

Bird Pest Control System with Sound Waves on Farmland

Fikri Hidayat¹, Mukhlidi Muskhir¹, Sukardi¹, Fadhli Ranuharja¹

¹Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

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ABSTRACT

The problem of pests on agricultural land is a significant challenge that can drastically reduce crop yields. Sound wave-based pest repellent systems were developed as a solution to overcome this problem without the use of chemicals that can damage the environment. This research aims to design and build a pest repellent by utilizing certain sound frequencies produced by amplifiers and speakers, which are activated when the PIR sensor detects pest movement. This tool uses an Arduino Uno as the main microcontroller to control the system, a PIR sensor to detect the movement of pests, and an RTC (Real-Time Clock) to set the device's operation schedule to match a specific time. This system is expected to be an effective and environmentally friendly solution to repel pests, as well as reduce damage to plants without disturbing the surrounding ecosystem. The test results show that this tool can work well in detecting the presence of pests and activating the sound of repellents automatically, so that it is effective in maintaining the quality of crops on agricultural land.

Corresponding Author:

Fikri Hidayat

Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang

Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia

Email: fikrihidayat12345@gmail.com

1. INTRODUCTION

Indonesia is an agrarian nation, meaning the agricultural sector plays a vital role in the overall national economy; this is evidenced by the large proportion of the population and workforce engaged in agriculture [1],[2]. Agriculture constitutes a crucial food-producing sector for the Indonesian people [3]. Food security in Indonesia focuses primarily on meeting basic needs that are affordable for the public [4]. In this context, rice serves as a staple food for the population [5]. According to data from Statistics Indonesia (BPS) for West Sumatra Province, rice production in 2023 reached 1,482,469 tons of Unmilled Dry Grain (GKG) an increase of 108,937 tons (7.93%) compared to the 2022 production of 1,373,532 tons. Despite this abundant production, farmers still face challenges that can impact rice yields [6].

Rice production is frequently influenced by conditions during the planting phase; a major issue is pest infestation, which can lead to crop failure and reduced yields [7],[8]. Bird pests are among the threats that can cause rice crop failure [9]. Rising bird populations lead to reduced yields, with attacks typically occurring as the harvest approaches. Once the rice plants begin to turn yellow, farmers become particularly vigilant in guarding their crops, especially during critical foraging hours: 6:00 AM to 10:00 AM and 2:00 PM to 6:00 PM. Such attacks cause the rice plants to wither and the grains to become empty [10],[11]. Farmers have attempted to address this bird pest problem, yet current control methods remain traditional—such as using scarecrows or cans attached to ropes that must be pulled manually [12]–[15]. To assist farmers, a bird-repelling system utilizing sound waves needs to be developed. The device employs an Arduino Uno microcontroller and a motion sensor to detect objects; when an object is detected, a speaker activates and emits a loud sound, effectively driving away pests from the rice crops. Additionally, the device is equipped with a solar panel, eliminating the need for grid electricity. This system can help farmers combat pest infestations particularly by birds that cause crop losses and reduce rice productivity.

2. METHOD

Design constitutes the initial stage in the process of creating a bird pest deterrent device or system for rice crops. The objective of this design phase is to outline the concept and perform detailed calculations prior to the actual fabrication of the device. The design process involves planning how the device is to be constructed and utilized to deter bird pests from rice crops. The development of the device in this final project encompasses everything from constructing the hardware housing for the deterrent system to programming the motion sensors and speakers. The components utilized in this project are illustrated in the following block diagram in Figure 1.

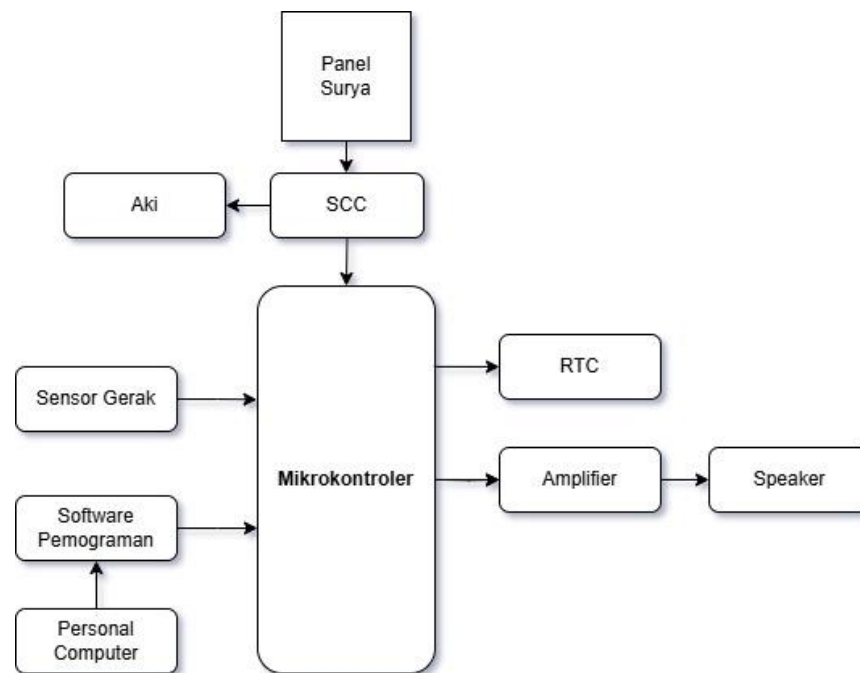


Figure 1. Diagram block

The following is an explanation of the functions of each component in the block diagram: 1) Solar panels are used to convert solar energy into electrical energy to charge the battery [16]. 2) The solar charge controller is a component of the solar power generation system. It controls the incoming current from the solar panels and the outgoing load current [17]. Its function is to regulate and optimize battery charging from the solar panels [18]. 3) The battery serves as a direct current (DC) source capable of converting chemical energy into electrical energy [19]. It supplies voltage to the Arduino and the amplifier. 4) The microcontroller acts as a processor to handle data generated by the motion sensor and analyzes it according to the programmed logic [20]. 5) The speaker converts electrical signals into audio frequencies (sound) [21]. It serves as the output device for emitting sound waves to repel bird pests. 6) An amplifier is an electronic component used to boost power or signal strength [22]. A 12V mini amplifier is used here to produce clearer and more distinct sound from the speaker [23]. 7) A motion sensor is a type of detector capable of measuring physical properties such as pressure and light [24]. The specific sensor used is the HC-SR501 PIR sensor, which detects the movement of bird pests in the vicinity of the agricultural area [25].

The device operates by first connecting all necessary components and switching the unit on; a motion sensor then detects any birds entering the rice field area within its range. The sensor's readings are sent to a microcontroller for processing, and the resulting output is transmitted to a speaker, which emits sound waves to drive away bird pests from the agricultural land. Additionally, detection events trigger a notification sent to a smartphone. Powered by a solar panel and a battery, the device does not require a connection to the main power grid. It can be operated manually via a switch or set to function automatically; the system activates at 08:00 AM and deactivates at 05:00 PM. Figure 2 shows the design of the proposed system.

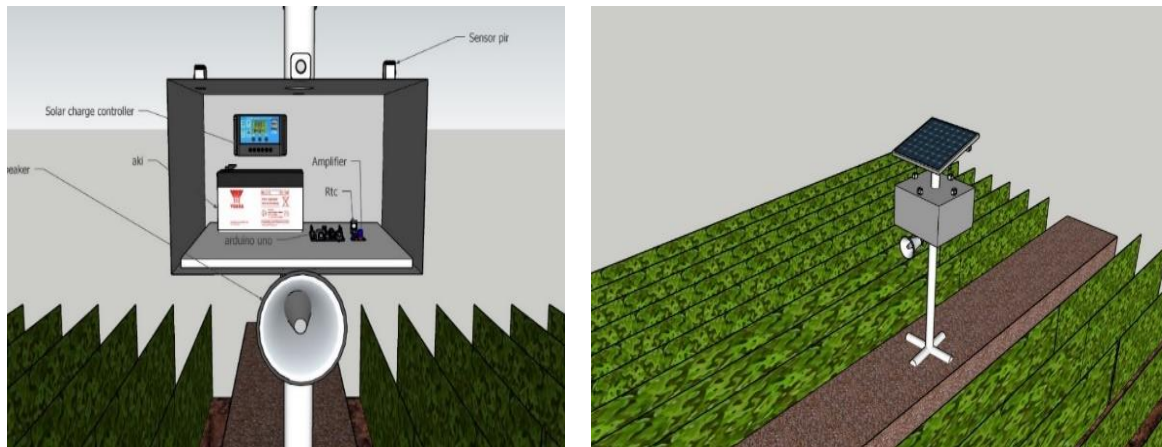


Figure 2. 3D Design of Pest Repellent Systems

Figure 2 shows the hardware design of the pest repeller system, presented as a 3D model. The 3D design reveals several components installed within the enclosure, such as a battery, solar charge controller, Arduino Uno, RTC, and amplifier. Figure 3 illustrates the overall design of the device, intended to show the pin connections for the components used in this final project. Following the hardware design phase, the software design phase—which includes the creation of a flowchart—is carried out. A flowchart is a diagram that maps out the logical flow of a procedure or system program. To outline the problem-solving steps, flowcharts utilize specific symbols that are standardized, easy to understand, and user-friendly.

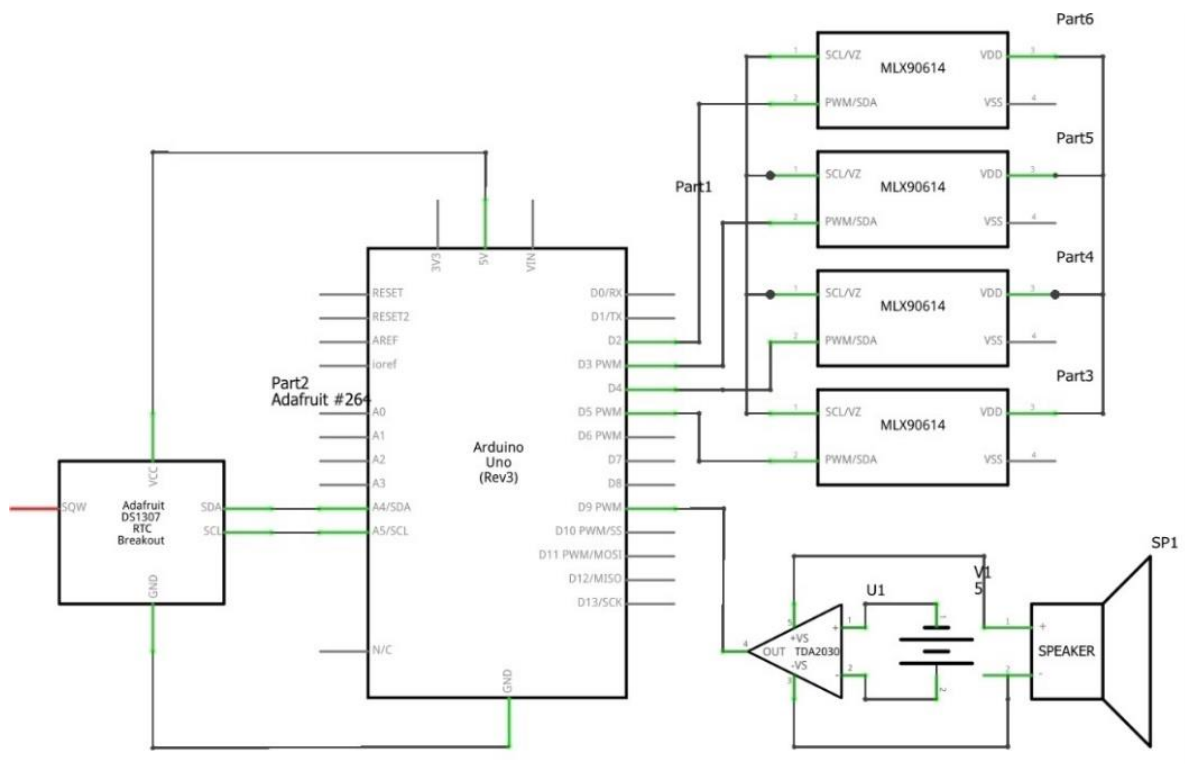


Figure 3. Overall series of tools

Figure 4 illustrates that the design of the pest repellent system begins with microcontroller input initialization and time detection via the RTC; if the RTC time falls within the predetermined range, the PIR sensor begins detecting objects. Conversely, if the time is outside this range, neither the PIR sensor nor the speaker will activate.

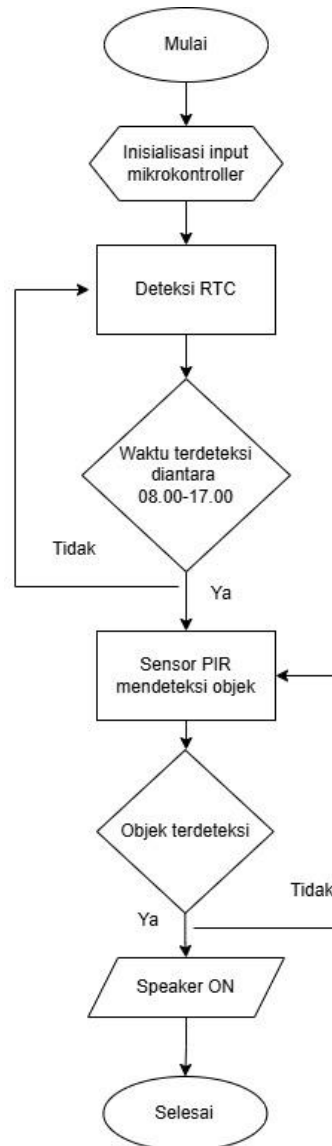


Figure 4. Flowchart

3. RESULTS AND DISCUSSION

Testing of this device was conducted to obtain empirical data and evidence confirming that both the hardware and software function correctly. The hardware design encompasses the overall system configuration and the specific circuitry employed, utilizing components such as a solar panel, battery, solar charge controller, Arduino Uno R3, PIR sensor, amplifier, speaker, and Real-Time Clock (RTC). These components were assembled according to the established circuit design; the image below illustrates the complete hardware setup for the bird pest deterrent system.

This pest repeller system utilizes an iron pipe as a support post and features a box—formed from iron plating and measuring 30 x 30 x 30 cm—to house the main components. A solar panel mounted on top serves as the energy source; additionally, a PIR sensor is installed on the exterior of the box within a protective casing to ensure water resistance, while a rain-resistant speaker is located at the bottom of the unit. Figure 6 above is the result of design of the expulsion system circuit pest bird . This circuit design uses Arduino UNO R3 as the center controls used to connect and control each component used. After the stage design , the next stage is stages component testing. The purpose of this stage is to find out whether the system can function properly according to design initially. From the tests that have been carried out in Table 1, the PIR sensor can detect object until distance 6 meters and if more than 6 meters PIR sensor can't detect object .



Figure 5. Hardware implementation

Table 1 PIR Sensor Distance Testing

Testing	Measuring Distance	Results
1	1 Meter	Detected
2	2 Meter	Detected
6	6 Meter	Detected
7	7 Meter	Not detected
10	10 Meter	Not detected

Table 2 describe the distance from the sound produced by the speaker is heard until a distance of 50 meters. Testing was carried out directly on the land agriculture or rice fields so that it can affect the quality of sound produced by the speakers.

Table 2. Speaker Testing

No	Distance	Speaker output
1	10 Meter	Sounds
2	20 Meter	Sounds
3	50 Meter	Sounds

Table 3 of the RTC test, it can be seen that this device can turn on or off automatically at a predetermined time. This device will turn on if the time on the RTC shows 08.00 am and will turn off if the time shows 17.00, this RTC test was carried out for 3 days to determine whether the on-off system on this device can work properly. When the device is in the off position, the PIR sensor and speaker will not be active, the PIR sensor will re-detect after 8:00 AM.

Table 3. RTC Testing

Day -	Time	Tool Status
1	08.00	Active
	17.00	Non-active
2	08.00	Active
	17.00	Non-active
3	08.00	Active
	17.00	Non-active

Table 4 and Figure 6 illustrate the voltage produced from the solar panels at every hour, the highest voltage that is 20 volts at 12:00 PM. This solar panel voltage test was conducted during a sunny day in the field area. agriculture.

Table 4. Solar Panel Testing

No	Hour	Voltage (V)
1	08.00	12.5
2	09.00	13.5
3	10.00	15.4
4	11.00	19.6
5	12.00	20
6	13.00	18
7	14.00	17.8
8	15.00	15.5
9	16.00	13
10	17.00	12.5

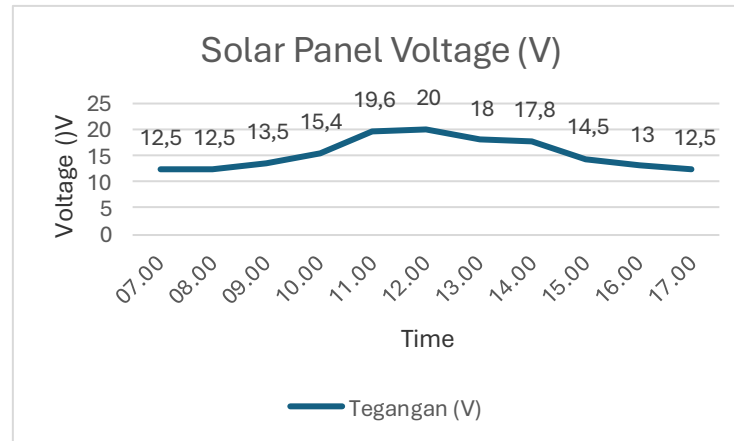


Figure 6. Solar Panel Voltage Graph

Based on the graph on then you can see the increase in voltage produced by the solar panel at certain times . The voltage is highest that is as big as 20 volts at 12 noon, while the lowest voltage that is as big as 12.5 volts at 07.00, 08.00 and 17.00. Table 5 illustrate the response time test was carried out to determine the response time required when the sensor detects movement. The length of time is calculated using a stopwatch which is calculated at the time the object located in front of the sensor area.

Table 5. PIR Sensor Response Time Testing

No	Component	1 Meter Distance Test		3 Meter Distance Test		5 Meter Distance Test	
		Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
1	PIR 1	0.46 Seconds	0.6 Seconds	0.68 Seconds	0.71 Seconds	0.75 Seconds	0.93 Seconds
2	PIR 2	0.5 Seconds	0.81 Seconds	0.63 Seconds	0.57 Seconds	0.66 Seconds	0.82 Seconds
3	PIR 3	0.84 Seconds	0.58 Seconds	0.54 Seconds	0.88 Seconds	0.69 Seconds	0.7 Seconds
4	PIR 4	0.72 Seconds	0.63 Seconds	0.4 Second	0.62 Seconds	0.7 Seconds	0.72 Seconds
Average delay		0.63 seconds	0.65 seconds	0.56 seconds	0.69 seconds	0.7 seconds	0.79 seconds

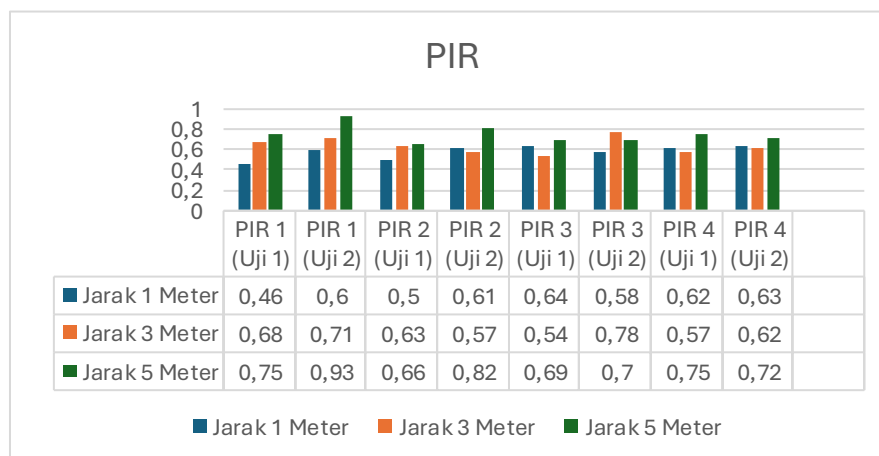


Figure 7. Chart Response time testing

Based on Figure 7 it can be analyzed that is from the results of each sensor response time at a distance of 1 meter, 3 meters and 5 meters consistent at times under 1 second . This indicates that the PIR sensor can detect properly and correctly. Meanwhile, for testing with variations distance when viewed from chart so Almost the same results were obtained , both in the first and second tests . It can be concluded that this test can be influenced by distance because the PIR sensor has range maximum distance from its detection.

4. CONCLUSION

System testing indicates that the device operates effectively. The motion sensor and speaker function optimally for bird deterrence when birds are present in a flock of at least three. Experimental results show that the sensor does not trigger when fewer than three birds are present and fails to detect a single sparrow. However, given the flocking nature of sparrows, field tests demonstrated that the PIR sensor successfully detected the presence of sparrow flocks and the speaker effectively drove them away. Furthermore, the use of a solar panel makes the device highly practical, as it eliminates the need for a grid power connection and simplifies operation.

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