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Dynamic Ultrasonic Wave Generators as an Alternative Technology to Field Rat Repellents

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***Abstract*— The case of crop failure caused by pest attacks is one of the problems in agriculture that is always interesting to study. Apart from weather factors, pest attacks on rice and corn agricultural commodities often occur just before harvest time. Currently, farmers often use toxic materials and even electricity as a means to repel and eradicate rat pests. However, this method can be dangerous for the farmers themselves. There have even been several cases of death due to electrical equipment installed in agricultural areas. Based on these problems, a pest repellent will be made by utilizing ultrasonic waves from a solar-powered power source so that it can be used efficiently, practically and safely. This tool is built using IC NE556C, Solar Panel, LDR Sensor (Light Dependent Resistor), and Ultrasonic Piezo PTC 4000 Speaker. IC NE556C timer and ultrasonic wave multivibrator are used to generate ultrasonic waves randomly according to the program. The purpose of making this tool is as an alternative to field mouse pest repellent using ultrasonic waves by utilizing solar energy in handling pests in agricultural areas.**

***Index Terms*— agriculture; rat pests; solar energy; ultrasonic waves.**

I. INTRODUCTION

The agricultural sector in Indonesia still plays a very important role for the country. Success in the agricultural sector will contribute significantly. However, this success is often hampered by the presence of rice field rats (*Rattus argentiventer*) [1]. Rice field rats are pests of various gardens, especially rice plants. This pest often results in crop failure for farmers.

Sectors in several regions in Indonesia often fail due to changes in natural conditions including climate, wind and temperature changes as well as several other factors, namely viruses, fungi, insect pests and rodents in excess on agricultural land [2]. Rice field rats are the main pests of rice plants from the mammal class which have very different characteristics compared to other types of rice pests. Rice field rats damage rice plants at all stages of rice plant growth and in rice storage warehouses. Severe damage occurs if the rats attack the generative phase, because at that phase the plant does not have the ability to form new tillers [3]. Rats damage rice plants starting from the center of the plot, then extending towards the edges [4]. Rats attack rice at night, during the day rats in holes in irrigation embankments, rice fields and village areas near rice fields. In the fallow period (the period before tillage) most of the rats migrated to the village area near the rice fields and returned to the rice fields after the rice crop was approaching its phase. Rice field pests are not only rats, but birds are also one of the rice field pests that can harm farmers [5]. Rice is one type of grain that is high in protein that is favored by birds [6]. No wonder the rice field birds attack the rice starting to turn yellow.

A large increase in the population of rice field rats recently occurred in Bojonegoro Regency, East Java province, which resulted in damage to rice and corn plants which resulted in crop failure. Control of rat pests is currently carried out in the traditional way by finding rat nests and catching these mice, the Javanese call them "*gropyokan"*, pumping water into the rat's nest and electricity [7]. The research that will be carried out utilizes the technology of using ultrasonic waves to repel rice field rats and so it is hoped that it will help farmers, especially farmer groups in Sugihwaras District, Bojonegoro Regency in dealing with rat pests. In addition, it will analyze several methods of rat repellent that have been carried out so that the most effective, inexpensive and safe method of rat repellent will be obtained.

The novelty in the application of solar energy rice field mouse pest repellent is the simplicity of the device circuit but the ultrasonic wave output can be programmed by detecting the brightness of the light with a light sensor to detect day and night. The ultrasonic waves produced can be set statically or swing dynamically simultaneously, so by applying this pattern the device can effectively repel pests by disrupting passive feeding behavior patterns and passive motion of pests.

In 2018, Azharul conducted research on farmers' rice fields with an area of about 200 ha with the aim of studying the breeding characteristics of paddy rats as a basis for control [8]. Observations included reproductive conditions, pregnancy, number of children, number of embryos, and number of placental scars. The results showed that the breeding of paddy rats in rice plants mainly occurred in the rice generative stadia period. In one growing season there were three births of rats with an average of 10 cubs for each birth. The highest number of children occurred in the first birth and decreased in subsequent births. The breeding ground for rice rats is mainly in the habitat of irrigation embankments. Based on the breeding characteristics, the control of the rice field rat population should be carried out early (early planting) before the rats breed, with the main target of controlling the irrigated embankment habitat. Application of pattern and timing of rice planting simultaneously can limit the breeding of field rats. This research is used as scientific information about rice field rats breeding for the proposed research.

In 2019, Oktivira conducted a study to determine the effect of crickets' ultrasonic waves on passive feeding behavior patterns and passive motion of rats [9]. Ultrasonic waves of crickets were exposed directly to rice field rats and observed through passive feeding behavior patterns and passive motion of rats were analyzed by factorial design variance. The observed factors include frequency, source distance, and duration of exposure to ultrasonic waves of crickets and their combination. The frequency of ultrasonic waves of crickets at a distance of 100 cm and a length of exposure of 45-60 minutes can cause changes in passive feeding behavior and passive motion of rats. This research by Tito adds to the reference that ultrasonic waves of crickets are able to influence the behavior of field rats[10].

In 2020, Fatahullah researched the application of pest control using the Arduino microcontroller[11]. With a focus as an appropriate technology, researchers utilize a microcontroller device with a solar power source as the main energy of the device [12], [13]. However, in this device, the light sensor device functions as a switch to turn off the device at night.

In 2020, Hikmah researched the use of a prototype bird repellent using a motion sensor to activate ultrasonic waves according to the detected bird target [14], [15]. The purpose of this research is to design and build a prototype of field mouse pest repellent in rice fields based on the internet of things (IOT). The focus is on sparrows, with the use of ultrasonic speakers with a certain frequency to repel leafhoppers and rats. This prototype is connected to the internet network which can be monitored and controlled remotely using desktop and android. Based on the results of the analysis in this study as input using the RCWL Microwave motion sensor [16]. able to repel pests by targeting rats and birds.

In 2022, Devika et al made a study using ultrasonic sound waves to disturb birds passing through the field. hardware and software used in this research are camera, object detection, buzzer, Arduino, OpenCV, and pySerial. This study used a video stream by utilizing YOLOv3 to detect birds crossing the area. When a bird crosses the area and is detected by the object detection video, the buzzer alarm will sound to turn on the ultrasonic sound wave so that the bird will be disturbed and leave the area [17].

The novelty in the proposed research, is the method of applying ultrasonic wave generation technology with a solar energy source to repel pests in rice fields having a novelty in incorporating the resulting ultrasonic wave output. which combines static and dynamic ultrasonic waves at the same time. If in previous studies using ultrasonic waves which are only emitted in a certain frequency range, this device is expected to combine static ultrasonic waves from the first speaker and dynamic ultrasonic waves from the second speaker. In addition to the simplicity of the design, what is superior in this device this novelty will be an interesting thing to learn.

Rats are agricultural pests that are quite skilled at adapting to new environments [18]. Based on the literature study, it is necessary to make better adjustments to the device to deal with this problem. So, it is necessary to add the innovation of combining the static and dynamic output of ultrasonic wave frequencies.

This device is designed without using a microcontroller programming, but even so the device will be able to effectively work to emit ultrasonic waves properly. By applying a light sensor or Light Dependent Resistor (LDR) for day or night detection, the device will generate ultrasonic waves according to predetermined settings according to pest behavior during the day and night. Besides the waves can be adjusted statically, the ultrasonic waves generated can swing like a dynamic whistle method so it will be difficult for pests to adapt.

II. METHOD

The research method used in this study is described as follows. Initially, a literature study was carried out to determine the basis for research and design alternative technology for field mouse pest repellent using ultrasonic waves with solar power supporting devices and light sensors, so that they can implement and find the supporting theory needed to provide the basis used for this research. A study was then conducted to find out whether this system was feasible to be developed or not, including to review the benefits resulting from the application of the system to be designed and developed. Among the various available

methods, the prototyping method was chosen to design and develop Ultrasonic Wave Generators as Alternative Pest Repellent Technology.

A. Literature Study Method

Studying the results of research that has been published in research journals on the use of ultrasonic waves and the behavior of field rats.

B. Field Study Method

Directly observing the behavior of rats on agricultural land in Sugihwaras Village, Sugihwaras District, Bojonegoro Regency.

Conducted a discussion with the Women's Farmer's Group in Sugihwaras Village, Sugihwaras Subdistrict, Bojonegoro Regency about the methods of getting rid of field rats that have been carried out in the area. So that it can provide counseling about the method of field rat repellent in the scope of electrical safety. Before providing counseling, an analysis of the field mouse pest repellent method that has been carried out and provides an alternative new method using ultrasonic waves in order to obtain an efficient, inexpensive and safe method of field mouse pest repellent.

C. Data Analysis Method

Conducted an analysis of several methods of rat repellent, both conventional and with the use of ultrasonic wave generators.

D. Conclusion Method

Conclusions were obtained based on the results of field studies and data analysis to obtain a safe, effective and inexpensive method of rat repellent.

E. Research Variable

The research variable in question is everything that will be the object of research. Variables can also be interpreted as factors that play an important role in this study, namely making a series of ultrasonic wave generators with a certain voltage and frequency that can disrupt the behavior of rice field rats so as not to damage rice plants, as well as observing the distance range when ultrasonic waves can disrupt the behavior of rice field rats. directly applied to paddy fields.

III. RESULT AND ANALYSIS

A. The Flowchart

To provide an overview of how the system functions, the following figure depicts the flowchart of the developed systems (Fig. 1). in the flowchart shown in Fig.1, the light sensor will only detect day and night. if the sensor has recognized the intensity of the light detected, the electronic circuit will emit an ultrasonic sound according to the settings that have been set using a potentiometer.

Potentiometer component is used to set the ultrasonic wave output. on the first potentiometer, serves to adjust the ultrasonic wave with a stable output, simultaneously the device will issue a fixed ultrasonic sound wave. then on the second potentiometer, serves to adjust the ultrasonic wave with a random output at a certain frequency range. This is done so that the rats have difficulty adapting to a fixed wave. In the novelty of the combination of the fixed and random wave method, it is hoped that it will be more effective in creating a rats repellent device.

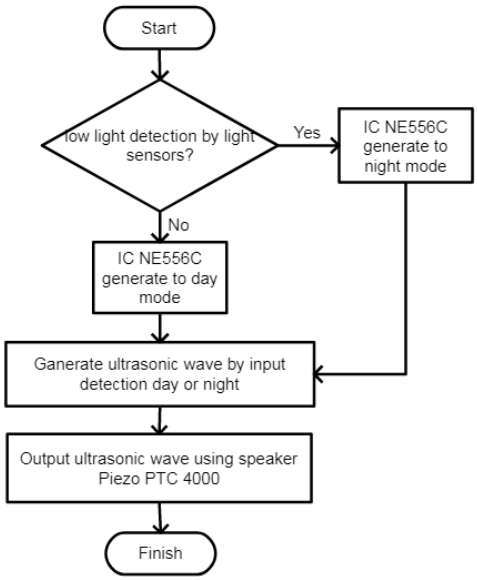

Fig. 1. System Flowchart

From the flowchart, it can be seen that the light sensor plays a role in detecting day and night, how to detect day and night obtained from bright lighting will be detected as day and less lighting will be detected as night. if it has been detected day and night, the IC NE556C will generate ultrasonic waves. it is intended to set day mode and night mode on the device manually. the result of the settings that have been made, the system will automatically emit ultrasonic waves according to day and night modes for the purpose of disturbing rat pests.

B. The System Design

The general mechanism of Solar Cell Energy and Light Sensors in Ultrasonic Wave Generators as Alternative Pest Repellent Technology is illustrated in the Figure 2.

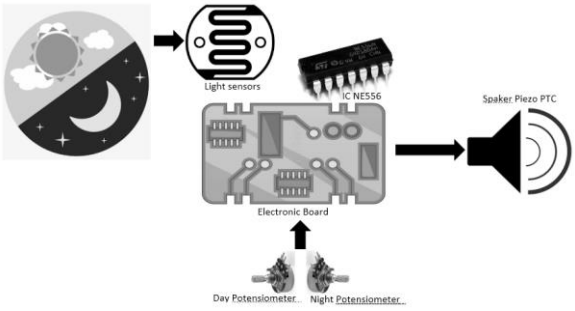

Fig. 2. General System

The following is an explanation of how to start system implementation the use of Solar Cell Energy and Light Sensors in Ultrasonic Wave Generators as Alternative Pest Repellent Technology:

1. LDR Sensor (Light Dependent Resistor), it will detect the intensity of light entering the system. if the light intensity is low, it will be detected as night and if the light intensity is high, it will be detected as day [19].
2. The manual setting using day and night potentiometers to provide different frequencies during day and night. the goal is that rice field rats (*Rattus argentiventer*) difficult to adapt to the ultrasonic sound produced [20].
3. The IC NE556 component will generate the resulting ultrasonic waves by swinging the predetermined ultrasonic wave range [17].
4. In the experiment the use of solar cell energy and light sensors in ultrasonic wave generators as alternative pest repellent technology, the experiment will be carried out by testing rat pests by providing various ranges of ultrasonic waves. The test will observe how much the rat will respond to the ultrasonic waves that have been generated by the electronic device.
5. The purpose of giving ultrasonic waves to rats is so that the rats are disturbed and will eventually respond to avoid the waves. this will prove that the rats repellent device is functioning properly.
6. The output of this device will combine different ultrasonic wave outs, namely the ultrasonic wave frequency that is fixed and dynamic with the aim that the rice field rats are not able to adapt.

The general digital circuit for solar cell energy and light sensors in ultrasonic wave generators as an alternative to field mouse pest repellent' technology is illustrated in Figure 3. In this digital circuit, the NE556 Integrated Circuit as the main component of the digital circuit was chosen because from various previous tests the NE556 IC proved better in producing ultrasonic waves and have more durability.

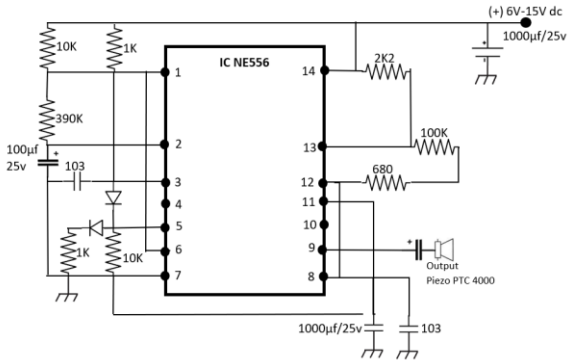

Fig. 3. General digital circuit for Solar Cell Energy and Light Sensors in Ultrasonic Wave Generators as Alternative Pest Repellent Technology

The IC NE556 series will activate ultrasonic waves with a certain range based on the settings with the potentiometer [21]. There are 4 modes of setting the ultrasonic waves generated (Fig. 4):

1. Frequency modes are the 45-48 MHz frequency mode in V_2 mode and 45 MHz constant in V_1 mode.
2. Frequency modes are above 40-45MHz in V_2 mode and constant 40 MHz in V_1 mode.
3. Frequency modes are above 35-40 MHz in V_2 mode and 35 MHz constant in V_1 mode.
4. Frequency modes are above 35-40 MHz in V_2 mode and constant 35 MHz in V_1 mode.

So that the frequency mode can be activated during the day and night as a dual timer [22]. So that each day and night mode can be set with variations of the four ultrasonic frequency modes.

Fig. 4. The IC NE556 display

C. *System Implementation*

The experimental scenario consists of 2 main scenarios, namely experiments with a static frequency and with a swing frequency or swinging a specified frequency range. In the first scenario, the experiment will be carried out using a method of providing a static or fixed frequency with a certain time span, while in the second scenario, it will be carried out by a method of providing dynamic or swing frequencies with a certain time span.

At the time of testing the device, the device is placed in a rice field area with a height of 40 cm from the ground (Fig. 5). Previously the agricultural area had

been selected with flood-free conditions and not affected by pests and during the vegetative plant period. The vegetative period was chosen because at this time, rats began to attack rice plants.

Fig. 5. The device implemented in the fields

1) First Experiment

The first experimental scenario, the pattern and behavior of rats were tested with a rat repellent device with various levels of frequency with a certain time span. By using a spectrum analyzer device [23], ultrasonic frequencies are detected in real conditions according to the environment. The picture shows the active ultrasonic spectrum in the 48 kHz range. In the research experiment, the rats used in the experiment were field rats (*Rattus argentiventer*) which are the main pests of rice plants. The experiment was carried out by placing mice in the same room simultaneously and observing the behavior of the mice during the experiment.

TABLE I. FIRST EXPERIMENT

No	Frequency (kHz)	The number of Rats to									
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	20	0	0	0	0	0	0	0	0	0	0
2	25	0	0	0	0	0	0	0	0	0	0
3	30	0	0	0	0	0	0	0	0	0	0
4	35	0	0	0	0	0	0	0	0	0	0
5	40	0	1	0	0	1	0	0	1	0	1
6	41	1	1	1	1	0	1	1	0	1	0
7	42	1	1	1	1	1	1	1	1	1	0
8	43	1	0	1	0	1	1	1	1	1	1
9	45	1	1	1	1	1	1	0	1	1	1
10	46	1	1	1	0	1	1	1	1	1	1
11	47	1	1	1	1	1	1	1	1	1	1
12	48	1	1	1	1	1	1	1	1	1	1

The first experiment, a summary of the experimental results is shown in Table I, there are two reactions of rats which are recorded by giving the number symbols 0 and 1. a reaction that shows the number 0 means that the mouse does not respond to ultrasonic sound and a reaction that shows the number 1 means that the mouse responds to sound ultrasonic.

2) Second Experiment

In the second experimental scenario, the pattern and behavior of the rats were tested with a rat repellent device with various levels of frequency with a certain time span. In the second experiment, the tool will be set to swing mode or the frequency of swinging up and down with a predetermined frequency range.

TABLE II. SECOND EXPERIMENT

No	Frequency (kHz)	The number of Rats to									
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	20-30	0	0	0	0	0	0	0	0	0	0
2	25-35	0	0	0	0	0	0	0	0	0	0
3	30-40	0	0	1	1	1	0	1	1	1	0
4	35-45	0	1	1	1	1	1	1	1	1	0
5	40-45	1	1	1	1	1	1	1	1	1	1
6	42-48	1	1	1	1	1	1	1	1	1	1

In Table 2, rats were given ultrasonic waves with various frequency ranges from 20 kHz to 48 kHz. But in the second experiment, ultrasonic waves will use the swing method such as the whistling concept.

After doing several ultrasonic waves testing on rats, the table shows a summary that describes each condition of the rats to ultrasonic waves. In the summary of the behavior of this ultrasonic wave, it will be a constant reference for ultrasonic waves to disturb rice rats.

a) Summary at 30 kHz

TABLE III. EXPERIMENT RESULT SUMMARY 30 KHZ

Repetition	Frequency (kHz)	Behavior
1	30	affected, respond
2	30	affected, respond
3	30	affected, respond

In Table 3, for testing the ultrasonic frequency of 30 kHz, the field rat pest began to respond to the arrival of the disturbed ultrasonic sound source but its behavior was still said to be not so disturbed. they still tolerate the sound that comes out.

b) Summary at 35 kHz

TABLE IV. EXPERIMENT RESULT SUMMARY 35 KHZ

Repetition	Frequency (kHz)	Behavior
1	35	affected, respond
2	35	affected, respond
3	35	affected, respond

In Table 4, for testing the ultrasonic frequency of 35 kHz, rice field rats respond to the arrival of the ultrasonic sound source and are disturbed but their behavior is still said to be not so disturbed. they still tolerate the sound that comes out.

c) Summary at 40 kHz

TABLE V. EXPERIMENT RESULT SUMMARY 40 KHZ

Repetition	Frequency (kHz)	Behavior
1	40	away from the sound source
2	40	away from the sound source
3	40	away from the sound source

In Table 5. for the 40 kHz ultrasonic frequency test, the rice field rat pest began to be disturbed but from its behavior it was still said to be not so disturbed, when the frequency was greater than 40 kHz i.e. 40.5 kHz the behavior of the rat began to be very disturbed, the rat was confused looking for a gap to get out. from his cage.

d) Summary at 45 kHz and higher

TABLE VI. EXPERIMENT RESULT SUMMARY 45 KHZ

Repetition	Frequency (kHz)	Behavior
1	45	away from the sound source
2	45	away from the sound source
3	45	away from the sound source

In Table 6. for testing ultrasonic frequencies above the 45 kHz to 48 kHz waves. in the frequency range of 45 kHz to 48 kHz the rats began to be very disturbed; the rats were confused looking for a gap to get out of their cage. It's a good thing that this study succeeded in getting the rats away from the source of the sound.

IV. CONCLUSION

In the experiment of rat behavior on ultrasonic waves concluded that the average rat responds to ultrasonic waves. The response shown is that the rat avoids the sound source. The affective ultrasonic sound waves in the use of this tool are in the range of 40 kHz to 48 kHz. Testing of equipment with frequencies above 50 kHz has not been carried out because of the capabilities of the equipment at the 50 kHz limit. So, with this matter the test limit is carried out below 50 kHz with consideration of the level of resistance of the PIEZO CT 4000 tool as ultrasonic sound output.

The device's power supply requires a voltage of 12V 10A using a lithium type battery [24]. The device has been tested to be able to meet the electrical power of the device overnight or without sunlight for more than 12 hours. The light sensor on the device will activate day and night modes according to the intensity of the light entering the sensor. Measurement of sound range in open area with Infrasound Detector, can be detected at a distance of 75 meters.

From various tests and experiments conducted, research shows that, ultrasonic wave testing on white rats shows effective results in the frequency range of 40.5 up to 48 kHz, with the average reaction away from the wave source (speaker) and moving aggressively. This shows that the white rat's sense of hearing will be disturbed in the ultrasonic wave capacitor range of 40.5 up to 48 kHz.

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