Signal and Image Processing Letters
Vol. 4., No. 2, 2022, pp. 49-57
ISSN 2714-6677
https://simple.ascee.org/



# Implementation of Base Station Communication Systems on Wheels Football Robots

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ARTICLE INFO

ABSTRACT (10PT)

In the wheeled soccer robot contest competition, you have to prepare a strategy to win the race. The strategy used is a communication system. The communication system on the wheeled soccer robot has an important role during the match. This research will discuss the implementation of the GUI on the Base Station using the processing 3 application in its manufacture and using the Java language and analyzing data transmission. The use of the GUI is shown to make it easier to control robots during matches and minimize human work. The communication system used uses multicast with the UDP (User Datagram Protocol) protocol. Based on the results of research using the UDP protocol, the data transmission carried out by the GUI at the Base Station can function as a robot sending data. The resulting average delay is the farther the distance the more the average delay generated. The success rate of delivery is 100%.

**Keywords**
Base Station
UDP
Robot
Communication
GUI



## 1. Introduction

The Wheeled Football Robot Contest was held to increase students' creativity and knowledge in the field of robotics. In order to win the match, then, each team must prepare a strategy [1][2]. In the strategy required communication on the robot. In contest matches, the communication-wheeled soccer robot functions to set strategies and is also used to listen to orders or instructions from the referee through the Referee Box application which is controlled via a computer [3][4]. The robot must be able to translate actions based on the instructions given such as Stop, Start, Kick Off and so on [5]. Therefore, it is necessary to have a communication system that bridges between the robot and the Referee Box, so that the robot translates and receives the instructions given [6].

Based on this problem, a GUI application is made on the Base Station to run these commands. In the GUI Base Station application, it is made using the processing 3 application using the Java programming language using the UDP (User Datagram Protocol) protocol. The UDP protocol was chosen because of the speed in sending it [7]. This protocol is suitable for use because data transmission is carried out in real time or continuously so that it requires fast data transmission [8][9]. Applications are made on this Base Station in order to minimize human intervention during matches and set match strategies [10][11].

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## 2. Research Method

### 2.1. System planning

In the design of the communication system, there is a Referee Box that functions as a server that sends data to the Base Station. Data is sent through the access point. There is an ESP 8266 Wi-Fi module on the robot to connect to the access point. The Base Station functions for receiving and sending data as well as managing robot movements and playing strategies. Data can be sent to the Base Station in this study using the UDP protocol. So that the flow of data communication to the robot can be seen in Fig.1.

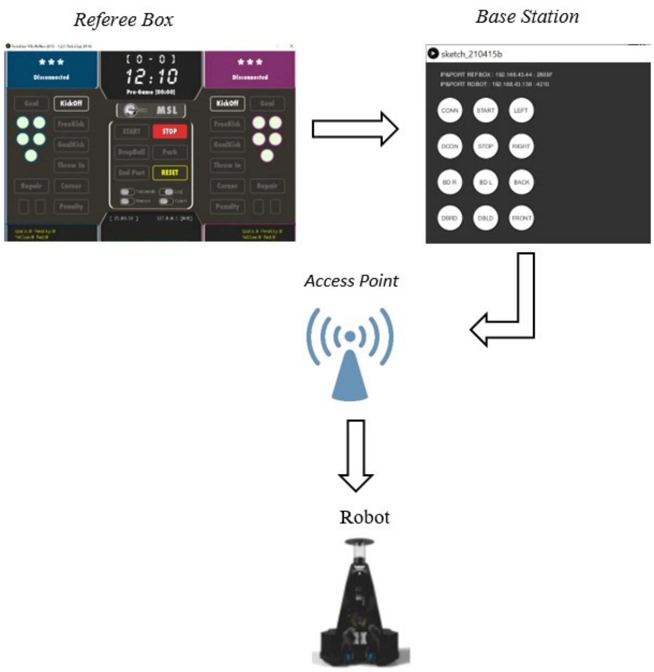



**Fig. 1.** Data communication flow to the robot

### 2.2. Communication System Block Diagram

In this study, there are three main stages of the flow of communication design, namely input, process and analysis. The communication planning block diagram can be described as shown in Fig. 2.

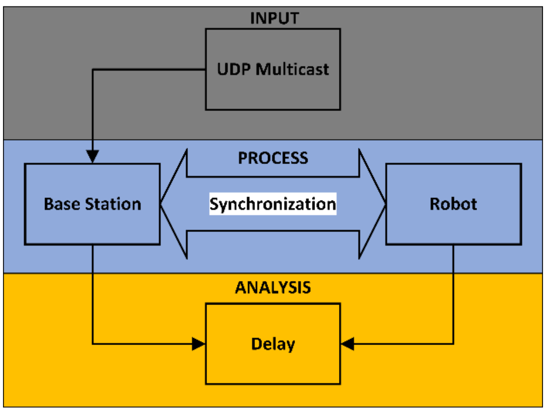



**Fig. 2.** Block diagram of communication test design

From the block diagram above it can be explained as follows:

1. Inputs

   UDP Multicast protocol which aims to transmit data from the Base Station to the robot.

2. Process
   a. Base Stations

      An application created using Processing 3. In this application there is a UDP algorithm that is used as a communication between the Base Station and the Referee Box and the Base Station with the robot. Base Station is a client that receives data from Referee Box.
   b. Synchronization

      In this process data transmission occurs between the robot and the Base Station where the Base Station acts as a server.
   c. Robot

      The robot will receive data from the Base Station to then receive commands from the Referee Box automatically.
3. Analysis

   After the data is sent to the robot, then it analyzes the amount of delay resulting from the sending process

### 2.3. Referee Box Communication Flowchart with Base Station

The first communication that is established between the Referee Box and the Base Station is that the Base Station opens a connection with the IP Referee Box already connected to the Base Station with the same network, so the Base Station and Referee Box can be connected. If there is an interruption the connection is lost while making a connection, the Base Station reconnects. If it is successfully connected to the Referee Box, then the Base Station will wait for the Referee Box to determine which team is cyan or magenta. When the selection is complete, the Referee Box will send the data char 'W' to the Base Station so that it indicates that the communication between the Referee Box and the Base Station is connected. The Referee Box communication flowchart with the Base Station is shown in Fig. 3.

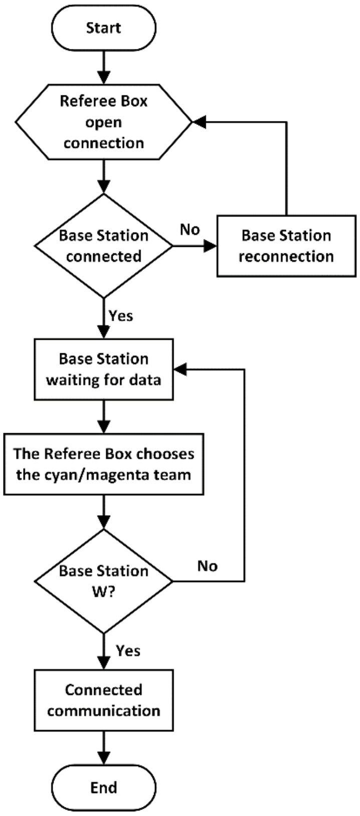



**Fig. 3.** Flowchart of the Referee Box communication with the Base Station

ISSN 2714-6677

### 2.4. Testing Process

In this study, the following stages were carried out:

1. Communication testing

   In this test, the Processing application will be used to create a GUI on the Base Station using UDP multicast as communication between the Base Station and Referee Box. To show the IP source and IP destination as well as the protocol that will be used on the system that will be created using the Wireshark application.

2. Transmission Time Testing

   This transmission time test is carried out in order to determine the average duration of time for sending and transmitting data sent.

3. Range Testing

   Testing the range of the media receiver in this case is done to measure the robot can receive data sent by the Base Station and see the delay obtained when testing the same command sending ten times with the same distance. This distance testing function also measures the robot can receive any command data that is sent with a certain distance.

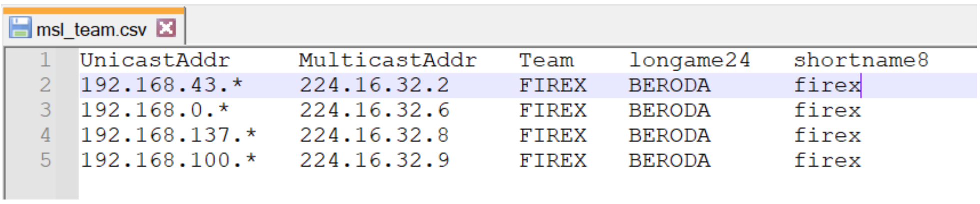
## 3. Results and Discussion

### 3.1. Communication Testing

In this communication test using the Processing application as a GUI creation on the Base Station and using UDP as communication between the Base Station and Referee Box.

### 3.2. Base Station **Configuration with Referee Box**

Configure the Referee Box by saving the IP that will be used. IP Referee Box configuration as shown in Fig. 4.



msl_team.csv

| | UnicastAddr | MulticastAddr | Team | longame24 | shortname8 |
|---|---|---|---|---|---|
| 1 | UnicastAddr | MulticastAddr | Team | longame24 | shortname8 |
| 2 | 192.168.43.* | 224.16.32.2 | FIREX | BERODA | firex |
| 3 | 192.168.0.* | 224.16.32.6 | FIREX | BERODA | firex |
| 4 | 192.168.137.* | 224.16.32.8 | FIREX | BERODA | firex |
| 5 | 192.168.100.* | 224.16.32.9 | FIREX | BERODA | firex |

**Fig. 4.** IP Configuration on Referee Box

After configuring the IP then open the Base Station GUI that was created in the Processing application. It is necessary to equalize the IP on the Base Station GUI so that the Base Station and Referee Box can be connected to each other by matching the IP that appears in the Referee Box application. GUI Base Station can be seen in Fig. 5. When the button on the GUI is clicked CONN on the GUI Base Station a Cyan and Magenta team sign will appear indicating that the Base Station and Referee Box are connected to each other. The connected Base Station and Referee Box can be seen in Fig. 6.

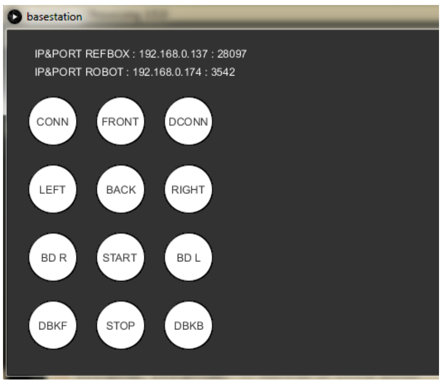



**Fig. 5.** Base Station GUI

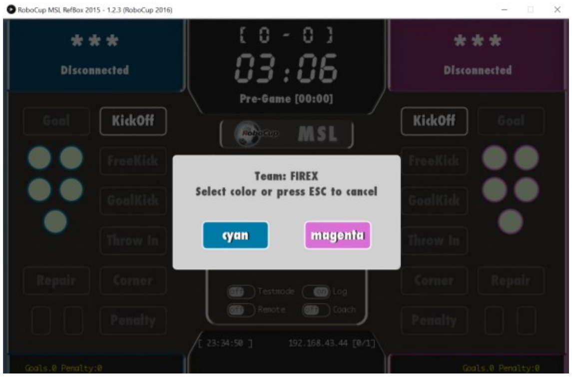



**Fig. 6.** Connected Base Station and Referee Box

After everything is connected, the Base Station and Referee Box can be used to send orders or robot strategies.

### 3.3. Communication System Testing Using Wireshark Software

Testing the communication system using Wireshark software aims to monitor data traffic indicating the IP source and IP destination and the protocol to be used as well as viewing the data sent. The display of monitoring results on Wireshark can be seen in Fig. 7 and the data sent by Wireshark is monitored in Fig. 8.

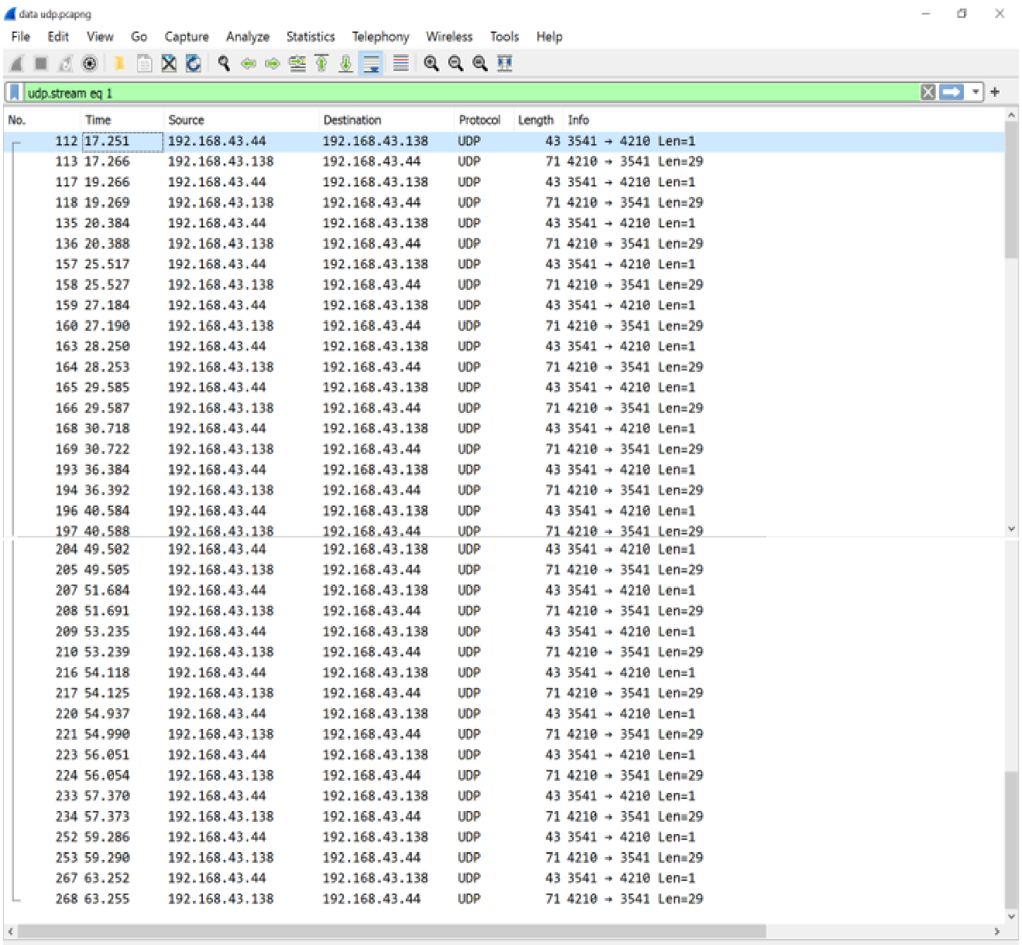



**Fig. 7.** Monitoring the commands on the Base Station and Referee Box


**Fig. 8.** The data sent is monitored by Wireshark as shown in Fig. 7

### 3.4. Transmission Time Testing

This transmission time test is carried out in order to determine the average duration of transmission time or delay of the data sent. From Fig. 7, it can be calculated the transmission time of each command in the Referee Box and Base Station sent to the robot.

To calculate the transmission time, can use equation (1)

$$t = receive\ time\ (ms) - send\ time\ (ms) \tag{1}$$

Based on the monitoring of the commands on the Base Station and Referee Box in Fig. 7, can see the transmission time of each packet sent. The transmission time test table is shown in table 3.1.

**Table 1.** Transmission Time Testing

| Test To- | Send Time (ms) | Receive Time (ms) | Transmission Time (ms) | Received Data Packages |
|---|---|---|---|---|
| 1 | 17.251 | 17.266 | 0.015 | W (Welcome) |
| 2 | 19.266 | 19.269 | 0.003 | S (Stop) |
| 3 | 20.384 | 20.388 | 0.004 | k (Kick Off) |
| 4 | 25.517 | 25.527 | 0.010 | f (free kick) |
| 5 | 27.184 | 27.190 | 0.006 | g (goal kick) |
| 6 | 28.250 | 28.253 | 0.003 | t (throw in) |
| 7 | 29.585 | 29.587 | 0.002 | c (corner) |
| 8 | 30.718 | 30.722 | 0.004 | p (penalty) |
| 9 | 36.384 | 36.392 | 0.008 | N (drop ball) |
| 10 | 40.584 | 40.588 | 0.004 | a (goal) |
| 11 | 49.502 | 49.505 | 0.003 | 5 (Left)) |
| 12 | 51.684 | 51.691 | 0.007 | 6 (Right) |
| 13 | 53.235 | 53.239 | 0.004 | 1 (BDR) |
| 14 | 54.118 | 54.125 | 0.007 | 3 (DBRD) |
| 15 | 54.937 | 54.990 | 0.053 | 7 (Back) |
| 16 | 56.051 | 56.054 | 0.003 | 2 (DBRD) |
| 17 | 57.370 | 57.373 | 0.003 | 4 (DBLD) |
| 18 | 59.286 | 59.290 | 0.004 | 8 (Front) |
| 19 | 63.252 | 63.255 | 0.003 | 0 (Dconn) |
| Rata-rata waktu transmisi | | | 0.007684 | |

Based on Table 1 Testing Transmission Time, the average transmission time or delay can be calculated as in equation (2).

$$transmission\ average = \frac{total\ transmission\ time}{number\ of\ data\ packets\ sent} \tag{2}$$

$$transmission\ average = \frac{0.1460}{19} = 0.007684$$

From Table 1 Testing the transmission time, a graphical image of the average transmission or delay can be made as shown in Fig. 9. From Fig. 9, it can be seen that the longest transmission or delay time when sending the 15th test data is 0.053 ms, while the fastest transmission or delay when sending the 7th test data is 0.002 ms.

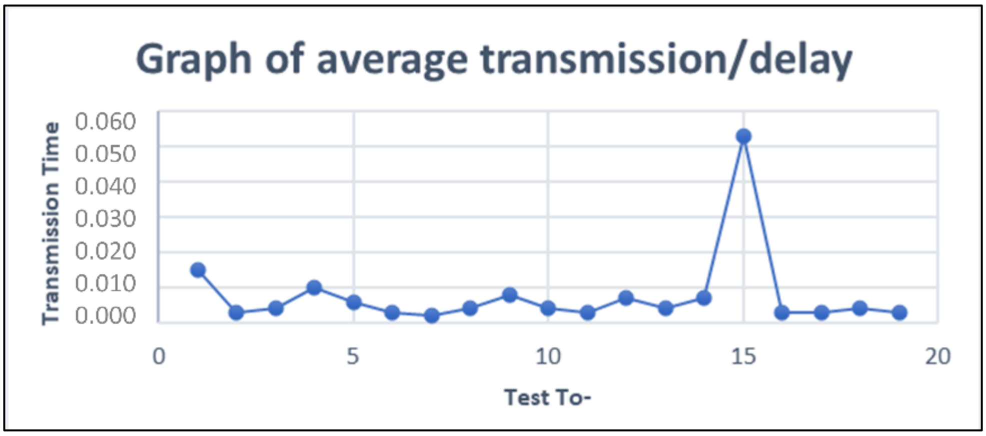



**Fig. 9.** Graph of average transmission or delay

### 3.5. Range Testing

Testing the range of the Wireless Access Point to the receiver, in this case is done to measure the robot can receive data or commands sent. In this test, it sends the S character or Stop command repeatedly and sees the delay for each delivery with the same distance on each test. In this test is done by testing the distance from 2 meters to 10 meters. The range test table with a distance of 2 meters from the Wireless Access Point can be seen in Table 2.

**Table 2.** Testing the Range of 2 meters

| Test To- | Distance (m) | Sent Characters | Delays (ms) | Message Status Received |
|---|---|---|---|---|
| 1 | 0 | S | 0.004 | Succeed |
| 2 | 0 | S | 0.007 | Succeed |
| 3 | 0 | S | 0.003 | Succeed |
| 4 | 0 | S | 0.004 | Succeed |
| 5 | 0 | S | 0.003 | Succeed |
| 6 | 0 | S | 0.006 | Succeed |
| 7 | 0 | S | 0.009 | Succeed |
| 8 | 0 | S | 0.006 | Succeed |
| 9 | 0 | S | 0.003 | Succeed |
| 10 | 0 | S | 0.008 | Succeed |
| Average | | | 0.0053 | |

From Wireshark monitoring it can be seen the sending time and the receiving time so that the delay of each delivery can be calculated. When sending with a distance of 2 meters from the Wireless Access Point, the delay is obtained as shown in Table 2. Table 2 shows that the lowest delay is 0.003 ms and the highest delay is 0.009 ms and the average delay obtained from testing a 2 meters distance is 0.0053 ms. Testing the distance received on the robot with a distance of 4 meters is shown in Table 3.

**Table 3.** Testing the Range of 4 meters

| Test To- | Distance (m) | Sent Characters | Delays (ms) | Message Status Received |
|---|---|---|---|---|
| 1 | 4 | S | 0.008 | Succeed |
| 2 | 4 | S | 0.008 | Succeed |
| 3 | 4 | S | 0.007 | Succeed |
| 4 | 4 | S | 0.004 | Succeed |
| 5 | 4 | S | 0.006 | Succeed |
| 6 | 4 | S | 0.007 | Succeed |
| 7 | 4 | S | 0.006 | Succeed |
| 8 | 4 | S | 0.008 | Succeed |
| 9 | 4 | S | 0.008 | Succeed |
| 10 | 4 | S | 0.009 | Succeed |
| Average | | | 0.0071 | |

At a range of 4 meters from the Wireless Access Point, the test command is the same as testing ten times the "S" or Stop command is sent. From Table 3, the biggest delay in the delivery test with a distance of 4 meters is 0.009 ms while the smallest distance is 0.004 ms with an average delivery of 0.0071 ms. Testing the distance received on the robot with a distance of 6 meters is shown in Table 4.

**Table 4.** Testing the Range of 6 meters

| Test To- | Distance (m) | Sent Characters | Delays (ms) | Message Status Received |
|---|---|---|---|---|
| 1 | 6 | S | 0.007 | Succeed |
| 2 | 6 | S | 0.005 | Succeed |
| 3 | 6 | S | 0.011 | Succeed |
| 4 | 6 | S | 0.011 | Succeed |
| 5 | 6 | S | 0.013 | Succeed |
| 6 | 6 | S | 0.012 | Succeed |
| 7 | 6 | S | 0.011 | Succeed |
| 8 | 6 | S | 0.011 | Succeed |
| 9 | 6 | S | 0.004 | Succeed |
| 10 | 6 | S | 0.012 | Succeed |
| Average | | | 0.0097 | |

From Table 4 the resulting delay is the largest delay of 0.004 ms and the smallest delay of 0.013 ms. The average delay obtained when the distance is 4 meters is 0.0097 ms. Testing the distance received on the robot with a distance of 8 meters is shown in Table 5.

**Table 5.** Testing the Range of 8 meters

| Test To- | Distance (m) | Sent Characters | Delays (ms) | Message Status Received |
|---|---|---|---|---|
| 1 | 2 | S | 0.012 | Succeed |
| 2 | 2 | S | 0.012 | Succeed |
| 3 | 2 | S | 0.012 | Succeed |
| 4 | 2 | S | 0.012 | Succeed |
| 5 | 2 | S | 0.012 | Succeed |
| 6 | 2 | S | 0.010 | Succeed |
| 7 | 2 | S | 0.011 | Succeed |
| 8 | 2 | S | 0.011 | Succeed |
| 9 | 2 | S | 0.013 | Succeed |
| 10 | 2 | S | 0.012 | Succeed |
| Average | | | 0.0117 | |

From Table 5 the delay from testing the 8 meters range gets the largest delay of 0.013 ms and the smallest delay of 0.010 ms. The average delay at a range of 4 meters is 0.0117 ms. Testing the distance received on the robot with a distance of 8 meters is shown in Table 6.

**Table 6.** Testing the Range of 10 meters

| Test To- | Distance (m) | Sent Characters | Delays (ms) | Message Status Received |
|---|---|---|---|---|
| 1 | 10 | S | 0.021 | Succeed |
| 2 | 10 | S | 0.059 | Succeed |
| 3 | 10 | S | 0.040 | Succeed |
| 4 | 10 | S | 0.008 | Succeed |
| 5 | 10 | S | 0.007 | Succeed |
| 6 | 10 | S | 0.007 | Succeed |
| 7 | 10 | S | 0.008 | Succeed |
| 8 | 10 | S | 0.009 | Succeed |
| 9 | 10 | S | 0.007 | Succeed |
| 10 | 10 | S | 0.017 | Succeed |
| Average | | | 0.0183 | |

The delay resulting from sending orders with a distance of 10 meters obtained the largest delay of 0.059 ms and the smallest delay of 0.07 ms. From Table 6, the average delay is 0.0183 ms

In testing the range distance, the success rate of the process of sending and receiving the "S" Stop command can be calculated with the equation (3).

$$Success\ rate\ = \frac{\text{Number of Successful Trials}}{\text{Number of Trials Performed}} \times 100\ \%$$
$$Success\ rate\ = \frac{10}{10} \times 100\ \% = 100\ \% \tag{3}$$

## 4. Conclusion

From the test it can be concluded that the data sent by the referee box can be conveyed to the base station and can be sent to the robot. The delay obtained when sending orders to the base station and referee box obtained different results. The average delay generated is that the farther the range the more the average delay generated. The success rate of delivery is 100%.

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