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Production of Solar Power Mosquito Killer with Voice Activation

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Abstract

Mosquitoes are carriers of diseases like malaria, dengue fever, chikungunya, zika fever, and lymphatic filariasis, which can be deadly in Tropical Africa and certain subtropical regions. The World Health Organization recognizes mosquito bites as the primary cause of over a million deaths annually due to malaria. It is crucial to reduce or eliminate the mosquito population in Africa if possible. Presently, malaria vector control methods mainly involve using insecticide-treated bed nets, long-lasting insecticidal nets, or indoor residual spraying. However, many existing mosquitos control products have not proven to be effective in eradicating mosquitoes in these regions. In this study, a solar-powered mosquito killer with voice activation was developed using an Arduino board, an ultrasonic sensor, an electric fence driver, a direct current (DC) fan, and UV lights. The Ultraviolet (UV) lights are visible to some insects and enhance the trapping effect by combining heat and carbon dioxide. The device has voice activation to minimize human contact. It is an improvement over previous methods that utilized voice-activated equipment without harmful elements or irritating insecticides. The device mimics a mosquito's sensory receptors to attract and ultimately eliminate them. The equipment includes a 5V DC fan operating at 1800-3700 rev/min, a mist humidifier emitting mist at regular intervals (operating frequency of 0.8MHz - 1.75MHz), an electric fence producing over 1000 volts to render mosquitoes lifeless upon contact, and a voice module for device control. The device is powered by an external outlet power cord supplying 5-12 volts to activate the micro-controller.

Keywords: Mosquitoes, Solar Power, Tropical Africa, UV lights, Voice control

1.0 Introduction

Mosquitoes are responsible for causing over a million deaths annually, ranking as the sixth leading cause of death worldwide, according to the World Health Organization (WHO). Malaria, a mosquito-borne disease, is the primary contributor to these deaths, with women and children being the most affected. Nigeria, with its humid climate that favors mosquito breeding, is highly endemic for malaria. Population projections by Oyejide *et al.* (2022), as cited by the Food and Agriculture Organization (FAO), indicate that Nigeria's population is expected to grow rapidly and undergo significant transformation over the next three decades. The population size is projected to nearly double, reaching almost 400 million, with the urban population tripling from 94 million in 2015 to 280 million by 2050. The Federal Ministry of Health (2021) reports that approximately 97% of Nigerians are at risk of contracting malaria, making it an epidemic in the country.

Malaria is a widespread vector-borne disease, prevalent in tropical and subtropical regions worldwide. It is caused by infection with Plasmodium, a protozoan parasite transmitted by female Anopheles mosquitoes, known for their blood-feeding behavior (Ayan *et al., 2014*; Spitzen *et al.,* 2008). Mosquitoes serve as vectors for several diseases, including malaria, dengue fever, chikungunya, Zika fever, lymphatic filariasis (elephantiasis), and Japanese encephalitis (National Institute of Allergy and Infectious Disease). In Nigeria, the main mosquito vectors of malaria include *Gambiae sensu stricto, Anopheles arabiensis, Anopheles melas, and Anopheles funestus,* as identified by the Nigeria Center for Disease Control (2015).

Nigeria bears the highest malaria burden in Africa, with more than 100 million individuals at risk each year (Hock, 2016). Existing malaria vector control strategies predominantly rely on insecticide-treated bed nets (ITNs), long-lasting insecticidal nets (LLINs), zapper bats, and indoor residual spraying (IRS). However, the implementation of these programs in Nigeria has faced significant challenges due to insecticide resistance, limited resources, and difficulties in scaling up interventions (United States Agency for International Development, 2019). The ineffectiveness of current control measures has sparked interest in the development of innovative approaches to alleviate the malaria burden.

One promising avenue involves the use of genetically modified mosquitoes (GMMs). GMMs can be engineered to induce population suppression through genetic sterility or render them incapable of transmitting Plasmodium, the malaria-causing parasite (Wilson *et al.,* 2015). These strategies aim to reduce mosquito populations or prevent them from spreading the disease to humans. In this study, a solar-powered mosquito killer with voice activation was developed. The device efficiently eliminates mosquitoes upon contact, and its design offers simplicity and ease of replication, distinguishing it from previous designs. This innovation presents a potential advantage in combatting mosquito-borne diseases.

2.0 Materials and Methods

In this section, we present the materials and methods employed in the development of an automated mosquito killer with voice activation. The primary goal of this device is to eradicate mosquitoes, specifically those that transmit the malaria parasite. The device incorporates sensing capabilities and can be activated by a voice command as an input, allowing for effective control of the device hardware. This voice-activated feature aims to reduce human contact, thereby minimizing the risk of transmitting diseases such as COVID-19 and other related illnesses.

2.1 Materials

This research incorporates the utilization of voice recognition technology to control various components within the system. The system employs a voice recognition module as a transmitter, allowing users to control the device using voice commands. To ensure the successful operation of the system, several key components have been integrated:

1. Micro-controller (MCU) Atmega328p: This micro-controller facilitates the interfacing of various appliances, such as the electrocution fence, the direct current fan, and UV lights. The UV lights emit wavelengths of 10nm to 400nm, which are visible to certain insects and help enhance the effectiveness of heat and carbon dioxide in attracting and trapping mosquitoes.
2. Mist humidifier and heating module: These components create a warm and humid environment around the device, making it more attractive to disease vectors.
3. Voice recognition module: This module interfaces with the micro-controller and other enclosed components to send specific commands, enabling the device to perform designated functions based on voice instructions.
4. Electric fence: The device is equipped with an electric fence that delivers an electrocution voltage of over 2000 Volts to mosquitoes, leading to their instant mortality.

5. DC fan: A DC fan generates a suction effect, enhancing the device's ability to capture mosquitoes and other insects.

2.1.1 Arduino Uno Board

The micro-controller utilized in the project was the Arduino board, which acted as a central control system for various electronic devices. It encompassed multiple digital I/O pins (14 in total), a power jack, a set of analog input ports (6 in total), a 16 MHz ceramic resonator, a USB connection, an RST button, and an ICSP header. These components enabled seamless connectivity between the board and a computer for further operation. The board could be powered through different means, including an AC to DC adapter, a USB cable, or a battery. Its operating voltage was fixed at 5V, but the recommended input voltage ranged from 7V to 12V, with an acceptable input voltage range of 6V to 20V. Notable specifications comprised a 40 mA DC current capacity for each input/output pin, 32 KB of flash memory, and a clock speed of 16 MHz.

2.1.2 The Voice Recognition Module

This module has the capacity to store and recognize 15 voice instructions, which are divided into 3 groups of 5 instructions each. The voice instructions are recorded group by group, and one group is imported using a serial command before the module can recognize the 5 instructions within that group. It is important to note that this module is speaker independent, but it requires a high-quality microphone for optimal performance.

The operating parameters of the module are as follows:

i. Voltage: 4.5-5.5V
ii. Current: Less than 40mA
iii. Digital Interface: 5V TTL level UART interface
iv. Analog Interface: 3.5mm mono-channel microphone connector + microphone pin interface
v. Size: 30mm x 47.5mm

The module boasts a recognition accuracy of 90% under ideal environmental conditions. It supports configuration via serial port commands, and the configuration settings remain intact even after power is switched off. The interface of the module operates at 5V TTL level. The serial data format consists of 8 data bits, no parity, and 1 stop bit. The default baud rate is set at 9600, but it can be adjusted as needed. The command format can be programmed in binary, decimal, or ASCII format.

2.1.3 Micro-controller Atmega328P

This micro-controller unit is interfaced with the trained voice module to give input command through the microphone to control other hardware as output. Some features of the atmega328p micro-controller is given below:

i. 28 Pins
ii. 8-Bit AVR
iii. 1.8 to 5.5 V Operating Voltage
iv. 32KB, 0.5 KB Program Memory which are used by boot-loader
v. EEPROM 1024 Bytes
vi. ADC 10-Bit
vii. 8 Number of ADC Channels
viii. 6 PWM Pins
ix. 16MHz Clock speed
x. 3 Timer
xi. A power Reset
xii. A Power Up Timer
xiii. 23 I/O Pins and a single reset pin

2.1.4 Dc Fan

This fan converts electrical energy into electromagnetic energy through direct voltage and the principle of electromagnetic induction, and then to electromagnetic energy into magnetic energy and to kinetic energy which causes the fans rotation. They consume less power 70% less than AC fans and are very efficient. The fan has two terminals, a positive terminal and a negative terminal through which power is supplied to the fan. The dc fan has an operating voltage of 1.5-6V, a speed of 1800-3700 RPM and a torque of 10- 70g. cm.

2.1.5 Mist Humidifier Module

An ultrasonic humidifier is a straightforward device that operates within a frequency range of 0.8 MHz to 1.75 MHz. It consists of a water

reservoir and a vibrating element, such as a diaphragm. The diaphragm vibrates at an extremely high frequency, surpassing the range of human hearing, hence the name "ultrasonic" humidifiers. These vibrations propel tiny water droplets into the air. Once airborne, the droplets evaporate, increasing the humidity in the room. It's important to note that these humidifiers do not heat the water, which is why they are often referred to as "cool mist" humidifiers. However, it's worth mentioning that certain evaporative humidifiers also achieve evaporation without heating and are marketed as "cool mist" humidifiers.

2.1.6 Zapper Circuit

A bug zapper uses a high voltage alternating current to kill bugs. Most bugs and mosquitoes have a resistance of 0.70 – 0.75ohms, whereas the voltage for the Zapper is between 1800 to 3000 volts. There are three stages to a bug zapper circuit:

i. Charging circuit stage
ii. Transistor stage
iii. Voltage booster stage.

2.1.7 Vero or Strip Board

Vero board, also known as stripboard or matrix board, is a widely used prototyping board that provides utmost flexibility for the direct connection of discrete components. This board is manufactured using a copper clad laminate board or an Epoxy-based substrate, and it is available in single and double-sided formats. Vero boards come in various sizes and offer both imperial and metric pitch options. With its versatility, Vero board serves as an excellent foundation for circuit construction, allowing for seamless adaptation through the utilization of our diverse range of terminal pins and assemblies.

2.1.8 Jumper Wires

Jumper wires, equipped with connector pins at both ends, provide a solderless means of connecting two points together. These wires are commonly utilized alongside breadboards and prototyping tools, facilitating the convenient modification of circuits as required. Composed of copper, known for its excellent conductivity, jumper wires enable efficient signal transfer. They are available in various configurations, including male-to-male, female-to-male, and female-to-female options.

2.1.9 Lithium Battery

Lithium-ion batteries, also known as Li-ion batteries, have become an integral part of modern life, providing a convenient source of electrical power for numerous applications. These batteries consist of electrochemical cells that generate electricity and are widely used in devices ranging from mobile phones and laptops to hybrid and electric vehicles. In recent years, they have gained popularity in large-scale applications such as Uninterruptible Power Systems. When connected to an external electric load, lithium-ion batteries undergo a redox (reduction-oxidation) reaction that converts high-energy reactants into lower-energy products, delivering the free energy difference to the external circuit as electrical energy. While historically the term "battery" referred to devices composed of multiple cells, its usage has expanded to include single-cell devices, encompassing lithium-ion batteries within the generic battery definition. Figure 1 (Figures 1 to 9) provides an overview of the key materials utilized in this study.

The coupled and exploded views of the device are presented in Figure 2 and 3 below

2.2 Research Design

2.2.1 System flow chart

The system flow chart is a diagram that explains the flow of the system command and how it is applicable in the device. It contains the system flow motion. All information is processed using a data flow diagram. It represents a specific type of symbol that represents activity that is performed at each step and it justifies all of the steps that are followed in an orderly sequence.

Figure 1. Major control components used to implement the device

Table 1. Material selection and quantity

Item No	Part	Description	Quantity
1	Right side	19.0mm thick plywood	2
2	Left side	19.0mm thick plywood	2
3	Base cover	6.35mm thick plywood	1
4	DC Fan	5 volts	1
5	Plastic case	Thermoplastic	1
6	Inner net	1.2mm x 1.2mm Hole, 2mm thick steel	5
7	Insulator	Plastic	4
8	Humidifier	Electronic component	1
9	Battery	17 volts	1
10	Base button	635mm thick plywood	1
11	Heating module	Electronic component	1
12	Outer net	25mm x 2.5mm, hole 2mm	5

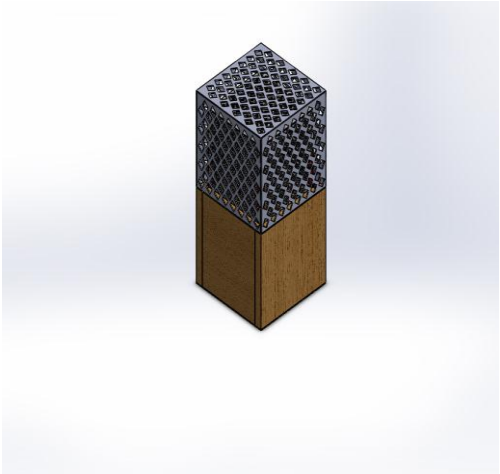

Figure 2. The 3D Isometric View of the Device

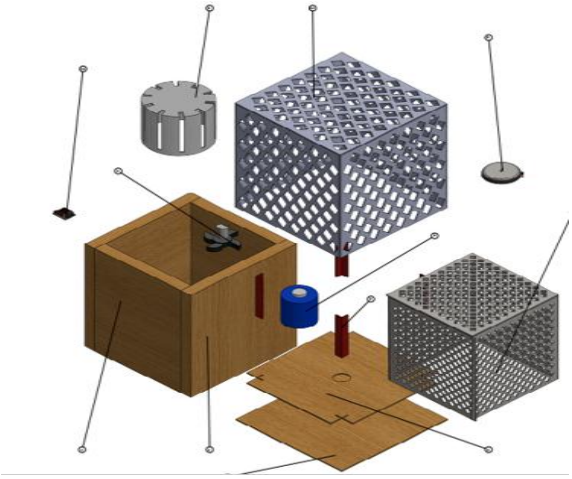

Figure 3. The Device 3D Exploded View Model.

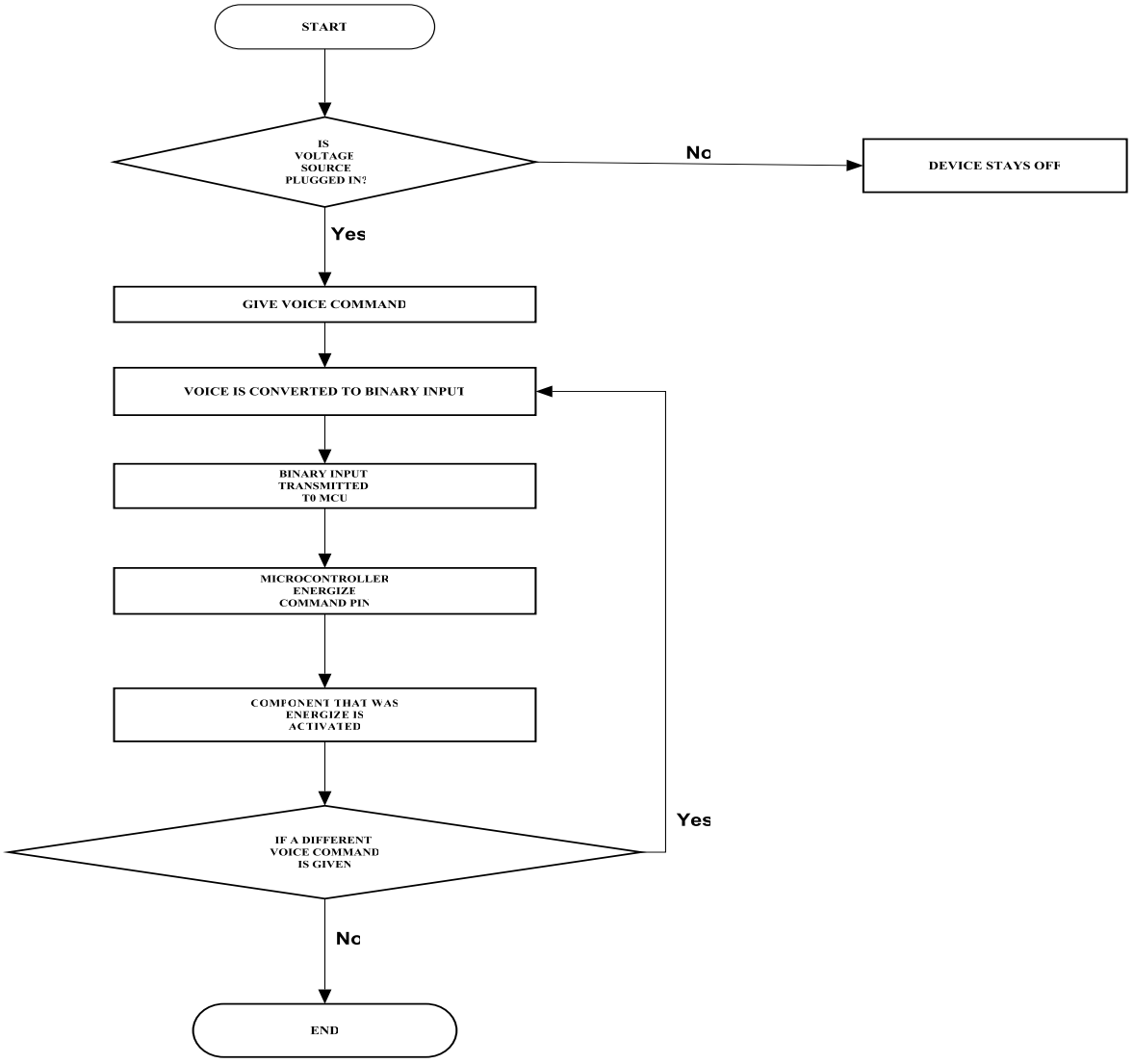

Figure 4: System Flow Chart

2.2.2 System Use Case Diagram

This explains the interaction between the input device and the system. The programming language will aid for effective working between the systems and the voice input. The command from the user and the interaction to execute a program is caption on the flow chart.

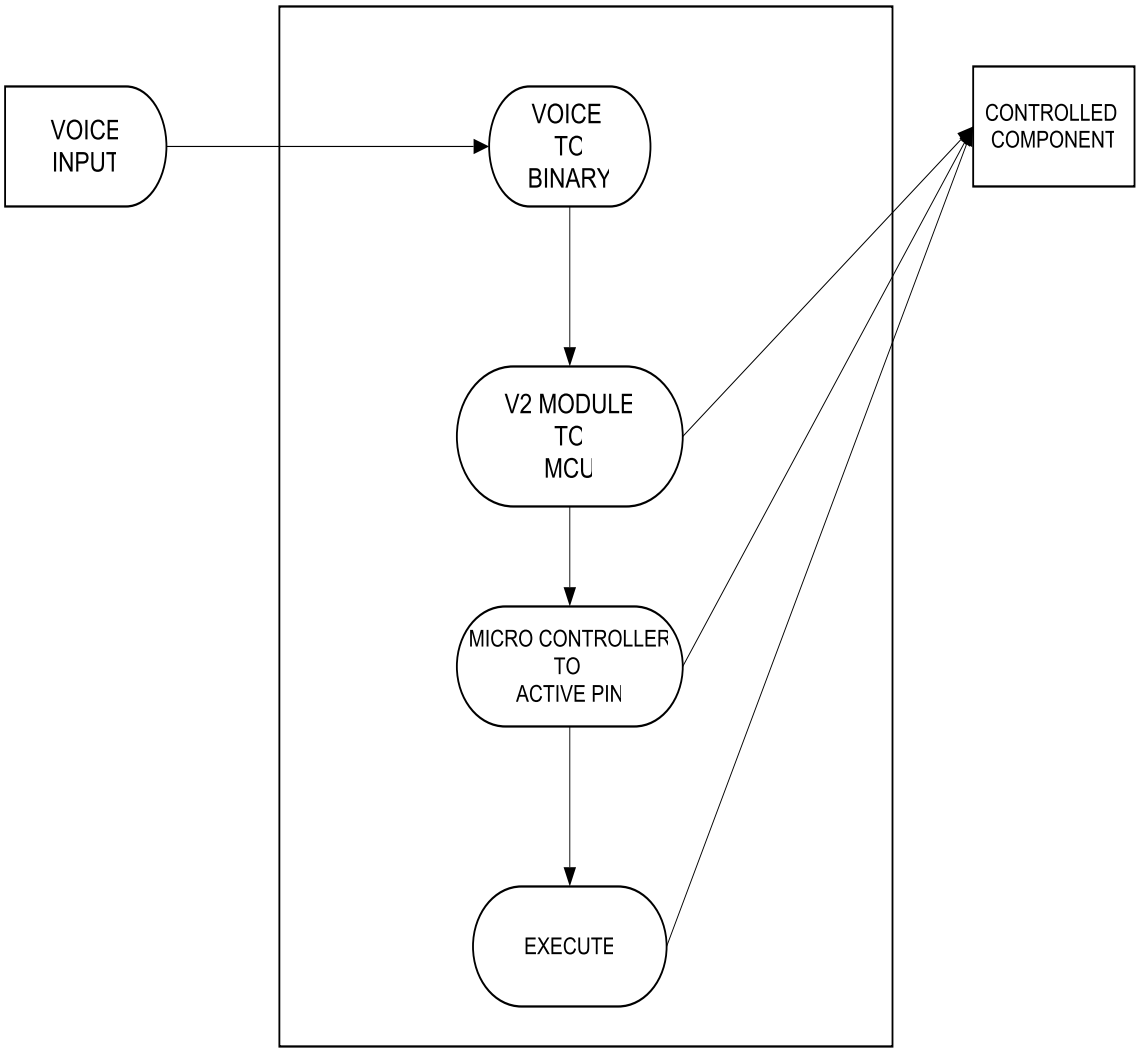

Figure 5: System Use Case Flow Chart

2.2.3 Design of the System Circuit

Schematic diagrams are used to visually represent the interconnections between various elements in a circuit, aiding engineers in comprehending the wiring, cables, and circuit boards. The integration of components within a circuit necessitates a clear understanding of their connectivity. In this study, the ports of the different components were carefully soldered onto the circuit board to establish secure and reliable connections. These illustrative diagrams serve as essential tools in depicting the circuit layout and facilitating a comprehensive understanding of the interconnections. The diagram of the circuit board is represented by:

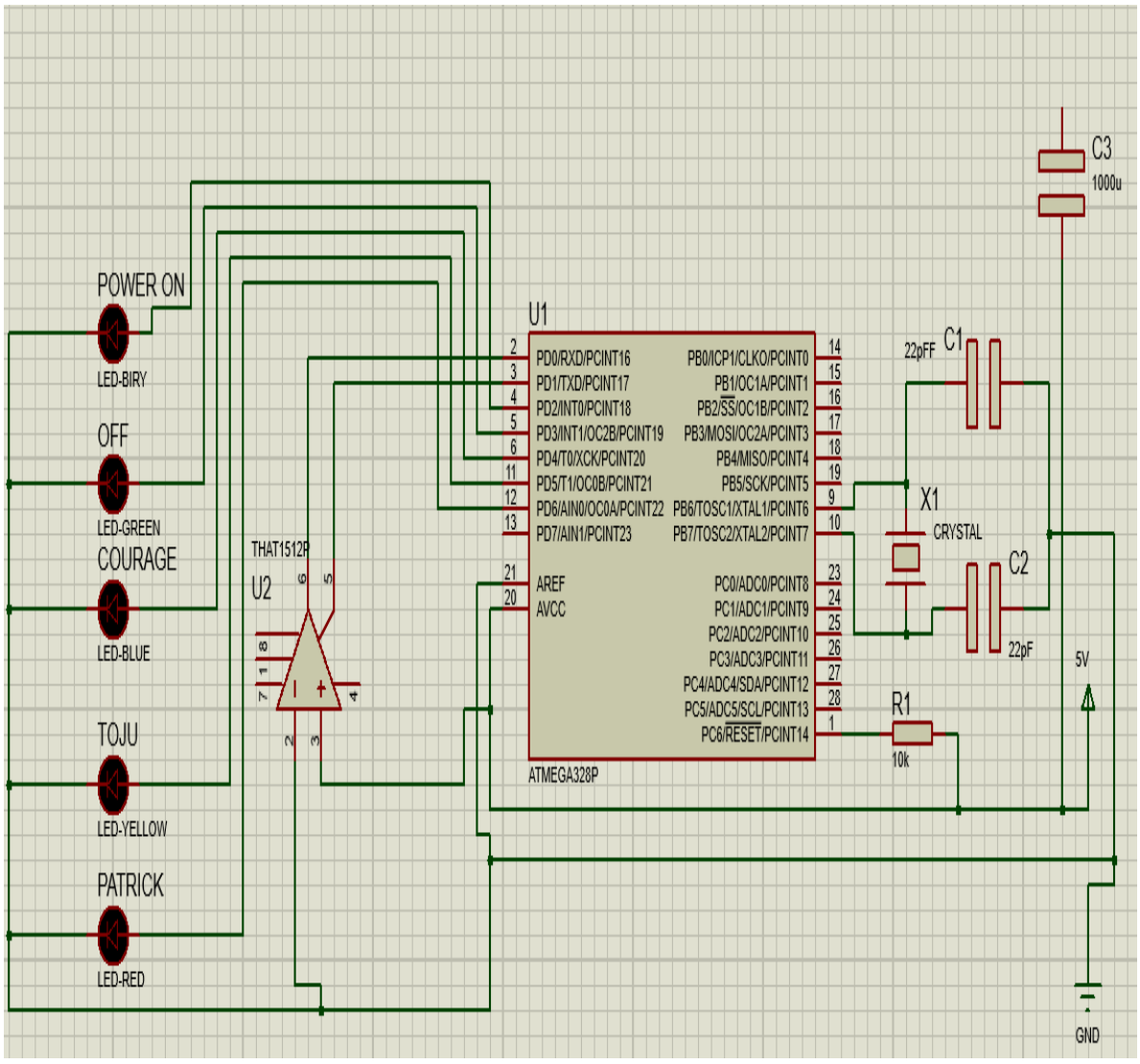

Figure 6: Schematic Diagram of Circuit

2.2.4 System Front End Design

The system front end design is the voice module. This module needs to be programmed (teach) to recognize some certain command. The module tutor was taught in the DOCKLIGHT V2.4 integrated development environment (IDE) platform.

To successfully program the voice using DOCKLIGHT V2.4, the following steps are required:

1. Configure the serial baud rate, with the default value being 9600.
2. Select the desired communication mode: Common Mode or Compact Mode.
3. Record five instructions from the desired group (first, second, or third group).
4. Import the specific group that needs to be used, with the limitation of recognizing only five instructions within one group at a time.

After completing the above settings, it becomes possible to speak and send voice instructions to the DOCKLIGHT V2.4. Successful speech identification is indicated by the serial port displaying the group number and command number in the following format.

2.2.5 Back End Design

The micro-controller unit was coded in C++ using the Arduino Integrated Development

Environment (IDE), which is a software application providing comprehensive development facilities to programmers. An IDE typically includes a source code editor, build automation tools, and a debugger. Therefore, the micro-controller unit's programming enables it to recognize and execute commands received from the V2 Voice Recognition Module during program execution.

3.0 Results and Discussion

Following the successful integration of the program and diverse hardware components comprising the device, a comprehensive performance evaluation was conducted under various environments and conditions. The primary objective was to identify design flaws and make necessary decisions to rectify them. Furthermore, an assessment was conducted on the utilized hardware, as depicted in Figure 5 to 8 and Table 2, to ascertain their efficacy and functionality.

3.1 Pretest

Throughout the circuitry design phase, rigorous testing was conducted to assess the response and functionality of the various components at specific intervals. The primary objective of this device is to attract and eliminate mosquitoes, thereby mitigating the transmission of vector-borne diseases. While the precise mosquito kill rate per square meter is yet to be confirmed, it is important to note that the device's outdoor performance currently remains below 50%. To ensure optimal effectiveness, it is recommended to utilize the device indoors, preferably in bedrooms. External factors, including wind, noise, and distance barriers, have been identified as potential influences on the device's performance, thus warranting indoor usage for improved outcomes.

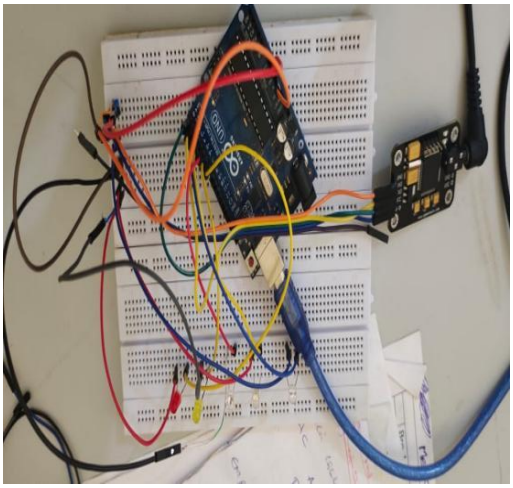

Figure 7. Connected Circuit on Bread Board Without Program Code

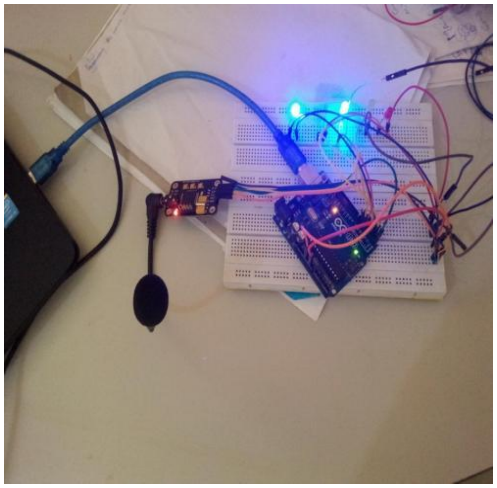

Figure 8. Circuit With Uploaded Codes

Table 2. List of Device Commands and Actions

S/N	VOICE COMMANDS	ACTIONS
1	TURN ON	Power ON device and the electric fence
2	OFF	Power OFF device
3	FAN	Power ON dc fan to create suction effect
4	HUMID	Power ON humidifier
5	ALL	Power ON all device component

3.2 Voice Recognition Module Test

The voice recognition module (V2) demonstrated high accuracy of over 80% for distances up to 18 feet in a quiet environment. The failure rate for five commands was observed to be one or less. However, the V2 model showed limitations in a public environment due to its inability to differentiate between synonym words, such as "fall," "hall," and "mall."

3.3 DC Fan for Suction Effect Test

The DC fan performed effectively and fulfilled its intended function. However, the suction effect produced was not as strong as desired, and it exhibited reduced effectiveness in windy areas when the ceiling fan was turned on.

3.4 Humidifier Test

The humidifier component functioned as intended, effectively producing the desired spraying effect. Upon issuing the appropriate command, the humidifiers successfully emitted mist.

3.5 Heating Module Test

The heating module powered up successfully upon receiving the command. A mini ZVS Tesla Jacobs ladder induction heating board was utilized for this purpose.

3.6 Zapper Circuit Test

The zapper circuit demonstrated its efficacy by generating an electric shock when mosquitoes made contact with the metal fence, effectively eliminating the pests.

4.0 CONCLUSION

The rising mortality rate of vector-borne diseases underscores the critical need for efficient and dependable mosquito control solutions. In this study, a device was developed with the primary objective of attracting and eliminating mosquitoes. The device demonstrated successful performance in responding to various voice commands, while its electric fence effectively electrocuted not only mosquitoes but also other insects upon contact. Furthermore, the humidifier functioned optimally, generating a mist that effectively attracted insects to its vicinity, as intended. These findings highlight the device's effectiveness in combating mosquito populations, thereby contributing to the overall efforts in disease prevention and control. By incorporating features such as voice command recognition, electric fence technology, and efficient humidification, the device offers a promising solution for mosquito eradication and the mitigation of associated health risks. Further research and development in this area hold the potential for substantial advancements in vector control strategies. Furthermore, the utilization of this device represents a remarkable approach in eliminating disease-carrying vectors in households and effectively reducing malaria transmission within our environment. To enhance its functionality, an upgraded version should incorporate a thermostat mechanism to ensure optimal temperature regulation within the device. Additionally, the inclusion of an ultrasonic sensor, calibrated to activate the suction fan upon detecting sound within a specific frequency range, would further enhance its performance. To reduce household electricity costs during device operation, implementing a self-powering feature is recommended. Lastly, establishing a wireless Bluetooth connection for the device's voice interface would overcome the observed limitations posed by noise interference associated with the current voice module.

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