Engineering and Technology Journal e-ISSN: 2456-3358
Volume 08 Issue 06 June-2023, Page No.-2342-2349
DOI: 10.47191/etj/v8i6.08, I.F. – 7.136

Insects Pest Trap Monitoring System Using Internet of Things Based Sensors

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ABSTRACT: The success of the harvest period will greatly affect the agricultural output itself. Processing of agricultural fields that still use traditional methods greatly affects crop yields, the cause of the effect of crop yields is the pests faced by farmers. Rice plant pests that often interfere are insect pests. Based on the background, in this study designed a monitoring system for traps and automatic midges to cope with rice plants from pest attacks using IoT (Internet of Things) technology. The purpose of this study is to obtain a monitoring system using sensors on IoT-based insect pest traps and find out the benefits of IoT technology in real time in monitoring insect pest traps.The automatic trap and midges monitoring system uses the ESP32-WROOM microcontroller, pest sting module, Passive Infrared Receiver sensor, ultrasonic sensor, DHT11 sensor, and the Blynk platform. Parameters monitored include temperature, humidity, presence of pests, pest characteristics, and light control. The results of this design are successful in monitoring the presence of pests on rice plants, controlling lights for on/off conditions, and displaying the temperature and humidity values of the rice fields displayed on the Blynk application on smartphones. This design tool can measure temperature and humidity values with an error percentage of 4.42% for temperature detection, and 6.03% for humidity detection. For PIR sensor readings can only detect insect pests from 0 to 5 meters. As well as ultrasonic sensors emit ultrasonic waves to repel pests with a radius of 4 meters.

KEYWORDS: insects pest, ESP32-WROOM, sensors, internet of things, ultrasonic sensor

1. INTRODUCTION

Technology makes everything easier. Humans always try to make innovations that can facilitate their activities, this is what makes technological developments increasingly produce tools as tools that can facilitate human activities and even exchange the role of humans in carrying out certain activities. The development of technology has become more advanced to the point of encroaching on every field of life. Almost all human activities cannot be separated from modern technology, ranging from the industrial world, home to the agricultural sector.

Indonesian agriculture is a sector that has an important role in the many economies in this developing country. One of the food crops in Indonesia is rice, whose harvest is still the staple food of the community. Rice is an agricultural crop and is one of the crops for staple food in the world. Agricultural ecosystems are simple ecosystems and monocultures when viewed from the community, vegetation selection, species diversity, and the risk of pest explosion.

The success of the harvest period will greatly affect the agricultural yield itself. The processing of agricultural fields that still use traditional means greatly affects the yield. In addition to land management, the cause of the influence of crop yields are pests faced by farmers. Farmers in eradicating pests are still in the traditional way. Pests of rice plants that often annoy farmers are leafhopper pests and insects. Generally, people in overcoming pests still use conventional traps and water rice plants using diesel or with pesticides, which of course can damage the surrounding ecosystem or pollute the environment

Based on the background above, in this research the author is interested in designing an automatic trap and midge monitoring system to overcome rice plants from pest attacks utilizing IoT (Internet of Things) technology. The system in this study used the ESP32-WROOM microcontroller. The measured pest trap parameters include temperature, air humidity, pest presence, pest characteristics, and lamp control. The results of measuring these parameters will be displayed in real time on smartphones. using the Blynk IoT platform. In addition, information will also be displayed on the 16x2 LCD on the system.

2. METHODOLOGY

The employed methodology in this study is experimental empirical research. The experimental empirical research method is carried out by designing and testing the tool in real time, so that data is obtained directly from the designed tool. As shown here, the employed methodology consists of two distinct steps. Each of these steps are further discussed in subsequent sections.

2.1Tools and Materials

Table 1. List Of Software Tools

No.	Software	
	Name	**Function**
1.	Arduino IDE	To create Mega 2560 and ESP8266 programs
2.	Solid Words	To design build tools
3.	SketchUp	To create the component image

Table 2. List of Hardware tools

No.	Hardware	
	Name	**Function**
1.	Laptop	To designing and creating the necessary software
2.	Smartphone	To display results from monitoring
3.	Soldering tools	To installing components on PCB
4.	Multimeter	As a measuring tool for parameters on the tool
5.	Hand Drill	To perforate the place of the component

Table 3. List of Materials

No.	Materials		
	Name	**Spec**	**Amount**
1.	ESP32 Module	WROOM	1
2.	Battery	12v-5Ah	2
3.	Step Down Voltage	LM2596	2
4.	Relay Module	4 Ch	1
5.	LED	$12V_{DC}$	1
6.	LCD 16x2	12C	1
7.	HVDC Module	2500-5000V	1
8.	PIR Sensor	HC-SR501	1

1.1 System Design

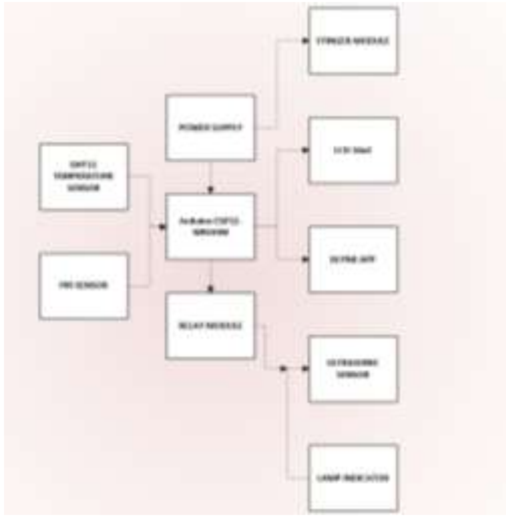

Fig.1. System Circuit FlowChart

Figure 1 is a flowchart for the insect pest trap monitoring system to be created. The designed system uses the ESP-32-WROOM microcontroller as a control. There are three types of sensors employed to measure parameters, namely DHT11 sensors, ultrasonic sensors, and PIR sensors. Then lamps and pest stingers as pest traps. For sending data to the Blynk application on smartphones, several providers are used.

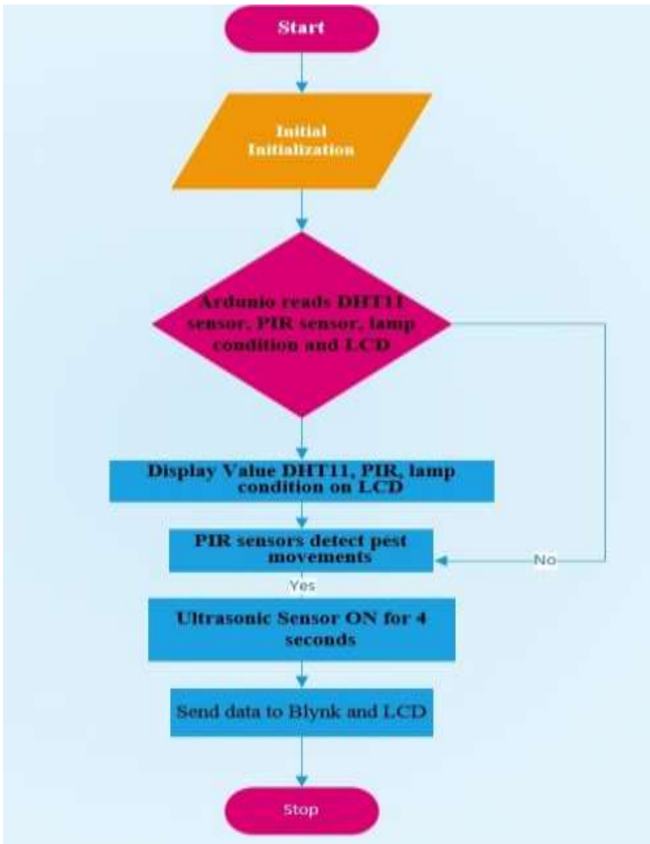

Fig.2. Tool Working System FlowChart

Based on the flowchart, the working principle of control using

ESP32-WROOM in this insect pest trap monitoring system can be explained as follows:

1) The initial stage is to connect the tool with the main power supply, which is with a voltage of 5 VDC.
2) The next stage is the initial initialization of the input, output, control and monitoring components on the system. At this stage the temperature sensor, air humidity and pest movement detection are processed by arduino ESP32-WROOM to be ready to read inputs from the sensors and send data to LCD16x2 and Blynk applications using IoT.
3) The sensors will read the parameters of the system, namely temperature, air humidity and the presence of insect pests. Data from the sensor will be read by Arduino ESP32-WROOM for further processing.
4) Arduino ESP32-WROOM will send readings to lcd16x2 and Blynk application, if pir sensor detects pest movement arduino will activate a relay that is already connected with ultrasonic sensors to emit ultrasonic waves for 4 seconds which is used to repel pests that perch on rice plants. Every PIR sensor detects pests or not, it will read the availability of pests on the 16x2 LCD and the Blynk application, and the condition of the lamp when on or off will be read on the 16x2 LCD and on the Blynk application.

3. RESULTS AND DISCUSSION

The tools designed in this study consist of two parts, namely hardware, software. The hardware part consists of an electronic circuit box. The hardware display of this tool is shown in Figure 3. For the results of software design in the form of the Blynk application on a smartphone shown in Figure 4.

Fig .3. Tool Design Results View

Fig .4. Blink App Display on Smartphone

1.2 Power Supply Testing

Power supply testing is carried out to maintain the quality of the power supply used, which can affect the system performance of the tool. This test is carried out by measuring the voltage at several points according to the method of analysis before. The main power supply in this tool uses 2 motor batteries assembled with a parallel circuit, with an output power of 12 V_{DC} / 5 Ah which is lowered using a buck converter to a power supply voltage of 5 V_{DC}. Details of the power supply test results are shown in Table 4.

Table 4. Power Suplly Test Result Data

No.	Result Data	
	Test Points	**Rated Voltage**
1.	Baterry	13.06 V_{DC}
2.	Input Buck Converter (1)	12.86 V_{DC}
3.	Input Buck Converter (2)	12.68 V_{DC}
4.	Output Buck Converter (1)	5 V_{DC}
5.	Output Buck Converter (2)	4,62 V_{DC}
6.	Vin Arduino ESP32-WROOM	4,93 V_{DC}
7.	Pin 5 Volt ESP32-WROOM	4.93 V_{DC}
8.	Pin 3.3 Volt ESP32-WROOM	3.36 V_{DC}
9.	Vcc Pest Stinger Module	4,65 V_{DC}
10.	Vcc PIR Sensor	4,94 V_{DC}
11.	Vcc DHT11 Sensor	3,35 V_{DC}
12.	Vcc Ultrasonic Sensor	4,94 V_{DC}

Based on the data from the voltage test results, it can be concluded that the value of the working voltage of the existing system in the insect pest trap system is still in accordance with the specifications or datasheets of the components that make up the tool. So that the tool has been supplied with an appropriate power supply for good tool performance.

1.3 PIR Sensor Output Voltage Testing

Testing the *output* voltage (V_{out}) of the PIR sensor is carried out to determine the relationship between the sensor voltage signal to the value of the results of measuring the presence of pests. In this test, a voltage measurement was carried out at the *output* point of the sensor module with a test sample in the form of insect pests on rice plants. The following is the data on the results of the *PIR sensor output* voltage testing that has been carried out can be seen in Table 5.

Table 5. Pir Sensor Output Result Data

No.	Distance (m)	Voltage (Vdc)	Logic	Information
1	0,5	3,35	1	Detected Pests
2	1	3,43	1	Detected Pests
3	1,5	3,49	1	Detected Pests
4	2	3,5	1	Detected Pests
5	2,5	3,49	1	Detected Pests
6	3	3,38	1	Detected Pests
7	3,5	3,37	1	Detected Pests
8	4	3,36	1	Detected Pests
9	4,5	3,38	1	Detected Pests
10	5	3,39	1	Detected Pests
11	5,5	0	0	No Pests
12	6	0	0	No Pests
13	6,5	0	0	No Pests
14	7	0	0	No Pests

From the test results in Table 5, the output voltage signal value of the PIR sensor is linear to the detection of the presence of insect pests. However, there are differences in radius distances such as those in Table 5. This can be seen when the sensor detects a pest passing within the radius of the sensor's range. A graph of the relationship between the output voltage of the PIR sensor to the pest detection radius is shown in Figure 5.

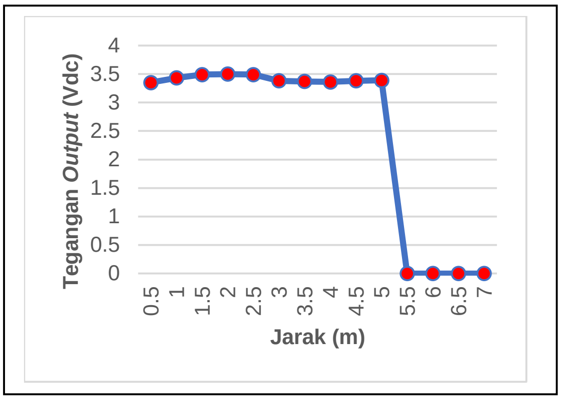

Fig .5. Grafik pengujian tegangan outpur sensor PIR

1.4 Testing HC-SR04 Ultrasonic Sensor

Testing of this HC-SR04 ultrasonic sensor was carried out to emit ultrasonic waves as a disruptor and repellent for the presence of pests that perch on rice plants. In this study using 3 ultrasonic sensors. This test was carried out several times by measuring the output voltage on the trig pin of the sensor to find out whether the sensor is working effectively to repel insect pests on rice plants.

Table 6. Ultrasonic Sensor Test Result Data

No.	Distance (m)	Voltage (V_{DC})			DESCRIPTION (ACTIVE/PASSIVE)
		Ultrasonic 1	Ultrasonic 2	Ultrasonic 3	
1	0,5	4,91	4,87	4,83	Passive
2	1	4,87	4,84	4,84	Passive
3	1,5	4,86	4,85	4,86	Passive
4	2	4,85	4,84	4,82	Passive
5	2,5	4,87	4,82	4,85	Passive
6	3	4,84	4,83	4,83	Active
7	3,5	4,90	4,80	4,88	Active
8	4	4,81	4,87	4,84	Active
Average		4,85			

Based on the data in Table 6, ultrasonic sensors 1, ultrasonic 2, and ultrasonic 3 can emit ultrasonic waves well and the resulting working voltage has an average of 4.85 V_{DC}. It can be concluded that ultrasonic sensors can work well by emitting ultrasonic waves as midges. However, the difference in the characteristics of pests from testing a radius of 0.5 meters to 2.5 meters was observed by the movement of "passive" pests with a tendency to be silent and remain perched on rice plants. Meanwhile, in testing with a radius of 3 to 4 meters, the movement of "active" pests was observed with a tendency to choose to leave the rice plant. A comparison graph of ultrasonic sensor voltage testing can be seen in Figure 6.

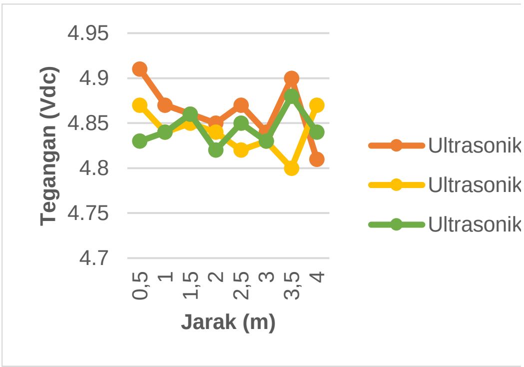

Fig .6. Comparison graph of ultrasonic sensor voltage testing

1.5 Testing Tempetature Sensor

Measurement of temperature and humidity parameters of the rice field environment in this study using the DHT11 sensor. At this stage, testing is carried out to determine the level of accuracy of the readings of the temperature and humidity sensors in the measurement of the temperature and humidity of the rice field environment. This test was carried out by measuring the temperature and humidity of the rice field environment using a temperature sensor and thermometer measuring instrument. The measurement results of the temperature and humidity sensors will be compared with the results of thermometer measurements as a reference. Table 7 and Table 8 show data on the test results of temperature and humidity sensors.

Table 7. DHT11 Sensor Test Result Data

No.	Temperature (°C)		Error (%)	Pest Characteristics (Active/Passive)
	Sensor DHT11	Thermometer		
1	21,10	21,8	3,21	Passive
2	21,20	21,9	3,19	Passive
3	21,10	21,9	3,65	Passive
4	21,40	22,3	4,03	Passive
5	21,60	22,1	2,26	Passive
6	21,40	22,4	4,46	Passive
7	21,70	23,9	9,20	Passive
8	21,30	22,5	5,33	Passive
Average			**4,42**	

In the test results in Table 7, an error rate (error) of sensor readings to the temperature was obtained compared to the thermometer with an average of 4.42%. The error that occurs is due to several factors such as the environmental conditions of the rice field area, so with a relatively small error value, it can be concluded that the DHT11 sensor has done a good temperature reading.

Table 8. DHT11 Sensor Test Result Data

No.	Humidity (%)		Error (%)	Pest Characteristics (Active/Passive)
	Sensor DHT11	Thermometer		
1	85,60	91	5,93	Passive
2	85,50	91	6,04	Passive
3	85,60	91	5,93	Passive
4	85,70	91	5,82	Passive
5	86,00	92	6,52	Passive
6	86,20	92	6,30	Passive
7	86,10	92	6,41	Passive
8	86,20	91	5,27	Passive
Rata-rata			**6,03**	

In the test results in Table 8, an error rate (error) of sensor readings on humidity was obtained compared to thermometers with an average of 6.03%. The error that occurs is caused by several factors such as the environmental conditions of the rice field area, which is relatively humid air, so that with a relatively small error value. It can be concluded that the DHT11 sensor has done a good job of reading humidity.

Based on Table 7 and Table 8, results were obtained from the characteristics of pests to the temperature and humidity conditions of rice fields. The characteristics of insect pests tend to be "passive" at an average temperature of 21.35 ºC and humidity of 85.86%, this is because insect pests do not have the ability to maintain their body temperature. So that in cold weather conditions, insects become lazy and do not move as actively as usual.

1.6 Data Delivery Testing

This data delivery test aims to determine the delay time of sending data from hardware to the Blynk server. In this test, different providers were used on smartphones, namely XL, Telkomsel and Indosat. This test is done several times to find out if there is a delay change or not.

Table 9. Provider Delay Comparison Data

No.	Time	Delay (s)		
		XL	Telkomsel	Indosat
1	17.50	0.21	0.85	0.28
2	18.00	0.51	0.74	0.75
3	18.10	0.64	0.56	0.54
4	18.20	0.73	0.4	0.61
5	18.30	0.62	0.63	0.6
6	18.40	0.58	0.39	0.6
7	18.50	0.64	0.48	0.98
8	19.00	0.61	0.47	0.69
9	19.10	0.99	0.39	0.81
10	19.20	0.95	0.52	0.79
Average		**0.65**	**0.54**	**0.67**

From the delay test using several providers, the provider that causes the least delay is from Telkomsel providers with an average delay obtained, which is 0.54 second. Meanwhile, from xl providers, a delay was obtained with an average of 0.65 second, and from Indosat providers, a delay was obtained with an average of 0.67 second. This is due to several factors that affect the delay in sending data, such as environmental and weather factors.

1.7 Blynk App Testing

This test was carried out by simulating the process of monitoring pest traps in rice fields. After the hardware has been connected to Blynk, the Blynk application on the smartphone will display the monitoring data sent by the hardware. There are three main components in the Blynk application display, namely the connection indicator between hardware and software, the pest presence indicator, the light on/off button, and the display of the value of the sensor reading. This test was carried out by comparing the results of measuring parameters on the hardware with the display on the Blynk application on a smartphone every 10 minutes. The test result data is shown in Table 10 and Table 11.

Table 10. Hardware Testing Result Data

No	Time	Hardware					
		Power	Temperature (°C)	RH (%)	Connection Indicator Tool	Pest Presence	Indicators
1	5pm	On	25,10	76,30	Online	Detected Pests	Off
2	5.10 pm	On	25,30	78,10	Online	No Pests	Off
3	5.20 pm	On	25,0	76,0	Online	No Pests	Off
4	5.30 pm	On	24,70	75,70	Online	Detected Pests	Off
5	5.40 pm	On	24,80	75,90	Online	Detected Pests	Off
6	5.50 pm	On	25,0	76,20	Online	Detected Pests	Off
7	6pm	On	24,50	76,10	Online	No Pests	On
8	6.10 pm	On	23,60	78,20	Online	Detected Pests	On
9	6.20 pm	Off	0	0	Offline	No Pests	Off
10	6.30 pm	On	21,20	83,70	Online	Detected Pests	On
11	6.40 pm	On	20,90	86,10	Online	Detected Pests	On
12	6.50 pm	On	21,60	81,60	Online	No Pests	On
13	7pm	On	21,30	83,90	Online	No Pests	On
14	7.10 pm	On	21,20	83,90	Online	Detected Pests	On
15	7.20 pm	Off	0	0	Offline	No Pests	Off

Table 11. Blynk App Testing Result Data

Blynk App				
Temperature (°C)	**RH (%)**	**Indicators Connection Tool**	**Pest Presence**	**Light Indicators**
25	76	Online	Detected Pests	Off
25	78	Online	No Pests	Off
25	76	Online	No Pests	Off
24	75	Online	Detected Pests	Off
24	75	Online	Detected Pests	Off
25	76	Online	Detected Pests	Off
24	76	Online	No Pests	On

23	78	Online	Detected Pests	On
23	78	Online	No Pests	On
21	83	Online	No Pests	On
20	86	Online	Detected Pests	On
21	81	Online	No Pests	On
21	83	Online	No Pests	On
21	83	Online	Detected Pests	On
21	83	Online	No Pests	On

Based on the data from the test results, it can be concluded that the Blynk application has worked well as planned. Data no. 9 and no. 15 indicate when the hardware is off or has not been supplied with a power supply. In these conditions, the hardware has not been connected to the Blynk server and the Blynk application will display the last data stored on the server. When the hardware is on or already connected to the power supply, the system will start working by connecting the connection between the hardware and the Blynk server. When the hardware is fully connected to the server, which is characterized by a connection status indicator in the application, the monitoring system will work as it should. This is based on data no. 1 to no. 8 and no. 10 to no. 14 where the appearance of the Blynk application is in accordance with the data on the hardware.

4. CONCLUTION

Based on the results of the analysis from the research data that has been carried out, it can be concluded that the insect pest trap monitoring system using the Blynk platform with parameters of pest presence, system control, temperature, and humidity has successfully worked according to planning with an average sensor reading accuracy of 95%. The Blynk application has successfully displayed the results of monitoring insect pest traps in real time. The Blynk application will display the status "No Pests" when the presence of pests is not detected on rice plants and will display the status "Pest Detected" when there are active moving pests on rice plants with a radius of 0 to 5 meters. In addition, the Blynk application can control the lamp for on / off conditions and displays a temperature value of 21.35 ^{o}C and humidity of 85.86 % in rice fields.

The average percentage of reading error for the DHT 11 sensor is 4.42 % for temperature detection, and 6.03 % for moisture detection. On the pir sensor readings to detect the presence of insect pests can only detect from 0 to 5 meters, 5 to 7 meters cannot detect insect pests. As well as ultrasonic sensors can disturb the presence of insect pests by emitting ultrasonic waves with a radius of 4 meters in terms of pest characteristics. The delay response time of Blynk servers using several providers varies, XL providers average a delay of 0.65 second, Telkomsel providers an average delay of 0.54 second, and Indosat providers an average delay of 0.67 second.

For further development, it is necessary to check the entire system periodically to keep the condition of the tool always in good condition. This tool can be developed by adding solar panels as charging from the main power supply, namely in the form of a battery / battery, and adding a buzzer as a repellent for birds and rats on rice plants, or other components to support the system.

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