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SMALL ROAD MONITORING SYSTEM FOR FOUR WHEEL VEHICLES

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Abstrak

Penerapan sistem pengaturan kendaraan pada persimpangan di daerah pedesaan belum memiliki sistem pengaturan yang baik dibanding dengan sistem pengaturan kendaraan di perkotaan. Kurang nya pemerataan pelebaran jalan di daerah pedesaan membuat masyarakat sering mengalami masalah dalam mengakses jalan ketika menggunakan kendaraan roda empat. Masyarakat sering mengalami masalah ketika mengakses jalan kecil terlebih jumlah kendaraan lebih dari satu yang melewati secara bersamaan. Permasalahan tersebut juga dialami pada Desa Tanjung Sari, Kecamatan Cijeruk, Kabupaten Bogor. Penelitian ini bertujuan untuk merancang dan membangun sistem pemantau jalan kecil sehingga masyarakat pengendara mobil mendapat peringatan apabila terdapat kendaraan roda empat yang sudah melewati jalan kecil. Metode pengenalan objek yang digunakan pada sistem pemantau jalan kecil bagi kendaraan roda empat adalah sensor ultrasonik HC-SR04 yang diletakan disisi kiri, kanan, dan atas. Mikrokontroler Arduino Uno R3 akan digunakan sebagai perangkat utama sistem. Komunikasi antar titik yang digunakan yaitu LoRa Ra-02 sebagai pengirim dan penerima. Hasil dari penelitian ini menunjukan prototipe sistem berfungsi dengan baik sesuai dengan tujuan yang telah dirancang.

Kata Kunci: Pathway; Internet of Things; Sensor Ultrasonik; Arduino Uno; LoRa.

Abstract

The application of the vehicle regulation system at intersections in rural areas does not yet have a good regulatory system compared to the vehicle control system in urban areas. The lack of equitable distribution of road widening in rural areas makes people often have problems accessing roads when using four-wheeled vehicles. People often experience problems when accessing small roads, especially when more than one vehicle passes at the same time. This problem was also experienced in DesaTanjung Sari, Kecamatan Cijeruk, Kabupaten Bogor. This study aims to design and build a small road monitoring system so that car drivers get a warning if there are four-wheeled vehicles that have passed the small road. The object recognition method used in the small road monitoring system for four-wheeled vehicles is the HC-SR04 ultrasonic sensor which is placed on the left, right, and top sides. Arduino Uno R3 microcontroller will be used as the main system device. The communication between points used is LoRa Ra-02 as the sender and receiver. The results of this study show the results of the system prototype running well in accordance with the planned functions.

Keyword: Pathway; Internet of Things; Ultrasonic Sensor; Arduino Uno; LoRa.

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1. Introduction

The control system for regulating traffic lights at every city intersection actually already has a control system with good functions [1]. This is much different when compared to city intersections with narrow road conditions such as residential or rural areas. Generally, villages spread across Indonesia have the same problem, namely when four-wheeled vehicles have difficulty accessing small roads, especially if there are more than one vehicle. Various efforts have been made by the government to overcome this, one of which is by carrying out infrastructure development, but this will not solve the problem in the near future due to the need for planning by the government to widen the existing small roads.

A good road infrastructure system or road control system is very important because it can improve people's welfare. Areas that have good road infrastructure will improve the economy for the surrounding community, otherwise the economy will be hampered if there are obstacles for people to cross small roads. The development of road infrastructure is very important, especially in rural areas where infrastructure facilities and infrastructure are still very minimal. Currently, the infrastructure development carried out in rural areas is still experiencing obstacles by one thing or another. Communities are required to face these problems with the resources they have. Technological developments can help people overcome problems and facilitate every human activity.

The applied technological innovation aims to help human life, especially in rural areas, especially with the use of small road monitoring technology for four-wheeled vehicles. Along with the drastic technological developments over the last few years, most of human work is being taken by machines. Some people believe that it will make humans even more and this is undeniable fact [2]. Basically, not many people practice this technological innovation, such as the small road monitoring system for four-wheeled vehicles found in Desa Tanjung Sari, Kecamatan Cijeruk, Kabupaten Bogor which is not yet available. People in the village tend to have problems accessing the road because the road is too small for four-wheeled vehicles. This also applies to other places throughout Indonesia.

The solution needed is a monitoring device or system that can give warnings to car drivers so that they do not experience difficulties in accessing roads around Tanjung Sari Village. This device was developed with an Internet of Things (IoT) system using the Arduino Uno as a microcontroller. The ultrasonic sensor HC-SR04 is used as object recognition for four-wheeled vehicles. The data transmission method will use LoRa which has high signal resistance and coverage. It is hoped that the innovation of developing a small road monitoring system for four-wheeled vehicles in Tanjung Sari Village can make it easier for the community to access roads in the village.

2. Methods

Research methodology is a basic aspect of working on a final assignment which contains stages or descriptions of making the final project, namely problem identification, literature study, determination of research objectives and methods, system development, analysis, and conclusions. The research flow is illustrated through the diagram in Figure 1 below.

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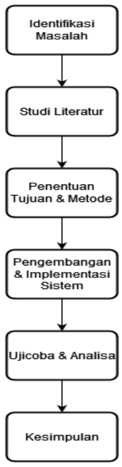

Figure 1. Research Method

Figure 1 is an overview of the research flow that will be carried out in this study. Problem identification is a stage used to identify existing problems and requires a solution. The literature study stage is the stage used by researchers to collect data and information related to topics generated by the previous stages. The stage of determining research objectives and methods is the final result to be achieved by researchers and the methods to be used to achieve these objectives. The system development stage is the stage carried out to implement the system that has been designed. The analysis phase is the stage carried out to analyze the results of the implementation of the system that has been designed. The conclusion stage is the stage carried out by the researcher concluding the results of the analysis in the study.

3. Result and Discussion

An overview of the small road traffic control system for four-wheeled vehicles is an overview of how the system will work. The design of a small road traffic control system for four-wheeled vehicles can be explained in Figure 2 below.

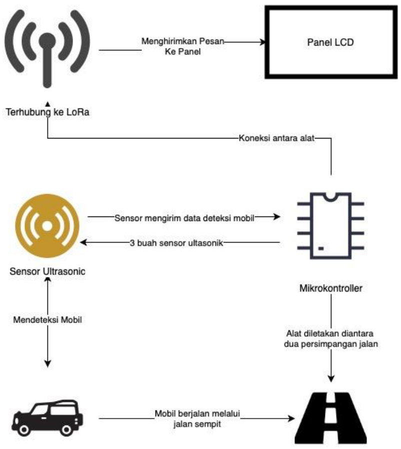

Figure 2. System Overview

Figure 2 is a general design drawing of a small road traffic control system for four-wheeled vehicles. The system consists of an Arduino Uno microcontroller which is a microcontroller board or microcontroller developer board based on the Atmega28 chip which consists of open source hardware and software [3]. The Arduino Uno microcontroller will be the main tool for running the system which will be placed on the small road. The microcontroller will be connected to the HC-SR04 ultrasonic sensor which will detect four-wheeled vehicles. The ultrasonic sensor works by receiving the reflected sound waves from an object or objects with a sound wave frequency of 20 Khz to 2 Mhz [4], [5]. LoRa Ra-02 functions as a transmission for sending and receiving data when the ultrasonic sensor detects a four-wheeled vehicle. The use of LoRa in a small road traffic control system for four-wheeled vehicles was chosen because LoRa has the ability to transmit long distances with low power usage [6], [7]. The distance that can be covered by LoRa is quite far, with a range of up to 15 Km. The LoRa Ra-02 is one of the LoRa devices created by AIThinke, with a sensitivity value of up to -130 dBm and an output power of up to +20 dBm [8]. Tool planning for a small road traffic control system for four-wheeled vehicles is illustrated with a block diagram in Figure 3 below

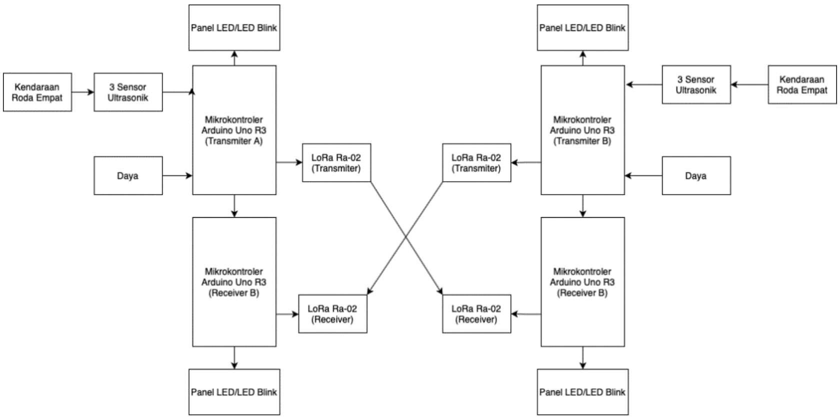

Figure 3. System Block Diagram

Figure 3 is a system block diagram depicting the flow of a small road traffic control system for four-wheeled vehicles. Four-wheeled vehicle objects detected by three ultrasonic sensors will send data to the Arduino Uno microcontroller to be managed. After the three data are processed and meet certain conditions, the microcontroller will send messages using LoRa to the recipient. When the receiving LoRa receives a message from the sending LoRa, the receiving LoRa will send data to the Arduino Uno microcontroller which will be forwarded to the LED panel which aims to be a marker that there are four-wheeled vehicles passing through the road. To find out the work steps of the system so that it can facilitate the design of the system, a process flow diagram is needed. Figure 4 is a process flow diagram for a small road traffic control system for four-wheeled vehicles.

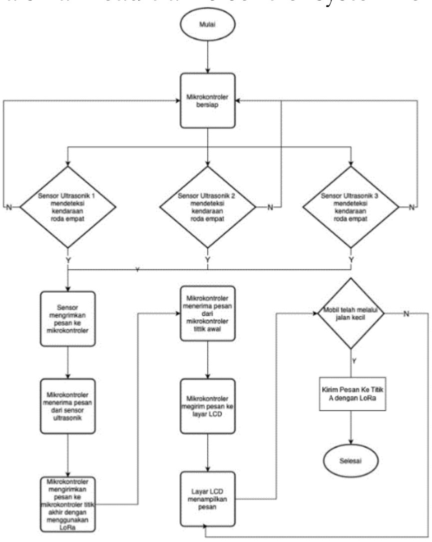

Figure 4. Flowchart

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Figure 4 is a process flow diagram that starts with the microcontroller getting ready to detect an object in the form of a four-wheeled vehicle. The microcontroller is connected to the three ultrasonic sensors which function to detect the presence of four-wheeled vehicles at a certain distance. The system flow is continued when the sensor detects a four-wheeled vehicle, the sensor will send a message to the microcontroller and will be connected to LoRa. The sending LoRa will send a message to the receiving LoRa, and if the receiving LoRa has received a message from the sending LoRa, the microcontroller will process the data and trigger the LED panel to light up indicating that there is a four-wheeled vehicle that is crossing the road from point A to point B. LoRa point B will send a message back to LoRa point A if the car has passed point B from point A. Schematic diagrams are used to describe a series of electronic components with electronic symbols on a small road traffic control system for four-wheeled vehicles. Figure 5 is a schematic diagram used.

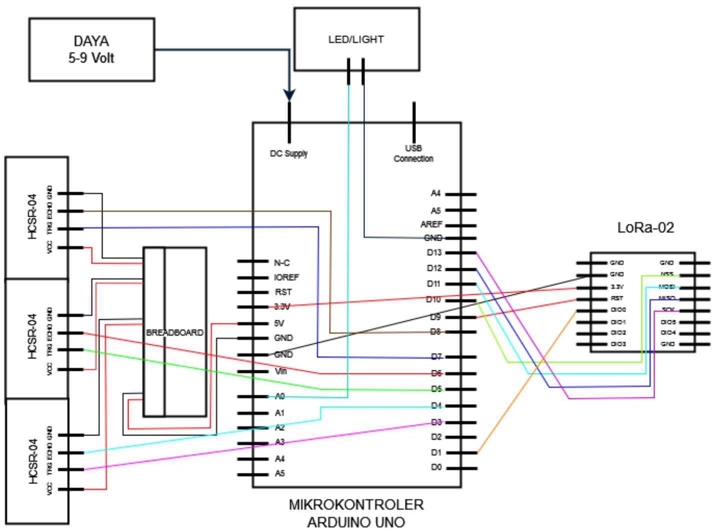

Figure 5. Schematic Diagram

Figure 5 is a schematic diagram consisting of three HC-SR04 ultrasonic sensors, breadboard, Arduino Uno and LoRa-02. Breadboard serves to connect the ultrasonic sensor with Arduino Uno so that the three ultrasonic sensors get power. Arduino Uno is the center of the system which functions to process sensor data and data obtained from LoRa Ra-02. LoRa Ra-02 functions to receive and send data. Hardware design aims to build the required system. Figures 6 and 7 below are the results of the hardware design of a small road traffic control system for four-wheeled vehicles.


Figure 6. Hardware Design Result


Figure 7. Hardware Design System

Figures 6 and 7 are the results of the hardware design of a small road traffic control system for four-wheeled vehicles. The hardware consists of HC-SR04 ultrasonic sensor, Arduino Uno microcontroller, LoRa Ra-02, LED light, and breadboard. Testing of tools and sensors is carried out to find out whether the tools and sensors can work properly, and can find errors or deficiencies in the system. Testing of the HC-SR04 ultrasonic sensor was carried out ten times in experiments on four-wheeled vehicles, two-wheeled vehicles, humans and animals. Table 1 is the result of testing the introduction of the HC-SR04 ultrasonic sensor on objects.

Table 1. HC-SR04 Sensor Testing on Object

Testing	HC-SR04 Sensor Testing on Object			
	Four-wheeled	Two-wheeled	Humans	Animals
1	Succeed	Failed	Failed	Failed
2	Succeed	Failed	Failed	Failed
3	Succeed	Failed	Failed	Failed
4	Succeed	Failed	Failed	Failed
5	Succeed	Failed	Failed	Failed
6	Succeed	Failed	Failed	Failed
8	Succeed	Failed	Failed	Failed
9	Succeed	Failed	Failed	Failed
10	Succeed	Failed	Failed	Failed

Table 1 is an object recognition test using the HC-SR04 ultrasonic sensor on a small road traffic control system for four-wheeled vehicles. The experiment was carried out ten times on different objects, namely four-wheeled vehicles, two-wheeled vehicles, humans and animals. The test results show that only sensor detection tests on four-wheeled vehicle objects are successful with a success rate of 100%. Tests on two-wheeled vehicle objects, humans and animals which were carried out ten times showed failure, which means that the small road traffic control system for four-wheeled vehicles only succeeded in detecting four-wheeled vehicle objects.

Testing the distance of sending and receiving data is carried out using LoRa Ra-02 which aims to determine the distance that can be traveled. Distance testing is carried out in two conditions, namely urban environmental conditions that have many obstacles such as buildings and trees. The next condition is carried out in a rural environment or environment without any obstacles. Table 2 is the result of testing the distance of sending and receiving data in an environment with many obstacles or in urban areas.

Table 2. Testing the Distance of Sending and Receiving Data with Obstacles

Distance	Data		Status
	RSSI	SNR	
0	-96	8.25	Succeed
25	-104	7.25	Succeed
50	-105	0.75	Succeed
100	-108	-3.25	Succeed
150	-107	-6.75	Succeed
200	-110	-8.25	Succeed
250	-110	-8.75	Succeed
300	-97	-10.75	Succeed (Unstable)
350	-97	-11.25	Failed (Unstable)
400	-	-	Failed

The results of testing the distance of sending and receiving LoRa Ra-02 data at a distance of 0 meters to 250 meters can be reached without problems. Testing at a distance of 300 meters encountered a problem, namely the data sent and received by LoRa Ra-02 was unstable. Testing at a distance of 350 meters can be categorized as failed because the packets sent and received are unstable. Testing at a distance of 400 meters failed where the device did not receive the package sent by the sender. Figure 8 and Figure 9 are graphs of testing the distance of sending and receiving data with obstacles.

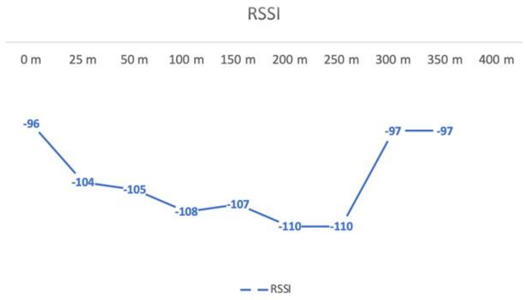

Figure 8. RSSI Value Chart

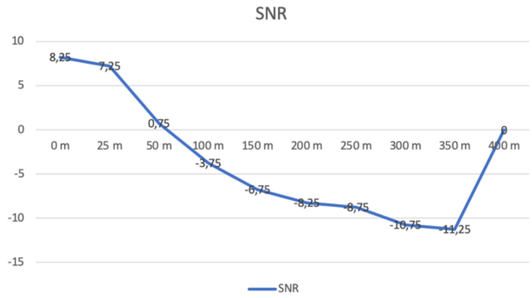

Figure 9. SNR Value Chart

The graph of testing the RSSI (Ratio Signal Strength Indicator) value data shows that the highest value obtained at a distance of 0 meters is -96 dBm and the lowest value at a distance of 250 meters is -110 dBm. The highest and lowest RSSI values in the experiment of sending and receiving LoRa Ra-02 data in an urban environment are fairly normal. RSSI LoRa Ra-02 in the experiment was considered normal with the highest value of -30 dBm and the lowest value of -130 dBm. The RSSI graph from the results of testing for sending and receiving LoRa Ra-02 data shows that the signal has decreased and increased from -97 dBm to -100 dBm. The RSSI LoRa Ra-02 value must be at the highest value -30 dBm and the lowest value -130 dBm to maintain a stable signal [8], [9].

The graph of the SNR (Singnal-to-Noise Ratio) test data shows that the highest value achieved is at a distance of 0 meters of 8.25 dB and the lowest value at a distance of 350 meters is -11.25 dB. The SNR value is quite good because the range of a good SNR signal ranges from +10 dB to -20 dB. If the SNR is close to +10 dB, then the signal is a signal with minimal distortion or noise interference. If the SNR value is close to or between -7.5 dB to -20 dB, then the SNR can be said to be in a state of lots of noise interference [8], [9]. The LoRa Ra-02 distance test was carried out in an urban environment which can be seen in Figure 10 below.

Figure 10. Map of LoRa Ra-02 Distance Test Locations with Obstacles

Figure 10 is a location map for testing the distance of sending and receiving LoRa Ra-02 data which is carried out in urban locations or where there are many obstacles such as buildings. Testing the distance of sending and receiving data using no obstructions is carried out to determine the distance and the success rate of sending data. Table 3 is the result of testing the distance of sending and receiving data in a minimal obstacle environment or rural area.

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Table 3. Testing the Distance of Sending and Receiving Data without Hindrance

Distance	Data		Status
	RSSI	SNR	
0	-78	9.50	Succeed
100	-99	9.25	Succeed
200	-101	8.75	Succeed
300	-105	8.25	Succeed
400	-101	5.50	Succeed
500	-111	-1.25	Succeed
600	-105	-2.00	Succeed
700	-97	-3.75	Succeed
800	-103	-7.50	Succeed
900	-103	-9.00	Succeed
1000	-112	-8.25	Failed (Unstable)
1100	-	-	Succeed

The results of testing the distance of sending and receiving LoRa Ra-02 data at a distance of 0 meters to 900 meters can be reached without problems. Testing at a distance of 1000 meters encountered a problem, namely the data sent and received by LoRa Ra-02 was unstable. Testing at a distance of 1100 meters failed where the device did not receive the packet that had been sent by the transmitter [10]. Figure 11 and Figure 12 are graphs of testing the distance of sending and receiving data with obstacles.

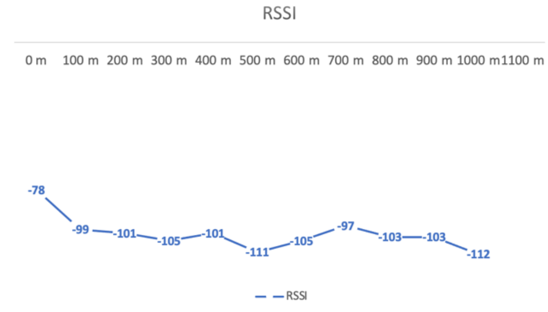

Figure 11. RSSI Value Chart

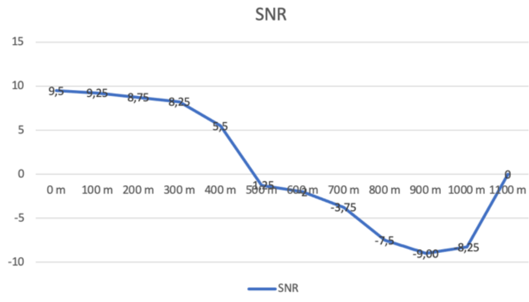

Figure 12. SNR Value Chart

The RSSI (Received Signal Strength Indicator) test graph shows that the highest value obtained at a distance of 0 meters is -78 dBm and the lowest value at a distance of 1000 meters is -112 dBm. The highest and lowest RSSI values in the experiment of sending and receiving LoRa Ra-02 data in an urban environment can be said to be normal. RSSI LoRa Ra-02 in the experiment was considered normal with the highest value of -30 dBm and the lowest value of -130 dBm. The RSSI graph from the results of testing sending and receiving LoRa Ra-02 data shows that the signal has decreased and increased from -78 dBm to -112 dBm. The RSSI LoRa Ra-02 value must be at the highest value -30 dBm and the lowest value -130 dBm to maintain a stable signal [8], [9].

The graph of the SNR (Singnal-to-Noise Ratio) testing data shows that the highest value achieved is at a distance of 0 meters of 9.25 dB and the lowest value at a distance of 900 meters is -9.00 dB. The SNR value is quite good because the range of a good SNR signal ranges from +10 dB to -20 dB. If the SNR is close to +10 dB, then the signal is a signal with minimal distortion or noise interference. If the SNR value is close to or between -7.5 dB to -20 dB, then the SNR can be said to be in a state of lots of noise interference [8], [9]. Distance testing is carried out in a rural environment or without obstacles which can be seen in Figure 11.

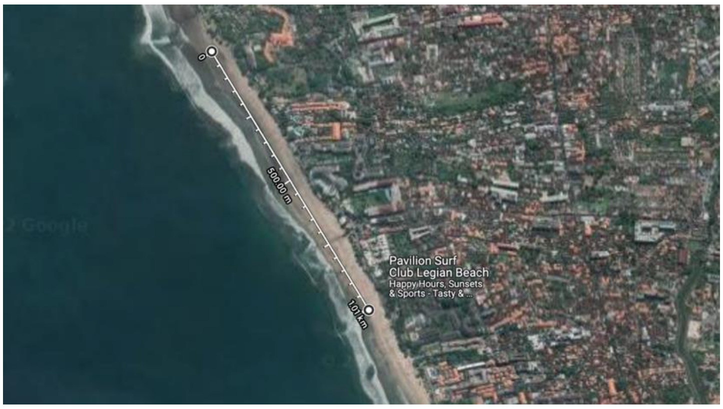

Figure 13. Map of LoRa Ra-02 Distance Test Locations without Obstacles

Figure 13 is a location map for testing the distance of sending and receiving LoRa Ra-02 data which is carried out in urban locations or where there are many obstacles such as buildings. Figure 13 is a display of the results of sending and receiving data from the Arduino IDE software.

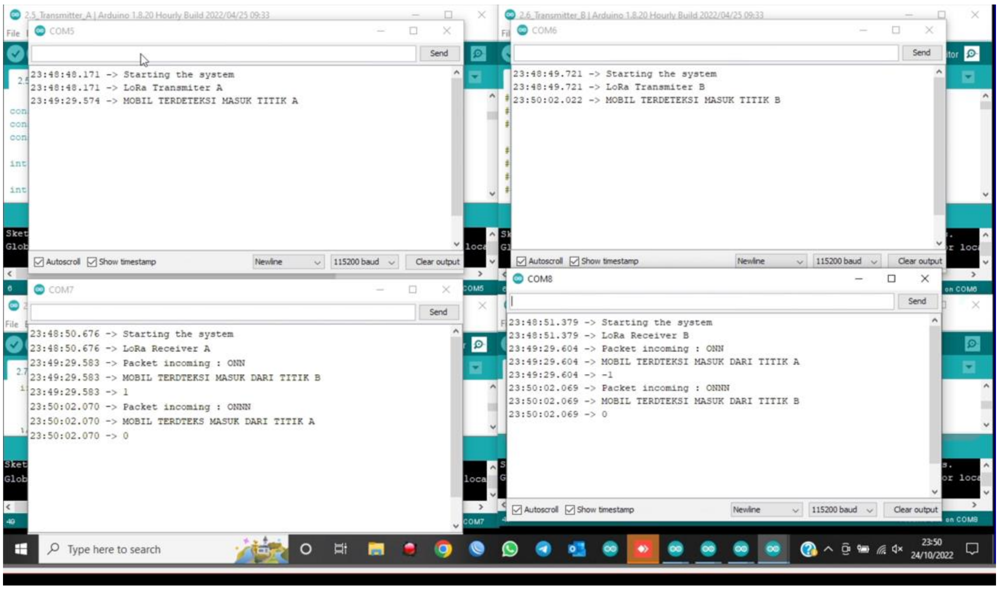

Figure 14. Display of Data Sending and Receiving Results

Figure 14 is the result of sending data to a small road traffic control system for four-wheeled vehicles. The device at the sending point can send the data properly without any interference.

4. Conclusion

Based on the research and testing that has been done, the first conclusion is that a small road traffic control system for four-wheeled vehicles has been successfully constructed using the HC-SR04 ultrasonic sensor as an object recognition method and LoRa Ra-02 as a means of sending and receiving data. The system was built using the Arduino Uno R3 microcontroller which was given a power of 5-9 volts. The second conclusion shows that the test results show that the use of the HC-SR04 ultrasonic sensor to detect four-wheeled vehicles is successful with a value of 100%. The test results of the HC-SR04 ultrasonic sensor to detect other objects such as two-wheeled vehicles, humans and animals are 0% indicating that the HC-SR04 ultrasonic sensor can only detect four-wheeled vehicles successfully. The third conclusion shows that the results of testing the distance of sending and receiving data in the presence of obstacles produce the lowest RSSI value of -96 dBm at a distance of 0 meters and the highest value of -110 dBM at a distance of 250 meters. The SNR value achieved on the results of testing the distance of sending and receiving data in the presence of obstacles is the highest value of 8.25 dB at a distance of 0 meters and the highest value of -11.25 dB at a distance of 350 meters. The maximum distance that can be covered by the LoRa Ra-02 in a densely populated environment is 350 meters. The results of testing the distance of sending and receiving data without any obstacles produce the lowest RSSI value -76 dBm at a distance of 0 meters and the highest value -112 dBM at a distance of 1000 meters. The SNR value achieved on the results of testing the distance of sending and receiving data in the presence of obstacles is the highest value of 9.25 dB at a distance of 0 meters and the highest value of -9.00 dB at a distance of 900 meters. The maximum distance that can be covered by the LoRa Ra-02 in a minimally populated environment is 1000 meters. The fourth conclusion in the study showed that the results of testing sending and receiving data at the same place in the prototype were carried out ten times, the results of sending and receiving data transmission were 100%. The results of the LoRa Ra-02 test showed an average RSSI value of -66.1 dBm and an average SNR value of 8.8 dB.

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