

Microcontroller-Driven Ultrasonic Mosquito Repellent System

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Abstract— Mosquito-borne diseases remain a significant threat to global health. This situation calls for safer and more sustainable ways to repel mosquitoes. Traditional control methods, like chemical sprays and topical repellents, can lead to environmental pollution, health risks, and the rise of resistant mosquito species. This paper discusses the design and implementation of a Microcontroller-Driven Ultrasonic Mosquito Repellent System as a more eco-friendly and cost-effective option. The system uses an Arduino UNO microcontroller to create high-frequency ultrasonic waves (20 to 40 kHz) via piezoelectric discs. This method effectively repels mosquitoes without harming humans or the environment. The device is powered by rechargeable Li-ion batteries and can charge with solar energy. It works efficiently in both indoor and outdoor spaces. Tests showed that the system can successfully repel mosquitoes within a 3-meter range while keeping power use low and not interfering with other electronic devices. These results suggest that microcontroller-based ultrasonic technology could lead to a sustainable, non-toxic solution for mosquito control that suits various environments.

Index Terms— microcontroller, ultrasonic repellent, eco-friendly design, mosquito control, sustainable technology.

I. INTRODUCTION

Mosquitoes are a big nuisance and also causes many health problems with their capability to spread diseases such as Zika virus, dengue fever, malaria, and West Nile virus [8]. These diseases effect millions of people globally, leading to severe health consequences and economic burdens. According to the US Centers for Disease Control and Prevention, at least 619,000 people died from malaria in 2021 in the world [10].

An extensive literature survey revealed that, out of a total of 3,578 mosquito species, only about 2.5%, i.e., 88 species act as vectors for 78 different types of diseases that affect humans worldwide [9]. Besides, 243 additional mosquito species (approximately 6.8% of the total) have been recognized as probable vectors of these diseases. According to the World Health Organization (WHO), nearly 700 million people contract a mosquito-borne disease every year and hence vector-borne diseases account for more than 17% of total transmittable diseases worldwide, causing over 700,000 deaths annually [5]. These concerning statistics highlight the urgent need for sustainable and effective mosquito control strategies.

These strategies should reduce health risks without harming the environment or increasing insecticide use. Conventional methods for the control of mosquitoes, such as chemical repellents and insecticides, often have limitations including health risks, environmental impact, and decreasing effectiveness due to mosquito resistance. Therefore, there is an urgent need for innovative and effective solutions to mitigate the threat posed by mosquitoes.

Our project aims to design a mosquito repellent system that leverages modern technology to provide a safe, efficient, and environmentally friendly solution to keep mosquitoes at bay. The proposed system will utilize a combination of ultrasonic sound waves (natural repellents), and smart technology to create an effective barrier against mosquitoes [6,7]. By combining all these aspects, we are hoping to provide a convenient and environmentally friendly solution that can be used in all kinds of places, ranging from private houses to outdoor areas.

II. LITERATURE SURVEY

Mosquito nets are a good and predominant solution for safeguarding people from the bites of mosquitoes, especially in areas where mosquito-borne illnesses are more common. While mosquito nets are effective, they have some limitations: Mosquito nets are primarily used during sleep, offering no protection during waking hours when individuals are outdoors or not under the net. Nets can develop holes or tears over time, reducing their effectiveness. Regular maintenance and replacement are necessary to ensure continued protection. A brief overview of existing studies on mosquito control methods is presented below.

"Mosquito-repellent controlled-release formulations for fighting infectious diseases" (2021) [1]. This study reviews various controlled-release mosquito repellent formulations using advanced encapsulation techniques. These formulations include polymeric microcapsules, nano emulsions, solid lipid nanoparticles, and cyclodextrins, which release active ingredients like DEET or citronella over time. The encapsulation process ensures the slow, controlled diffusion of repellents, enhancing their effectiveness and duration of protection. But this method requires advanced technology for formulation and production and some nano-carriers might cause skin sensitivity over prolonged use.

"A Critical Review of Current Laboratory Methods to Evaluate Mosquito Repellents" (Luker, 2024) [2]. This article reviews laboratory methods developed over the past two decades to evaluate mosquito repellents. The author focuses on methods for assessing the effectiveness of spatial and contact repellents. Spatial repellents act within a treated area to repel mosquitoes from approaching, while contact repellents require physical contact. The review also addresses the challenges of testing repellents in a controlled environment, emphasizing the need for standardized testing methods to accurately predict real-world repellent performance. But this method has limited real-world applicability and requires additional methods to confirm efficacy.

"Effectiveness of Plant-based Repellents Against Different Anopheles Species: A Systematic Review" [3]. This systematic review examines the efficiency of plant based mosquito repellents, particularly targeting species in the *Anopheles* genus, known for spreading malaria. Given the growing interest in eco-friendly alternatives to synthetic repellents like DEET, the study aggregates findings on the effectiveness of various plant-based oils (e.g., citronella, lavender, and pine) in repelling mosquitoes. These repellents offer benefits of lower toxicity and environmental impact but can vary significantly in efficacy and protection duration. But these repellents showed inconsistent efficacy across mosquito species and limited standardization, as plant based repellents may vary in concentration and composition across products.

"The Fabrication and Assessment of Mosquito Repellent Cream for Outdoor Protection" [4]. This article details the formulation of an essential oil based and natural mosquito repellent cream as an alternative to synthetic products like DEET, which are associated with environmental and health concerns. The cream combines citronella, clove, and lemongrass oils to provide effective mosquito protection while being safe for both human use and the environment. The study includes extensive testing to confirm the cream's repellent efficacy, safety, and compatibility for outdoor use. But these creams have potential for allergenic reactions in sensitive individuals and shorter protection time compared to some synthetic repellents, which may limit its use in high-risk areas.

Also, all the existing Ultrasonic mosquito repellers available in market are either plug in type or need AC power supply. They can be used only indoor and cannot work when there is power outage. Also, all these repellers need minimum 3-4 weeks to be effective in repelling mosquitoes completely. Some of them cause interference to other electronic appliances in range. Some of them are lantern type which may be a disturbance during sleeping hours.

To overcome the above-mentioned limitations, we would like to design a low cost, portable mosquito repeller that can be used both indoor and outdoor by using battery operated power supply and can be effective within few minutes of starting the device, which does not cause any interference with other appliances in range and any skin or other irritations [11,12].

III. PROPOSED SYSTEM

Proposed method focuses on developing an Arduino-based mosquito-repellent system. It utilizes the Arduino UNO microcontroller to generate ultrasonic sound waves through piezoelectric discs to repel mosquitoes. The system is powered by a set of Li-ion rechargeable batteries, which can also be charged using solar energy. An LCD screen displays system data like the ultrasonic signal's frequency value. The device is designed to operate within a 3-meter radius, emitting mechanical ultrasound signals to deter mosquitoes from the surrounding area. Testing was also done to determine its capacity to keep mosquitoes at bay in this range, and the system was compared with conventional methods of mosquito control in terms of cost and the environmental impact.

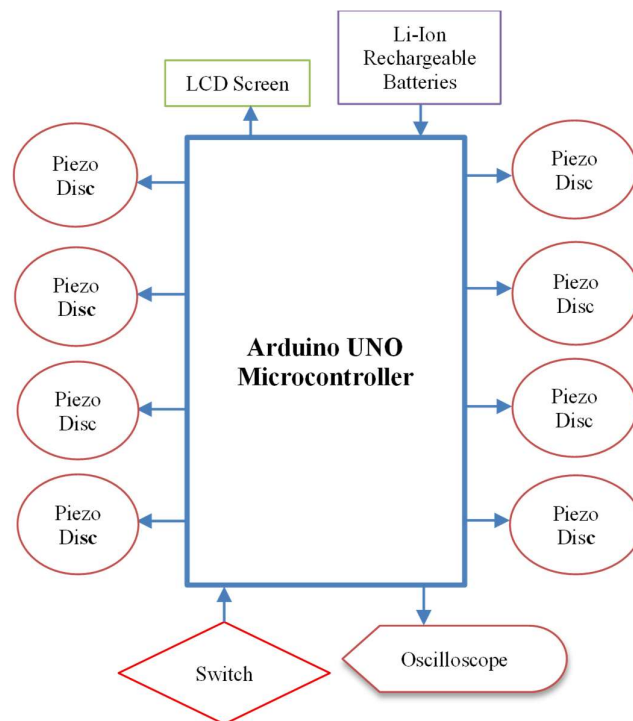


Figure 1. Proposed mosquito-repellent system Block diagram

Fig. 1 illustrates the block diagram of the designed mosquito-repellent system. The system employs Arduino UNO along with piezoelectric disks, a front-line solution to address this issue of mosquito populations. This work uses the Arduino microcontroller and an array of eight piezoelectric discs to produce ultrasonic sound waves, i.e. sound waves with a frequency greater than 20 kHz to drive off harmful mosquitoes without the application of any harmful chemicals or pesticides. Thus, the system put forward is eco-friendly.

This project demonstrates the capability of applying technology to solve practical problems and emphasizes the necessity of utilizing environmentally friendly solutions for mosquito eradication. Fig. 2 shows the process flow chart of the proposed system. The process flow is described below.

- Start – The process begins.
- Power ON – The system is powered using a switch and battery.
- Display Welcome Message – Shows a welcome message on the LCD screen.
- Check Switch – If the switch is OFF, go back and turn it ON; if ON, continue.
- Turn on Piezoelectric Discs – Activates the piezoelectric discs through Arduino UNO.
- Emit Ultrasonic Sound – The discs produce ultrasonic sound waves.
- Display Frequency – Shows ultrasonic sound waves frequency value in the oscilloscope.

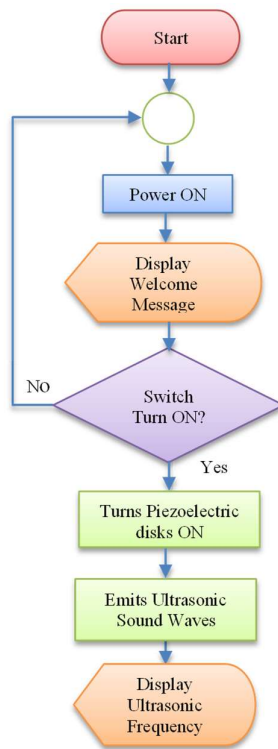


Figure 2. Flow chart of the proposed mosquito-repellent system process

A. Features of the Proposed system

The uniqueness of the proposed solution is that it is a portable, environmentally friendly, low-cost mosquito repelling system that produces ultrasonic frequencies. In contrast to conventional mosquito repellents, which usually use chemical compounds that are a threat to human health and the environment, this device features:

- **Ultrasonic Sound Waves:** While ultrasonic repellents are not entirely new, their integration with Arduino technology and optimization for mosquito deterrence make this approach innovative. The device releases certain ultrasonic frequencies designed to keep mosquitoes at bay without disturbing humans or other animals.
- **Low-Cost and Portable Design:** The system's components, including the Arduino Mega microcontroller and piezoelectric disks, are both affordable and accessible. This makes the device feasible for widespread adoption, particularly in low-resource settings where mosquito-borne diseases are prevalent.
- This system can be used both indoor and outdoor by using battery operated power supply and can be effective within few minutes of starting the device, which does not cause any interference with other appliances in range.

This innovative combination of ultrasonic sound technology, cost-effective materials, and user-friendly features positions the system as a novel solution in the domain of mosquito control.

B. Hardware Description

Arduino UNO

The Arduino UNO board features Microchip ATmega328 microcontroller and it is most commonly used as an open-source microcontroller. Arduino UNO serves as a versatile tool for creating enhanced computer-like systems capable of controlling, interacting with, and sensing various inputs and outputs beyond standard desktop computers. The board is equipped with both analog and digital input/output (I/O) pins which makes the interfacing with a wide range of expansion boards and external circuits possible. Originally, Arduino is an open-source electronics platform built around straightforward software and hardware. Arduino boards when connected, reads the inputs from sensors, buttons, or even online messages, and convert these inputs into actions such as activating motors, turning on LEDs, or communicating data online.



Figure 3. Arduino UNO board

An Arduino programming language built upon the processing development environment and derived from Arduino Software (IDE) and Wiring is used to program the Arduino. This IDE offers a user-friendly platform for writing and transferring code to the microcontroller on the Arduino board, enabling users to define specific instructions and behaviours for their projects. An Arduino board is shown in Fig. 3. In our project we have used an Arduino program to turn the piezo disks on and to communicate information with LCD display.

Technical specifications

- Microcontroller: ATmega328
- Recommended Input Voltage: 7-12V
- Operating Voltage: 5V
- DC Current for 3.3V Pin: 50 mA
- DC Current per I/O Pin: 40 Ma
- Digital I/O Pins: 14 (6 PWM output)

Piezo electric Disks

A piezoelectric disk as shown in Fig. 4, is a circular, typically ceramic, element that generates a voltage when subjected to mechanical stress or force, or conversely, deforms or vibrates when an electric field is applied. These disks are the heart of many piezoelectric devices used in sensors, actuators, and transducers. When voltage is given, an electric field forms across the piezoelectric material. The internal crystal structure realigns due to this field, causing the disc to expand or contract. If the voltage is alternating (AC), this expansion and contraction happen rapidly, making the disc vibrate. At certain frequencies, these vibrations produce ultrasonic sound waves, beyond the range of human hearing.



Figure 4. Piezoelectric disks

LCD (16X2) Display

The I2C LCD 16x2 display comprises of 2 rows and 16 columns, which makes it possible for the display of 32 characters at a time. Each character is represented in a 5x8 pixel matrix, which provides clear and readable output for various applications.



Figure 5. 16x2 LCD Display

This display module is equipped with an I2C interface, which typically includes an I2C controller module. This module converts the parallel data into serial format suitable for I2C communication. To connect the 16x2 LCD to an Arduino microcontroller, only four connections are needed: power (VCC), ground (GND), SDA (data line), and SCL (clock line). A 16x2LCD display is shown in Fig. 5 and its interfacing with Arduino UNO is shown in Fig. 6.

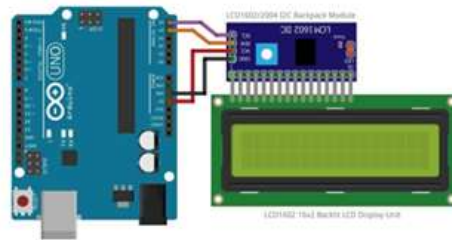


Figure 6. Interfacing of 16x2 LCD display with Arduino

Li-Ion Rechargeable Batteries

Li-Ion rechargeable batteries are used in this project to provide a stable and portable power supply to the entire system. They offer less weight design, more energy density, and extended lifespan compared to conventional batteries. These features make them ideal for powering electronic circuits like the microcontroller, piezoelectric discs, and display unit.

IV. RESULTS AND DISCUSSION

An ultrasonic mosquito repellent system is built with an Arduino UNO, piezoelectric discs, and supporting electronic components. The primary goal of this system is to generate high-frequency ultrasonic sound waves, typically in the range of 20 kHz to 40 kHz, which are known to repel mosquitoes without affecting humans. The prototype of the proposed method is shown in Fig. 7 and ultrasonic sound frequency measurement using an oscilloscope is shown in Fig. 8.

At the heart of the system are several piezoelectric discs wired in parallel. The piezo disks are employed as ultrasonic sound emitters. When a high-frequency signal is transmitted from the Arduino to the piezo disks, they oscillate at high speed, producing ultrasonic sound waves. The waves are unpleasant for mosquitoes and serve to repel them out of the vicinity.

The Arduino is programmed to output a PWM (Pulse Width Modulated) signal of a particular ultrasonic frequency. The signal is then fed into the piezo disks through the breadboard circuit, which is equipped with MOSFET to boost the signal and safeguard the Arduino from excessive current draw. The setup also features a voltage regulation and power management system, powered by two 18650 lithium-ion batteries and driven by a switch. In order to show the frequency which is being generated, a 16x2 LCD display is interfaced with the Arduino. This display indicates the present frequency (e.g., "Frequency: 31.44 kHz") which is being emitted.

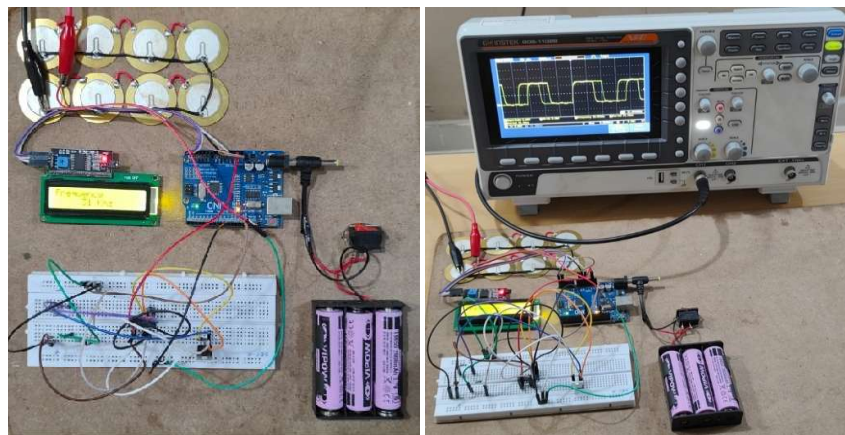


Figure 7. Prototype model of the proposed method Figure 8. Ultrasonic sound waves frequency measurement using an oscilloscope

V. CONCLUSIONS

The mosquito-repellent system developed from ultrasonic sound waves produced by piezoelectric disks and an Arduino UNO microcontroller is a sustainable and effective solution to the adverse effects of the conventional methods of controlling mosquitoes. The system is cost-effective, portable, and eco-friendly and can be used in many different settings. Although there are some drawbacks to the system, including decreased effectiveness in range, as a whole, the project has shown potential for applying technology towards solving significant problems of public health and the environment.

In future work, the mosquito-repellent system may be optimized further to increase the range and power of the ultrasonic sound waves to make the system more efficient. We are looking into the possibility of incorporating other means of mosquito control, e.g., trapping or sterilizing, into the system and broadening its application to other insect and pest control schemes, e.g., in agriculture or domestic pests. The efficiency of the system can be different depending on the species of mosquitoes found in the area, as some mosquitoes might be less responsive to ultrasonic sound waves. This can be overcome by the application of different methods complemented with the use of the ultrasonic repellent system.

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