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Design and Build Smart Farming Automatic Plant Watering Based on the Internet of Things

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Abstract – *The agricultural sector is important in every country, especially in Indonesia, where the majority of the population are farmers. The problem faced in this modern era is that the agricultural system still uses traditional methods which are less efficient in the use of time. The main aim of this research is to make the agricultural sector more superior in Indonesia, to increase the efficiency of agricultural production using IoT (internet of things) technology. The research method used is by detecting the water content in the soil, temperature and humidity in the air and the weather on agricultural land. The tools and materials used are soil moisture sensors and ESP32. Soil moisture levels are also adjusted by irrigation using a water pump. If the soil humidity is below the limit, the humidity sensor will send information data to the ESP32 module and the data will be sent to the IoT (Internet of things) platform. ESP32 collects data from all sensors and connects the data to the cloud and displays it in Blynk. The results of this research were that the highest solar panel voltage read by the multimeter was 20.5 V and the lowest was 18.3 V. The soil moisture sensor can work according to commands, when the soil moisture condition is* < 50 *the pump will turn on and when the soil condition is* > 50 *the pump will not turn on. The INA219 sensor displays the voltage, current and power of the load when it is on or off. The average error read from the INA219 sensor voltage is 2.515%, the highest error is 5.6% and the lowest is 0.8%.*

Keywords – *Smart Farming; Automatic Plant Watering; Internet of Things; Soil Moisture Sensor; IoT Technology.*

I. INTRODUCTION

ACCORDING to a report by the Central Statistics Agency (BPS), the number of smallholder farmers in Indonesia reached 17,248,181 million in 2023. Agricultural development plays a significant role in Indonesia's overall national progress. The country places agriculture as a key component of its development strategy due to its abundant natural resources, high rainfall, and solar intensity, which make the territory highly suitable for crop cultivation [1, 2].

Indonesia's climatic conditions are characterized by tropical islands and two distinct seasons: the dry season (May to October) and the rainy season (November to April) [3]. The concept of the "Internet of Things (IoT)" arises from the idea that electronic devices can be accessed and controlled via the internet. Implementing IoT technology in agriculture is expected to accelerate modernization, integrate smart agricultural systems, and address agricultural challenges efficiently. The integration of Internet of Things (IoT) technology in agriculture is revolutionizing the industry, offering solutions for modernization and efficiency [4, 5]. IoT applications in agriculture include precision farming, automated irrigation, soil monitoring, and pest control [6]. These technologies enable real-time data collection, advanced analytics, and intelligent decision-making systems [7, 8]. The implementation of IoT in agriculture faces challenges such as interoperability, affordability, and data security [8, 9]. However, the potential benefits include increased productivity, improved product quality, reduced labor costs, and enhanced sustainability [10, 11]. Machine learning and computer vision techniques are being integrated with IoT systems to further optimize crop management and disease detection [11]. As IoT technology continues to evolve, it is expected to play a crucial role in addressing agricultural challenges and driving the sector towards smart farming practices [5, 9].

With rapid technological advancements, Indonesia has immense potential to optimize its natural resources. Indonesia's abundant natural resources offer immense potential for economic development and technological

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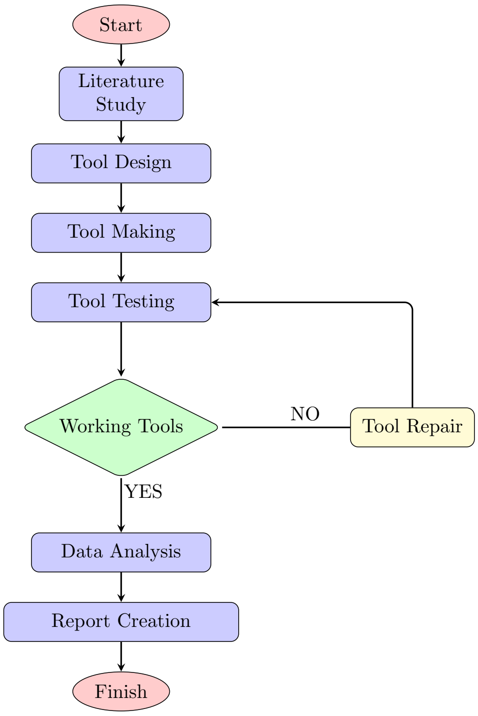

Figure 1: Research flowchart

advancement. The country possesses significant renewable energy capacity, including solar, hydro, wind, and geothermal sources [12]. However, challenges such as inadequate infrastructure, underinvestment, and regulatory issues hinder optimal resource exploitation [13]. To address these challenges, Indonesia is embracing technological innovations like the MyHydro mobile application for smart agriculture [14] and exploring appropriate technologies suited to local needs [15]. The government is also focusing on sustainable development practices in sectors like oil and gas mining [16] and optimizing agricultural resources for food and energy security [17]. As Indonesia navigates the Fourth Industrial Revolution, it must balance technological advancements with environmental concerns and social equity [18]. Strategic development of both natural and human resources is crucial for Indonesia's future prosperity and global competitiveness [19]. One such approach is the monitoring of soil moisture through computer technology and the internet. Presently, the Internet of Things (IoT) is transforming traditional farming practices by overcoming natural limitations. For instance, climate change and excessive rainfall often reduce crop productivity [20–23].

Innovations in agriculture, such as the use of microcontrollers and sensors, enable real-time monitoring of soil conditions. Soil moisture, an essential factor for plant growth, can now be measured to determine the appropriate response. When soil moisture falls below a set threshold, an automated watering system is activated. Integrated with web servers, this system allows remote monitoring and control. Using an FC-28 Soil Moisture Sensor and ESP32 as the main controller, the system effectively maintains optimal soil conditions [24–27].

The proposed smart farming system simplifies field monitoring for farmers by leveraging IoT through the Blynk application. This system aims to enhance crop yields by enabling precise and regular watering while saving time and energy. Key components include the NodeMCU ESP32 microcontroller, which processes sensor data such as soil moisture levels and INA219 readings for pump output parameters. Sensor data is transmitted to the Blynk platform, providing farmers with actionable insights.

Additionally, this smart farming system utilizes renewable energy in the form of solar panels with a 50 Wp capacity, serving as the primary electricity source. By relying on solar energy, the system eliminates dependence on conventional PLN power, making it entirely self-sufficient and environmentally friendly.

II. RESEARCH METHODS

The research method used is design, with the steps of literature study, design, manufacture, and testing followed by analysis. The first stage is a literature study to understand how the reading and transmission of soil moisture sensor data and signals to water pumps work and connect it to IoT through the Blynk application. The second stage is the design of the tool, which includes the collection of data on the necessary tools and materials. The third stage is the manufacture of tools, starting from PCB (Printed Circuit Board) printing to assembling IoT components to solar PV.

The fourth stage is to test the tool at the specified location, correct errors if found, and retest until the tool is working properly. The fifth stage is the analysis of test result data to determine accuracy, as well as the collection of monitored current, voltage, and power data. The last stage is the preparation of reports and conclusions from the results of research and observations at the test site.

i. Preparation of Tools and Materials

This smart farming system is designed to help farmers monitor their farms remotely and activate water pumps if the moisture content in the soil is below the specified soil moisture sensor value. The components required to support this research are: (a) 50 Wp Solar Panel; (b) ESP32 NodeMCU; (c) Soil Moisture Sensor; (d) INA219 Sensor; (e) Battery; (f) SCC (Solar Charger Controller); (g) Buck Converter; (h) Relay; (i) Jumper Cable; (j) DC Water Pump; (k) Resistor.

ii. Designing a Block Diagram System

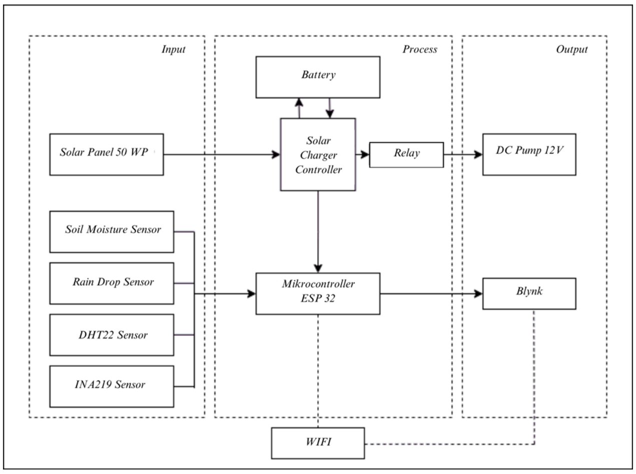

Figure 2: Diagram Block System

Based on Figure 2, this smart farming system uses solar PV as the main power source with a solar panel capacity of 50 Wp. A Solar Charger Controller regulates the 12 V/3.5 Ah battery charging system and power supply to the load in the form of a 12 V DC water pump, activated using a relay. The system can be monitored via IoT using the Blynk application, which utilizes the ESP32 microcontroller for data processing. Sensors such as the INA219 and soil moisture sensors provide real-time data displayed on the Blynk application.

iii. Hardware Planning

The following is the hardware design of the smart farming system that will be made which will be a reference later when making tools.

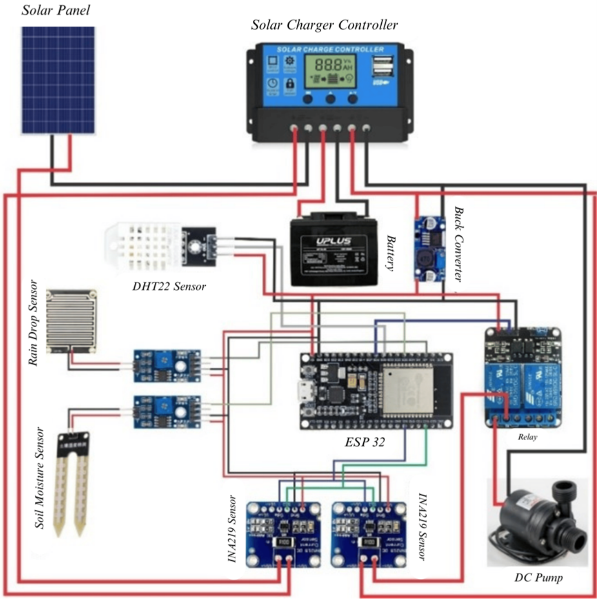

Figure 3: Hardware Design

Figure 3 shows the hardware design of the system. A 50 Wp solar panel is connected to a Solar Charger Controller to manage battery charging and the water pump. An INA219 sensor measures the voltage, current, and power output from the DC water pump. The soil moisture sensor triggers the relay to activate the water pump automatically based on programmed values. Data from these sensors are read by the ESP32 and synchronized with the Blynk application via Wi-Fi.

iv. Tool Manufacturing

The tool manufacturing process involves several stages, including making electrical circuits, mechanical frames, and software systems. The following is the process of the electrical network as follows:

1. Define and select the components needed to make the tool.
2. Create a PCB (Printed Circuit Board) design and print it.
3. Assemble components on the PCB and integrate them into the system.
4. Conduct tests on the tool. The placement of the tool is shown in Figure 4.

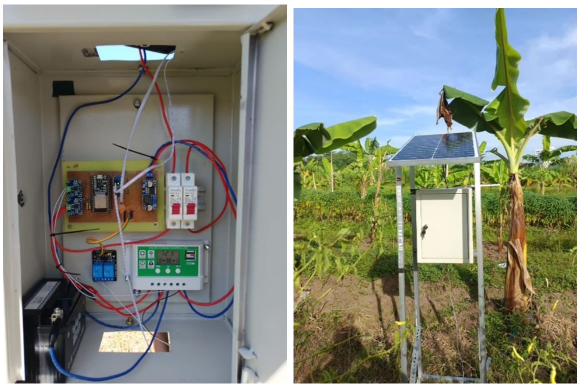

Figure 4: Tool placement: (a) Inside the box panel, (b) In the field

The completed electrical circuit needs to be placed in a suitable container to protect it from environmental factors. This ensures that each electrical component functions properly and remains operational over a long period of time. A box panel measuring 30 x 40 x 18 cm, along with light steel structures of 1.4 meters and 1.7 meters in height, is used to house the panel box and sensors. The mechanical structure of the tool is depicted in Figure 5.

Researchers utilized the Blynk platform for remote monitoring of field conditions. Programming was conducted using Arduino IDE software, incorporating two sensors. To integrate the ESP32 microcontroller with the Blynk platform, it was necessary to install the Blynk library and define the Blynk Template ID and authentication credentials obtained from the Blynk

Figure 5: Mechanical Manufacturing of Tools

application. This setup ensured that the sensors could connect and present monitoring data on the Blynk platform.

Additionally, the SSID and WiFi password were configured to enable the ESP32 to connect to the internet and synchronize with the Blynk application. The INA219 sensor was programmed with a formula adjuster for calibration, ensuring accurate data readings. Similarly, adjustments were made for the soil moisture sensor values.

In the sensor program, the 'void loop' was updated with 'Blynk.virtualWrite' commands to align the sensor readings with the Blynk dashboard design based on the defined virtual pins. This smart farming program was configured to automatically activate the pump when the soil moisture level fell below 50%, and to deactivate the pump when the soil moisture level exceeded 50%, indicating wet soil conditions. The IoT dashboard view is illustrated in Figure 6.

v. *Tool Testing and Repair*

Testing and repairing this tool is one of the important stages to check from the performance of the tool that we have made whether it has been completed and produce an output that is in accordance with the researcher's wishes. The test was carried out on garden land owned by residents around the researcher's residence and data collection was carried out for 3 days. Repairs will be made if the device is damaged or the program has an error when testing.

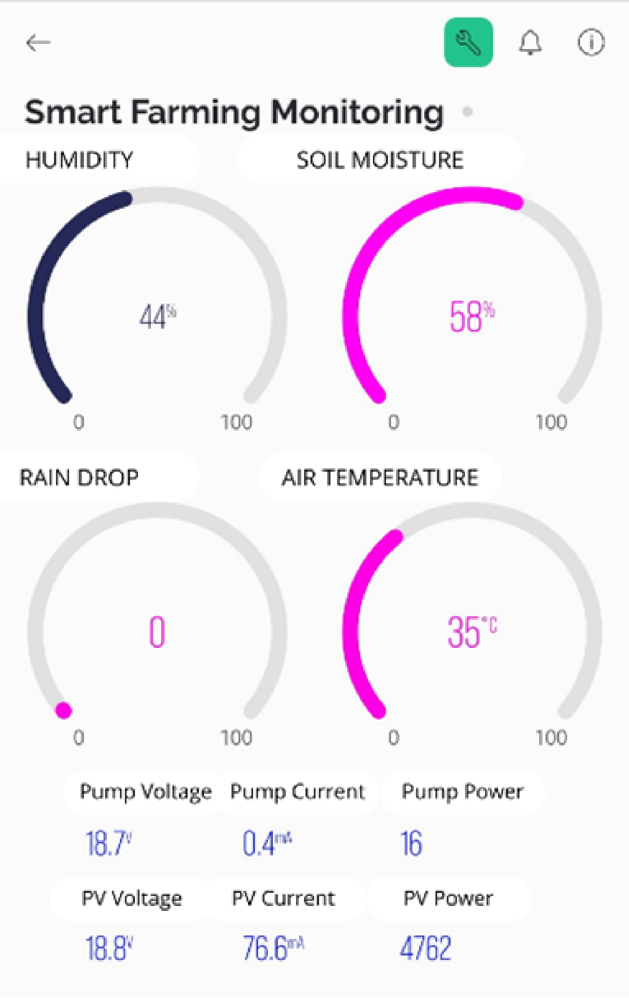

Figure 6: Blynk Smart Farming Dashboard

vi. *Data Analytics*

The data analysis stage is a critical step in the research process, involving the collection, processing, and presentation of data to address the research problems. This stage involves parsing, calculating, and interpreting data to produce relevant and actionable information.

To analyze the sensor readings, measurement differences and error values were calculated by comparing the values obtained from the manual measuring instrument with the actual sensor readings. The formulas for measurement difference, error value, and accuracy are defined as follows:

$$\Delta M = R - M \tag{1}$$

$$E\% = \frac{\Delta M}{R} \times 100 \tag{2}$$

$$A = 100\% - E\% \tag{3}$$

where ΔM is the measurement difference, R is the reference value from the manual measuring instrument, M is the measured value from the sensor, $E\%$ is the error value in percentage, and A is the accuracy percentage. Using these equations, the sensor's performance was evaluated to ensure its reliability and accuracy in real-world conditions.

vii. Report Preparation

The final stage involves compiling the tool design process, research results, and observations into a comprehensive report.

III. RESULTS AND DISCUSSION

The test of the tool was carried out in a garden in the Pabelan area. This smart farming system was created to help farmers monitor their land remotely. Data collection was conducted over three consecutive days and five times a day.

i. Measurement of Solar Panels

Testing of the solar panel used a measuring instrument to record voltage and current. Voltage and current were measured using a multimeter, and power was calculated using the formula:

$$P = V \times I$$

The test data from the solar panel are shown in Table 1.

Table 1: Solar Panel Measurement Data

No.	Time (Hours)	Temperature (°C)	Condition	Voltage (V)	Current (A)	Power (W)
1	07:17:07	29	Bright	20.5	1.5	30.75
2	10:17:26	38	Bright	20.0	0.45	9.0
3	12:14:48	38	Sunny Cloudy	20.4	0.46	9.3
4	14:11:55	35	Sunny Cloudy	19.8	1.5	29.7
5	16:23:31	31	Sunny Cloudy	18.3	0.41	7.5
6	07:15:40	27	Bright	20.5	0.47	9.6
7	10:23:05	33	Bright	20.3	0.44	8.9
8	12:33:37	40	Bright	20.4	1.5	30.6
9	14:31:20	40	Bright	20.1	0.45	9.0
10	16:23:11	36	Bright	19.3	0.46	8.8
11	07:22:20	27	Bright	20.5	1.5	30.75
12	10:22:25	35	Bright	20.3	0.42	8.5
13	12:20:30	39	Bright	20.2	0.44	8.8
14	14:16:57	36	Sunny Cloudy	20.0	0.45	9.0
15	16:15:27	30	Overcast	19.2	1.5	28.8
Average	–	–	–	**19.98**	**0.8**	**15.93**

Table 1 shows the results of testing solar panels using a multimeter measuring instrument. On the first day of sunny weather, the voltage generated from the solar panel in the morning was 20.5 Volts. In the afternoon, the voltage dropped to 18.3 Volts, and the current generated was 0.41 A, resulting in a power of 7.5 W.

On the second day, under sunny weather conditions, the voltage obtained was 20.5 Volts with a current of 0.47 A, yielding a power of 9.6 W. In the afternoon, the voltage measured by the multimeter was 19.3 Volts. This voltage drop occurred because the sun's intensity decreased during the day. The current was 0.46 A, resulting in a power of 8.8 W.

On the third day, under sunny conditions during the day, the voltage was measured at 20.2 Volts with a current of 0.44 A, producing a power of 8.8 W. In the afternoon, under cloudy weather, the voltage dropped to 19.2 Volts.

When the pump was on during the first day, the current measured was 1.5 A, with a power of 30.75 W. The pump turned on again at 14:11:55, and the multimeter recorded a current of 1.5 A with a power of 29.7 W. On the second day, the pump activated during the day, producing a current of 1.5 A and a power of 30.6 W. On the third day, in the morning, the pump turned on to water the plants, generating a current of 1.5 A and a power of 30.75 W. In the afternoon, under cloudy conditions, the pump activated with a current of 1.5 A and a power of 28.8 W.

The analysis of this study obtained the measured values from the multimeter, including voltage, current, and power. The calculated average voltage was 19.98 Volts, the average current was 0.8 A, and the average power was 15.93 W. The conditions of current and power under loaded and unloaded states are illustrated in Figure 7. Figure 7 illustrates the solar panel's performance under loaded and unloaded conditions.

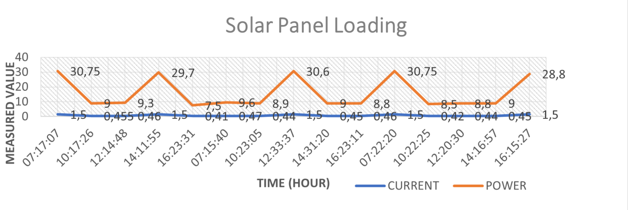

Figure 7: Solar Panel Loading Graph

ii. INA219 Sensor Testing

The INA219 sensor was tested for its ability to measure voltage, current, and power. These measurements were compared with values obtained using a multimeter to assess the sensor's accuracy.

Voltage Testing

The first test is the voltage test on the water pump. Continued testing on the current in the pump. Finally, data was taken on the power at the pump. The test data is shown in Table 2 for the voltage as follows in Table 2. Table 2 shows the INA219 sensor's voltage readings compared with a multimeter. The sensor's highest voltage reading was 12.4 V, while the multimeter recorded a maximum of 12.5 V. The average error was 2.515%,

Table 2: Pump Voltage Test Data

No.	Time (Hours)	INA219 Sensor (V)	Multimeter (V)	Difference (V)	Error (%)
1	07:14:10	11.7	12.1	0.4	3.3
2	10:15:41	12.2	12.3	0.1	0.8
3	12:07:01	12.2	12.4	0.2	1.6
4	14:09:48	12.0	12.4	0.4	3.2
5	16:11:44	11.8	12.4	0.6	4.8
6	07:13:57	12.2	12.4	0.2	1.6
7	10:21:24	12.2	12.4	0.2	1.6
8	12:19:05	12.0	12.5	0.5	4.0
9	14:21:07	12.1	12.3	0.2	1.6
10	16:21:30	12.4	12.5	0.1	0.8
11	07:17:50	11.8	12.5	0.7	5.6
12	10:20:30	12.0	12.3	0.3	2.4
13	12:17:32	11.9	12.4	0.5	4.03
14	14:15:25	12.1	12.3	0.2	1.6
15	16:13:10	12.2	12.3	0.1	0.8
Average	–	**12.0**	**12.36**	**0.35**	**2.515**

and the sensor's accuracy was calculated as:

$$\text{Accuracy} = 100\% - \text{Error} = 97.48\%$$

Table 2 presents the results of the output voltage test of the water pump. The comparison used is data measured by the INA219 sensor and a multimeter. The highest voltage recorded by the INA219 sensor was 12.4 Volts, while the multimeter recorded a maximum of 12.5 Volts. The lowest voltage recorded by the INA219 sensor was 11.7 Volts, compared to 12.1 Volts measured by the multimeter. The average error obtained from the INA219 sensor readings was calculated to be 2.515%. This error value was derived by comparing the voltage readings from the INA219 sensor to those from the multimeter. Based on the analysis, it can be concluded that the INA219 sensor provides accurate voltage measurements, with an accuracy value of 97.48%. A graphical representation of the voltage differences between the INA219 sensor and the multimeter measurements is shown in Figure 8.

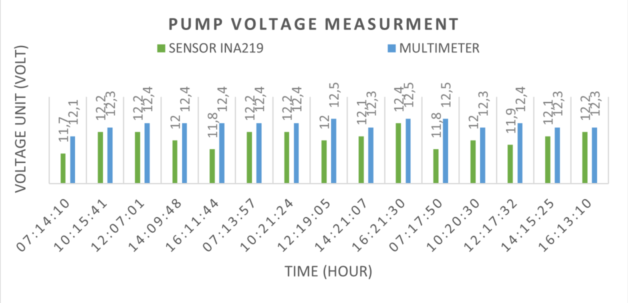

Figure 8: Graph of Pump Voltage Measurement Difference

From the results, a graph was generated to illustrate the differences in voltage measurements by comparing the readings from the multimeter with those from the INA219 sensor. Figure 8 shows that the sensor test values and the multimeter readings are closely aligned, despite the voltage fluctuations observed in the graph. In the graph, the green bars represent the measurements from the INA219 sensor, while the blue bars represent the values recorded by the multimeter. The average difference between the two measurements is 0.35 Volts, which corresponds to an average error of 2.515%.

Current Testing

The second test involved measuring the current using the INA219 sensor and a multimeter. This current test was conducted on the water pump, both in active and off conditions, at predetermined times. The test data are presented in Table 3.

Table 3: Pump Current Test Data

No.	Time (Hours)	INA219 Sensor (A)	Multimeter (A)	Difference (A)	Error (%)
1	07:14:10	1.3	1.1	0.2	15.0
2	10:15:41	0.0	0.0	0.0	0.0
3	12:07:01	0.0	0.0	0.0	0.0
4	14:09:48	1.3	1.2	0.1	7.6
5	16:11:44	0.0	0.0	0.0	0.0
6	07:13:57	0.0	0.0	0.0	0.0
7	10:21:24	0.0	0.0	0.0	0.0
8	12:19:05	1.4	1.2	0.2	14.0
9	14:21:07	0.0	0.0	0.0	0.0
10	16:21:30	0.0	0.0	0.0	0.0
11	07:17:50	1.2	1.1	0.1	8.3
12	10:20:30	0.0	0.0	0.0	0.0
13	12:17:32	0.0	0.0	0.0	0.0
14	14:15:25	0.0	0.0	0.0	0.0
15	16:13:10	1.3	1.2	0.1	7.6
Average	–	**1.3**	**1.16**	**0.14**	**10.5**

Table 3 provides the data of current measurements for the water pump, comparing values from the INA219 sensor and a multimeter. On the first day, when the pump was active, the sensor recorded currents of 1.3 A and 1.3 A, while the multimeter measured 1.1 A and 1.2 A, respectively. On the second day, the pump was turned on once at 12:19:05, with the sensor reading 1.4 A and the multimeter recording 1.2 A, resulting in a difference of 0.2 A.

On the third day, the pump was activated twice: in the morning at 07:17:50 and again at 16:13:10. During these times, the INA219 sensor measured 1.2 A and 1.3 A, while the multimeter recorded 1.1 A and 1.2 A, with differences of 0.1 A for both readings. The analysis shows that the INA219 sensor readings closely align with those from the multimeter, with an average difference of 0.14 A. This indicates that the INA219 sensor can accurately measure current, achieving an accuracy of:

$$\text{Accuracy} = 100\% - 10.5\% = 89.5\%$$

A graphical representation of the current differences is shown in Figure 9.

The results of the current measurement obtained from the INA219 sensor and the multimeter are shown in Figure 9. The graph displays the current values measured during the active condition of the pump, where the current rose to 1.4 A. In the orange bar graph, the

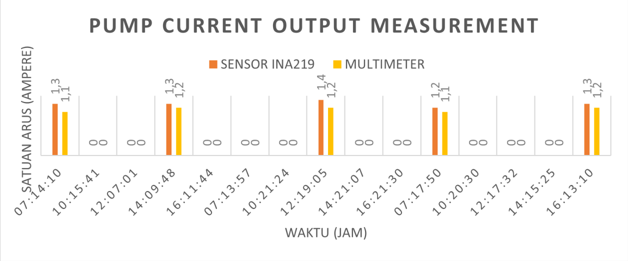

Figure 9: Pump Current Graph

INA219 sensor's measurements are represented, while the yellow bar graph indicates the values recorded by the multimeter. The average difference between the two measurements was calculated to be 0.24 A.

Power Testing

The third test involved measuring the power output, similar to the voltage and current tests. However, for this test, the power values were calculated using the formula:

$$P = V \times I$$

The power measurements were taken for the pump under both active and inactive conditions. The test data are presented in Table 4.

Table 4: Pump Power Test Data

No.	Time (Hours)	INA219 Sensor (W)	Calculated (W)	Difference (W)	Error (%)
1	07:14:10	13.4	13.1	0.3	2.2
2	10:15:41	0.0	0.0	0.0	0.0
3	12:07:01	0.0	0.0	0.0	0.0
4	14:09:48	12.1	14.8	2.7	18.0
5	16:11:44	0.0	0.0	0.0	0.0
6	07:13:57	0.0	0.0	0.0	0.0
7	10:21:24	0.0	0.0	0.0	0.0
8	12:19:05	13.5	15.0	1.5	10.0
9	14:21:07	0.0	0.0	0.0	0.0
10	16:21:30	0.0	0.0	0.0	0.0
11	07:17:50	15.6	13.7	1.9	12.0
12	10:20:30	0.0	0.0	0.0	0.0
13	12:17:32	0.0	0.0	0.0	0.0
14	14:15:25	0.0	0.0	0.0	0.0
15	16:13:10	13.7	14.7	1.0	6.8
Average	–	**13.66**	**14.26**	**1.48**	**9.8**

Table 4 shows the results of the power measurements for the water pump, comparing the INA219 sensor readings with calculated values. On the first day, at 07:14:10, the power recorded by the INA219 sensor was 13.4 W, while the calculated value was 13.1 W, resulting in a difference of 0.3 W. Later that day, at 14:09:48, the sensor recorded 12.1 W compared to the calculated value of 14.8 W, with a difference of 2.7 W.

On the second day, the pump activated once at 12:19:05, where the INA219 sensor recorded 13.5 W, and the calculated value was 15 W, resulting in a difference of 1.5 W. On the third day, the pump was activated twice: in the morning at 07:17:50, the sensor recorded 15.6 W, while the calculated value was 13.7 W, resulting in a difference of 1.9 W. In the afternoon, at 16:13:10, the sensor recorded 13.7 W, while the calculated value was 14.7 W, resulting in a difference of 1.0 W. The analysis indicates that the INA219 sensor provides accurate power readings with an average error of 9.8% and an accuracy of:

$$\text{Accuracy} = 100\% - 9.8\% = 90.2\%$$

A graph of the differences in power measurements is shown in Figure 10.

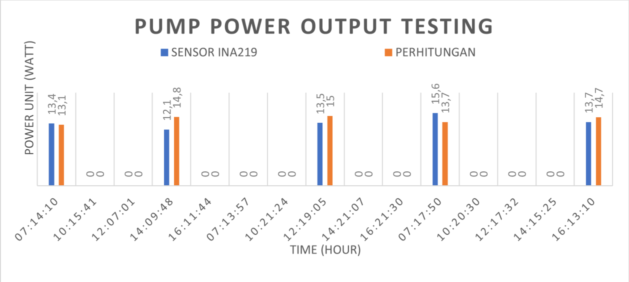

Figure 10: Pump Power Graph

Figure 10 illustrates the power readings for the pump from the INA219 sensor and the calculated values. The results of the pump power measurement are shown alongside the calculation comparison. Figure 10 illustrates that when the pump is active, the power increases. This occurs because activating the pump requires current. For example, when the pump was turned on, the INA219 sensor recorded a power of 13 Watts, while the calculated value was 12 Watts, resulting in a difference of 1 Watt. The accuracy of the INA219 sensor was determined to be 90.2%.

In Figure 10, the blue bar graph represents the power measurements recorded by the INA219 sensor, while the orange bar graph represents the calculated values. The average difference between the measurements was 1.48 W.

iii. Soil Moisture Sensor Testing

The soil moisture sensor test aimed to activate the water pump when the soil moisture level fell below 50%. This test was conducted over three days in an open plantation area. The results of the test are presented in Table 5.

Table 5 shows the results of the soil moisture sensor test. On the first day, the soil moisture was 37% when the pump activated under dry soil conditions. At 14:06:53, the soil conditions were dry again, prompting the pump to water the plants. In the afternoon, the soil moisture increased to 88%, and the soil condition became moist under sunny cloudy weather.

On the second day, the pump activated at 12:13:05 with a soil moisture of 35% under sunny weather conditions. In the afternoon, the pump did not activate as

Table 5: Soil Moisture Sensor Test Data

No.	Weather	Time (Hours)	Sensor Data (%)	Soil Condition	Pump Condition
1	Bright	07:20:10	37	Dry	Active
2	Bright	10:12:24	67	Humid	Off
3	Sunny Cloudy	12:04:11	64	Humid	Off
4	Sunny Cloudy	14:06:53	36	Dry	Active
5	Sunny Cloudy	16:06:12	88	Wet	Off
6	Bright	07:07:45	75	Wet	Off
7	Bright	10:16:25	63	Humid	Off
8	Bright	12:13:05	35	Dry	Active
9	Bright	14:16:35	88	Wet	Off
10	Bright	16:13:17	60	Humid	Off
11	Bright	07:10:15	34	Dry	Active
12	Bright	10:19:50	95	Wet	Off
13	Bright	12:16:22	75	Humid	Off
14	Sunny Cloudy	14:05:14	60	Humid	Off
15	Overcast	16:05:18	40	Dry	Active

the soil moisture was 60%, and the weather remained sunny.

On the third day, in the morning, the soil moisture was 34%, and the pump activated under dry soil conditions. During the day, the soil condition became moist with a moisture level of 75%, and the pump did not activate. In the afternoon, at 16:05:18, under cloudy weather conditions, the soil moisture was 40%, and the pump activated again to water the plants.

The analysis of the soil moisture sensor indicates that it can accurately read the soil moisture level. When the soil moisture is below 50%, the water pump activates, and when the soil moisture is above 50%, the pump does not activate.

IV. CONCLUSION

Based on the results of the research conducted, the design and construction of the Internet of Things (IoT)-based automatic plant watering smart farming system, although functional, is still not perfect. The overall findings from the tests conducted using various sensors are as follows: The INA219 sensor readings did not fully meet expectations. For solar panel voltage, the sensor could not perfectly measure the voltage. However, the current and power readings by the sensor were accurate, and the power comparison with the calculated data revealed slight discrepancies. The soil moisture sensor operated as expected. When the soil moisture level was below 50%, the pump automatically turned on. Conversely, when the soil moisture level exceeded 50%, the pump remained off, in line with the intended design to automate the pump activation process. The research demonstrated that the proposed system effectively automates plant watering using IoT technology, providing a foundation for further refinement and optimization.

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