IMPLEMENTATION OF WOKBOLIC ANTENNA 433 MHZ FOR WIRELESS SENSOR NETWORK DEVICES USING THE LORA PROTOCOL

Ridwan Satrio Hadikusuma[1*], Yuliarman Saragih[2], Reni Rahmadewi[3]
[1,2,3]Universitas Singaperbangsa Karawang
HS.Ronggo Waluyo, Puseurjaya, Kec. Telukjambe Tim., Kabupaten Karawang, Jawa Barat 41361.
Ridwansatrio2@gmail.com[1*], yuliarman@staff.unsika.ac.id[2], reni.rahmadewi@staff.unsika.ac.id[3]

Abstract – *Wireless Sensor Network (WSN) is a network consisting of sensor devices capable of detecting the physical condition of the surrounding environment and sending information on the sensor readings to the user for mon-itoring. To be able to transmit data wirelessly, an antenna is needed to be able to transmit signals on the WSN. A wokbolic is a parabolic antenna device that serves to transmit wireless signals. The purpose of this research is to implement the Wokbolic antenna on WSN to analyze the transmission system as an improvement on the existing Wokbolic antenna system. The hardware used in the preparation of this thesis uses the LoRa(Long Range) protocol to transmit the signal further. Implementing a 433 MHz gayabolic antenna using the LoRa protocol on the transmitter side has better transmission results compared to a wireless sensor network using the LoRa protocol without awanbolic antenna. This is evidenced by the comparison of the low RSSI value in the wireless sensor network that implements the wokbolic antenna as its transmission medium with an average RSSI of –65,43 dBm in 40 tests. In testing the transmission system for wireless sensor network devices at a dis-tance of 10.52 km which was tested 40 times, the average value of the delay in the transmission system on the node side that implements the 433 MHz wok antenna is 1014,2 ms. This value is certainly lower than the trans-mission system that does not implement a 433 MHz wokbolic antenna with a delay value of 18134,83 ms.*

Keywords*: antenna, network, sensor, LoRa, RSSI*

1. Introduction

Wireless communication technology has driven the development of micro and nanosensor applications in wireless communication networks. A number of sensors that are able to communicate wirelessly with each other, known as the Wireless Sensor Network (WSN) can be used to monitor an area, especially the use of IoT (Internet of Things) in smart cities, such as air quality monitoring to monitoring natural disaster mitigation such as floods, tsunamis and volcanoes[1-3]. JSN requires low energy consumption, so the IEEE 802.11 protocol on a wireless LAN (Local Area Network) network used for devices with high power consumption is not suitable for WSN implementation [4]. To be able to transmit data wirelessly, an antenna is needed to be able to transmit signals on the WSN. a wokbolic is a parabolic antenna device that functions to transmit wireless signals[5][6].

Previously, there had been research related to “Android-Based Flood Monitoring Application Using LoRa Communication” which was researched by Aldi Wahyu Saragih, Athiyyatul Farhanah and Cahyana. In his research, it is known that the community needs a technology that is able to provide early information regarding the arrival of floods in order to be able to evacuate early to avoid losses [7]. Talking about communication that is able to provide fast transmission so that information can reach the community widely and quickly, there is a research related to "Development and Implementation of a Hybrid Wireless Sensor Network of Low Power and Long

Range for Urban Environment" by Juan Bravo Arrabal. In this study, it was stated that the use of the LoRa module on WSN allows the transmission of sensor data capable of covering distances of up to more than 8 km in urban areas [8]. There was a similar study by Dina Angela and Helmi Hartanto regarding "Design of 433 MHz Bow-Tie Microstrip Antenna for Wireless Sensor Network Devices" and found out that with a wide bandwidth, the antenna can have a high data rate and is very suitable for use as a WSN antenna. The antenna also produces an omnidirectional radiation pattern. This has met the design requirements as well as the demands of the WSN device so that it can be placed anywhere[9]. The implementation method of wokbolic antenna at 433 MHz frequency for wireless sensor network devices with LoRa protocol has significant potential. The use of this frequency provides wide coverage and good penetrating ability, which allows signals to better reach devices [7], even in areas with interference or difficult coverage. In addition, the efficiency in the use of the frequency spectrum and LoRa's ability to transmit data over long distances with low power consumption add advantages to this method. An analysis of related work may also reveal performance advantages of the wokbolic antenna, whether in terms of radiation pattern, resistance to interference, energy efficiency, or other innovations that distinguish it from other approaches in the related literature. Thus, this method is promising in the development of wireless sensor networks with the LoRa protocol, providing a solution that is efficient, reliable, and has a wide signal range.

A wireless sensor network was designed using a wokbolic antenna with a 433 MHz LoRa (Long Range) module for the first time. When a sudden flood occurs, the air level sensor will measure the air level and report it to the public using a LoRa communication system that can reach a distance of more than 15 km (in Line of Sight conditions in rural areas) from the sensor location. Ultrasonic sensors are also used to monitor coastal areas. Suppose air begins to rise through the dam and into residential areas and almost drowns the sensor. In that case, the ultrasonic sensor will read and send a signal to the microprocessor, and the microprocessor will sound a warning alarm using a bell. The use of wokbolic antennas is carried out to increase the antenna's propagation range (coverage). To optimize the transmission of data sent from nodes in the WSN, it is necessary to evaluate the 433 MHz wokbolic antenna performance for Wireless Sensor Network devices using the LoRa protocol. This research aims to produce a wireless sensor network that can predict the arrival of floods in real-time with low power consumption and has a long transmission distance so that it can contribute to flood-prone areas.

2. Methods

Research on making a flood sensor by utilizing LoRa type Ai Thinker Ra-02 SX 1278 using a wokbolic antenna as a transmission medium for antenna performance analysis on a wireless sensor network as a test tool to obtain an analysis of an effective transmission system in LoRa communication is included in the realm of research and development (R&D). This is evidenced by the results of research in the form of technological products carried out based on technical steps. The research step in this implementation refers to the project work procedure, meaning that the work sequence is planned according to a simple design and continues to increase into complex products. The research steps are as shown in the block diagram in Figure 1.

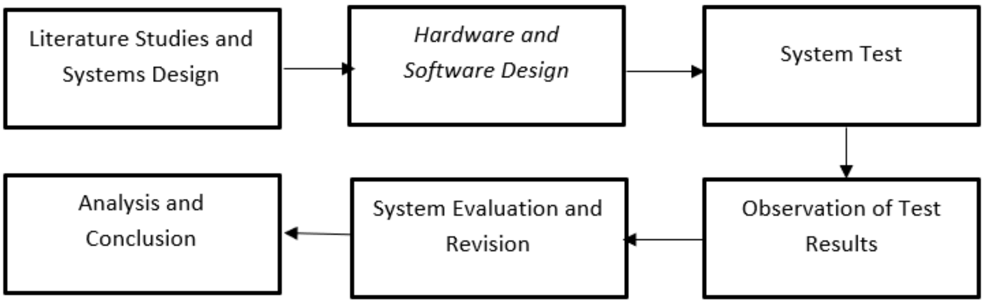

Figure 1. Block diagram of a wireless sensor network design using a wokbolic antenna

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This research uses Research and Development (R&D) research methods. This is based on data that will be presented empirically with the aim of testing the truth of the theory that is realized in the realization of a real communication system, namely LoRa applications, modulation techniques, transmitter and receiver circuits as well as RSSI quantities that can be measured and assessed or expressed in one quantity. As explained in figure 1, the block diagram flow starts from left to right, following the arrows. This research begins with conducting literacy studies and designing systems until it ends with analyzing and drawing conclusions.

2.1. Object of Research

The object of this research takes the theme of implementing a 433MHz wokbolic antenna for wireless sensor network devices using the LoRa protocol, so as to produce a device performance that is in accordance with the design idea. It is hoped that the results of the research and analysis of the performance of the wokbolic antenna in this study can be functionally useful and add to the repertoire of electronics science, especially in the field of telecommunications. Data pro-cessing is determined by the design of the program on the wireless sensor network for the flood sensor in executing the incoming data as a variable which will later be transmitted using LoRa using a 433 MHz wokbolic antenna.

2.2. System Planning

In system design the important thing is the assembly process, it should be emphasized that the installation of flood sensors on nodes in the wireless sensor network must be very precise against several disturbances such as rain and wind to avoid abnormal performance (system damage) of the sensor. In general, assembling guidelines refer to technical construction systems starting from the process of translating system drawings that have been made as shown in Figure 2, the design process, cutting and assembly and wiring (cable installation). In Figure 2, we can see that the system in this study is divided into 2. The first is the Node which contains the sensor network. While for the second is a gateway that stores the results of sensor processing to the cloud server so that the client can read it. to transmit data from Node to the gateway using a wokbolic antenna as the transmission medium.

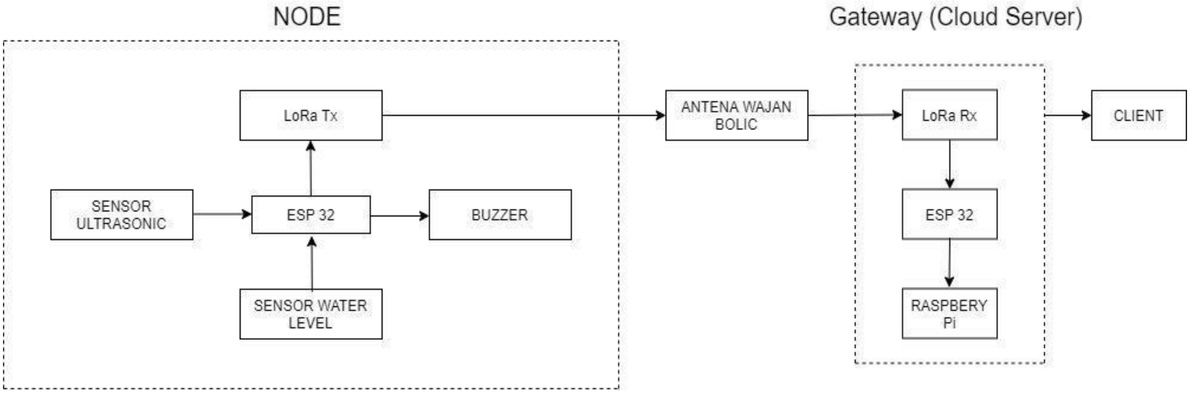

Figure 2. System block diagram

2.3. Electronics Design

The series of flood sensors on nodes in the wireless sensor network system uses the LoRa protocol which is designed to be implemented in Figure 3 below.

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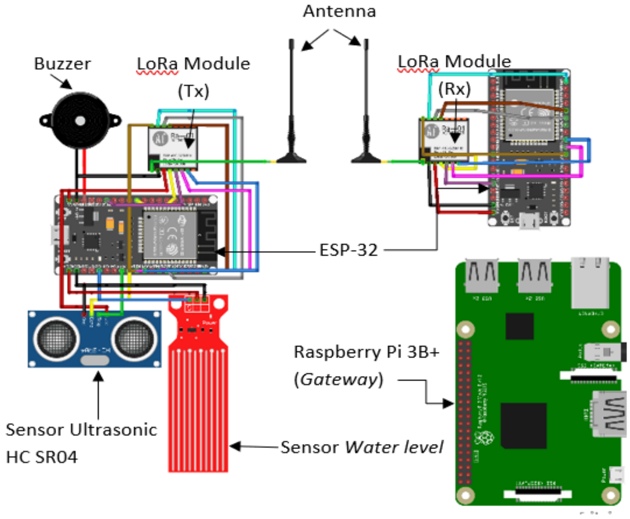

Figure 3. Electronics design

LoRa which is used for modulating transmission and reception signals uses LoRa type Ai Thinker Ra-02 SX 1278 with a frequency range between 410 – 425 MHz and uses a voltage of 3.3V as input. This study follows the frequency regulation recommended by Semtech in the Asian region, which is 433 MHz. In the designed flood sensor, the water level sensor is used to detect the water level so that water level monitoring data is generated in flood-prone areas and the HC-SR 04 ultrasonic sensor which detects the water level when the water level sensor is completely submerged in flood water. if the water level has reached 50 cm from the ultrasonic sensor, the sensor buzzer will sound loudly warning that the water has started to rise and the sensor will not work because it is completely submerged in water.

2.4. Transmission Media Design

The design of the transmission system on this tool is made simply using a LoRa module with a wokbolic as the antenna. This transmission system consists of 2 433 MHz LoRa Modules as a transmitter and a receiver, also using a wokbolic antenna on the transmitter side and a helical antenna on the receiver side. The LoRa module which is used as a transmitter is connected to the Wokbolic antenna and connected to the analog pin on Esp 32 which is used as a node. The design of the transmission media design to be built can be seen in Figure 4 below.

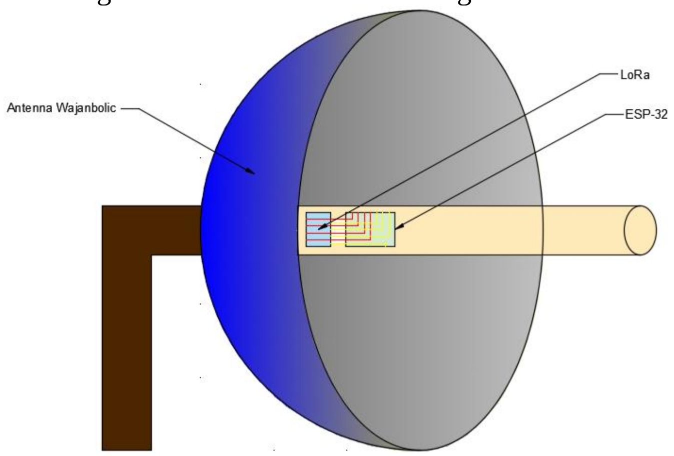

Figure 4. Wokbolic 433 MHz antenna design

After the tools and materials are collected, calculations are carried out to design the wokbolic antenna. This formula is used to determine the size of the pipe covered with aluminum foil. Calculations can use the following formula[10]:

$$F = \frac{D^2}{16\ x\ d} \quad (1)$$

where, F is the aluminum foil layer on the pipe, D is the diameter of the pan and d is the depth of the pan. because in this study using a frying pan with a diameter of 50 cm and a depth of 11 cm, the F value obtained is:

$$F = \frac{50^2}{16\ x\ 11} \quad (2)$$

Then the wokbolic antenna is placed at a height of 12 m using a USB cable with a length of 12 m and the height of the paralon on the antenna reflector is 35 cm. because the purpose of this research is to implement a wokbolic antenna that works at a frequency of 433 MHz, a LoRa module with a 433 MHz frequency band specification is needed which is placed on the reflector part of the wokbolic antenna so that the antenna has optimal performance.

2.5. Testing Methods and Instrument

The testing method on flood sensors in a wireless sensor network uses a 433 MHz wokbolic antenna to get the results of RSSI analysis carried out separately on the main parts. To see the performance of the tool that has been made, testing must be done. Before testing the tool will be calibrated with a similar tool as a reference. This test is to determine the character, pattern value, unit, magnitude, working principle of the transmission system on the flood sensor. This sensor is actually measured based on the ability to read water level data in detecting floods, the speed and distance of data transmission, the accuracy of the flood sensor readings and the range. Furthermore, the test results will be analyzed based on theory. each test requires an instrument (measuring instrument) to determine the value of a system according to its magnitude so that it can be analyzed. In the research of making this flood sensor, several instruments are needed, including: breadboard, jumper cable, 2.4 GHz antenna (Tx and Rx) and AVOmeter.

2.6. Data Collection and Data Analysis Techniques

Data retrieval is carried out through measurements using a serial monitor as a reference for sensor readings and accuracy. Measurement or data retrieval in the research on the performance analysis of the 433 MHz wokbolic antenna on the flood sensor in this wireless sensor network is focused on software measurements and performance results. Data collection to determine accuracy, precision, range and response was carried out by measuring various different conditions. The testing process is repeated, and the measurement data from several conditions are averaged as the final result.

Data obtained from the results of trials conducted with a minimum of 40 repetitions. Data analysis in this study was carried out quantitatively [11]. This is done by calculating the measurement results and then comparing them with the results of theoretical analysis. The results of this analysis are a combination of the results of measurements and theoretical calculations. From this data analysis, conclusions will be drawn from what has been formulated.

3. Results and Discussion

3.1. Design Implementation

The flood sensor on a wireless sensor network with a wokbolic antenna using the LoRa protocol is designed and implemented in Figure 5 below.

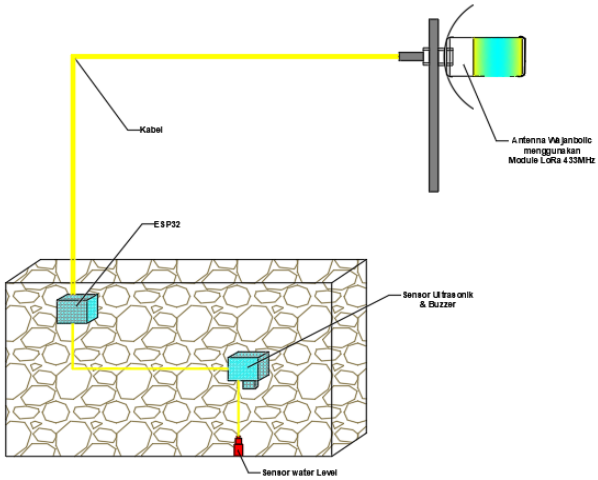

Figure 5.The design of the implementation of the 433 MHz wokbolic antenna for wireless sensor network devices using the LoRa protocol

Having previously carried out the design for the flood sensor tool, both hardware and software design, the results of the design are then implemented in real form or in the form of an actual tool. The implementation of the 433 MHz wokbolic antenna on this wireless sensor network is only built using 1 node as an early flood detector and consists of a water level sensor, an ultrasonic sensor HC-SR04 and a buzzer. On the node side, the esp32 microprocessor is used as a data processor for the sensor readings used. Determination of the type of antenna that will be used as a transmission medium in the WSN is selected based on the criteria for the WSN system to be built, such as the location of the WSN sensor node placement, the topology you want to use on the WSN network, or the working frequency of the JSN antenna. For certain WSN devices, the antenna needed is an antenna that has a radiation pattern that radiates in all directions or is omnidirectional [12, 13]. Data processing at the node side of the wireless sensor network is carried out as shown in the flow chart in Figure 6 below.

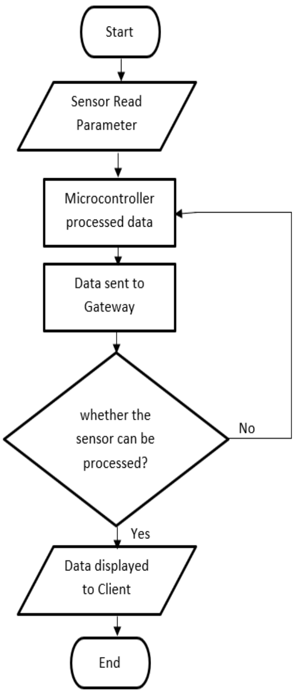

Figure 6. Flowchart of data processing at the node side of a wireless sensor network

The wireless sensor network built is also equipped with a Raspberry Pi 3B+ which is used as a gateway. This gateway will function as a bridge to send data from the node side to the client. With the use of gateways, it is possible to develop multisensors or multiple nodes. Sending sensor data from the node to the gateway uses a communication network with the LoRa protocol so that it does not depend on the cellular network which could lose the network when a flood arrives near the sensor placed because of the submergence of the BTS at the cellular communication provider.

3.2. Wokbolic Antenna Implementation 433 MHz

After calculating the wok design according to the formula used and getting a wok with a diameter of 50cm and a pan depth of 11 cm, and a PVC pipe length of 35 cm, the next step is to directly design a wokbolic antenna by following these steps :

1. Make a hole in the front of the PVC pipe (which will be covered with aluminium foil about 7cm) so that the USB port can enter and connect to the esp 32 along with the LoRa module. Mark the end of the pipe as the end of the feeder, which will not be covered with aluminium foil.
2. Cover the PVC pipe with aluminium foil as far as 3 inches and make sure it does not exceed the feeder limit.
3. Cut some aluminium foil into a circle about 3 inches and insert it into the doff.
4. Make a hole in the centre of the pan and the centre of the doff with a drill, attach the handle to the back of the pan and tighten it with a nut on the part that has been perforated.
5. Insert the LoRa and ESP 32 modules that have been filled with the receiver program into the PVC pipe, and make sure the USB cable can fit into the pipe.
6. Attach the front doff with aluminium foil.
7. Connect the USB cable from the ESP 32 to the Raspberry Pi 3B+, which is a gateway in the designed wireless sensor network.

The implementation of this 433 MHz wokbolic antenna functions as a signal amplifier (extender), where the signal emitted by the LoRa module can cover more comprehensive coverage [14], and the network using the LoRa protocol can be used from node access points to gateway access points, depending on the location of the wireless device. After measuring the antenna design, the antenna design and radiation pattern results were obtained using the NI AWR Design software. Based on the design, it is known that the antenna's Return Loss (RL) is -54.75 dB and the Gain is 16.00 dBi. Furthermore, based on the NI AWR Design software simulation, the antenna has the highest Gain at an angle of 0°. Therefore, it can be said that the antenna has a directional radiation pattern. This shows that the simulation results are valid. However, the antenna can be used as a medium-range (1-15 km) point-to-point network link. The RL and radiation pattern results can be seen in Figures 7 and 8. Figure 7 shows that the RL in the study was stable at -54.75 dB in the 433 MHz frequency range. This result is precisely what Hou [15] did in a previous study regarding using antennas in LoRa. You will find that the RL on the LoRa transmission is very stable if you get the design results in the range of 45 - 60 dB.

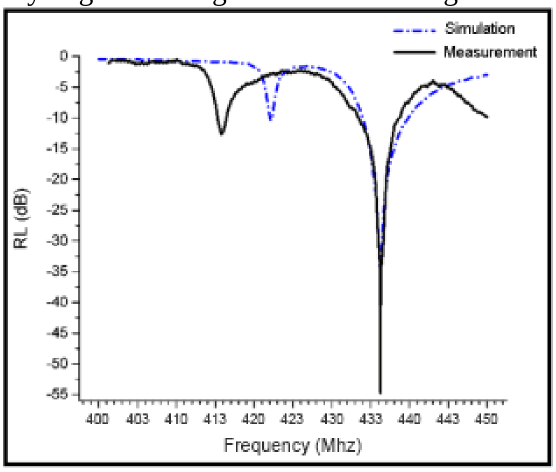

Figure 7. Return loss value against frequency

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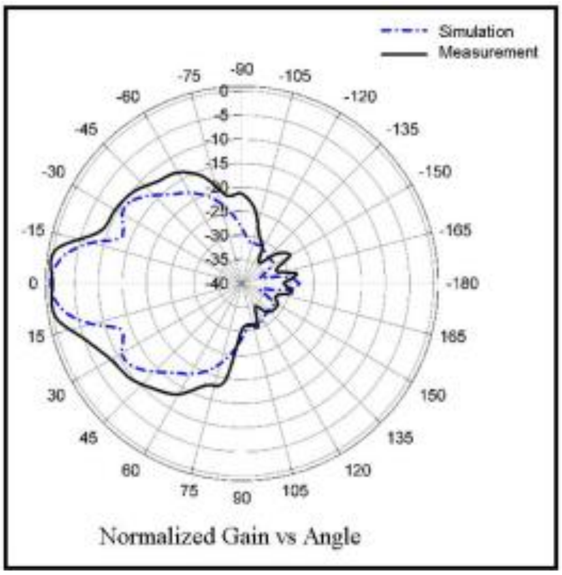

Figure 8. Radiation pattern at 433 MHz

Compared to previous research on the wokbolic antenna, the results obtained in this study provide a complete explanation of the implementation of the wokbolic antenna using the LoRa protocol in the 433 MHz frequency band. The RL value indicates that the antenna works optimally with small power losses. The gain value indicates that the measured value is following the theory. This research can be used as a reference in research, especially on implementing the wokbolic antenna using the LoRa protocol. This research also opens the opportunity to examine other characteristics of the wokbolic antenna in the future. Investigations that can be carried out later include combinations of other types of antennas, optimization of reflectors with smaller sizes, and trials of their use in actual conditions.

Based on the radiation pattern of the simulation results and the frequency band used, the placement of the transmitter and receiver should be placed with LoS (Line of Sight) propagation. It means that signal propagation is carried out in free space utilizing direct and indirect signals caused by ground reflections. LoS propagation is often referred to as direct wave propagation because the waves emitted from the transmitting antenna propagate directly to the receiving antenna and do not propagate above the ground [14]. The wokbolic antenna on the sending side is implemented as shown in Figure 9.


Figure 9. Implementation of the 433 MHz wokbolic antenna

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3.3. Wokbolic Antenna Test 433 MHz

To determine the location at the time of testing, the distance from the transmitter to the receiver is taken randomly based on the closest, intermediate and far distances. During the test, the antenna is also placed at 12 meters from the ground height. The wokbolic antenna as a transmitter is installed at coordinates 6°19'25.0" South 107°18'21.5" East, "shoots" the receiver point on the gateway side, which is carried out 4 times with different distance tests with a point located at 6°22'43.8" South 107°19'50.5" East, with a distance of about 1.54 kilometres from the transmitter access point as shown in Figure 10.

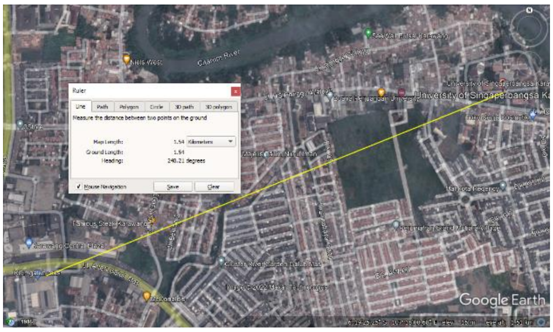

Figure 10. Coverage testing at a distance of 1.54 km

In the second location in the distance test, the receiver on the gateway side is placed at a point at 6°20'34.4" South 107°20'46.3" East, with a distance of about 5.13 kilometres from the transmitter access point. For the receiver's location during the third distance test, the receiver point on the gateway side is installed at coordinates 6°20'48.3" South 107°22'43.7" East, with a distance of about 8.32 kilometres from the transmitter access point. Finally, at the fourth location in the distance test, the receiver on the gateway side is placed at a point at 6°21'21.7" South 107°23'30.8" East, with a distance of about 10.52 kilometres from the transmitter access point.

Based on the 40 data collected, there is a very significant difference when sending data on the wireless sensor network in conditions using a wokbolic antenna or without a wokbolic antenna. Therefore, based on the data above, 40 samples were taken to see the RSSI comparison when the flood sensor on the wireless sensor network sent data to the gateway using the LoRa protocol. The results were obtained, as shown in Figure 11.

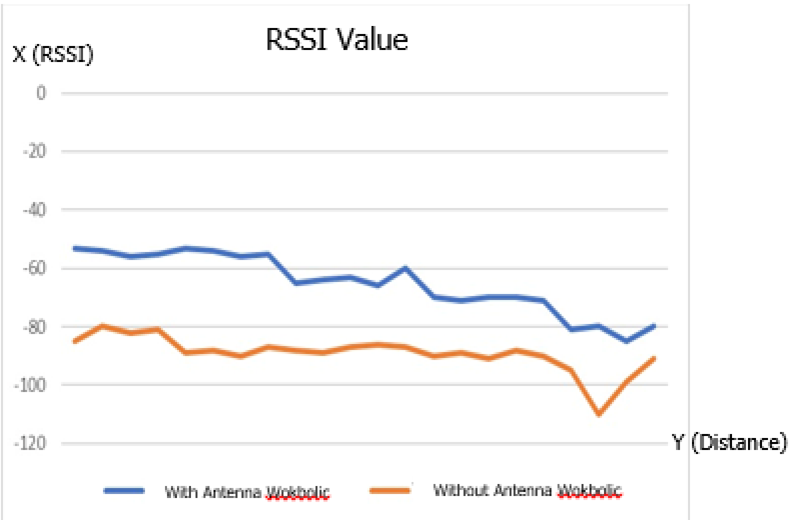

Figure 11. Comparison of RSSI values in transmission on sensors in wireless sensor networks

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From the picture above it also proves that the implementation of the 433 MHz wokbolic antenna for wireless sensor network devices using the LoRa protocol has an effective impact in reducing the RSSI value as well as having a wider coverage than using other transmission modules such as bluetooth modules, WiFi modules and other protocols such as MQTT and so on. From the picture we can also see that the RSSI value decreases with increasing distance. The flood sensor readings in a wireless sensor network that uses a gankbolic antenna as its transmission medium are also capable of transmitting data in real time as shown in the serial monitor on the gateway side as shown in Figure 12.

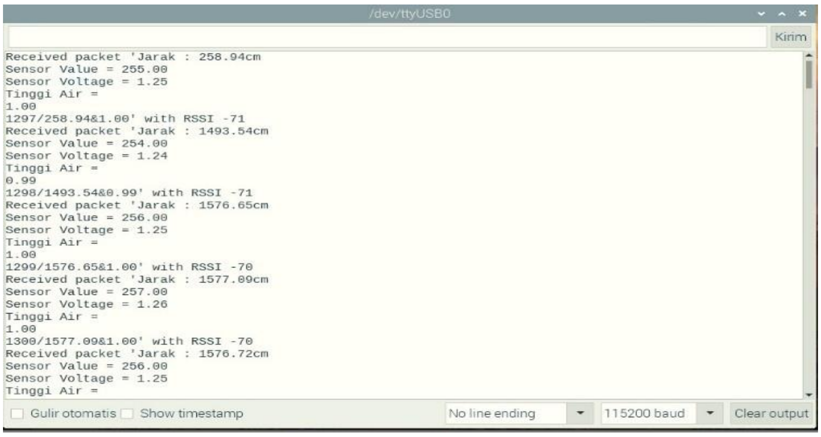

Figure 12. Sensor reading data on the gateway side

3.4. Transmission System Testing For Wireless Sensor Network Devices

Tests on the transmission system for Wireless Sensor Network devices are carried out on the node side to ensure that each component of the flood sensor in the node system is functioning correctly and can detect flooding early and send the results of data readings on each sensor used in real-time to the user side. The antenna distance on the transmission system on the node side is placed at a distance of 10.52 km from the receiver on the gateway side. The results of the flood sensor testing on the node side can be seen in table 1.

Table 1. Flood Sensor Testing On The Node Side

Condition on node	WATER LEVEL SENSOR STATUS	Ultrasonic Sensor Status	Buzzer Condition
No water (dry)	Detected	Detected	OFF
Submerged in Water (Water Level < 50 cm)	Detected	Detected	OFF
Submerged in Water (Water Level > 50 cm)	Detected	Detected	ON

The node consisting of the flood sensor has a delay when transmitting sensor data readings to the gateway side. Delay is the time required for data to travel the distance from the origin (transmitter) to the destination (receiver). This delay is a parameter in the success of a transmission system. The amount of delay is influenced by several things such as physical media, distance and the amount of bandwidth. Testing the transmission system for wireless sensor network devices is carried out by observing the time difference between the timestamp read on

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the serial monitor on the node side, and the timestamp read on the serial monitor on the gateway side.

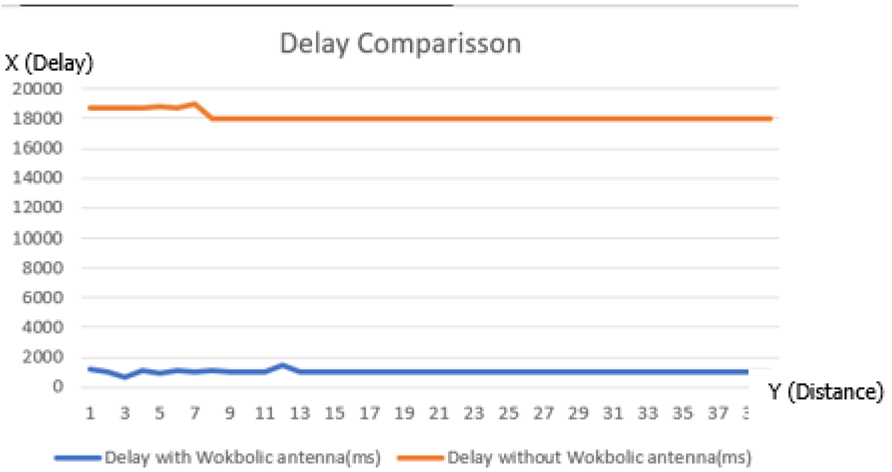

Figure 13. Comparison of RSSI values in transmission on sensors in wireless sensor networks

4. Conclusion

In this study, it is known that implementing a 433 MHz wokbolic antenna using the LoRa protocol on the transmitter side has better transmission results than a wireless sensor network using the LoRa protocol without a wokbolic antenna. This is evidenced by comparing the low RSSI value in the wireless sensor network that implements the wokbolic antenna as its transmission medium with an average RSSI of –65,43 dBm in 40 tests. Furthermore, it is also known that in testing the transmission system for wireless sensor network devices at a distance of 10.52 km, which was tested 40 times, the average value of the delay on the transmission system on the node side that implements the 433 MHz wokbolic antenna is 1014,2 ms. This value is undoubtedly lower than the transmission system that does not implement a 433 MHz wokbolic antenna with a delay value of 18134,83 ms.

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