AN IMPLEMENTATION OF SUSTAINABLE SOLAR POWERED MOSQUITO TRAP DEVICE

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Abstract: Mosquito control is an ongoing problem that must be constantly monitored and achieved. This is due to the creature's ability to transmit a variety of deadly diseases, and mosquitoes kill one million people each year. Traditional insecticide and bug zapper prevention methods are ineffective and have an adverse effect on the environment in a diverse range of ways, including the extinction of beneficial insects, mosquito biological evolution, and climate change. A solar-powered mosquito trap is developed in this study to attract mosquitos into the trap by sucking them toward a shock net while they are drawn to an SMD LED light. This project aims to create a low-cost, high-efficiency and environmentally friendly mosquito trap device.

Keywords:* *Mosquito trap; solar power; SMD LED; cost effective; environment friendly.

1. INTRODUCTION

Mosquitoes carry a deadly payload in some parts of the world: malaria, a parasite that kills over 600,000 people each year. Malaria threatens nearly half of the world's population, according to the World Health Organization [1]. "Build a better mousetrap, and the world will beat a path to your door," as the old adage goes, and the same could be said for mosquito traps. [2]

The majority of current mosquito prevention and treatment tools for the general public use mosquito nets, mosquito swatters, mosquito lamps, and other tools. The Mosquito-attractant is primarily caused by three factors: vision, smell, and temperature. Mosquito-attractant products on the market primarily use phototaxis to attract mosquitos, followed by UV light. Then, using the internal electric shock net, shock mosquitos or inhale mosquitos with a powerful fan to dry them in the air. [4]

Although mosquito-attracting temperatures, airflow, and carbon dioxide concentrations have been produced recently, associated items lack systematic quantitative analysis, and placement options are constrained by where the power source is located.

Mosquito control is primarily accomplished through the use of pesticides, which the planet could do without. Solar energy has now entered the picture. When sunlight irradiates the surface of solar panels, parts of the photons are absorbed by silicon and converted into electrical energy, making solar cells an efficient way to harness the energy of the sun. The battery then stores the power generated by the sunlight and discharges power to the lamps via the controller.

The goal of this study was to create a Solar Energy-Based Mosquito Trap by luring insect pests with an ultraviolet light emitting diode tube and powering it with a 12 Volt battery. For use at night, the battery charging system derives electrical energy from a 20-watt solar cell. [5] This proposed Solar Energy-Based Insect Pests Trap will have an automatic control system that will lure insect pests and trap them. The whole system will be powered by solar energy.

2. Design Consideration

A practical problem in society has been chosen as a challenging problem, and the efforts of this research are devoted to providing a solution to mosquito trapping. Mosquitoes transmit dangerous diseases such as malaria, dengue fever, and yellow fever. These diseases spread rapidly from person to person. Mosquitoes not only carry diseases that affect humans, but they can also transmit several diseases and parasites to dogs and horses [6]. Mosquitoes and other insects are drawn to a light source on top of the trap and pulled towards a collapsible cage by the mosquito trap. The trap is lightweight and ideal for field implementation where electricity is not available.

Solar power generation has increased dramatically because it is less polluting than fossil fuel power generation. Furthermore, because there are no moving parts, it requires little maintenance and wear, making solar power appealing to people [7]. The use of solar energy to power this device makes it simple but extremely effective.

A. System overview

The overall simplified block diagram is presented in fig. 1

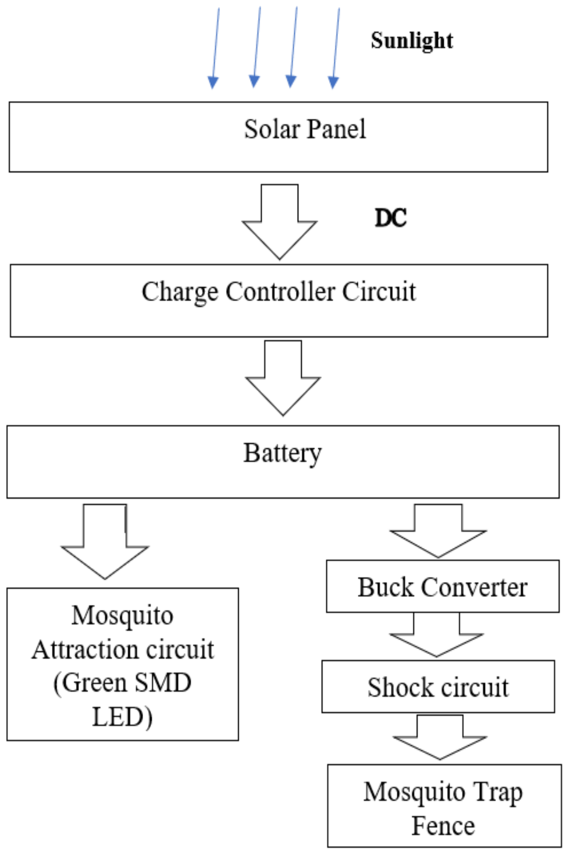

Fig. 1 Simplified block diagram of solar powered mosquito control trap.

A general block diagram was constructed to depict a simplified circuit operation of the project and classify the designated process of certain components. The block diagram consists of input, process, and output.

B. The input block

This block consists of solar panels, a battery charger, and lead acid batteries, which are simplified into a charging block. The charging block provides power to other components as well as charging the batteries using solar energy.

- Solar Panel

Any solar PV system that converts sunlight directly into DC power needs a solar module as a key component. A silicon solar cell generates 0.5 to 0.6 volts. Typically, a Module is created by joining 36 cells together. Such a module has sufficient voltage to run pumps and motors as well as charge 12-volt batteries. A PV power system's fundamental building block is the PV module. More power can be generated by connecting modules.

- Battery storage and charge controller

In order to use current electricity generated by solar panels when sunlight is not visible, at night, or for other uses, batteries store it. In PV systems, batteries are frequently used to store the energy generated by the PV array throughout the day and to supply it to electrical loads when needed (during the night and periods of cloudy weather). Batteries are also employed in PV systems to power electrical loads at stable voltages, operate the PV array close to its maximum power point, and supply surge currents to electrical loads and inverters. To safeguard the battery from overcharging and over discharging, a battery charge controller is typically employed in these systems.

Design Specifications

Panel Description:
Panel Nominal Volatge= 12 V
Panel Power rating= 25 watt

Battery Description:
Battery standby voltage=6.9 V
Battery Nominal Capacity= 4500 mAh
Two batteries connected in series for a 12-volt circuit.
Battery standby Voltage, = 12.0 V
Battery nominal capacity= 9000 mAh = 9 Ah
Battery watthour rating = 108 Wh
With 25-Watt solar panel, time need to charge= 5 Hours (approximately)
The project proposed a 25-watt solar panel for the existing mosquito trap device where 5 hours of sunlight period is enough to charge the battery storage.

C. The process block

In this block, the mosquito attraction circuit consists of SMD LED light and an electric shock-based mosquito circuit will run simultaneously once they are supplied with enough input power.

- SMD LED

A surface mounted diode is an SMD. In comparison to the first-generation DIP LEDs, this technology is superior. The SMD type LEDs are encased in epoxy resin and put on an aluminum substrate [8].
SMD spotlights are more powerful and energy-efficient than earlier LED lights due to their higher lumen output for reduced energy consumption, which is one of the largest advancements. This is

due to the fact that they operate on the idea that fewer, larger SMD LEDs produce a higher lumen output. Due to its adaptability, the LED chip, which is permanently bonded to a printed circuit board, is very well-liked.

When compared to an SMD LED display, the commonly used DIP LED display has a narrower viewing angle. Only H120° and V60° are supported, while the SMD LED displays have a large viewing angle that can reach H160° and V160° [9].

As a result, SMD LED screens are a fantastic choice if you have strict viewing angle requirements.

Typically, compared to other light sources, LED lights emit a brighter light. This is as a result of the higher lumen they offer. A 50–100 lumen per watt standard is used when describing SMD LED lighting. This indicates that even at high brightness levels, less energy is used [10].

A focused light beam with a 25- or 40-degree beam angle is typically produced by the combination of three or four high-powered LED chips found in power LED bulbs or integrated LED downlights. SMD LED bulbs are composed of a number of tiny LED chips, typically 20 per bulb as shown in fig. 2.

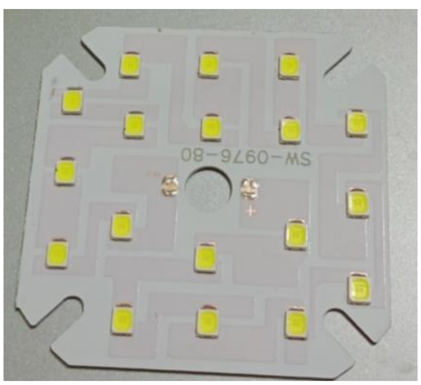

Fig. 2 SMD-LED

- Color LED for alluring mosquito

For mosquito species like the Culex and Anopheles species that are active and bite at night, light-based traps work well. Such traps are ineffective for catching Aedes aegypti, which is mostly a daytime biter and is the main vector for dengue and zika viruses.

According to the study, mosquitoes are drawn to the color red, orange, black, and cyan most. These hues stayed put for a longer period of time while they were present [12]. Mosquitoes may be drawn to these hues because they have longer wavelengths and because human skin contains hues with orange and red tones. Even after accounting for the moon's phases, which frequently cause interference with LED traps, the LED trap attraction outperformed the incandescent control by a large margin.

Light does not always attract mosquitoes. Instead, they control their behavior and activity with light. Because they hunt for food that is active during the day, mosquitoes that bite during the day are drawn to a variety of light sources. Since mosquitoes cannot see farther than a few feet, they are drawn to or naturally navigate a certain color palette [13].

One of the hues that can be seen in light is blue. They might come inside if your indoor or outdoor lighting has a bluish hue. Like the majority of insects, mosquitoes prefer colors like violet, blue, or green [14].

A study found that mosquitoes are most drawn to green LEDs, followed by red and infrared lights. 43 percent of the insects gathered were mosquitoes, which were attracted to the green light the most. Mosquitoes were drawn by 31.8 percent of blue light and 24.9 percent of control (incandescent) light, respectively [15]. Fig. 3 shows the range of sensitivity of mosquitoes towards light.

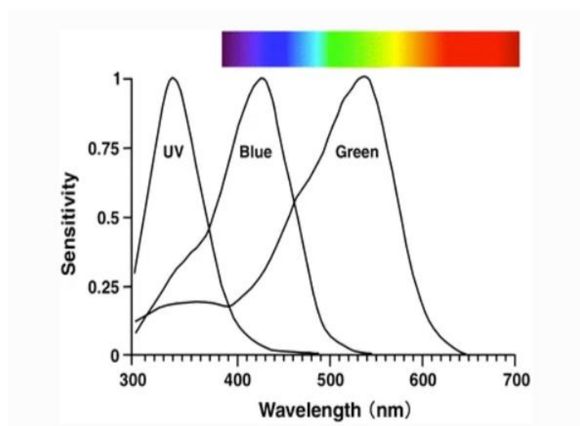

Fig. 3 Mosquito interaction to light [16]

D. The output block

The output block is the execution block of this project, which is to attract mosquitoes to the shock trap through LED light and execute the operation of mosquito killing.

3. System Development

The implemented circuit of the project is designed and simulated in a power circuit simulator (proteus) to evaluate the functionality of the design.

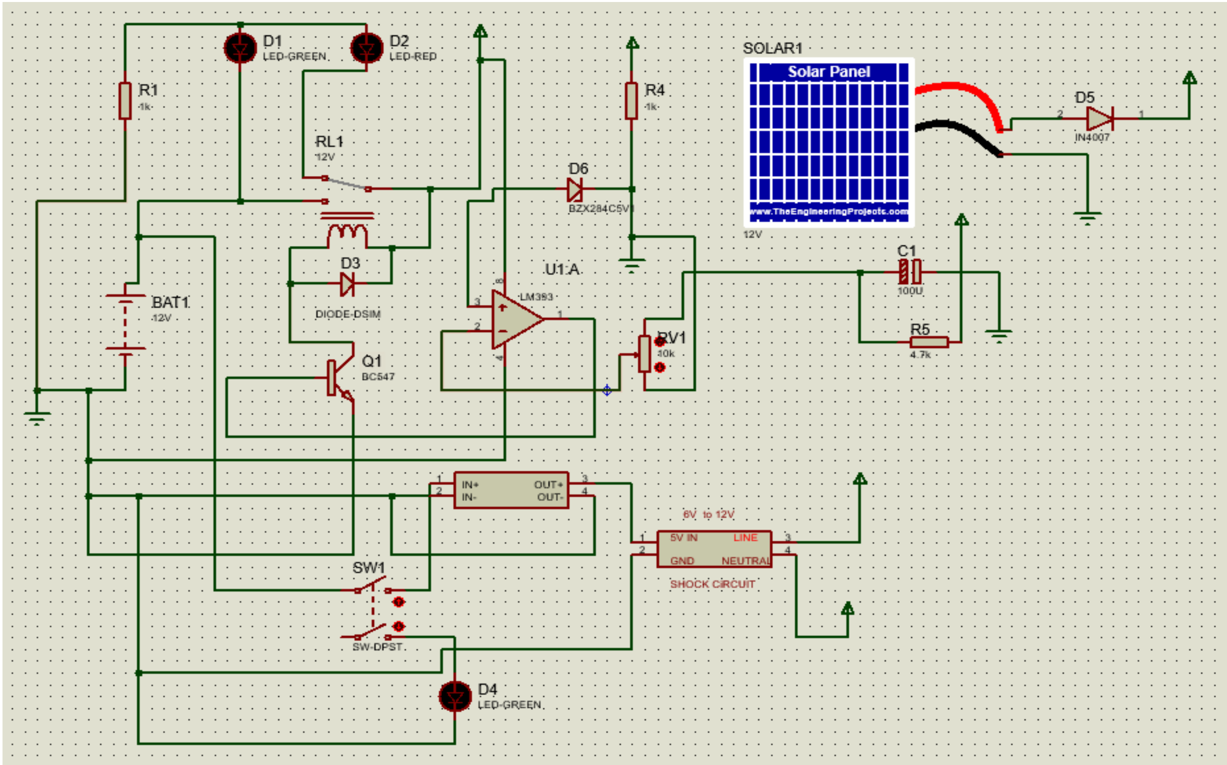

Fig. 4 Circuit diagram of solar powered mosquito control trap.

Fig. 4 shows that a 12 V, 25-watt solar panel is used as the power source for the project. A charge controller circuit is designed to control the charging mechanism of battery storage. The battery powered the rest of the project elements. A blocking diode D6 is used to prevent the reverse current from battery to solar panel at night time.

In the charge controller circuit section given in fig. 4, Relay (RL1) is used to control the switching mechanism during the charging period of Battery up to its maximum level. When the battery voltage reaches to 13.15 V, Zener diode way to comparator active the base drive of Q1 transistor which cut off the relay coil voltage and disconnected the battery from panel charging. IC LM393 comparator is used to set the overcharging level of voltage for the battery by adjusting a 10K variable resistor. Here, Green LED shows the charging and Red LED shows the disconnect mode.

In the next part of the project, a LM2596 buck converter was used to step down the 12 V into 4.5 V for the shock circuit for the mosquito trap and another switch directly connected to the 12 V SMD green LED.

The capacitor-based shock circuit creates a closed circuit through the net which is charged by almost 2 kV voltage which is stored in the disk capacitor.

4. System Implementation

Fig. 5 presents the complete charge controller circuit with blocking diode. Here the diode close to the input circuit is the blocking diode used to block the reverse current flowing from the battery to the panel during night time.

Fig. 5 Battery charge controller circuit.

Two indicator LEDs are used near the relay output circuit towards battery storage. Green LED indicates the charging of the battery and Red LED indicates the overcharging state of the battery.
The Internal circuitry of HVINV1 is shown in fig. 6. This circuit produces high voltage electric shock to the trap. At switch ON position, the battery provides power to charge a 2 kV ceramic disk capacitor which is parallel connected with the output terminal of the shock circuit and creates shocks in the trap net when a circuit is closed by a mosquito

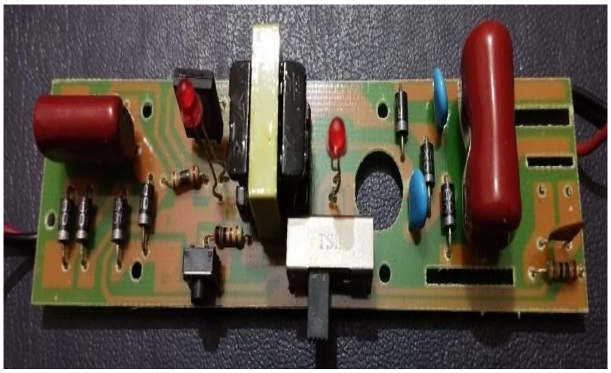

Fig. 6 Shock generation circuit

Since red and yellow are imperceptible to mosquitoes, they have a reduced visible spectrum. Light has distinct wavelengths.
Blue and green lights are more alluring to them. The majority of insects are drawn to light; this is a phenomenon known as phototaxis [17].
It must be taken into account that some insects are nocturnal (active at night), such as Anopheles species, while others are diurnal (active during the day), such as Aedes aegypti (which may transmit yellow fever or dengue fever) known as Malaria mosquito. However, night-active mosquitoes also require some light for direction.
A research paper named "Light-emitting diode (LED) traps improve the light-trapping of anopheline mosquitoes" showed that LED lamps emitting blue (470 nm) or green (520 nm) light consistently caught high numbers of Anopheles mosquitoes, regardless of the lunar cycles [18].
A rigorous analysis was done during the selection of LED light color as the project is mainly designed to trap the mosquito in daytime hours, which means working hours in schools and offices.
Fig. 7 demonstrates the complete electrical setup with a convenient mechanical structure for the mosquito trap.
The upper portion of the structure for mosquito killing and the lower portion consist of the control circuitry of the project
Green LED is used to assure the maximum attraction of mosquitoes at day time.
The green LED in the control circuit indicates the charging of the battery during the sunlight period and the red LED of the charge controller circuit is lit up when the battery reaches its maximum charging level.

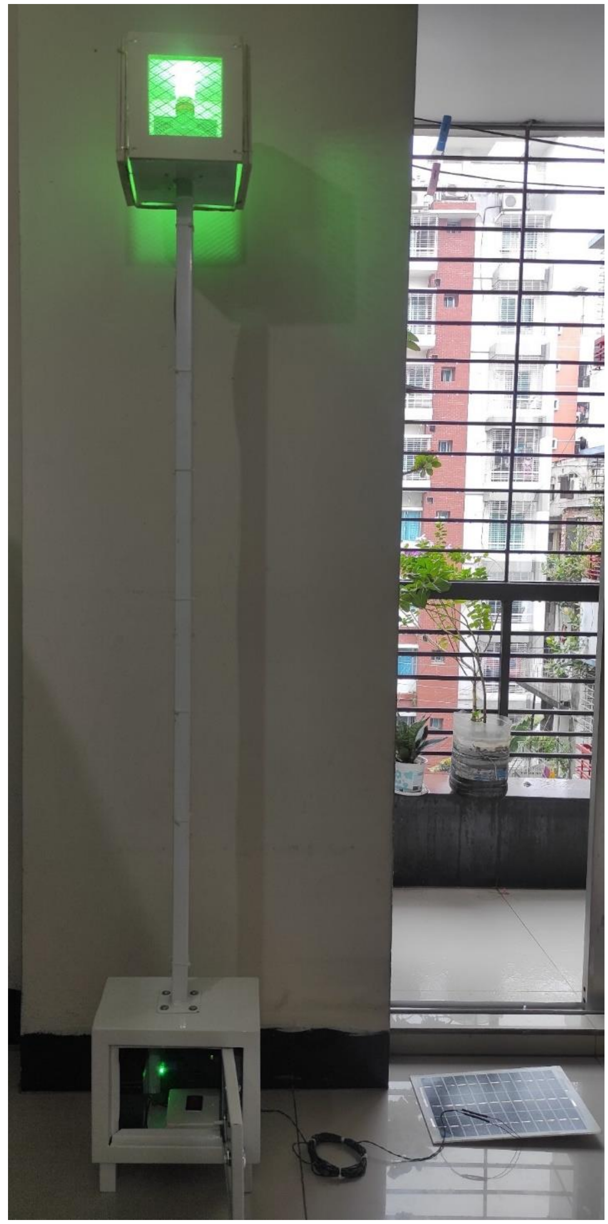

Fig. 7 Complete setup for mosquito trap with solar panel, Green SMD-LED and shock trap.

A. *Cost Summary*

The project's total cost estimation is provided in Table I. The majority of the total cost is made up of the price of the frame construction. This project's commercial implementation will lower the system's overall cost.

TABLE I. OVERALL COST SUMMARY

Name of apparatus	Quantity	Total Price (BDT)
LED	5	10
Solar Panel	1	750
Switch	2	20
OPM	1	30
Capacitor	9	50
Relay	1	15
Diode	10	100
Lead Acid Battery	2	360
Battery Holder	1	60
Potentiometer	1	30
LM2596BuckConverter	1	150
ON OFF Switch	1	10
Connecting Wire	As required	120
Resistors	As required	10
Bread Board	1	300
Vero Board	As required	100
SMD LED	2	300
Frame	As required	3500
	Total	5915

The cost of commercially available mosquito repellent on the market is shown in Table II.

TABLE II. PRICE LIST OF COMMERCIALLY AVAILABLE MOSQUITO KILLER [19]

Mosquito Killer Model	Price (BDT)
KB-100 Mini Fogger Machine	14000
Mini Thermal Fogger MS-5000 Pest Control	13000
Mini Mosquito Fogging Machine	12000
40-Watt UVA Tube Mosquito Pest Killer	3500
360-Degree Mosquito Killer Lamp	3000
Smart Auto Mosquito Killer	2450
3-In-1 Mosquito Killer Lamp	1450

By contrasting the costs of various products on the market with the established system, it can be seen that commercial implementation of the system is both possible and beneficial.

B. Performance Evaluation

The trap device is practically installed in the yard area of Energy Institution, Dhaka University as shown in fig. 8.

Fig. 8 View from practically implementation site.

The device illustrated effective performance during the performance evaluation. The height of the frame is selected so that other insects cannot be exposed to the shock net as much. Although insects are capable of perceiving light in the 300–650 nm range, they prefer the 300–420 nm range, which includes UV radiation. Probably the most significant component in a light's appeal to insects is its UV output [20]. Since most insects are drawn to UV light and mosquitoes prefer wavelengths in the blue-green range (400–600 nm) [21], that's why UV light is not taken under consideration for the light trap to minimize other insect interaction. The implemented solar-powered mosquito killer's panel voltage and charge controller output voltage statistics are shown in Table III.

Charge controller is designed here to control the overcharging of the battery and limit voltage up to 13.15 V. For one instance, the shock circuit produces 2 kV.

TABLE III . SOLAR PANEL AND CHARGE CONTROLLER OUTPUT

Time	Solar Panel Voltage (V)		Charge Controller Output (V)	
	Day 1	Day 2	Day 1	Day 2
9:00 AM	18.3	18.4	13.03	13.0
10:00 AM	18.5	18.7	13.0	13.10
11:00 AM	18.7	18.16	13.0	13.0
12:00 PM	19.88	19.96	13.15	13.15
1:00 PM	18.14	18.88	12.95	13.15
2:00 PM	18.02	18.44	13.1	13.05
3:00 PM	17.56	17.76	13.0	13.05
4:00 PM	15.20	16.90	13.0	13.0

46 mosquitoes in all were caught over the course of the two trapping days and nights. Comparing among light sources, the total number of mosquitoes was captured in the light trap fitted with blue LED (n = 24; 52.17%) and green LED (n = 22; 47.82%).

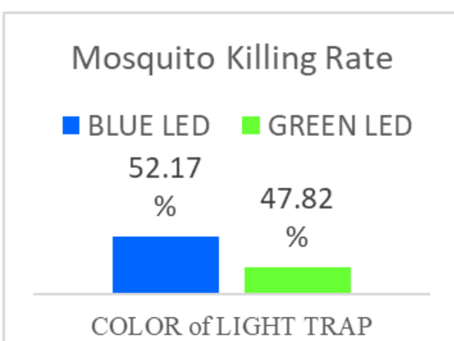

Fig. 9 Comparison graph of mosquito killing rate between BLUE LED and GREEN LED.

Fig. 9 exhibits the mosquito killing rate respectively by BLUE LED and GREEN LED. The design's primary goal is to install a mosquito killer in the office and school building's hallway during the day. According to a recent study, mosquitoes that bite at night specifically avoid blue and ultraviolet (UV) light during the daytime [22].

Different LED light wavelengths have different effects on mosquito behavior; for instance, Anopheles mosquitoes are attracted to green LEDs at 520 nm more than blue LEDs at 470 nm [23]. That's why green SMD LED is preferred over blue and UV LEDs for the implementation of the light trap mosquito killer.

The forward voltage drops across the Green LED and BLUE LED are also considered in the design.

The measured forward voltage drops across

BLUE LED = 3.2 Volt

GREEN LED =2.2 Volt.

As the battery sizing is the main concern for the project during long running cloudy day when sun is not available. So, the LED with less forward voltage drop is also given priority during the consideration of LED light color as the attraction rate of GREEN LED is close to BLUE LED.

5. Conclusion

Mosquitoes are mostly brought on by sight, smell, and temperature. In this study, a 25W PV module is used to charge a 12V, 9AH battery bank while green SMD is employed to attract mosquitoes. The charge of a 12V battery is controlled by a charge controller that is connected to a buck converter and a capacitor-based shock circuit, which raises the battery voltage to a 2000V shock voltage. The device demonstrates its ability to control the battery charging and discharging, draw mosquitoes, shock them, and effectively kill them. This mosquito-controlling trap can be easily used in day and night time and both in indoor and outdoor environments and it works effectively. However, the project's primary consideration throughout design was how it would be used in offices and classrooms during working hours. The likelihood of attracting more mosquitoes can be increased by properly selecting the light's hue through the analysis of the light spectrum and the light's precise wavelength. The mechanical structure used for the project can be modified to address several of the concerns raised in order to prevent any vulnerable situations like human interaction or hazard for other insects for further implementation.

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