
23	LCD displays the message hati – hati dalam berkendara
24	LCD displays the message hati – hati dalam berkendara

The test results from the LCD displays show that at a distance <= 10cm where the train object is detected, or where the train is not detected, according to the distance, the LCD displays the message as expected.

Tests on the LED also has a correlation with the Sensor Ultrasonic HC-SR04. The LED will display red when the Sensor Ultrasonic HC-SR04 detects the train object. It will display green when object passes the distance limit, it is shown in Table 6 below:

Table 6. Testing on LED Display

Distance (Cm)	Results
7	LED Displaying red means there is a train
8	LED Displaying red means there is a train
9	LED Displaying red means there is a train
10	LED Displaying red means there is a train
21	LED Displaying green means no train
22	LED Displaying green means no train
23	LED Displaying green means no train
24	LED Displaying green means no train

The test results from the LED displays show that at a distance <= 10cm where the train object is detected, or where the train is not detected, according to the distance, the LED displays colours as expected.

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Tests on the buzzer also has a correlation with the Sensor Ultrasonic HC-SR04. It will sound when the Sensor Ultrasonic HC-SR04 detects the train object and will stop when object passes the distance limit, it is shown in Table 7 below:

Table 7. Testing on Buzzer

Distance (Cm)	Results
7	Buzzer Sounds
8	Buzzer Sounds
9	Buzzer Sounds
10	Buzzer Sounds
21	Buzzer doesn't sound
22	Buzzer doesn't sound
23	Buzzer doesn't sound
24	Buzzer doesn't sound

The test results from the Buzzer shows that at a distance <= 10cm where the train object is detected, or where the train is not detected, according to the distance, buzzer sounds as expected.

4. Conclusion

Based on the results of the conclusions and discussion that has been done, the conclusions are as follows: when the HC-SR 04 Sensor detects the train object, with the specified test distance, which is below 10 cm, the servo motor will move to close at 180 angles, the LCD, LED and buzzer can display the expected alerts. Meanwhile, outside the distance of 10 cm, the motor servo will open at 70 angles, the LCD, LED and buzzer display messages as expected. The research results which show that all sensor components work properly, are expected to optimize the task of the railroad crossing guard by providing automation for the process of opening and closing the railway door and providing additional warning information for the community around the railway door location so as to reduce the potential for accidents to occur due to crossing the railway door. when a train is passing.

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