SMART ULTRASONIC VARIABLE FREQUENCY PEST REPELLENT
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ABSTRACT
The paper represents detailed information about Ultrasonic Pest repellent. The device produces variable ultrasonic frequencies which are capable of repelling, disorienting, disrupting acoustic communications for pests and insects. With the use of the GSM module, the device can be controlled from anywhere in the world giving it worldwide access. In addition, with the use of Power Amplifier, Microcontroller (Arduino UNO), and Truncated cone there is an increase in range, efficiency, and area of effect of the device. Also, with the help of BLE technology and its mesh networking abilities the device can be used to cover large areas of agriculture with increasing the efficiency of the device. The main agenda behind the device is to reduce the use of insecticides and pesticides, which tend to cause soil pollution and also cause various environmental, physical, and health risks. Keeping this in mind, these chemical fertilizers also affect the food chain and every one belonging to the food chain. The uses of the device are not only limited to the Agriculture sector or prevent the side effects of chemical fertilizers but also can be used in the Wildlife sector to prevent interaction between Wild Animals like Snakes and Scorpions with Humans. Thus, preventing the animals from escaping the wildlife sanctuary and loss of life on both sides.

Keywords: Ultrasound, Variable Frequency, GSM Module, Arduino UNO, Truncated Cone, BLE, Pests.

I. INTRODUCTION
Insects and pests are of major concern to the Agriculture Industry. They not only cause the potential loss to the revenue due to crop damage but if they are left untreated, they can cause significant damage to machinery, equipment, and property as well. The major problems that concern Agriculture Industry are:
1. Crop Damage: Insects are the major threat to crop damage. They are responsible for major two kinds of damage. Firsts they cause direct damage to the plants by eating leaves, burrowing holes in stems, fruits, and /or roots. The second is the indirect one, where the insects do not harm the plants but transmits bacteria, viral, or fungal infection to the plants.
2. Damaged to Finished Goods: The Pest and insects also cause harm to the finished products. The SPIs (Stored Products Insects) are a big problem in these regards. These pests infest grains and commodities causing damage to raw food materials and infecting the finished goods. Making them unfit for human consumption and so resulting in loss of revenue and reputational damage.
3. Equipment and Machinery Damage: Rodents are the major problem. Rats and mice are known to cause huge damage to farm buildings and equipment. The incisor teeth are that these animals have continued to grow at a rate of 5 inches per year throughout their lifespan and need to be worn down by gnawing. As such both rats and mice will gnaw at anything posing a great threat to equipment and machinery. To overcome this problem, to increase productivity, and to increase the food production for increasing demand there was an increase in the use of pesticides and insecticides after World War 2. Studies show that plants need to fight 10000 species of pests and insects and these pesticides are doing their work. But some other studies show that only 1% of the pesticides sprayed are delivered to the intended target. Nearly 500 formulations of pesticides are being used which tend to cause great environmental damage, loss in soil fertility, degradation of the underground water table, reduction in quality of yield obtained, etc. Although it is estimated that less than 0.1% of the pesticides sprayed reach the target, the rest of it is there in the environment. Many pesticides persist in the ecosystem for a longer time; Organo Chlorine pesticides (OCP) insecticides are, for instance, detectable in surface water for 30 years after their use and had been banned. The senseless and widespread use of OCP’s between the 60s and 70s caused a striking decrease in the wildlife population all over the world. DDT, Dieldrin, and other toxic OCP’s affected the population of birds and other wild species. The pesticides enter the food chain and affect non-target organisms including mankind. Some alarming reports have been published which showed that nearly 3 million farmers suffer annually from pesticide poisoning, 25 million farmers from mild poisoning, resulting approximately into 180,000 fatalities among agriculture workers annually because of incorrect perceptions, lack of knowledge, regulations, and education among farmers.
On the other hand, when we researched snakes, we encountered the problem that a huge number of snakes are escaping the wildlife sanctuaries, these escaping snakes then interact with the human world which poses a great danger to the snakes. A huge number of snake fatalities are caused due to snakes coming on roads on highways.

Snakes are an important part of our ecology. A decrease in the number of snakes causes an imbalance in the food cycle which further causes an increase in the number of small animals and insects like rats, frog’s, rabbits, toads, etc. Rats are the main cause of deadly diseases like plague. To avoid the disastrous effect caused by the pesticides and to avoid snake & human interaction we looked forward to the ultrasonic insect repellent system. The historical shreds of evidence show that in ancient times and ancient china mechanically operated sensory repellent devices were used to ward off rodent infestation in agricultural crops and buildings. Many of these devices were powered by wind and water and they generated vibrations, movements, and sound. This use of sonic and ultrasonic stimuli to repel or control the pests is called an audio genic seizure response. With the help of this phenomenon and today’s technology, we build a device that repels pests and insects with the help of ultrasonic frequency, and with the help of mesh network and truncated cone created using BLE technology we increase the efficiency and area of effect. The following image is the survey of snakebite to people:
II. LITERATURE REVIEW

This research paper focuses on the design of a power amplifier for the ultrasonic transducer. The use of high ultrasonic transducer excitation voltage permits the improvement of the signal-to-noise ratio. Assuming that the transducer input impedance is higher than the amplifier output it is suggested to use the transformer as a voltage step-up and impedance matching the element. Also, the use of the high transformer step-up ratio allows us to use a low voltage power supply. The transformer appearance at the amplifier output allows designing the B class push-pull amplifier output. The high transformer step-up ratio allows the use of low power supply voltages. Thanks to this low voltage MOSFETs can be used, which are quite cheap. The moderate power supply usage efficiency also allows excitation by a high-power continuous waveform in the indicated frequency range.

The research paper of the University of Nebraska Lincoln gives a brief description of how insects affected the land and the problems caused by them. Insects attack crops on the farm and are the biggest headache of farmers. Farmers use pesticides to remove insects from the farm, such pesticides causes pollution in large amount which will affect all the animals, plants and people living around this area. Also, they suggested a way to get rid of insects using ultrasound that doesn't cause any type of pollution (like fertilizers used in the soil causes pollution like soil, air-water), so this is a better way to get rid of insects from the farm without using harmful pesticides. They experimented with rats using ultrasound. They took confined groups (two) of wild Norway rats for this experiment. Each group contains six rats (3 males, 3 females). These rats are placed in a room that has floor space with a concrete floor and brick walls lined with sheet metal to prevent rat climbing. Each room could then be entered by rats through ultrasound baffling ports and each room was baited with 32 paper packets each containing 14.5g of whole rolled oats at a density of 1/m2. Rat activity in each room was monitored with photocell sensors, infrared closed-circuit television. Measures were taken every 4-5 day interval over 4 weeks. They found that rats are stopping going to the room (in which food is stored) because in that room ultrasound is present all the time. This shows that rat's activities can be stopped by using ultrasound.

The first author gives a brief description that insects are divided into categories using a standard classification system. Each insect is identified by its unique genus and species just like plants. The class insect refers to organisms with three pairs of legs, external mouthpart, and three body regions of the head, thorax, and abdomen. The head is a hardened region consisting of eyes, antennae, and mouthpart. Antennae function as sensors to detect the odour, sound, taste, and feel of the surrounding. The mouthpart defines how an insect can feed therefore plays a role in insect what type of insect control mechanism will be more useful. Thorax contains the wings and legs attached to the middle of the body. Various types of legs and wings are present on the insects depending on their habitat. The abdomen is the lower bulky part of the insect body. It may be hidden behind the wings of the insect in some cases. The abdomen carries the eggs of the female insect. Insects feed on the crops in many different ways. Some insects feed by chewing the leaves of the crop while some feed...
internally by sucking the nutrients inside the plant. During this process, the insects cause great damage to the plant and even cause their death. For controlling the insects, it is, therefore, necessary to study the insect which affects the field. The feeding of insects varies from insect to insect hence a particular pesticide may for a specific insect only. Therefore, selecting proper resisting varieties will save time as well as the damage caused to the crops.

The main objective of this research work is to develop a prototype model of a variable frequency ultrasonic pest repeller. It leads to the design and development of an ultrasonic pest repeller where the frequency of emission of ultrasonic sound is continuously varied step-by-step automatically from the range of 25 kHz to 65 kHz. The pest repeller using high-frequency pulsed acoustic waves and electromagnetic waves to attack the nervous system of pests. This system directly attacks the pest’s brain and their nervous system, which causes discomfort and change in the behaviour of the pest. This results in the repulsion of the pest from the radiated area. This pest repeller that being design is different from other repellers because this is functioning with multifrequency modulated sounds.

The design part of the multi-frequency pest repeller is achieved by the generation of Pulse Width Modulation (PWM) wave frequency.

The frequency generated through Pulse Width Modulation (PWM) can be calculated by

\[ F = \frac{20 \text{Mhz}}{4 \times X \times Y} \]

X = Pulse
Y = Range Finder
20 Mhz = Crystal Oscillator

An ultrasonic pest repeller is the best way to repel the pest without killing it using pesticides. Extra effort has been made in developing the frequency varying range. In the future 'super ultrasonic transducer' can also be used.

### Table 1. Output Frequency Vs Pulse

<table>
<thead>
<tr>
<th>Output Frequency (kHz)</th>
<th>Pulse (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25kHz</td>
<td>200</td>
</tr>
<tr>
<td>30kHz</td>
<td>166</td>
</tr>
<tr>
<td>35kHz</td>
<td>143</td>
</tr>
<tr>
<td>40kHz</td>
<td>125</td>
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<tr>
<td>45kHz</td>
<td>111</td>
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<tr>
<td>50kHz</td>
<td>100</td>
</tr>
<tr>
<td>55kHz</td>
<td>91</td>
</tr>
<tr>
<td>60kHz</td>
<td>83</td>
</tr>
<tr>
<td>65kHz</td>
<td>77</td>
</tr>
</tbody>
</table>
Fig. 3. Output Frequency Graph of 25 and 30 kHz.

Fig. 4. Output Frequency Graph of 35 and 40 kHz.
Fig. 5. Output Frequency Graph of 45 and 50 kHz.

Fig. 6. Output Frequency Graph of 55 and 60 kHz.
The research is on an acoustic transformer. The role of the horn is to help acoustic waves to propagate from one region in a waveguide to a region with a larger cross-sectional area with a little reflection as possible. In this research, an acoustic projector was designed by use of the developed transformer and a piezoelectric unimorph-type actuator. The sound pressure measured at the mouth of the constructed acoustic projector was compared with the sound pressures evaluated at the same location by numerical calculation to investigate the differences between the numerical simulation model and the actual acoustic projector. Sound pressures generated by several acoustic radiators were calculated numerically and compared with the measured and calculated sound pressures of the developed acoustic projector to evaluate the effects of the use of the proposed acoustic transformer.

III. DESIGN AND DEVELOPMENT

The device can be divided into three parts, 1) Communication Unit, 2) Ultrasonic frequency Generation Unit, 3) Amplification unit.

1. Communication Unit: The unit mainly consists of two parts A) SIM 900A GSM module and B) HM-10 Bluetooth module.

The SIM 900A GSM module is used for the human-machine interface. The use of the GSM module increases the range of operation of the device and can be interfaced from anywhere in the world. SIM 900A GSM module is basically a dual-band GSM/GPRS engine that works on frequencies EGSM 900MHz and DCS 1800MHz. It features GPRS multi-slot class 10 / class 8 and supports the GPRS coding schemes CS-1, CS-2, CS-3, and CS-4. It is designed using power-saving techniques. The basic block diagram of the module is given below,

![Block Diagram of SIM 900A GSM Module.](image)

The other unit that is used is the HM-10 Bluetooth module. This module is used to create a mesh network so that many devices can be connected to one master device. The Bluetooth module is version V4.0 BLE. It works on the 2.4 GHz ISM band, with operating voltage +3.3VDC 50mA. It has a working temperature of -5 ~ +65 Centigrade, hence can be used in fields and harsh conditions. The module has a range of 100 m in open space. The modules are configured as MASTER and SLAVE devices. With the use of the ring-star networking topology method, many devices can be connected to one and the power consumption of the network is low. The proposed block diagram would be like this
Fig. 8. Working of HM-10 Bluetooth module.

2) Ultrasonic frequency Generation Unit: The controlling unit is mainly Arduino UNO. It is a microcontroller board based on the ATMEGA 328p microcontroller. Due to its easily programmable feature and easy-to-use feature, it was the primary choice as a developmental board. The ATMEGA 328p is an 8-bit AVR microcontroller with 32KB In-system programmable flash. With the use of advanced RISC architecture and fully static operation and low energy consumption, it was a good option. The 14 Digital I/O pins are used to interface various modules with the Arduino. The ultrasonic frequency is generated using Arduino Uno along with a crystal oscillator. The Arduino generates a square wave which is then given to the input of the Power Amplifier.

Fig. 9. Arduino UNO Board.

3) Amplification Unit: The amplification unit consists of two parts A) Power Amplifier and B) Truncated Cone. The power amplifier is used to increase the magnitude of the power of the signal given to it. The power amplifier used is a TPA3118 stereo amplifier with AM avoidance. It employs multiple switching frequency options to avoid AM interference; this is achieved together with an option of either master or slave-making it possible to synchronize to various devices. It is also fully protected against faults with short circuit and thermal protection. In the device, a single stereo 60Watt digital amplifier is used.

Fig. 10. Amplification Unit Board.
The other part of the amplification unit is a truncated cone. The truncated cone is a horn design. In the past when power amplifiers were not present truncated cones were used to amplify sound. The role of the horn is to help acoustic waves propagate through a medium from one region in a waveguide to a region with the larger cross-sectional area with the least reflection possible. In general, an acoustic radiation device with a horn is known to have an efficiency of up to 20% than 0.1 to 2% without a horn. In this device, we will be using a multicellular radial horn to amplify the sound.

**IV. METHODOLOGY**

The device uses a SIM 900A GSM module. the GSM module is set to read SMS with the help of AT Commands. When the GSM module receives the SMS from the user specifying the mode in which the device should operate, this message is then passed to the Arduino UNO module. The Arduino UNO module reads this message and produces the ultrasonic frequency defined in that mode. The same message is also transmitted to other devices using the Bluetooth module. The output of the Arduino Uno is input to the power amplifier. The power amplifier amplifies the input from the UNO module and avoiding AM interference. The output is then given to the piezoelectric speaker. The piezo-electric speaker has a multicellular radial horn at the end of it which tends to amplify the sound and give it a direction. Hence increasing the efficiency of the device. Other devices connected to the master device are placed such that the area of effect of the devices slightly overlaps each other and covers the field. The relative position of the master devices is based on the number of devices required to cover the field and the topography of the field. The following diagram shows a circuit diagram of the master device.

![Fig. 11. Cone Structure is used as an accessory to amplify the range.](image)

![Fig. 12. Connections on Breadboard.](image)
V. OBSERVATION

To test the working of the device, the targeted animal was the snake. For the testing on snakes, the area should be closed so that the snakes won’t escape the area and cause any harm. Thus, a nearby zoo (Katraj zoo, Pune) was selected for the experiment. Permission was taken with the zoo in charge for this experiment. The pit was circular having a diameter of 10 meters and a depth of 3 meters. 4 snakes were present in the pit. The main device was placed at an edge of the left side of the pit and the other slave device was placed few meters away from the main device. The expected outcome was the no snakes should enter the 5 meters arc from the device. The device was placed in on mode for 1 hour and the observation was taken.

VI. RESULT AND DISCUSSION

As it was earlier calculated that that snakes should not come inside 5 meters arc of the device in order to consider it working. During, the first hour period the frequency was not changed, and no snake entered the 5 meters arc of the device. After one hour the frequency of the device was changed to see if the change of the frequency makes the snakes enter the arc comfortably. Thus, the frequency of a grasshopper was set. After few minutes two snakes comfortably entered the arc. As soon as the snakes entered the region the frequency was again set to the frequency of the snakes and it was noticed that the snake again went away from the device arc. Thus, the conclusion was made that the device is completely working properly and the frequencies entered are correct and effective.

FUTURE SCOPE

1. The current device is powered by a battery of 12V. Thus the charging of the battery is required from time to time. To avoid this, the device can also be powered by using solar cells.
2. As the device contains electronic components it needs to be protected from water. The material to be used for protection must not cause much interference to the sound waves.
3. Use of a piezoelectric transducer can be done to power the device. A piezoelectric transducer is a device that uses the piezoelectric effect to measure changes in acceleration, pressure, strain, temperature, or force by converting this energy into an electrical charge.

The above-mentioned methods are cost-effective.

VII. CONCLUSION

The implementation of the Bluetooth module gives the device capability to repel insects from a wide range. Using this device is an effective way to stop the usage of chemical pesticides with hazardous to the environment.
The device is capable of repelling a variety of pests by using multiple frequencies. The device can be used to keep the snakes out of a particular area as well as to stop the snakes from escaping from a particular area. This is the first device that is made using ultrasonic waves to keep pests, snakes, and other deadly animals like scorpions away. The main device controls all the other devices connected to it using the Bluetooth module, any changes made on the main device automatically make changes on the slave devices as well. Also due to the GSM module the user need not have to go to each device to make changes. All the instructions will be given to the device via SMS.

Thus, this device is an effective way to stop the use of chemical pesticides as well as for the protection from animals like snakes and scorpions and also to avoid the snakes getting escaped from the zoos.

VIII. REFERENCE


