

# Design of Monitoring Device for the Process of Organic Waste Decomposition into Compost Fertilizer and Plant Growth through Smartphones based on Internet of Things Smart Farming

Haris Isyanto<sup>\*1</sup>, Jumail<sup>2</sup>, Rahayu<sup>1</sup>, Nofian Firmansyah<sup>1</sup>

<sup>1</sup>Department of Electrical Engineering, Universitas Muhammadiyah Jakarta

<sup>2</sup>Department of Informatics Engineering, Universitas Muhammadiyah Jakarta  
Jl. Cempaka Putih Tengah 27, Jakarta, Indonesia

\*Corresponding author, e-mail: haris.isyanto@umj.ac.id

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**Abstract** – Based on data published by the Ministry of Living Environment and Forestry in 2020, Indonesia produces at least 93,200 tons of waste per day in various types of composition or around 34 million tons of waste per year. From the collection of waste, it could be used as compost fertilizer which is taken from leaf waste. From these problems, a device was designed that could monitor the decomposition process of organic waste into compost fertilizer. This device is equipped with a temperature sensor, humidity sensor, sensor of soil pH, soil moisture sensor, and color sensor to monitor the composting fertilizer process. The device could also detect plant growth as an indication that the compost fertilizer made is in good condition. Our device was used on the Internet of Things (IoT) and the blynk application as a monitoring application. From the test results, the temperature sensor's accuracy is 98.2%, the humidity sensor is 96.1%, the soil pH sensor is 95.26%, the soil moisture sensor is 98.55%, and the color sensor successfully detects the results of plant growth well. The design of this device is expected to invite the public to be wiser in sorting waste and using it for the surrounding environment.

**Keywords:** Decomposition Process, Organic Waste, Compost Fertilizer, Monitoring Device, Internet of Things

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## I. Introduction

The waste problem is still serious in Indonesia. From data published by the Ministry of Living Environment and Forestry in 2020, Indonesia generates 93,200.61 tons of waste per day, and 34,018,221.21 per year [1]. Of the types of waste generated, about 60% is organic waste that should be recycled, and of 39.81% of the total organic waste, 14.02% is wood, twigs, and leaves waste [1]. One way to help and overcome the waste problem is by recycling waste with a composting process, in addition to reducing waste it also reduces the volume of waste but is beneficial for plants and the physical environment of the soil. This organic waste can be used as compost taken from leaf waste. Composting can be done conventionally or the result of fermentation using a bio activator which results in compost, which is an organic fertilizer.

The main purpose of the application of compost is to supply nutrients to plants and improve the physical properties of the soil both physically, chemically and biologically. The use of compost as a source of plant nutrition is a chemical residue-free program to increase plant and soil productivity. This organic waste is classified as environmentally friendly waste. The less waste we throw away, the more we are responsible for the preservation of the earth.

Compost fertilizer is a type of organic fertilizer made from plant residues, one of which is leaf litter. In the manufacturing process, the core materials needed are organic materials and decomposing organisms that will be used, such as Effective Microorganism 4 (EM4) liquid. Microbial activity (microorganisms) is determined by several factors, including temperature and humidity. Microbes can work optimally at temperatures between  $\pm 45^{\circ}\text{C}$  for several weeks, depending on the amount of material

used. The ideal moisture in the composting process is at a percentage of  $\pm 60\%$  [2]. If the humidity is not suitable, it can cause inhibition of microbial growth and even cause microbes to die.

In this advanced era, many technologies are found based on digital, wherein it is possible to ensure time and energy efficiency as well as good management [3]. Now the internet can be accessed easily and can be integrated with devices such as computers, smartphones [4].

All interactions that we do with the help of the internet can be called Internet of Things (IoT) [4]. The development of IoT has a positive impact on human life [3]. Monitoring for temperature, humidity, and pH will be carried out based on the Internet of Things which the researcher will design beforehand using the blynk web platform and with NodeMCU as the microcontroller.

In big cities, the activities of each community are very dense, where people are busy with their time-consuming work [3]. So from these factors, this idea was born and hoped to be used properly. Communication interaction that utilizes an internet connection continuously. Communication between machines using IoT by exchanging data through remote control. The technology is also a major supporter of smart city development. The development of IoT technology, which is used properly, will certainly be useful for realizing a big city into a smart city that is comfortable for its citizens.

In this study, researchers will also add one function, namely monitoring plant growth which researchers have reviewed previously from other journals as a reference for reading leaf quality based on the frequency of the color produced. In addition, researchers also use the blynk application as a monitoring medium so that it will make it easier for tool users to monitor fertilizer and plant growth. Because in addition to the application being free of cost and easy to access, the interface is also very clear and easy to understand.

## II. Related Work

There are two journals related to the research conducted by the author:

1. Atmojo, Reksa Suhud T. Design and Build Monitoring of Compost Fertilizer Decomposition Process based on Low Cost & Multi-Point Board Module. No. 1, 2019, pp. 174–79.

The link in the first journal has discussed the design of monitoring temperature and humidity in the compost decomposition process using the NodeMCU and Thingier.io microcontrollers as media for the IoT cloud platform. In this journal, a composter box is also designed as a place for monitoring the decomposition process and collecting data, and analyzing the temperature and humidity that occur during the composting process [5].

Oktavia, Windy & et al. Leaf Indicator System Using AT-Mega32 Microcontroller Based Color Sensor. Faculty of Engineering, University of Muhammadiyah Ponorogo. Ponorogo. 2018.

The second journal is related to the implementation of the ATmega32 microcontroller-based color sensor to detect pakcoy vegetables with the best quality seen from the color of the leaves. Data analysis was carried out using a color sensor by sorting the quality of the leaves from the best to the quality of the leaves that were not feasible based on the frequency that was read by the color sensor [6].

### II.1. Internet of things (IoT)

IoT is a concept that aims to expand devices or devices connected to internet connectivity so that they can control and monitor devices. In this study, the internet of things is used to monitor the process of decomposition of organic waste into compost to know the process of plant growth. The monitoring process includes monitoring temperature, humidity at the plant location, soil moisture, and soil pH. [4], [7]–[10].

### II.2. Sensor DHT-22

DHT-22 sensor is a component that functions to detect temperature and humidity. DHT-22 sensor could detect temperatures from  $-40^{\circ}\text{C}$  to  $80^{\circ}\text{C}$  and humidity 0% to 100% which has a sensor accuracy of  $\pm 0.5^{\circ}\text{C}$  at 1% temperature and humidity. In this study, the DHT-22 sensor functions as real-time monitoring of temperature and humidity in the smart farming room [7], [8], [11].

### II.3. Soil moisture sensor

A soil moisture sensor is a component to detect soil moisture. How to install a soil moisture sensor, simply stab it in the dry or wet soil to produce a moisture value. In this research, the soil moisture

sensor is used to monitor soil on compost in real-time [3], [7], [12], [13].

#### II.4. Soil pH sensor

A soil pH sensor is a sensor to detect a level of acidity (acid) and alkalinity (alkali) of the soil. The measurement scale on the sensor has a range of 3.5 to 8 pH. In this study, the soil pH sensor was used to monitor a pH level in compost fertilizer [7], [12]–[14].

#### II.5. Color sensor

The color sensor with the TCS230 type is a component to detect color on a particular object. The color sensor can detect the number of 3 basic colors, namely: red, green, and blue, or called RGB. The workings of the color sensor utilize a photodiode to reflect the object it detects. In this study, the color sensor is used to detect the color of the leaves on the plant so that the expected results are monitoring the growth of plants.

### III. Research Method

The methodology applied in this research is about the application system on the device. The flowchart shows the process from the initial device initialization, where 2 NodeMCUs are used to process and transfer data to the sensor using the blynk application through an internet connection. The following are the stages of the research methodology flowchart, which is shown in Figure 1 System Flowchart. [6], [10], [15].

The initial design of this device will focus on making a composter box, where the box used is a plastic container box with a size (LxWxH) 49cm x 31cm x 27cm. The working principle of this device is that four sensors are placed in the composter box. The DHT-22 sensor is used to detect temperature and humidity. This sensor works an important role as a determinant of the quality of the compost made. Because the temperature should be kept within the range of 45° C and humidity in the range of 60% so that the microbes that develop during the compost decomposition process can continue to grow. The more microbes that develop, the faster the compost decomposition process is completed.

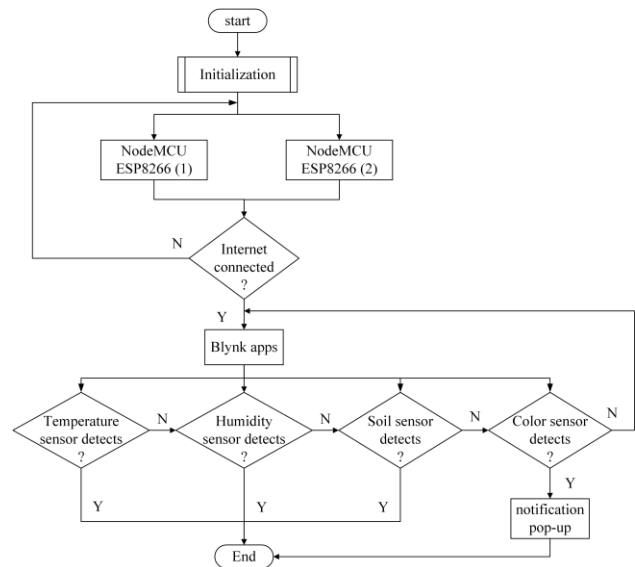


Fig. 1. Flowchart of System

Another sensor installed is a soil moisture sensor. This sensor will detect the water content contained in the compost. As we know, water content is one of the characteristics of compost that can be evaluated with agronomic value. And if it is adjusted to SNI 19-7030-2004, then the value of the desired moisture content in compost is a maximum of 50% [16]. Therefore, the composter box must be slightly modified by making a small hole at the bottom, so that there is no excess water that has the potential to float during the compost decomposition process. So that it can maintain the water content not to exceed the desired maximum limit.

In this research, the soil pH sensor was used to measure the level of acidity and alkalinity in composted soil. If referring to SNI 19-7030-2004 regarding the desired acidity level in the compost made, then the minimum pH level for compost is 6.80 and the maximum is 7.50, which is a neutral soil pH level.

The last sensor used is the TCS230 color sensor which functions as an indicator of plant growth by placing a color sensor on compost that is ready to use and tested for growing plants. We expect that the color sensor will be able to detect when the plants appear, by first calibrating the frequency that will be detected according to the growth of the plant [16].

These sensors will later be connected to the NodeMCU ESP8266. In this research, we use 2 (two) NodeMCU modules in their application. The first NodeMCU module is used for 2 (two) sensors, including analog outputs such as a sensor of soil moisture and a sensor of soil pH. While in the

second NodeMCU module, only one ADC pin is used. This microcontroller will also be connected to the internet network, which will send detection data for each sensor that will be monitored in the blynk application through the user's smartphone. This application also provides various widget views with various functions, such as monitoring temperature, humidity, and can also be used as a switch. With this application, it is easier for users to monitor the process of fertilizers decomposition remotely without having to come to the location, and of course with a microcontroller connected to the internet.

#### IV. Results and Discussion

In this research, we will explain the results of software and hardware design, the results of device performance testing on each sensor that will be displayed on the blynk monitoring application. As well as a comparison between manual measurements and sensor applications on each sensor tested.

##### IV.1 Software design

Before testing begins, we will explain the features of the widget and put the functionality of the widget provided in the blynk application. Design of blynk application, as shown in Figure 2.

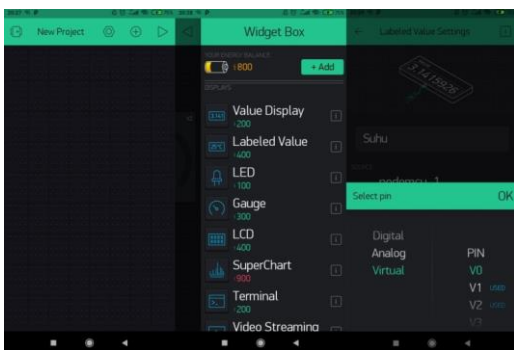


Fig. 2. Design of blynk app

In this research, we used five widgets in the blynk application, including display values for pH level, Labeled Value for temperature, Gauge for humidity and water content, and using notifications to notify the color sensor. For the test results, the blynk application software testing is carried out simultaneously with the test results of each sensor. The final view of the monitoring application software design, as shown in Figure 3.

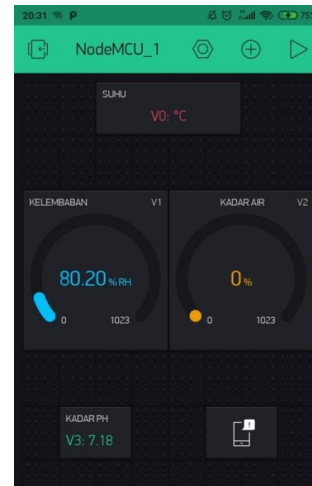


Fig. 3. Design of monitoring application

##### IV.2 Testing of Device Performance

Each sensor should be tested to check the performance of the device and the overall functionality of the device. This aims to determine the ratio of the percentage of error between standard measurements and sensor measurements. This will affect the final measurement and device accuracy obtained on each sensor. So that it can be seen and compared its advantages with the results of other measuring instruments.

The measurement results that have been compared with standard measuring instruments will later be calculated using the percentage error value using equation 1.

$$\text{Percentage of error} = \frac{|a-b|}{a} \times 100\% \quad (1)$$

Where:

- a = Standard measuring instrument value
- b = Sensor measurement value

##### IV.2.1. Testing of Temperatures

Standard Measurements use the HTC-1 Temperature & Humidity Meter. The results of this temperature sensor measurement are compared with the measurement results from the HTC-1 Temperature and Humidity Meter.

This test aims to compare the percentage error between standard thermometer measurements and temperature sensor measurements. Testing of temperatures, as shown in Table 1.

TABLE I  
TESTING OF TEMPERATURES

Time (minutes)	Thermometer (°C)	Temperature sensor (°C)	Errors (%)
0	30.9	31.0	0.3
30	29.9	30.6	2.3
60	29.6	30.1	1.6
90	29.3	29.6	1.0
120	29.3	30.3	3.4
150	29.3	30.1	2.7
280	29.4	29.7	1.0
210	29.3	30	2.3
<b>Average error percentage</b>			<b>1.8%</b>

Table I shows that the average error percentage from comparing standard measuring instruments and temperature sensor measurements is 1.8%. So, the accuracy of the tested temperature sensor reached 98.2%.

From the results of the comparison calculation, the percentage of error in the measurement is obtained. The temperature sensor test results can be shown in Figure 4.

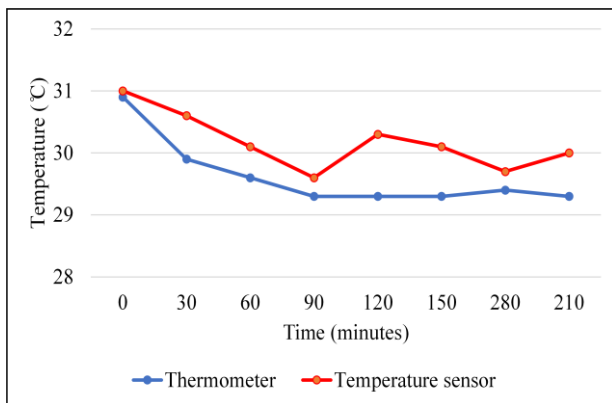


Fig. 4. Testing of temperature

#### IV.2.2. Testing of Humidity

Testing of temperature and humidity sensors is carried out simultaneously so that temperature and humidity data are taken at the same time. This humidity measurement also uses the HTC-1 Temperature and Humidity Meter. Measurement of this moisture sensor results is compared with the measurement results from the HTC-1 Temperature and Humidity Meter.

This test aims to compare the percentage error between standard humidity meter measurements and humidity sensor measurements. Testing of Humidity, as shown in Table II.

TABLE II  
TESTING OF HUMIDITY

Time (minutes)	Humidity meter (%RH)	Humidity sensor (%RH)	Errors (%)
0	56	58.60	4.6
30	56	58.20	3.9
60	58	59.10	1.8
90	57	58.40	2.4
120	55	57.20	4.0
150	55	57.40	4.3
180	56	58.70	4.8
210	56	58.60	4.6
<b>Average error percentage</b>			<b>3.9%</b>

Table II shows that the average error percentage from comparing standard measuring instruments and temperature sensor measurements is 3.9%. So, the accuracy of the tested humidity sensor reached 96.1%.

From the results of the comparison calculation, the percentage of error in the measurement is obtained. The humidity sensor test results can be shown in Figure 5.

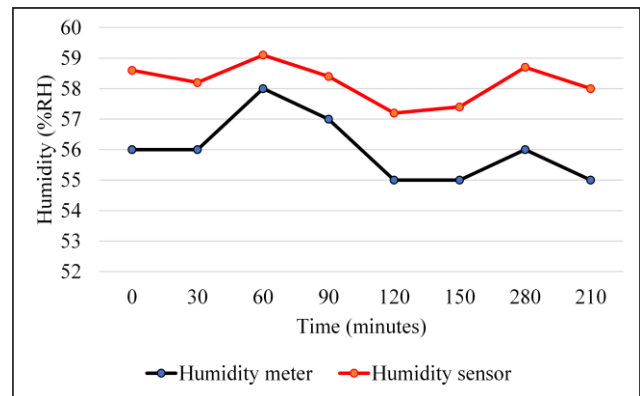


Fig. 5 Testing of humidity

#### IV.2.3. Testing of Soil pH

Testing of Soil pH that we have carried out at 4 (four) points around our house. The locations of sampling for soil pH sensors are as follows:

1. Backyard of the house
2. The front page of the house
3. Home ornamental plant pots
4. Soil samples from the garden near the house

Standard measurements are carried out using a 3 in 1 Soil pH Moisture Meter as a reference measuring instrument. The measurement results from the soil pH sensor are compared with the soil pH meter.

This test aims to compare the percentage error between standard soil pH meter measurements and soil pH sensor measurements. Testing of Soil pH, as shown in Table III.

TABLE III  
TESTING OF SOIL pH

Measuring point	Soil pH meter (pH)	SOIL pH sensor (pH)	Errors (%)
NETRAL	7.0	7.32	4.5%
1	6.5	7.02	8.0%
2	7.0	7.11	1.5%
3	7.0	7.12	1.7%
4	6.5	7.02	8.0%
<b>Average error percentage</b>			<b>4.74%</b>

Table III shows that the average error percentage from comparing standard measuring instruments and soil pH sensor measurements is 4.74%. So, the accuracy of the tested soil pH sensor reached 95.26%.

From the results of the comparison calculation, the percentage of error in the measurement is obtained. The soil pH sensor test results can be shown in Figure 6.

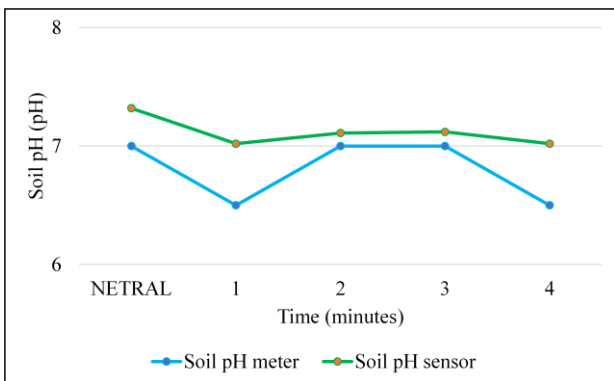


Fig. 6. Testing of Soil pH

IV.2.4. Testing of the Color Sensor

Testing of the color sensor is done with bringing leaf samples closer to the photodiode on the TCS230 color sensor. This test aims to detect the color of plant growth measured on the leaves. Tests were carried out in the form of measuring distance and angle of inclination on the green color sensor. Leaves are measured by the type of leaves that are shiny (glossy). Testing of the color sensor can be shown in Figure 7.



Fig. 7. Testing of Color Sensor Distance

From the measurement of the leaf distance color sensor, it was obtained that the results of maximum distance measurement were detected 2 cm from the leaf to the position of the color sensor LED light, which can be shown in Table IV.

TABLE IV  
TESTING OF COLOR SENSOR DISTANCE

Measurement distance (cm)	Leaf object (glossy green color)
0	DETECTED
0,5	DETECTED
1,0	DETECTED
1,5	DETECTED
2,0	DETECTED
2,5	NOT DETECT

When a leaf object is detected, a notification will appear "PLANT GROWTH DETECTED" from the blynk application on the smartphone screen, as shown in Figure 8.



Fig. 8. Notification of Color Sensor Detection

In testing the color sensor, the position of the color sensor must be directly above the leaf object. This is an important factor of the sensor in detecting objects. Sensors cannot detect objects if they are positioned inappropriately or not facing each other. This is because the sensitivity of the photodiode on

the color sensor is relatively low. After testing the color sensor distance detection, the next step is to test the slope angle on the color sensor, which can be shown in Table V.

TABLE V  
TESTING OF COLOR SENSOR SLOPE ANGLE

Slope angle (°)	Leaf object (glossy green color)
0	DETECTED
1	DETECTED
2	DETECTED
3	DETECTED
4	DETECTED
5	DETECTED
6	NOT DETECTED

From the results of testing the color sensor slope angle, the measurement results obtained the results of maximum slope angle 5° from the leaf objects, which can be shown in Table V.

The leaf surface is also a determining factor for sensor detection. The sensor will be more sensitive to glossy leaf surfaces because the photodiode of the sensor must accept the reflected light to detect the object, which is shown in Figure 9.



Fig. 9. Measurement of color detection on glossy green leaves

#### IV.2.5. Testing of Soil Moisture

Testing of soil moisture that we have was carried out the same as Testing of Soil pH, which was carried out at 4 (four) points around our house. The locations of sampling for soil moisture sensors are as follows:

1. Backyard of the house
2. The front page of the house
3. Home ornamental plant pots
4. Soil samples from the garden near the house

TABLE VI  
TESTING OF SOIL MOISTURE

Measuring point	Soil moisture meter (%)	Soil moisture sensor (%)	Errors (%)
NETRAL	0	0	0
1	40	39	2.5
2	40	40	0
3	30	31	3.3
4	40	40	0
<b>Average error percentage</b>			<b>1.45%</b>

Standard measurements are carried out using a 3 in 1 Soil pH Moisture Meter as a reference measuring instrument. The measurement results from the soil moisture sensor are compared with the soil moisture meter.

This test aims to compare the percentage error between standard soil moisture meter measurements and soil moisture sensor measurements. Testing of Soil Moisture, as shown in Table VI.

Table VI shows that the average error percentage from comparing standard measuring instruments and soil moisture sensor measurements is 1.45%. So, the accuracy of the tested soil moisture sensor reached 98.55%.

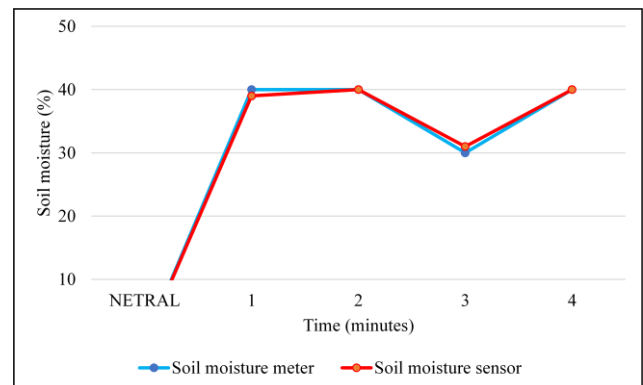


Fig 10. Testing of Soil Moisture

From the results of the comparison calculation, the percentage of error in the measurement is obtained. The soil moisture sensor test results can be shown in Figure 10.

## V. Conclusion

1. The design and placement of the widget on blynk application have conformed with that expected for monitoring every sensor in the device.
2. From the results of testing the temperature and humidity sensors, the temperature measurement obtained an average error

percentage of 1.8%. So that the accuracy of this temperature sensor reaches 98.2%. Furthermore, the humidity measurement obtained an average error percentage of 3.9%. So the accuracy of this humidity sensor reaches 96.1%.

3. From the results of testing the Soil pH sensor, the measurement results obtained an average error percentage of 4.74%. So the accuracy of this Soil pH sensor reaches 95.26%.
4. From the results of testing the color sensor, it is obtained that the results of distance measurement were detected 2 cm from the leaf objects to the position of the color sensor LED light. And the results of the measurement of the slope angle obtained 5° from the leaf objects
5. A pop-up notification has successfully appeared when a leaf object is detected by the color sensor on a blynk application via smartphone screen.
6. From the results of testing the soil moisture sensor, the measurement results obtained an average error percentage of 1.45%. So the accuracy of this Soil moisture sensor reaches 98.55%.

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### Authors' information



**Haris Isyanto** received a Bachelor of Engineering degree from the Department of Electrical Engineering Universitas Muhammadiyah Jakarta in 1996, a Master's Engineering degree from the Department of Electrical Engineering, Universitas Trisakti, Jakarta in 2000. He

is a senior lecturer at the Department of Electrical Engineering, Universitas Muhammadiyah Jakarta Indonesia. His research interests are electrical engineering, wireless, 5G, IoT, electronics, and sensors.



**Jumail** received a Bachelor of Engineering degree from the Department of Informatics Engineering Universiti Utara Malaysia in 2008, a Master's Engineering degree from the Department of Informatics Engineering, Universiti Teknologi PETRONAS, Malaysia in

2013. He is a lecturer at the Department of Informatics Engineering, Universitas Muhammadiyah Jakarta Indonesia. His research interests are informatics engineering, information technology, multimedia, digital storytelling, interactive learning.



**Rahayu** received high school education at SMAN 1 Muntok, Bangka in 2005, with an associate of Engineering degree (Diploma 3) from the Department of Electrical Engineering at State Polytechnic of Sriwijaya, Palembang in 2008. She is a college student at the

Department of Electrical Engineering, Universitas Muhammadiyah Jakarta. Her research interests are electrical engineering and telecommunication engineering.



**Nofian Firmansyah** was born in Malang, Indonesia. Received his first education at SDN Kesatrian 5 Malang, then continued his Junior High School at SMPN 5 Malang, then continued his Vocational High School at SMKN 8 Malang. After that, he continued his associate of

engineering degree (Diploma 3) from the Department of Electrical Engineering at the State University of Malang. He is a college student at the Department of Electrical Engineering, Universitas Muhammadiyah Jakarta. His research interests are electrical engineering.