# Design and Build a Portable Traffic Light Based on Wireless Communication

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***Abstract*— Highways are an important means of transportation for people to achieve their desired goals, therefore the community and the general public also need highways that are in prime condition. However, as time progresses, many highways are not maintained, so many community activities are disrupted, resulting in queues or traffic jams. Traffic jam itself is a condition where traffic is blocked due to several factors, examples of these factors are road damage, facilities that do not function as they should, such as traffic lights that go out and require officers to come to regulate traffic flow. Therefore, we need a system that is easy to carry, easy to install and easy to apply. This research entitled "Design of a PorTable Traffic Light Based on Wireless Communication" is expected to work well with a system that can calculate queues using ultrasonic sensors and a traffic light system that can make decisions about whether the traffic light will work. The results of this research are divided into 2 which can work continuously and automatically. The results of testing the sensor system can work to calculate distances up to a range of 823 cm, but this exceeds the normal size in one lane in Indonesia which is only 600 cm wide. The percentage of error on the sensor is no more than 1% and testing the timer on the traffic light works quite well with a percentage of green light error of 4.67%, yellow light 55.5% and red light 4%.**

***Keywords*— *APILL, PorTable Traffic Light, Ultrasonic Sensor, Wemos D1 Mini.***

## I. INTRODUCTION

Highways are one of the important means of land transportation for society. Safe and comforTable highways can improve the quality of industry and economy in the community area. However, as time goes by, the condition of the highway will decline according to the age of the road. One of the obstacles that can occur is the accumulation of vehicle queues which results in traffic jams.

Traffic congestion or accumulation of vehicle queues is an event where a condition of traffic congestion is caused by several factors . These factors could be an increase in vehicle volume but not balanced by the widening of roads, natural disasters such as floods, landslides or strong winds, vehicle accidents that require a time-consuming evacuation process, construction or road/bridge repair projects that cause some roads to be closed. temporary. Traffic support facilities do not work as they should, such as traffic lights that are out.

Traffic congestion is an important thing to pay attention to so that the safety and comfort of road users is guaranteed. Congestion that occurs still requires the function of officers to regulate the flow of passing traffic using a road opening and closing system. Therefore, we need a tool that can regulate traffic when there is a buildup of vehicle queues without having to wait for officers to arrange it. The tool must be easy to move and install so that it can immediately carry out the process of breaking down vehicle buildup .

One effort to overcome traffic jams is to use traffic control devices that are automatic and easy to install. It is hoped that this tool can regulate traffic by providing the right decisions to regulate traffic flow automatically, so that it can reduce the accumulation of vehicle queues in one lane and can improve traffic performance. Traffic lights work by using sensors to detect the presence of vehicles. The sensor that is often used to detect the presence of objects and especially vehicles, is an ultrasonic sensor. Ultrasonic sensors work by emitting sound waves and then measuring the time it takes for the sound waves to return. Sound waves emitted by the ultrasonic sensor will be reflected back by the objects it encounters. The time it takes for the sound waves to return is then used to calculate the distance of the object from the sensor.

According to Law no. 22/2009 concerning Road Traffic and Transportation: traffic signaling devices or APILL, traffic lights are lights that control traffic flow installed at road intersections, pedestrian crossings/zebra crossings, and other traffic flow areas. This light indicates when the vehicle must move and when the vehicle must stop alternately from various directions.

An ultrasonic sensor is a sensor that functions to convert physical quantities (sound) into electrical quantities and vice versa. Ultrasonic waves are generated through a device called a piezoelectric with a certain frequency. This piezoelectric will produce ultrasonic waves (generally with a frequency of 40kHz) when an oscillator is applied to the object. In general, this tool will fire ultrasonic waves towards an area or target. After the wave touches the target surface, the target will reflect the wave back. The reflected wave from the target will be captured by the sensor, then the sensor calculates the difference between the time the wave was sent and the time the wave was reflected.

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Wemos D1 mini is a WiFi module based on ESP-8266. The Wemos D1 mini has a chip on board which no longer requires a microcontroller for data processing. Wemos D1 mini also has digital pins and analog pins which can be connected to other sensors or actuators. WEMOS D1 Mini is fully supported by the Arduino IDE platform, has a CPU speed of 80/160 MHZ, Flash memory of 4 MB, operating voltage of 3.3 V, with small dimensions of 34.2 mm × 25.6 mm.

A device that works based on electromagnetism to move a number of arranged contactors or an electronic switch that can be controlled from other electronic circuits by utilizing electric power as the energy source. Relays are needed in electronic circuits as executors and interfaces between loads and electronic control systems that have different power supply systems.

## II. METHOD

The research stages that will be taken in determining the next steps in preparing this research are as Fig. 1.

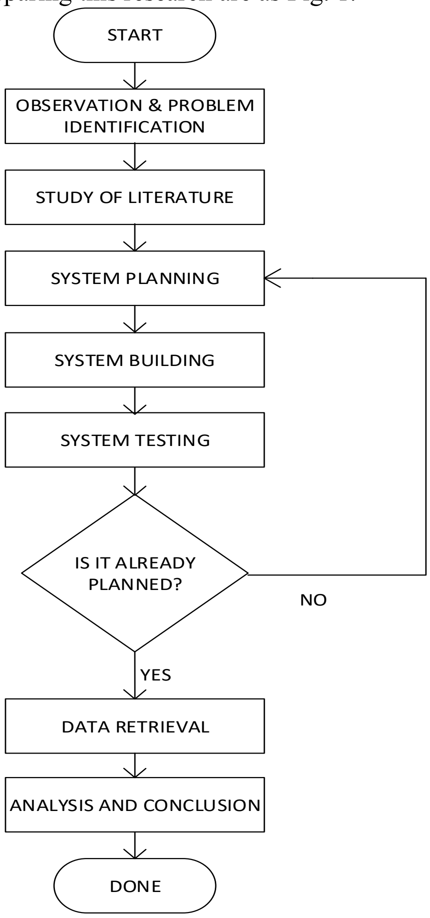


Figure 1. Research Design Flowchart

### *A. Observation & Problem Identification*

This is the stage of determining the research object and understanding the problems that occur and identifying it as the stage of determining the core of the research.

### *B. Study Of Literature*

This is the stage of searching for journals as references and theoretical bases that are relevant to the cases and problems found.

### *C. System Planning*

This is the system design stage that will be created by considering the selection of component specifications that will be used.

### *D. System Creation*

This is the work stage after the system design stage, this stage is carried out based on the design that has been created and carried out based on the component job sheet itself.

### *E. System Testing*

It is a test of a system that has been designed and created. With the aim of knowing whether the system that has been created is running according to the plans that have been made previously.

### *F. Data Retrieval*

This is the data retrieval stage when the system has successfully worked.

### *G. Analysis And Conclusion Drawing*

This is the stage of analyzing data that has been tested previously. At this stage the author carries out data analysis, as shown in Fig. 2.

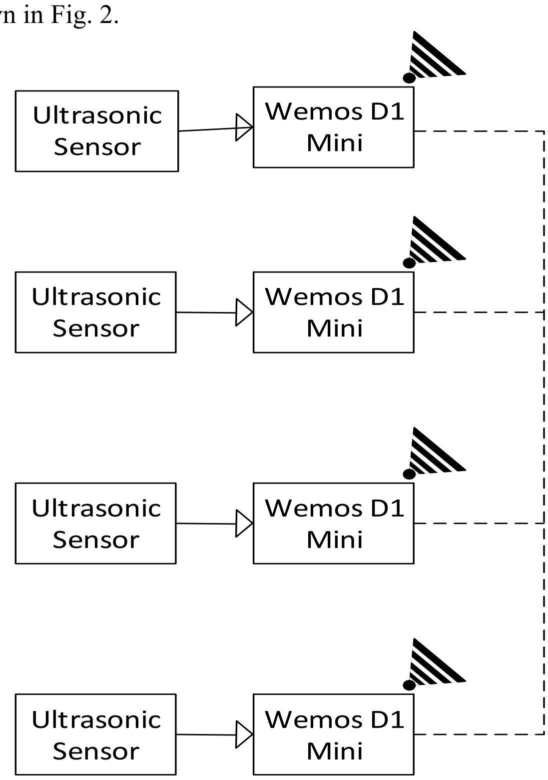


Figure 2. Block Diagram Of Sensor Parts

The Ultrasonic sensor as a vehicle distance calculator has a pulse output of 0 and 1. The Wemos module is a device for sending sensor reading data.

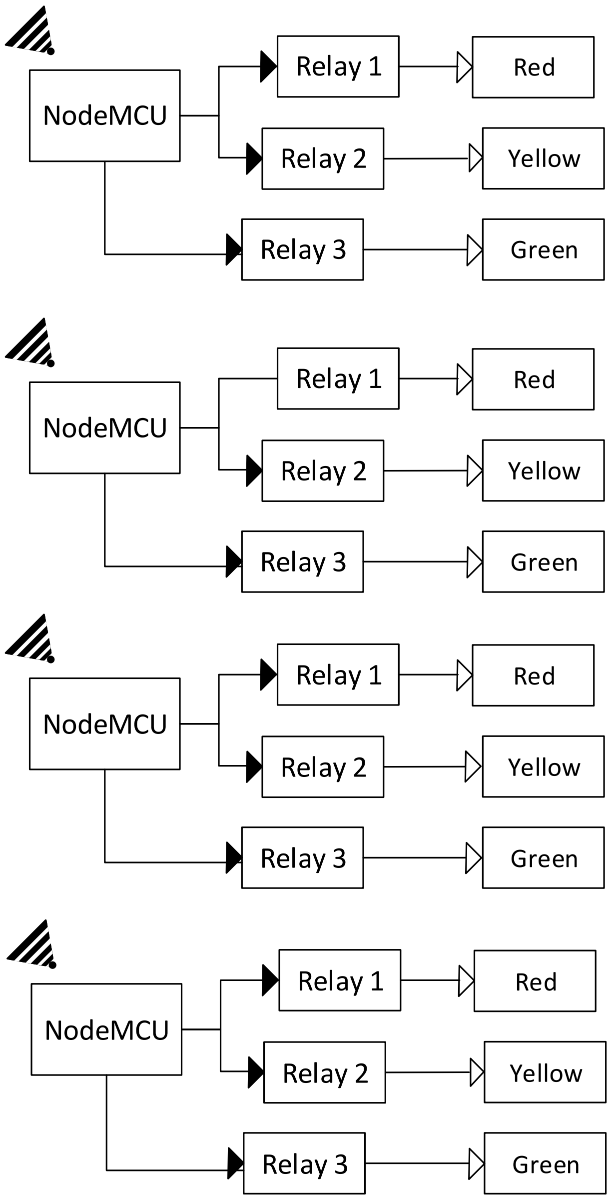

Figure 3. Parts Of The Traffic Light System

Figure 3 shows nodeMCU as a device for receiving data from the ultrasonic sensor section which is sent using the Wemos D1 Mini. The relay is an automatic switch to turn on the red, yellow and green lights that have been determined by the NodeMCU.

The image is a system flow diagram which explains the system operation scheme starting from the process of starting by pressing the ON switch button on each box, then continuing with the system initialization process, this process is in the form of connecting the internet from the nodemcu to the traffic light box and sensor box. After that, the traffic light will turn on for 15 seconds at the start of the process to ensure safe conditions, and after that the sensor will work to identify the vehicle in front. From the vehicle identification carried out by the sensor, several conditions will be generated. The 4 traffic lights produce a probability of 16 conditions, and to make it easier to determine the logic, we will use the number 2 as a sign of busy conditions and the number 1 as a sign of quiet conditions. These 16 conditions can be explained in the Fig 4 and 5.

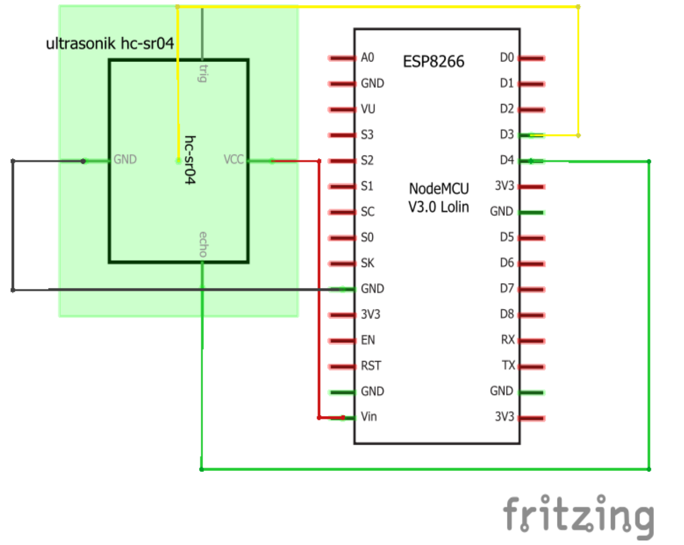

Figure 4. Schematic Diagram Of Object Detector

There are 2 components, namely the hc-sr04 ultrasonic sensor and the ESP8266 NodeMCU. All 4 ultrasonic sensor pins are connected to the ESP8266, namely VCC which is connected to the Vin pin on the ESP8266 board, then GND is connected to the GND pin, echo is connected to pin D4, and the trigger pin is connected to pin D3 of the ESP8266.

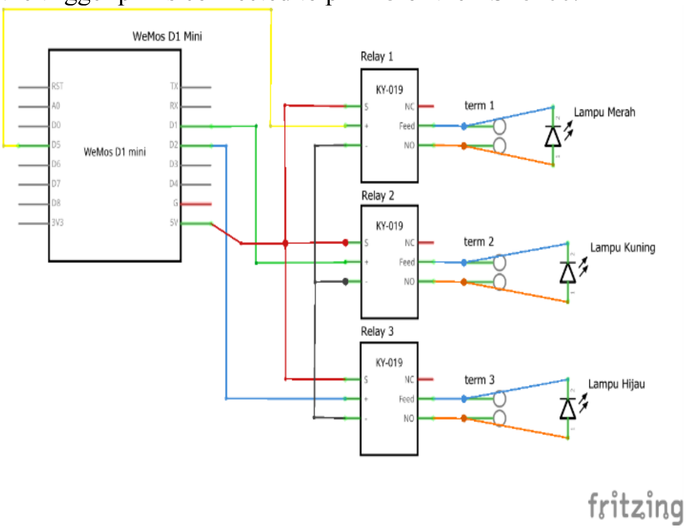

Figure 5. Schematic Traffic Light Diagram

There are several components, namely Wemos D1, 3 relays and 3 LED lights. Each input pin from the relay is connected to pins D5, D1 and D2 on the Wemos D1 mini, and the output on the relay uses NO (Normally Open).

## III. RESULTS AND DISCUSSION

### *A. Maximum Sensor Distance Testing*

TABLE I
MAXIMUM SENSOR DISTANCE TESTING

| No | Distance | Information |
|---|---|---|
| **1** | 10 | Detected |
| **2** | 50 | Detected |
| **3** | 70 | Detected |
| **4** | 100 | Detected |
| **5** | 150 | Detected |
| **6** | 200 | Detected |
| **7** | 250 | Detected |
| **8** | 300 | Detected |
| **9** | 350 | Detected |
| **10** | 400 | Detected |
| **11** | 450 | Detected |
| **12** | 500 | Detected |
| **13** | 550 | Detected |
| **14** | 600 | Detected |
| **15** | 823 | Detected |
| **16** | 825 | Not detected |

Based on Table I, maximum sensor distance testing with distance variations ranging from 10 cm, 50 cm, 70 cm, 100 cm, 150 cm, 200 cm, 250 cm, 300 cm, 350 cm, 400 cm, 450 cm, 500 cm, 550 cm , 600 cm, 823 cm, 825 cm obtained maximum reading values at a distance of 823 cm.

*B. Testing Sensor A Against Actual Distance*

TABLE II
TESTING SENSOR A AGAINST ACTUAL DISTANCE

| No | True Value | Sensor Value | Error Percentage (%) |
|---|---|---|---|
| **1** | 10 | 10 | 0.0 |
| **2** | 50 | 50 | 0.0 |
| **3** | 70 | 70 | 0.0 |
| **4** | 100 | 100 | 0.0 |
| **5** | 150 | 150 | 0.0 |
| **6** | 200 | 200 | 0.0 |
| **7** | 250 | 250 | 0.0 |
| **8** | 300 | 300 | 0.0 |
| **9** | 350 | 350 | 0.0 |
| **10** | 400 | 400 | 0.0 |
| **11** | 450 | 449 | -0.22 |
| **12** | 500 | 501 | 0.19 |
| **13** | 550 | 550 | 0.0 |
| **14** | 600 | 600 | 0.0 |
| **15** | 650 | 650 | 0.0 |
| **16** | 820 | 823 | 0.36 |
| | **Average error** | | 0.022 |

The results of testing the detection value of the ultrasonic sensor against the actual distance are attached in Table B. The Table II showed that the highest error percentage value was 0.36 with the average percentage error value for ultrasonic sensor readings in this study being 0.022%.

*C. Testing Sensor B Against Actual Distance*

TABLE III
TESTING SENSOR B AGAINST ACTUAL DISTANCE

| No | True Value | Sensor Value | Error Percentage (%) |
|---|---|---|---|
| **1** | 10 | 10 | 0.0 |
| **2** | 50 | 50 | 0.0 |
| **3** | 70 | 70 | 0.0 |
| **4** | 100 | 100 | 0.0 |
| **5** | 150 | 152 | 1.31 |
| **6** | 200 | 200 | 0.0 |
| **7** | 250 | 250 | 0.0 |
| **8** | 300 | 300 | 0.0 |
| **9** | 350 | 350 | 0.0 |
| **10** | 400 | 400 | 0.0 |
| **11** | 450 | 455 | 1.09 |
| **12** | 500 | 504 | 0.79 |
| **13** | 550 | 550 | 0.0 |
| **14** | 600 | 599 | -0.16 |
| **15** | 650 | 651 | 0.15 |
| **15** | 820 | 823 | 0.36 |
| | **Average error** | | 0.22 |

The Table III results of testing the detection value of the ultrasonic sensor against the actual distance are attached in Table III. The test results showed that the highest error percentage value was 1.31 with the average percentage error value for ultrasonic sensor readings in this study being 0.22%.

### *D. Testing Sensor C Against Real Distance*

TABLE IV
TESTING SENSOR C AGAINST REAL DISTANCE

| No | True Value | Sensor Value | Error Percentage (%) |
|---|---|---|---|
| 1 | 10 | 10 | 0.0 |
| 2 | 50 | 50 | 0.0 |
| 3 | 70 | 70 | 0.0 |
| 4 | 100 | 100 | 0.0 |
| 5 | 150 | 152 | 1.31 |
| 6 | 200 | 200 | 0.0 |
| 7 | 250 | 250 | 0.0 |
| 8 | 300 | 300 | 0.0 |
| 9 | 350 | 349 | -0.28 |
| 10 | 400 | 400 | 0.0 |
| 11 | 450 | 451 | 0.22 |
| 12 | 500 | 503 | 0.59 |
| 13 | 550 | 550 | 0.0 |
| 14 | 600 | 599 | -0.16 |
| 15 | 650 | 651 | 0.15 |
| 16 | 820 | 823 | 0.36 |
| | **Average error** | | 0.171 |

The results of testing the detection value of the ultrasonic sensor against the actual distance are attached in Table IV. The test results showed that the highest error percentage value was 1.31. The average percentage error in ultrasonic sensor readings in this study was 0.171%, as shown in Table IV.

### *E. Testing Sensor D Against Actual Distance*

TABLE V
TESTING SENSOR D AGAINST ACTUAL DISTANCE

| No | True Value | Sensor Value | Error Percentage (%) |
|---|---|---|---|
| 1 | 10 | 10 | 0.0 |
| 2 | 50 | 50 | 0.0 |
| 3 | 70 | 72 | 2.7 |
| 4 | 100 | 100 | 0.0 |
| 5 | 150 | 152 | 1.31 |
| 6 | 200 | 200 | 0.0 |
| 7 | 250 | 251 | 0.39 |
| 8 | 300 | 300 | 0.0 |
| 9 | 350 | 349 | -0.28 |
| 10 | 400 | 402 | 0.49 |
| 11 | 450 | 450 | 0.0 |
| 12 | 500 | 500 | 0.0 |
| 13 | 550 | 550 | 0.0 |
| 14 | 600 | 600 | 0.0 |
| 15 | 650 | 652 | 0.30 |
| 16 | 820 | 823 | 0.36 |
| | **Average error** | | 0.25 |

The results of testing the detection value of the ultrasonic sensor against the actual distance are attached in Table V. The test results obtained the highest error percentage value of 1.31. The average percentage error in ultrasonic sensor readings in this study was 0.25%, as shown in Table V.

### *F. Timer Testing on Traffic Lights*

TABLE VI
TIMER TESTING ON TRAFFIC LIGHTS

| No | Red Light Error Percentage (%) | Yellow Light Error Percentage (%) | Green Light Error Percentage (%) |
|---|---|---|---|
| 1 | 0 | 20 | -1 |
| 2 | 1.96 | 16.6 | 1.96 |
| 3 | 0.99 | 11.1 | 1.96 |
| 4 | 4.76 | 16.6 | 1.96 |
| 5 | 4.76 | 9 | -1 |
| 6 | 0.9 | 16.6 | 0.9 |
| 7 | 0.9 | 42.8 | 0.9 |
| 8 | 0 | 20 | 1.96 |
| 9 | -1 | 20 | 3.8 |
| 10 | -1 | 9 | 1.63 |
| 11 | 0 | 0 | 0 |
| 12 | 1.9 | 16.6 | 0.9 |
| 13 | 2.9 | 27.2 | -1 |
| 14 | 4.7 | 27.2 | 3.8 |
| 15 | 0 | 0 | -1 |

## IV. CONCLUSION

Based on the background, research results, analysis and discussion, the following conclusions can be obtained: Reading the maximum distance value from the HC-SR04 ultrasonic sensor in the research, the accuracy of the reading distance value was up to 823 cm or 8.23 m. Reading the actual distance using the HC-SR04 ultrasonic sensor value, the error value was less than 1%. The timer testing on the traffic light system in the research can be categorized as quite good. With the highest percentage of errors at green lights 3.8%, at yellow lights 42.8% and at red lights 4.76%. The thing that can affect it is that the distance is quite far so that the network is unsTable, thus affecting data processing.

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