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LoRa-based DC Motor Control and Yagi Antenna

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ABSTRACT

With the advancement of wireless communication technology, appropriate solutions such as LoRa SX1278, a long-range intermediate module with a wider range of IoT applications have become available. Nevertheless, problems still exist, especially in Non-Line of Sight (N-LoS) circumstances that can favor transmission. On the other hand, the demand for more effective motors in the household sector is growing, where DC motors provide purchasing managers with advanced and low-cost direct control capabilities over AC induction motors. Suggested approaches include the use of omni-directional antennas to increase the transmission range of LoRa as well as the application of DC motors to improve operational efficiency. This work develops the necessary techniques to increase the communication range of LoRa and optimize the use of DC motors in a small industrial setting. The research procedure consisted of investigating the automatic control of a 12V DC motor using an Arduino Uno and a DHT22 temperature sensor, and the study of remote control via LoRa SX1278 with switching mode logic. The tests conducted confirmed that the percentage error of DC motor control was 0.78%, 0.42%, and 0.26% in each category, respectively. There is also a clear 600m and 6250m data transmission range on the LoRa in two different locations, featuring the same switching logic. In summary, the embellishment of LoRa SX1278 through omni-directional antenna anchoring and mode switching logic on the LoRa SX1278-based DC motor control system displays efficient operation and extended transmission range, thus offering antimicrobial potential in household industrial applications.

1. INTRODUCTION

The development of wireless communication technology in recent years has brought significant innovation, especially in the development of long-range transceiver modules such as LoRa SX1278 [1]-[3]. LoRa (Long Range) is a technology that enables real-time long-distance data transmission with high energy efficiency, which is essential in Internet of Things (IoT) applications and wireless sensor networks [4][5]. The SX1278 RF module is designed to enable long-range communication over frequency bands that range from 137 MHz to 525 MHz, and comes with an improved sensitivity of -148 dBm while having a maximum output power capability of +20dB as well - perfect if you are using wireless in areas that require long-range coverage without consuming much power [6]-[9].

On the other hand, in the world of home industry, the use of efficient motors is a pressing need. Motors used in household and small industrial applications must be able to provide high performance with low energy

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consumption. Currently, AC induction motors are often used in these applications. However, induction motors have drawbacks such as being less efficient and requiring more complex controls compared to DC motors. As a result, DC motors are an attractive option as they can be engineered to have higher efficiency in addition to having better controllability for use in the home industry [10][11].

While long-distance data transmission may be advantageous in most LoRa SX1278 modules, there is also the issue of the biggest challenge of all being the transmission range, especially in Non-Line Of Sight (N-LoS) situations where tall buildings and dense urban environments force signals to bounce. These conditions can cause significant signal degradation, thus lowering the expected effectiveness of long-distance communication [12]-[17]. On the other hand, in the context of using motors for home industry applications, AC induction motors are often considered inefficient. They are more expensive and difficult to control at very high speeds compared to DC motors, which can mean higher operating or maintenance costs as AC motors are typically 25% more inefficient compared to the equivalent power class of Permanent Magnets Synchronous Motor PMSM machines fed by inverters in the near future [18].

The main objective of this research is intended to solve the two main problems mentioned above. In detail, the objective of this research is to increase the data transmission range for the LoRa SX1278 module using an omni-directional type antenna. In addition to the kicking function, this antenna is designed to improve signal reception in N-LoS scenarios in urban environments and provide a longer communication range. In addition, the purpose of this research is to make industrial home applications more efficient by using DC motors. In terms of energy consumption and operational efficiency, DC motors are much better in every respect compared to AC induction motors, therefore DC motors are becoming a more efficient alternative.

Some related research is the development of innovations in DC motors by utilizing the Internet of Things POOR [19][20], besides the use of Wi-Fi is also present in monitoring both room temperature and others on DC motors in the industrial world SAHA [21]-[24]. The LoRa SX1278 module has become popular in recent years, one of which is in combination with a DC motor [25]. Thus, the purpose of the research is to innovate monitoring and control of DC motors using LoRa SX1278 remote communication tools, so that it can make a significant contribution to the development of control and telecommunications technology.

The contributions of this paper including enhanced DC motor control with Yagi antenna, improverd Yagi antenna for LoRa SX1278, and optimized data transceiver communication.

2. METHOD

2.1. Long Range (LoRa)

LoRa, short for Long Range, is a long-range communication technology that belongs to the Low Power Wide Area Network (LPWAN) class, and is mainly used for Internet of Things (IoT) applications. In terms of LPWAN technology, there are two leading players, LoRa, and NB-IoT, which continue to expand their market scale. LoRa technology operates in the unlicensed spectrum below 1 GHz and is based on RF wireless techniques in the form of a star-point LoRaWAN network. Data from end nodes can be transferred to the server via a LoRa gateway. Meanwhile, the security aspect is guaranteed by symmetric key encryption as a security method [26][27].

LoRa, which uses chirp spread spectrum (CSS) to modulate sensitivity and data rate, is one of the first technologies developed for military transmission because it is capable of transmitting over long distances and providing resistance to interference. This technology is ideal for applications that require very little data, such as transmission rates of 0.3 kbit/s to 50 kbit/s. The LoRa frequency range used in Indonesia is from 920 to 925 MHz, which is facilitated by transmitter power adjustment to improve coverage and save energy [28][29].

LoRa provides a communication radius of 10-40 km in rural areas and 1-5 km in urban areas, the latter of which can achieve a reception sensitivity of -148 dBm. If we look at band efficiency and range, LoRa has surpassed previous technologies such as WiFi which is only about 100 meters and consumes more power. In addition, LoRa technology is very cheap and allows more devices to be connected per base station than WiFi. LoS, or Line-of-Sight, is the highest performing scenario for LoRa but can operate effectively at shorter distances of up to 15 meters under NLoS, or Non-Line-of-Sight conditions [30]-[33].

LoRa technology is best suited for Internet of Things applications that do not require high data rates but must cover the largest possible area and be the most energy efficient. After all, it is a technology that makes it possible to maintain long-term operation from a single rechargeable battery, the idea of connecting it to various other industrial or household activities is tantalizingly created. LoRa technology has also met economic demands on a large scale. Moreover, it is well suited for urban and rural settings as it has a strong application base

2.1.1. LoRa Modulation Mode

LoRa SX1278 has various modes of operation that can be adapted to the needs of long-distance communication applications and low power consumption. Some of the modes include [34][35]

2.1.1.1. Transmitter Mode

It allows the module to function as a data sender, using the Chirp Spread Spectrum (CSS) technique to modulate and send data at speeds up to 50 kbps. The module also offers adjustable transmission power between +5 dBm to +20 dBm, with a maximum range of up to 15 km under Line of Sight (LoS) conditions. Parameter settings such as Spreading Factor (SF) and Bandwidth (BW) affect the data transmission rate and range.

2.1.1.2. Receiver Mode

As a receiver, the LoRa SX1278 can receive signals with the highest sensitivity of -148 dBm, allowing reception of very weak signals from a considerable distance. It features AGC to optimize signal reception. ACK/NACK is supported in this mode to ensure the integrity of the received data.

2.1.1.3. Transceiver Mode

Transceiver mode combines transmitter and receiver modes such that the LoRa SX1278 can switch from transmit to receive and vice versa. In dynamic networks, such as mesh network topologies, where each node can be used as both a sender and receiver, this module works perfectly. Therefore, this module is the best candidate for a wide variety of applications that require long-distance communication.

2.1.1.4. Sleep Mode

In sleep mode, the power consumption is very low, only a few microamps, and most of the internal components are disabled. The module will remain in this mode until it is commanded to switch to another mode. This is what makes this module particularly suitable for IoT applications with long idle periods with minimal power supply.

2.1.1.5. Sleep Mode

Standby mode allows the LoRa SX1278 to be immediately ready for operation with low latency time. Power consumption is less than in active mode; however, the module can switch to transmit or receive mode fast enough for a good response with still reasonable power savings.

2.1.1.6. CAD Mode

CAD mode-This function allows the module to check for any channel activity before transmission or reception. This, in turn, prevents signal clashes by checking if any other signals are currently active on the channel, so communication can take place with much less integrity and interference.

2.1.1.7. FHSS Mode

FHSS mode now allows the module to skip multiple frequencies during transmission. This mode is useful in environments full of wireless devices as it provides a much lower risk of interference, making the signal much more robust against outside interference.With the advantages of flexibility, wide range, and low power consumption, the transceiver system on the LoRa SX1278 is a superior solution in various IoT applications, from environmental monitoring systems to industrial automation. Figure 1 shows the LoRa SX1278 module

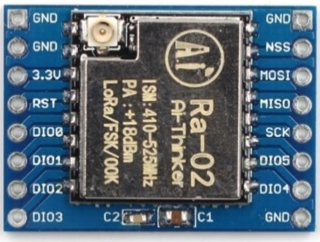


Figure 1. LoRa SX1278 Module

2.2. Arduino Uno

The microcontroller board, Arduino Uno R3, is an open-source device created to simplify electronics and programming for novice users. Contrary to what one might think, this board was not released in 2005 as this was the inception of the Arduino platform, but the Uno R3 was specifically released afterward, which brought together the two worlds of software and hardware to enable the creation of electronic projects. The board comes with 32KB flash memory, 2KB SRAM, and 1KB EEPROM, and is built on the ATmega328P microcontroller, an 8-bit AVR-RISC chip from Atmel. The Arduino Uno has 14 digital pins (6 of which are PWM supported), 6 analog pins, and a USB connection for programming and testing purposes [29][33][36][37].

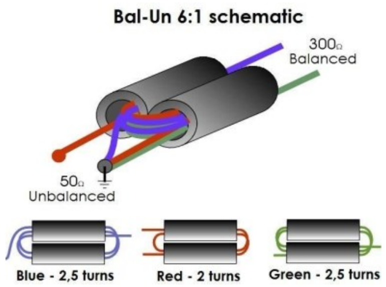
The Arduino Uno's PWM application is its forte as it can modulate the pulse width to gain analog control of digital outputs such as DC motor speed or LED brightness. In addition, this board can communicate through serial channels such as UART, SPI, and I2C, so it can connect to peripheral devices. The Arduino Uno is known for its ease of use, cost-effectiveness, and compatibility with various sensors and add-on modules, which is the reason why it is the first choice for school projects, hobbies, and technology development such as the Internet of Things (IoT) [38]-[41].

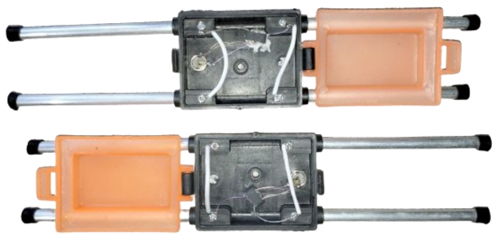
2.3. Yagi Antenna

The application of LoRa transceiver is really feasible to be implemented by Yagi antenna. Through the use of signal amplification, this device can finally get more communication range so that noise from neighbors will not affect data transmission, improve transmission energy efficiency and in LoS line of sight reaches about 600 meters which was previously only 350 meters. There may be instances where this directional antenna is able to get clearer data but the transmission is long and not so strong due to the presence of other antennas. This type of antenna, which is very close to the world of technology today, can be a noisy reconciliation through the noise emitted by other devices. LoRa can select various suitable frequencies in this band including the 915 MHz and 868 MHz free bands [42][43].

At its core, a Yagi Antenna is basically an antenna that has one frontend element and other reflector and directional mounts. The elements are interconnected in such a way that one side is covered by the elements. The driver moves the electric current to the radio waves while the signal is being amplified, in the process, the reflector reflects the signal back to the source for amplification, and the director points the signal in the right direction. The impedance matching between the LoRa module and the antenna is an important aspect of the common view. Yagi is at 300Ω while LoRa is at 50Ω. In a multi-team environment, each antenna is connected to the LoRa device by electrical and mechanical methods. Full details of the control system or parameters to be set will be provided to future engineers at the end of this project [44][45].

Another type of LoRa is used with the Yagi antenna, the 3dBi antenna. This antenna is LOS (37 miles with line of sight). The official frequency difference marking the 3dBi and Yagi antennas is 90 MHz. The antenna gain is 3dBi which means it is good for simple applications from a single 2.4GHz device. The 3 dBi links with a WiFi radio with an output of 15 dBm, which implies a fourfold speed growth to the 240MB/s level. The 3dBi antenna is able to create a wide coverage without a single focus because it transmits signals in every horizontal direction [46][47]. The Design of the Yagi Antenna design results are shown in Figure 2.





(a) (b)

Figure 2. Components of the Yagi Antenna
(a) Design Planning, b) Yagi Antenna design results on Dipole

2.4 DC Motor

A 12-volt DC motor is one of the most commonly used as a fan prime mover due to its superior efficiency and control. These motors work by converting 12-volt DC electrical energy into mechanical energy that is used to drive the fan. The current flowing through this motor can be regulated in the range of 1 to 2 amperes depending on the load and speed. Due to its voltage, the DC motor rotates at 1500 - 3000 RPM, giving the fan enough rotation to generate enough airflow to cool or clean the room from dust particles [48]-[51].

The main advantage of DC motors in fan applications is their ability to regulate speed easily. This speed regulation can be done by changing the voltage entering the motor; for example, lowering the voltage from 12 volts to 6 volts can reduce the motor's rotation speed by half, resulting in a softer breeze. In addition, DC motors are highly efficient in energy use, with electrical-to-mechanical conversion efficiencies that can reach 85-90%, higher than AC motors that typically have efficiencies of around 70-80%. This high efficiency not only reduces power consumption, but also minimizes the heat generated, thus extending the overall life of the motor and fan [52][53].

In addition, 12-volt DC-type motors mostly have built-in protection systems for surges and products to ensure safer performance over time. Powered by DC motors, they consume about 12 to 24 watts of power and are highly energy-efficient machines that are ideal for use in portable applications or ventilation systems due to their low power requirements with high performance. These features and benefits make 12-volt DC motors an ideal choice for fan applications, especially in households as well as small industrial compact designs [54]-[58].

2.4.1. DC Motor Control System

The LoRa switching process in your designed system involves switching roles between two LoRa modules, LoRa 1 and LoRa 2, from transmitter (TX) to receiver (RX) and vice versa. The main purpose of this switching is to provide flexibility in motor control, either automatically through sensors on LoRa 1, or manually from a remote user-operated LoRa 2. The following is an overview of the LoRa switching process:

2.4.1.1. Initial operating system

LoRa 1 (Tx) Transmitter which is LoRa 1 module is placed on a device connected to Arduino, temperature sensor, and dc motor. In the initial operation, the DHT-22 module will send temperature data to be managed by Arduino to provide PWM signals as input for motor speed according to the category that has been programmed. In other hand, LoRa 2 (Rx) Receiver module is placed on the device connected to the Arduino and is specialized only for receiving data. In the initial operation, LoRa 2 only functions to forward the received data to Arduino to be managed.

2.4.1.2. Switching Process

It starts with setting a time interval in Arduino programming, so that at a certain time each LoRa module switch operating modes. Synchronization beetween modules when LoRa 1 and LoRa 2 communicate with each other to inform that the time for role switching has come. Usually, this signal can be a special message agreed upon between modules to signify switching. Then, LoRa 1 Module synchronization, In this mode, the Arduino Uno on the LoRa 1 device will manage the programmed time interval data, and at the same time, the LoRa 1 module will stop sending sensor data and DC motor speed. Then the module will change mode to Receiver, and will only receive data from other LoRa devices. After that, LoRa 2 Module synchronization. In this mode, the mode change on LoRa 2 is controlled manually through the mode push button that has been connected to the programming code on the Arduino uno. When the TX mode button is pressed, the Arduino uno will provide data signals to LoRa 2 to change modes. At the same time, the module will change function to Transmitter, and send data.

2.4.1.3. Mode change operating system

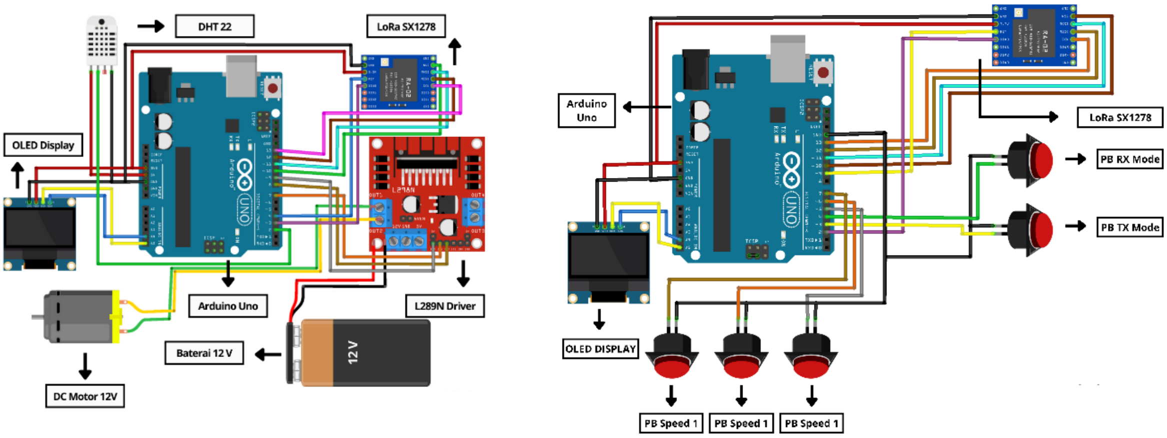
The condition of LoRa 1 in Receiver mode means that it will only function as a data receiver, then forwarded to Arduino to be managed and the data will be displayed on the OLED Display. However, the condition of LoRa 2 in Transmitter mode is that the module will function as a data sender. Arduino will turn on the button function for the dc motor speed regulator through the program that has been made. Each button has its own function, the signal is managed by Arduino and forwarded to the LoRa 2 module to be sent to other LoRa modules.

2.4.1.4. Return to the initial operating system

Once the next time interval is reached, the switching process will be performed again. LoRa 2 reverts to RX and LoRa 1 reverts to TX, allowing the temperature sensor-based automatic settings to be re-enabled. Soft switching is usually controlled by a program running on a microcontroller connected to the LoRa (such as Arduino or ESP32). This program regulates when switching occurs based on time of day, environmental conditions, or user input. For smooth role switching, a simple communication protocol is used to ensure that both modules receive the switching signal and perform the role switching without conflict. By using LoRa switching, this system can combine sensor-based automatic control and remote manual control, increasing flexibility in the operation of DC motors in various scenarios.

3. RESULTS AND DISCUSSION

The design of this tool is divided into two main parts, the first is software design and hardware design. The software design includes the tool circuit scheme. Figure 3 shows the circuit scheme for each LoRa Transmitter and LoRa Receiver module for monitoring and controlling dc motors, as well as sending and receiving data signals.



(a) (b)

Figure 3. Device Schematic: (a) LoRa Transmitter, (b) LoRa Receiver

3.1. Testing room temperature-based dc motor control

Testing is carried out based on the room temperature that has been read by the DHT-22 sensor in the form of (°C) degrees Celsius, temperature categorization is divided into 3 conditions, the first condition is when the temperature is below 25 ° C, the second condition is when the temperature is between 25-30 ° C, the last condition is when the temperature is above 30 ° C. The speed of the dc motor will automatically adjust to each temperature category, testing the motor speed is carried out with each condition is five trials to see the success rate and program error.

3.1.1. State of temperature category 1

Table 1 displays data on the state of temperature category 1, which is below 25 ° C with five tests. The dc motor speed value that has been programmed on the Arduino uno and the speed measurement using a tachometer is calculated the difference and percentage error in each test, then the average percentage error is calculated. During the test results with measuring instruments, it was found that the average percentage error rate was 0.78%.

3.1.2. State of temperature category 2

Table 2 displays data on the state of temperature category 2, which is between 25-30 ° C with five tests. The speed value of the dc motor that has been programmed on the Arduino uno and the speed measurement using a tachometer is calculated the difference and percentage error in each test and then the average percentage error is calculated. During the test results with measuring instruments, it was found that the average percentage error rate was 0.42%.

Table 1. DC Motors speed control testing at temperature category 1

Test to-	DC Motor Speed (RPM)	Tachometer Measurement (RPM)	Difference	Error (%)
1	200	199	1	0,50%
2	210	208	2	0,96%
3	208	206	2	0,97%
4	212	210	2	0,95%
5	206	205	1	0,49%
Average Error (%)				0,78%

Table 2. DC Motors speed control testing at temperature category 2

Test to-	DC Motor Speed (RPM)	Tachometer Measurement (RPM)	Difference	Error (%)
1	674	671	3	0,45%
2	670	668	2	0,30%
3	664	662	2	0,30%
4	680	677	3	0,44%
5	678	674	4	0,59%
Average Error (%)				0,42%

3.1.3. State of temperature category 3

Table 3 displays data on the state of temperature category 3, which is above 30 ° C with five tests. The dc motor speed value that has been programmed on the Arduino uno and the speed measurement using a tachometer is calculated the difference and percentage error in each test and then the average percentage error is calculated. During the test results with measuring instruments, it was found that the average percentage error rate was 0.26%.

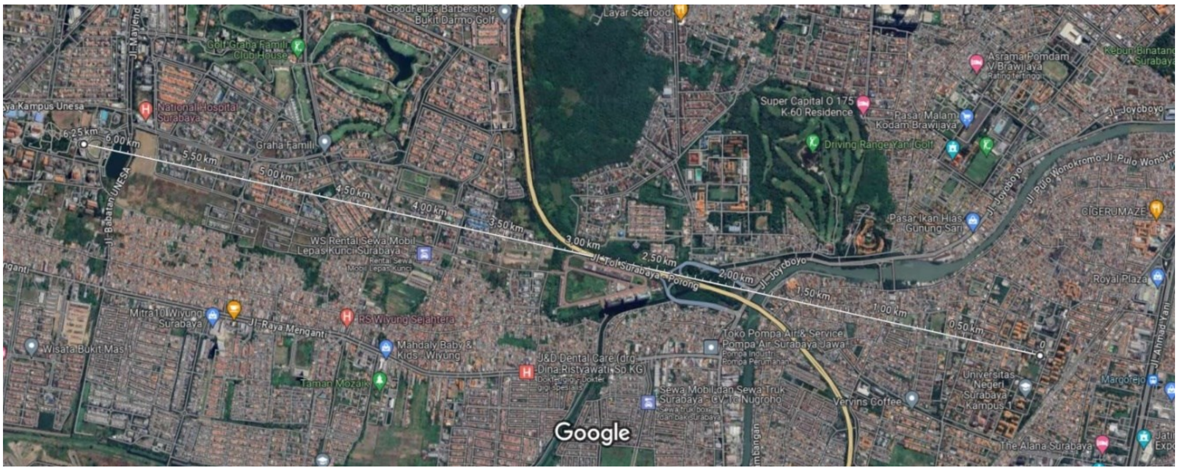
Table 3. DC Motors speed control testing at temperature category 3

Test to-	DC Motor Speed (RPM)	Tachometer Measurement (RPM)	Difference	Error (%)
1	985	981	4	0,41%
2	980	978	2	0,20%
3	993	989	4	0,40%
4	988	987	1	0,10%
5	995	993	2	0,20%
Average Error (%)				0,26%

3.2. Testing DC Motor control data transmission

Testing the transmission of dc motor control data was carried out in two test sites, the first test was carried out at UNESA Ketintang Campus 1, building K10 lt. 3 building became the transmitter and the data transmission experiment was carried out as far as possible. The second test was conducted between UNESA Campus 1 and UNESA Campus 2, with the UKM Center building lt.3 being the transmitter. Figure 4 shows the location of the two testing sites with their respective distances. Testing is done by sending data signals in the form of, Data- is the test sequence when the device is turned on, then the room temperature, and motor speed. Each data will be synchronized between the sending device and the receiving device to be categorized as to the status of data transmission.

(a)



(b)

Figure 4. Data Transmission test map. (a) Building K10 UNESA 1, (b) UNESA 1 – UNESA 2

3.2.1 Data transmission test 1

The data transmission test 1 is listed in Table 4

Table 4. Data Transmission testing 1 in K10 UNESA building 1

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
K10	100	Data 3 Temperature: 18 °C Motor speed: 200 rpm	Data 3 Temperature: 18 °C Motor speed: 200 rpm	Connect
	200	Data 8 Temperature: 22 °C Motor speed: 208 rpm	Data 8 Temperature: 22 °C Motor speed: 208 rpm	Connect
	300	Data 15 Temperature: 22 °C Motor speed:214 rpm	Data 15 Temperature: 22 °C Motor speed:214 rpm	Connect
	400	Data 18 Temperature: 25 °C Motor speed: 664 rpm	Data 18 Temperature: 25 °C Motor speed: 664 rpm	Connect
	500	Data 20 Temperature: 30 °C Motor speed: 684 RPM	Data 20 Temperature: 30 °C Motor speed: 684 rpm	Connect
	600	Data 25 Temperature: 30 °C Motor speed: 985 RPM	Data 25 Temperature: 30 °C Motor speed: 985 rpm	Connect
	700	Data 30 Temperature: 35 °C Motor speed: 995 rpm	Data - Temperature: - Motor speed: -	Disconnect

3.2.2 Data transmission 2

The data transmission test 2 is listed in Table 5

Table 5. Data Transmission testing 2 between UNESA

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
Between UNESA	6250	Data 1 Temperature: 18 °C Motor speed: 114 rpm	Data: - Temperature: - Motor speed: -	Disconnect
	6250	Data 6 Temperature: 20 °C Motor speed: 208 rpm	Data 6 Temperature: 20 °C Motor speed: 208 rpm	Connect
	6250	Data ke : 15 Temperature: 26 °C Motor speed: 664 rpm	Data ke : 15 Temperature: 26 °C Motor speed: 664 RPM	Connect
	6250	Data ke : 19 Temperature: 30 °C Motor speed: 985 rpm	Data ke : 19 Temperature: 30 °C Motor speed: 985 rpm	Connect
	6250	Data ke : 25 Temperature: 35 °C Motor speed: 995 rpm	Data ke : 25 Temperature: 35 °C Motor speed: 995 rpm	Connect

3.3. Transceiver mode-based DC Motor control testing

The data transceiver testing is listed in Table 6 and Table 7. However, Table 8 and Table 9 are described for transceiver 2. Then, In table 10 and 11 for transceiver 3 mode.

Table 6. Data transmission test 1 with transceiver mode in K10 UNESA building 1

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
K10	100	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	200	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	300	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	400	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	500	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	600	Motor speed: Speed 1	Motor speed: Speed 1	Delay
	700	Motor speed: Speed 1	Motor speed: -	Disconnect

Table 7. Data transmission test 1 with transceiver mode between UNESA

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
Between UNESA	6250	Motor speed: Speed 1	Motor speed: -	Disconnect
	6250	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	6250	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	6250	Motor speed: Speed 1	Motor speed: Speed 1	Connect
	6250	Motor speed: Speed 1	Motor speed: Speed 1	Connect

.

Table 8. Data transmission test 1 with transceiver mode in K10 UNESA building 1

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
K10	100	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	200	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	300	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	400	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	500	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	600	Motor speed: Speed 2	Motor speed: Speed 2	Delay
	700	Motor speed: Speed 2	Motor speed: -	Disconnect

Table 9. Data transmission test 2 with transceiver mode between UNESA

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
Between UNESA	6250	Motor speed: Speed 2	Motor speed: -	Disconnect
	6250	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	6250	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	6250	Motor speed: Speed 2	Motor speed: Speed 2	Connect
	6250	Motor speed: Speed 2	Motor speed: Speed 2	Connect

Table 10. Data transmission test 1 with transceiver mode in K10 UNESA building 1

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
K10	100	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	200	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	300	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	400	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	500	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	600	Motor speed: Speed 3	Motor speed: Speed 3	Delay
	700	Motor speed: Speed 3	Motor speed: -	Disconnect

Table 11. Data transmission test 3 with transceiver mode between UNESA

Transmitter Location	Testing Distance (meters)	Transmitted data	Data read	Transceiver Status
Between UNESA	6250	Motor speed: Speed 3	Motor speed: -	Disconnect
	6250	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	6250	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	6250	Motor speed: Speed 3	Motor speed: Speed 3	Connect
	6250	Motor speed: Speed 3	Motor speed: Speed 3	Connect

4. Conclusion

This research focuses on controlling a 12V DC motor automatically using a combination of DHT22 temperature sensor and Arduino Uno as a data manager and main regulator in the circuit scheme, besides that the control function can be done manually by utilizing remote control using LoRa SX1278 module. The remote-control function uses feedback communication, where the LoRa module, which starts as a data signal receiver, is converted into a data signal sender. Tests were conducted with 3 different categories. The percentage error data of the 12V DC motor control function carried out with Tachometer measurements for each temperature category are 0.78%, 0.42%, and 0.26%. The second test is sending control function data using LoRa SX1278 and Yagi antenna in two different experimental site conditions. Each of the K10, and Inter UNESA buildings displays the distance that can be traveled is 600m and 6250m. Utilization of communication feedback logic or switching mode for delivery conditions according to the second test shows the same data results as the initial mode. From the whole test, the 12V DC Motor control function with logic innovation and different antenna types, shows success and has been shown in each test result.

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