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DEVELOPMENT PERFORMANCE AND EVALUATION OF ULTRASONIC PEST AND INSECT REPELLING SYSTEM

Khapare Nilima Kailas
Asst.Professor of Physics Dept.
K. K. Wagh College of Agril. Engg. And Technology.
Nashik, Maharashtra

Bodke Pranali S.
Asst.Professor of Electrical Dept.
K. K. Wagh College of Agril. Engg. And Technology.
Nashik, Maharashtra

Khapare Kailas Namdev
M.Sc (Chemistry) Lab Incharge,
Maharashtra Rajya Draksh Bagaitdar Sangh, Pune,
Nashik Division

Abstract:-The common method of pest control is the use of the pesticides. Pesticides are substances or a mixture of substances used for destroying, preventing, repelling or mitigating pests. To solve the above problem ecofriendly device can be used for repelling pest and insects. The aim of paper is to repel the insects and pests from the area. This paper explained the use of an electronic device which can utilize sonic or ultrasonic sound waves to repel pest. Rodents have their audible frequency ranges from 1 Hz to 100 KHz.High frequency sound produced causes intense auditory stress to the rodents and force them to leave the area. Effectiveness of ultrasonic devices increase by continuously varying frequency of oscillation, so pest will not habitual.

Key Words:- pest,insects,ultrasonic sound, oscillating unit, amplifier unit, power unit, frequency generator

1.1 Introduction of Ultrasonic Pest Repelling System (UPRS)

An UPRS consist of electronic circuit which emits ultrasonic frequency (above 20,000 Hz), these frequencies affect the auditory senses of pests such as rodents, avian and nocturnal insects by making them uncomfortable in their abode.

Rodents have their audible frequency ranges from 1 Hz to about 100 KHz.High frequency sound produced causes intense auditory stress to the rodents & force them to leave the area. Effectiveness of ultrasonic devices increased by continuously varying frequency of oscillation, so pest will not habitual. The objective of this study is to develop an electronic device for that generates multiple frequencies of oscillation and at the same time covers a broad frequency range of pests**.**

Various methods for repelling or mitigating the pests and insects are:

1.1.1 Chemical method:

The use of pesticides (chemicals) is the most common method used. Pesticides are substances or a mixture of substances used for destroying, preventing, repelling or mitigating pests. Pesticides are commonly used in and around homes because they are easy to apply, fast-acting, and effective against a wide variety of pests. Chemical method of pest control has been found to be very effective but quite expensive to maintain. Also, these chemicals are highly poisonous and harsh both to human beings and pest. Air pollution is most important risk factor arising due to the use of chemical method. Human risk factors such as respiratory diseases, particularly for bronchial asthma and chronic obstructive pulmonary disease (COPD) etc. are taking place. Moreover, it adversely affects the environment, it brings about the genetic mutation of the internal make up of these pests that they produce offspring that are immune to these chemicals that were used on their predecessor. This, coupled with society's growing concern about environmental risks, makes alternative methods of pest control increasingly attractive.

1.1.2 Bio Pesticides:

It is an ecofriendly and alternative means to chemical pesticides, which encompasses a broad range of microbial pesticides, biochemical derived from micro-organisms and other natural sources, and processes involving the genetic incorporation of DNA into agricultural commodities that confer protection against pest damage. The potential benefits to agriculture and public health programs through the use of bio pesticides are considerable. The interest in bio pesticides is based on the disadvantages associated with chemical pesticides. The total world production of bio pesticides is over 3,000 tons/year, which is increasing at a rapid rate. The market share of bio pesticides is only 2.5% of the total pesticide market.

1.1.3 Mechanical method:

The mechanical method of controlling pest involves generating sounds mechanically to scare pests away. It also involves setting of traps, the use of guns and other mechanical means to kill pests. Any pest can be controlled by sound. Fireworks, acetylene exploders, balls horns and other noise makers have been utilized in bird control. Each has some applications but there is always one problem or the other which limits the situation to which it is applicable. Some specialized setup is required making better mechanical method of pest and insect control.

1.1.4 Integrated Pest Management:

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. It is an Ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with

the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

1.1.5 Sonic/ Ultrasonic Devices:

An electronic device can utilize sonic or ultrasonic sound waves, ultraviolet or UV rays, visual scare characteristics or other means to discourage, scare or repel pests. The most popular of these are the ultrasonic pest repelling systems. The electronic device emits high frequency sound through the tweeters which causes auditory stresses to pests.

1.2 Importance of the Study

Insects and pests exist in the natural environment. They are very detrimental to human beings when they cause damage to the crops and stored valuables. Each method has some or the other drawback. The main focus was given on the Ultrasonic pest repelling devices (UPRS).

However, research has confirmed that pests, insects and rodents get used to this high frequency sound, and shows no repellence effect. Therefore, in order to improve the efficiency of the UPRS there was a need to generate multiple frequencies of oscillations. The UPRS is an eco-friendly system which does not affect the biological parts of the pests and insects. It just repels the pests away from undesired area.

Indeed, this project is to create a suitable system to drive pest and insects away from field and from storage structures. This Non-invasive method provides ultrasonic frequency output through tweeters and promotes easy set up and installation of the device. The device has also the potential to drive rodents away.

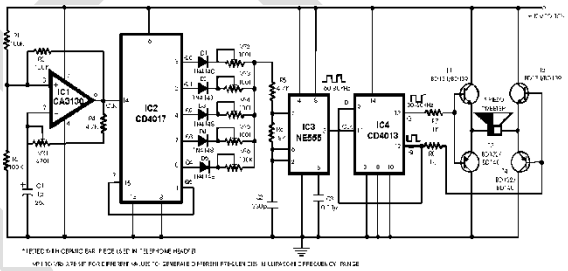
1.3 Problems Statement:

Various pests' and insects cause harmful effect to the crops, they can carry some diseases with them which in turn affects the total production. They also affect the quality of the agricultural commodities. Small birds eat the fruits and crop grains and also scattering grains on ground which reduces the overall production. Some of the insects also hampers the growth of plants, wilting of leaves etc. insects and pests also affect the sanitatory conditions in storage structures.

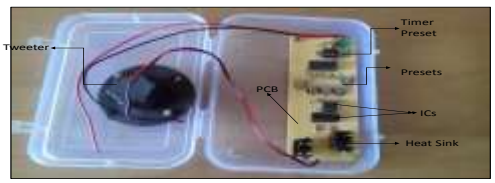
Rodents in storage structures cause spilling of grains, and are very detrimental for causing huge storage losses. Because of this, the physical properties of grains stored are greatly affected. Rodents like rats and mice contaminate the stored commodities by their urine and feces. They gnaw plastic bags, light metal bins and cause grain loss as well as loss of property. Also, these rodents eat roots of many plants and thus make them weak.

Therefore a system that can be applied Non-invasively can be made to repel the pests & insects away from the desired area. The system produces Ultrasonic frequency by which they are repelled.

The Ultrasonic Bird and Pest repelling system is to be made by using electronic circuit comprising various components as shown in following circuit diagram:



Ultrasonic pest repelling circuit mounting:



1.4 The device comprises of the following units:

1. The power unit,
2. The pulse generator unit,
3. The oscillating unit and
4. The amplifier unit.
5. The output unit

1.4.1. The power unit

The battery is used in the power unit that supply power to different electric component used in circuit. Electric circuits usually require a DC power supply that can maintain fixed voltage while supplying enough current to drive a load. Batteries make good DC supplies, but their relatively small current capacities make them impractical for driving high-current frequently used circuits. A regulated 12 volts power supply is used to convert a 230VAC, 50Hz line voltage into a usable fixed DC voltage.

1.4.2. The pulse generator unit

It consist of IC 1 and IC 2 unit.In this, accurate pulses are produced. By using the module, frequency of emission of ultrasonic sound is continuously varied step by step automatically. Five stages of variation were used. For each clock pulse output from operating ICI CA3130 (which is wired here as a low frequency square wave oscillator), the logic 1 output of IC2 CD4017, which act as the counter, shifts from the output of D1 to the output of D5. Five presets are set for different values and connected to the input of the oscillating unit. By varing the presets we can get different variations in the frequency output. Variable resistance is also used for Varying the Pulse timings in the circuit.

1.4.3. The oscillating unit

The oscillator unit which consists of the CA3130 op-amp, a 470 Ω variable resistor, RV1, 3 100 kΩ fixed resistors and a 4.7 kΩ fixed resistor. The CA3130 Op Amp is wired as a low-frequency square wave oscillator. The clock pulse from this unit generates a frequency which is ≤ 150 Hz and is fed into the input of the CD 4017 decade counter, U2, for each clock pulse output of the CA3130 Op-amp.RV1 is used to change clock pulse rate.

1.4.4. The amplifier unit

The amplifying unit which consists of a CD4017 decade counter, signal diodes, D1 to D2, five 100 kΩ presets/variable resistors a 555 timer, a CD4013 dual D-type flip flop, two 1kΩ fixed resistor. The pulse output from the oscillator unit is fed into the clock input of the CD4017 decade counter. Five presets RV2 through RV6, one of each connected to Q0 to Q4 output pins of U2 through signal diodes, D1 to D5, are set at different values from 10 to 60 kΩ, to produce different frequency output at each shift of the decade counter. The diodes serve as a protection against reverse current. The outputs of the presets are connected to pin 7 of the 555 timer. The 555 timer is wired as anstable multivibrator operating at a frequency of above 60 kHz. Its output is not symmetrical. At this stage, the low frequency generated by the oscillator unit is amplified to a very high frequency.

1.4.5. The output unit

The output unit which consists of PNP and NPN transistor, labelled Q1 and Q3, Q2 and Q4, bipolar transistors and a piezo sounder/tweeter. The outputs of the CD4013 are connected to the transistors. The CD4013 is a stable dual flip-flop IC, which generates a symmetrical square wave whose frequency value is half the frequency value of the input from the stable multivibrator. The transistors do the function of final amplification in push-pull mode and drive the high frequency piezo tweeter/sounder.

As the input supply of 12 V is given through the Battery source or Single power supply the Amplified Ultrasonic frequency is produced in the Tweeters. The range of frequency depends on the Inverse square law.

1.5 Design Parameters

1.5.1 Time high:

$$\mathbf{T_H = 0.693\ C_A\ (R_A + R_B)}$$

Where T_H= Time High In seconds,

R_A= Input Resistance of the Oscillator

R_B = Resistance of the Diodes

C_A = constant (330 X 10^{-12})

1.5.2 Time Low:

$$T_L = 0.693\ C_A\ R_B$$

Where T_L= Time Low In seconds

1.5.3 Frequency Minimum:

Frequency is the reciprocal of Time Period. It is defined as the Number of Oscillations taking place per unit Time.

$$F_{Min} = \frac{1}{TMax}$$

Where T_{max}= Maximum Time Period in Seconds

1.5.4 Frequency Maximum:

$$F_{Max} = \frac{1}{TMin}$$

Where T_{Min}= Minimum Time Period in Seconds

1.5.5 Intensity of Sound Emitted: (Inverse Square Law)

$$I = \frac{P}{4\pi r2}$$

Where P = Power of the Circuit

I= Intensity of Sound

r= Effective Distance Covered by the Sound

1.6 Circuit Test:

1.6.1 Testing:

The circuit test includes checking of the circuit mountings on PCB, checking the logic of the circuit with the help of digital Multimeter. Various circuit components were Checked and Tested for Their rated Values. All ICs were tested for their respective functions.

1.6.2. Result:

Complete apparatus was set in the laboratory. Input supply of 12 V was verified on the digital multimeter, and the circuit was started. The output frequency is observed to be Oscillating from **30Hz to 40 KHz.**

1.6.3.1 Time High:

$T_H = 0.693C_A (R_A + R_B)$
$= 0.693X (330 X 10^{-12}) X (105.318X10^3 + 18 X 10^3)$
$= 28.2 X 10^{-6}$ Seconds

1.6.3.2 Time Low:
$T_L = 0.693C_A (R_B)$

$= 0.693X (330 X 10^{-12}) X 18X 10^3$
$= 4.12 X 10^{-6}$ Seconds

$T_{Max} = T_L + T_H$
$= 4.12 X 10^{-6} + 28.2 X 10^{-6}\ 10^6$
$= 32.32\ 10^{-6}$ Seconds

1.6.3.3 Minimum frequency:

$$F_{min} = \frac{1}{T_{max}}$$

$$= \frac{106}{32.32}$$
$= 30.94$ KHz

Similar calculations are made for frequency Maximum

$F_{Max} = 105.2$ KHz

1.7 Following points should be considered for testing UPRS:

The electronic circuit when powered will emit ultrasonic sound through the Transducers. The intensity of sound is measured by ultrasonic level detector. Following points should be considered for testing the ultrasonic bird and pest repelling system:

1.7.1. Signal attenuation due to Atmospheric effect:

In this part the distance covered by the ultrasonic sound is observed on Sunny, rainy and dull days. The atmospheric factors like humidity, air velocity, temperature etc. affect the distance covered by the sound. The sound travels longer distances in rainy seasons and, travels longer in mornings on the pretext of relatively lower temperatures in mornings. The waves travel for long distances in moist air as compared to dry air.

1.7.2. Effect of Gadget Elevation on the Signal Reach:

In this part the distance covered by ultrasonic sound is observed as per the elevation of the Gadget from the ground surface. As the elevation increases the area covered by the ultrasound increases.

1.7.3. Effect of power input:

In this part the distance covered by ultrasonic sound is observed as per the power input. The area covered by the ultrasound increases if the power input is increased. (As per the Inverse Square law). However here the input voltage is not exceeded beyond 15V.

1.7.4. Field Test:

Observations showed that the birds' activity would be greatest early in the morning and gradually decline as the day progresses. So perfect timing should be considered for evaluating the field tests.It is known that most of the bird activity takes place in early mornings, therefore for testing morning time should be selected.

1.7.5.Special Arrangements:

If the multiple systems are used for covering the larger area then the following two arrangements can be used effectively (as per the Quadblaster system for gardens):

1. **Spatial Infestations:**

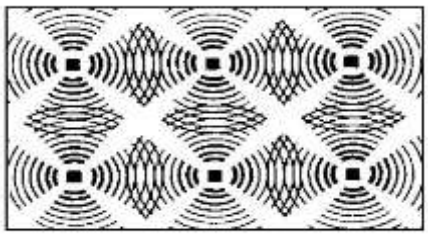


Figure: Illustrates a solution for a widespread bird problem. The atmosphere is totally saturated by the use of multiple units. The sound waves overlap and cover the whole area.

2. **Perimeter Defense**:

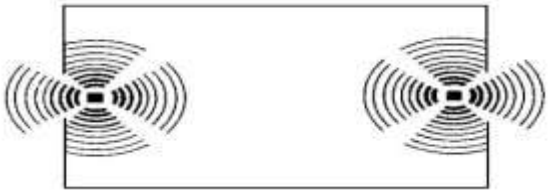


Figure: Demonstrates the placement of the units once the bird problem is under control. The *Perimeter Defence* discourages birds from returning.

1.8 Actual testing of the device:

The judgement of the performance of the ultrasonic pest and insect repelling system is bit tedious, as there is no such criteria to judge repellence. Pests and insects move on continuously so it becomes difficult to adore them. Apart from such indispensable consequences, the testing of the device was conducted on a trial and error basis.

1.8 .1 Testing of the device on Wheat pest: (Local Name- *'Sonde pest'*)

From figure we can see that, the pest moves away from the wheat grains. However the performance of the device is not judgemental. The frequency of operation showed variation from 90 Hz to 31 KHz.

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