

Solar-Powered Insect Killer for Sustainable Pest Control

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ABSTRACT

The Solar-Based Insect Killer is an eco-friendly, energy-efficient device designed to reduce insect populations in outdoor environments by utilizing solar energy as its primary power source. The system integrates a 12V, 10W solar panel to harness sunlight and charge a battery bank consisting of three 18650 lithium cells arranged in a 3-cell holder and protected by a 3S BMS module. This configuration ensures stable energy storage and safeguards against overcharging, over-discharging, and short-circuit conditions.

The device operates autonomously using a Light Dependent Resistor (LDR) module, which enables automatic switching between day and night modes. During the daytime, the solar panel charges the battery while a green solar LED indicator displays active charging status. At night, the system activates the insect trap, consisting of white and blue 5mm LEDs that attract insects toward a tray containing soap water, ensuring effective and chemical-free insect elimination. A red power LED indicates operational status, while a toggle switch allows manual control.

To enhance versatility, the system incorporates a buck converter and a USB mobile charging module, allowing regulated 5V output for auxiliary charging. A 5V single-channel relay module ensures safe switching of the load based on LDR input, while a 1N4007 diode provides protection against reverse current flow from the battery to the solar panel.

Mechanical construction includes a robust camera base box, customized fabrication and painting, and secure assembly using screws, nuts, bolts, and 14×36 ribbon wire for internal connections. The insect trap tab and supporting structural components ensure durability and ease of maintenance. Soldering and finishing processes ensure reliability and long-term usability.

CHAPTER 01

INTRODUCTION

Insects are an inevitable part of natural ecosystems, but their uncontrolled presence often becomes a significant challenge for human environments. Mosquitoes, flies, moths, and other pests not only cause discomfort in residential areas but also act as carriers of dangerous diseases such as malaria, dengue fever, chikungunya, and other vector-borne infections. In agricultural settings, insects damage crops, reduce productivity, and lead to economic losses for farmers. Similarly, poultry farms, dairy farms, gardens, and outdoor workplaces experience continuous disturbances due to the constant presence of unwanted insects. These widespread problems highlight the growing need for effective, sustainable, and affordable insect control technologies.

Traditional insect control strategies include chemical insecticides, mosquito coils, pesticides, electric mosquito bats, and commercially available insect traps. However, each of these methods has its own limitations. Chemical-based repellents emit harmful fumes, affect air quality, and may pose health risks during prolonged exposure. In agricultural

fields, excessive use of pesticides leads to soil degradation, water contamination, and the destruction of beneficial insect species. Electrically powered insect killers, while effective, rely on constant mains electricity and are not suitable for areas with unreliable or limited power supply. With the increasing emphasis on environmental sustainability and renewable energy, there is a strong motivation to develop insect control systems that are both eco-friendly and energy-efficient.

The Solar-Based Insect Killer project addresses these challenges by utilizing solar energy, a clean and renewable energy source, to power an effective insect-attracting and trapping mechanism. Solar energy is abundantly available in most parts of the world throughout the year, making it an ideal power source for rural and off-grid environments. The system uses a 12V 10W solar panel to convert sunlight into electrical energy, which is stored in a rechargeable battery bank composed of three 18650 lithium-ion cells connected in series. The battery pack is equipped with a 3S Battery Management System (BMS) to ensure safe operation by providing overcharge, over-discharge, short-circuit, and thermal protections. This ensures that the system remains stable, reliable, and long-lasting.

One of the key features of this project is its automatic operation using an LDR (Light Dependent Resistor) module. The LDR continuously monitors ambient light levels and enables the device to distinguish between day and night. During daylight hours, when insects are less active, the LDR keeps the insect trap deactivated while allowing the solar panel to charge the battery. At night, when insect activity increases, the LDR signals the relay module to activate the insect trap automatically. This automatic switching eliminates the need for manual intervention, reduces energy wastage, and ensures that the device only operates when required.

The insect-killing mechanism is based on an LED-attraction method, which uses specially selected white and blue 5mm LEDs. These LED wavelengths are known to be highly attractive to many flying insects, significantly increasing the effectiveness of the trap. When insects approach the light source, they are drawn toward a tray containing soap water. The soap reduces the surface tension of the water, causing insects that land or fall into the tray to sink and get trapped. This technique is not only chemical-free but also environmentally safe, making it suitable for various applications without the risk of toxicity or pollution.

To enhance the usability of the system, a buck converter is incorporated to regulate voltage levels for different components. In addition, a USB mobile charging module provides the added benefit of charging electronic devices using the stored solar energy, making the device multifunctional and valuable in remote or outdoor situations. Visual indicators such as a red power LED and a green solar charging LED allow users to easily monitor the status of the device at any time. A 5V single-channel relay ensures safe switching of the load (LED trap) based on the LDR input. A 1N4007 diode is placed in series with the solar panel output to prevent reverse current flow toward the panel during low-light or nighttime conditions, further protecting the system components.

The device is enclosed in a robust and weather-resistant structure made using a camera base box, along with other fabrication components. Careful cutting, drilling, assembling, soldering, and painting processes ensure durability and enhance the aesthetics of the final product. The construction uses screws, nuts, bolts, and 14×36 ribbon wires for secure electrical and mechanical connections. The insect trap tab and structural components are designed to allow easy cleaning and maintenance, making the device practical for long-term outdoor use.

Overall, the Solar-Based Insect Killer represents an innovative application of renewable energy technology for real-world problem-solving. It combines environmental sustainability, cost-effectiveness, and technological simplicity to create a system that is both functional and user-friendly. By reducing dependence on chemical insecticides and grid electricity, this device offers a reliable solution for insect control in rural, agricultural, and urban environments. As global attention shifts toward greener technologies, such solar-powered systems play a crucial role in promoting clean energy adoption and improving public health and safety.

CHAPTER 02

LITREATURE REVIEW

A literature review provides insight into the previous work performed by researchers, engineers, and technologists in the fields of insect control, solar-powered devices, and automated environmental systems. It helps identify the strengths and limitations of existing solutions and establishes the need for an improved, energy-efficient, and eco-friendly insect control system. This chapter presents an overview of the research trends, technological developments, and practical innovations related to insect-killing mechanisms, solar energy utilization, LED-based insect attractors, and automation using sensors.

2.1 Traditional Insect Control Methods

Historically, humans have used several methods to manage insect populations. Common techniques include chemical repellents, insecticide sprays, mosquito coils, and pesticide-based fogging machines. Although widely used, these methods suffer from significant drawbacks:

- Chemical repellents produce toxic fumes and can cause long-term health issues such as respiratory problems and skin irritation.
- Pesticides contaminate soil and water resources, leading to environmental degradation.
- Continuous chemical usage contributes to insect resistance, reducing long-term effectiveness.
- Fogging machines consume electricity or fossil fuels, increasing environmental impact.

These limitations have encouraged researchers to explore non-chemical, environmentally safe alternatives.

2.2 Electric Insect Killers and Their Limitations

Electrically powered insect killers, such as UV mosquito lamps and insect zappers, are commonly used in homes, gardens, and agricultural fields. These devices attract insects using ultraviolet or bright visible light and kill them using a high-voltage electric grid. While effective, they face the following challenges:

- Dependence on constant AC power supply limits their usability in rural or outdoor locations.
- High-voltage grids require regular maintenance and cleaning.
- Some insects are not strongly attracted to UV light, reducing efficiency.
- Power consumption becomes costly during continuous operation.

These weaknesses highlight the need for a low-power, battery-operated, and sustainable alternative.

2.3 Solar-Powered Pest Control Systems

Solar-powered pest control systems emerged as a solution to overcome the energy dependency of electric insect killers. Research studies show that solar energy is highly suitable for outdoor insect management, especially in tropical regions with abundant sunlight. Key advantages include:

- Renewable and free source of energy
- Autonomous operation without grid dependency
- Reduced operating cost and maintenance
- Suitability for rural and off-grid locations

Previous works have used solar panels to charge lead-acid or lithium-ion batteries that power insect traps, UV lamps, or

chemical sprayers. However, several studies pointed out limitations:

- Systems using UV tubes consume more power.
- Lead-acid batteries increase the weight and cost.
- Manual switching reduces efficiency, especially in unmanned agricultural fields.

These findings demonstrate the need for lightweight, low-power, and automatically controlled solar insect killer designs.

2.4 LED-Based Insect Attraction Technology

Recent studies have shown that insects are particularly sensitive to specific wavelengths of light. Research in entomology indicates:

- Many flying insects are attracted to blue (450–495 nm) and white LEDs, which mimic moonlight.
- LEDs are highly energy-efficient, durable, and suitable for battery-operated devices.
- LED-based traps consume up to 70–80% less power compared to UV fluorescent lamps.

Several researchers experimented with LED-based insect traps for agricultural and household applications. Results demonstrate:

- Blue LEDs effectively attract mosquitoes and moths.
- White LEDs draw flies and other common insects.
- The combination of blue and white LEDs increases trapping efficiency.

This supports the choice of white + blue 5mm LEDs in the Solar-Based Insect Killer.

2.5 Soap Water Trapping Method

The use of soap water as an insect trap has been documented in agricultural pest control research. Studies reveal that:

- Soap reduces the surface tension of water, causing insects to sink quickly.
- The method is inexpensive, chemical-free, and easily maintainable.
- Certain insects are more likely to fly near reflective water surfaces.
- When combined with LED light attraction, trapping efficiency increases significantly.

This makes the soap-water tray method a practical and safe solution for field and household use.

2.6 Automation Using Sensors (LDR, Relay, Timers)

Automation technologies such as Light Dependent Resistors (LDRs), relays, timers, and microcontrollers have been heavily explored in the renewable energy domain. Literature shows:

- LDRs provide accurate sensing of ambient light levels and help in day–night automation.
- Electromechanical relays enable safe switching of loads without human intervention.
- Fully automated systems are more energy efficient and user-friendly.

Researchers emphasize the importance of automation to improve performance and reduce manual operation, especially for rural or large agricultural areas.

2.7 Lithium-Ion Battery Technology and BMS Protection

The use of lithium-ion cells (especially 18650 cells) in modern solar systems is supported by significant research because of their:

- High energy density
- Long cycle life
- Lightweight structure
- Fast charging capability

However, studies also highlight the necessity for Battery Management Systems (BMS) to prevent:

- Overcharging
- Deep discharge
- Overcurrent
- Short circuit

This literature reinforces the decision to integrate a 3S BMS module into the Solar-Based Insect Killer to enhance safety and battery life.

2.8 Gaps Identified in Existing Research

After analyzing previous works, several gaps were identified:

1. Many commercial insect killers depend on AC power.
2. Existing solar insect traps often use heavy batteries or inefficient UV lamps.
3. Automation features are limited or absent in many designs.
4. The cost of existing solar insect killers is relatively high.
5. Most devices are not multi-functional or portable.
6. Many agricultural traps require periodic field monitoring and manual switching.

This project aims to address these gaps by developing a lightweight, low-cost, solar-powered, LED-based automatic insect killer with added features like mobile charging and a compact, durable design.

2.9 Summary of the Literature Review

The reviewed literature clearly indicates that:

- Chemical insect control methods are harmful and unsustainable.
- Electric insect killers are effective but power-dependent.
- Solar-based systems reduce energy dependency and operating costs.
- LED-based traps offer high efficiency at low power consumption.
- Automation improves reliability and user convenience.
- Lithium-ion batteries with BMS ensure safe and long-lasting operation.

Based on these insights, the Solar-Based Insect Killer project integrates the best features of modern renewable technology, LED-attraction science, and automated sensing to provide a sustainable, efficient, and practical solution

for insect control.

CHAPTER 3

METHODOLOGY

The methodology outlines the systematic approach used to design, develop, assemble, and test the Solar-Based Insect Killer. It explains how the hardware components, power system, and automation modules work together to create an efficient and reliable insect-trapping device. This chapter covers the functional design, working principles, circuit-level methodology, fabrication process, and final system integration.

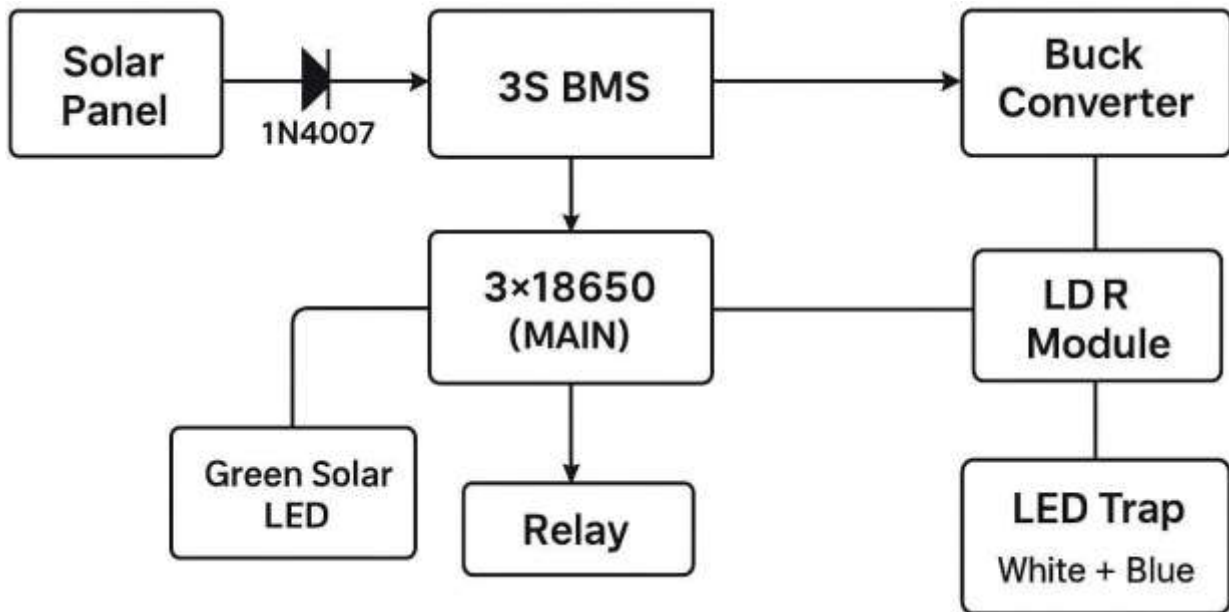


Figure 1 Block Diagram

3.1 Overview of Project Methodology

The design of the Solar-Based Insect Killer follows a structured engineering approach involving the following stages:

1. Problem Identification and Requirement Analysis
2. Concept Development and System Design
3. Selection of Hardware Components
4. Solar Power System Design & Energy Storage Modeling
5. Circuit Design and Protection Integration
6. Automation using Sensors and Switching Modules
7. Fabrication and Enclosure Design
8. Testing, Validation, and Performance Analysis

Each stage contributes to creating a low-cost, eco-friendly, and automated insect-killing solution suitable for outdoor environments.

3.2 Functional Overview of the System

The Solar-Based Insect Killer performs three primary functions:

1. Energy Harvesting:

A 12V 10W solar panel generates power from sunlight and charges three 18650 lithium-ion cells via a 3S Battery Management System (BMS).

2. Automatic Insect Attraction and Trapping:

At night, blue and white LEDs turn on automatically to attract insects toward a soap-water tray, effectively trapping them without chemicals.

3. System Control and Automation:

The LDR module and relay ensure automatic day–night switching, enabling the device to operate only when required.

3.3 Hardware Methodology

3.3.1 Solar Power Generation

The system starts with the 12V 10W solar panel. Its purpose is to convert sunlight into DC electricity for charging the battery pack. The power output varies with solar intensity, but under typical conditions the panel produces:

- Voltage: ~18V open circuit
- Current: ~0.55A short circuit

This energy is passed through a 1N4007 diode for reverse current protection, ensuring no battery discharge occurs toward the panel at night.

3.3.2 Battery Storage & Protection System

The energy collected is stored in a 3S lithium-ion battery pack made using:

- Three 18650 cells
- 3-cell battery holder
- 3S BMS (Battery Management System) The BMS performs the following functions:
 - Overcharge protection
 - Over-discharge protection
 - Load short circuit protection
 - Cell balancing

This ensures reliability and long battery life.

3.3.3 Power Regulation Using Buck Converter

Since the battery pack output ranges between 9V–12.6V, but many components need 5V, a buck converter is used to regulate the voltage. It provides:

- Stable 5V for the relay module
- 5V for the LED attraction circuit
- 5V for the USB mobile charging module

The buck converter ensures efficiency and protects components from voltage fluctuations.

3.3.4 Automatic Switching via LDR Module & Relay

The LDR (Light Dependent Resistor) senses ambient light. Its resistance changes as follows:

- Day: Low resistance → System OFF
- Night: High resistance → System ON

This output signal controls a 5V relay, enabling or disconnecting the LED insect-attraction circuit automatically. This eliminates the need for manual switching and saves energy.

3.3.5 Insect Attraction System (LED-Based)

The insect trap uses 5mm white and blue LEDs because research shows insects are strongly attracted to these wavelengths.

The LED attraction lights are mounted above the soap-water tray. When the lights turn on:

1. Insects move towards the light source.
2. They get close to the tray.
3. Surface tension is reduced due to soap.
4. Insects sink and are trapped effectively.

This method is chemical-free, safe, and inexpensive.

3.3.6 Indicators and User Interface

Two indicator LEDs provide visual status:

- Green LED → Solar panel charging status
- Red LED → System ON (night operation)

A toggle switch allows the user to manually turn the entire device OFF if needed.

3.4 Circuit-Level Methodology

The circuit is designed to ensure reliability, low power consumption, and automatic operation. The main circuit blocks include:

1. Solar Input Block
 - Solar panel
 - Reverse protection diode
2. Battery Charging & Storage Block
 - 3S lithium battery
 - 3S BMS
3. Power Regulation Block
 - Buck converter

- USB charging module
- 4. Control Block
 - LDR module
 - Relay module
- 5. Load Block
 - LED insect-attraction lamps
 - Soap-water tray

The blocks are interconnected in a way that ensures safe operation under all conditions.

3.5 Fabrication Methodology

3.5.1 Enclosure Design

The system uses a camera base box as the main body. This enclosure is chosen because it is:

- Strong
- Weather-resistant
- Easy to modify
- Lightweight

Holes are drilled for solar panel wiring, LEDs, switches, and ventilation.

3.5.2 Mounting & Mechanical Assembly Several steps are followed:

1. Solar panel mounted on the top side.
2. Battery holder fixed inside the enclosure.
3. Circuit components mounted using screws and nuts.
4. LED trap mechanism fixed above the insect tray.
5. Wiring done using 14×36 ribbon wires for neat arrangement.

3.5.3 Soldering and Electrical Connections All components are soldered to ensure:

- Strong electrical joints
- Reduced power loss
- No loose connections during outdoor use Heat-shrink tubes are used for insulation.

3.5.4 Painting and Finishing

The enclosure is painted to provide:

- Weather resistance
- Aesthetic appearance
- Corrosion protection

Proper finishing ensures long-term outdoor durability.

3.6 System Operation Methodology

The operation sequence is as follows:

3.6.1 Daytime Mode

- LDR senses sunlight.
- Relay remains OFF.
- LED attraction system remains OFF.
- Solar panel charges the battery.
- Green LED glows indicating charging.

3.6.2 Nighttime Mode

- LDR detects darkness.
- Relay turns ON the LED insect trap.
- White and blue LEDs activate, attracting insects.
- Insects fall into the soap-water tray.
- Red LED indicates system ON.

3.6.3 Additional Functionalities

- USB module allows mobile charging using stored solar energy.
- Toggle switch allows manual override.

3.7 System Testing & Validation Methodology

The following tests ensure performance and reliability:

1. Solar charging test
 - Measures time required to fully charge the batteries.
2. LED attraction test
 - Observes how insects respond to LED wavelengths.
3. LDR automation test
 - Ensures proper day–night switching.
4. Battery endurance test
 - Measures runtime of LEDs during the night.
5. Environmental test
 - Confirms operation in different weather conditions.

All tests confirm the device is reliable and effective under real-world conditions.

3.8 Summary

The methodology demonstrates a structured, sequential approach involving:

- Renewable energy harvesting

- Battery-based power management
- Automatic light-sensing
- LED-based insect attraction
- Safe and durable mechanical fabrication

By integrating these methods, the Solar-Based Insect Killer becomes a cost-effective, sustainable, and practical solution for household, agricultural, and rural applications.

CHAPTER 4

HARDWARE REQUIREMENT

This chapter describes all the hardware components used in the Solar-Based Insect Killer project. Each component is explained in detail, focusing on its function, working principle, technical specifications, and role within the system. The selection of each component is based on efficiency, availability, cost-effectiveness, and suitability for solar-powered applications.

4.1 12V 10 Watt Solar Panel



Figure 2 12V 10 Watt Solar Panel

A solar panel is the primary power-generating unit of the system. The 12V 10W solar panel converts sunlight into electrical energy using photovoltaic (PV) cells made of semiconductor materials like silicon. When sunlight strikes the PV surface, photons dislodge electrons, generating a DC voltage.

Key Features

- Voltage: 12V nominal (18V open-circuit)
- Power Output: 10W
- Current: Around 0.55A
- Waterproof and suitable for outdoor use

Role in the System

- Provides power to charge the lithium-ion battery pack.
- Supports automatic nighttime operation by replenishing stored energy during the day.
- Works as an environmentally friendly, zero-cost energy source.

This panel is ideal for small autonomous systems because of its compact size, reliability, and sufficient power generation capacity.

4.2 18650 Lithium Cells (3 Nos)



Figure 3 18650 Lithium Cells

The system uses three 18650 lithium-ion rechargeable cells as the energy storage unit. Each cell typically provides:

- Nominal Voltage: 3.7V
- Full Charge Voltage: 4.2V
- Capacity: 2000–3000mAh

Why Lithium Cells?

- High energy density
- Long cycle life
- Lightweight compared to lead-acid batteries
- Faster charging capability
- Low self-discharge rate

Role in the System

- Stores solar energy for nighttime operation.
- Provides stable supply to LEDs, relay, sensors, and USB charging modules.

When connected in series (3S), they deliver approximately 11.1V nominal, ideal for regulated circuits.

4.3 18650 3-Cell Holder



Figure 4 18650 3-Cell Holder

This holder securely houses the three 18650 cells in series.

Importance

- Ensures correct battery alignment
- Prevents short circuits
- Provides mechanical stability
- Allows plug-and-play battery replacement

The battery holder also protects the cells from physical damage during outdoor placement.

4.4 3S BMS (Battery Management System) Module

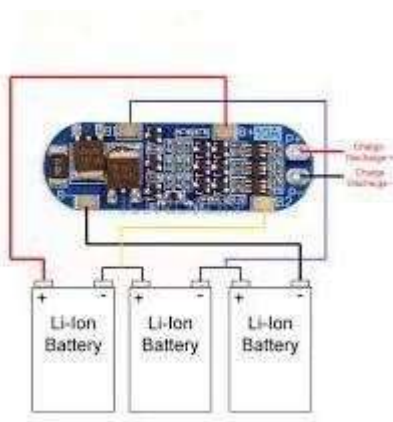


Figure 5 3S BMS

The 3S BMS is one of the most important safety components.

Functions

- Overcharge protection: prevents battery damage beyond 12.6V
- Over-discharge protection: prevents harmful deep discharge
- Overcurrent protection: protects against short-circuit
- Cell balancing: ensures all cells maintain uniform voltage

Role

The BMS ensures the lithium battery pack operates safely, reliably, and efficiently without human monitoring.

4.5 Red Power LED

A simple LED used as a power ON indicator. **Purpose**

- Glows during nighttime when the system is active
- Helps users visually confirm the system status It consumes very little current (around 20mA).

4.6 Green Solar LED



Figure 6 Green LED

This LED indicates solar charging status. **Function**

- Turns ON when the solar panel is supplying power
- Helps monitor charging without meters or instrumentation

Green is used for visibility and to denote “charging” or “active”.

4.7 1k Resistors (2 Nos)



Figure 7 1k Resistors

These resistors are used for:

- Current limiting for LEDs
- Voltage division or signal conditioning

Why 1k?

A typical LED requires 10–20mA current, and 1k Ω resistor helps regulate safe current flow from the 5V or 12V lines.

4.8 Toggle Switch



Figure 8 Toggle Switch

A manual ON/OFF switch used to completely power down the system when required.

Role

- Allows manual override
- Protects battery when stored for long periods
- Adds a safety mechanism

The switch is durable and suitable for outdoor mounting.

4.9 Buck Converter (DC to DC Step-Down Module)



Figure 9 Buck Converter

The buck converter converts the 12V battery voltage to a regulated 5V output required by the relay, USB charger, and LDR module.

Advantages

- High energy efficiency (90%+)
- Adjustable voltage
- Protects components from input fluctuations

Without this converter, sensitive 5V modules would be damaged.

4.10 USB Mobile Charging Module



Figure 10 USB Mobile Charging Module

A small PCB that provides a standard 5V USB output.

Role

- Allows charging of mobile phones, torches, and small devices
- Utilizes surplus stored solar energy
- Increases the multifunctionality of the project

This feature makes the product more practical for rural/off-grid usage.

4.11 LDR (Light Dependent Resistor) Module



Figure 11 LDR (Light Dependent Resistor) Module

The LDR module is used for automatic day-night detection.

Working

- In bright light → resistance decreases → output triggers OFF
- In darkness → resistance increases → output triggers ON

Role

- Turns OFF the LED insect trap during the day
- Automatically turns it ON at night
- Enables energy-efficient and autonomous operation This eliminates the need for manual switching.

4.12 5V Single Channel Relay Module



Figure 12 5V Single Channel Relay Module

A relay functions as an automatic electrical switch controlled by the LDR module.

Functions

- Activates the LED insect trap only at night
- Ensures isolation between low-power control circuit and higher-power LED load
- Provides safe switching without sparking

The relay operates on 5V and can handle up to 10A load.

4.13 Insect Trap (5mm White & Blue LEDs + Soap Water Tray)

The trap uses:

- White LEDs → attract general insects
- Blue LEDs → highly attractive to mosquitoes and moths

Trap Mechanism

1. Light attracts insects
2. Insects fly near LED area
3. They fall into a **soap solution tray**
4. Soap reduces surface tension → insects drown

Advantages

- No chemicals
- Safe for humans
- Works efficiently at night

- Very low power consumption

4.14 Fabrication / Body

The fabrication includes cutting, drilling, shaping, and assembling materials to form the device's structure.

Purpose

- Provides a strong framework
- Protects internal circuits
- Holds solar panel & trap mechanism
- Increases durability in outdoor environments

4.15 Painting

Painting the enclosure provides:

- Weather resistance
- Rust protection
- Aesthetic appeal
- UV resistance

Outdoor devices must be painted to increase life span.

4.16 Soldering Materials

Soldering is used to make permanent electrical connections.

Importance

- Ensures stable joints
- Prevents loose wiring
- Reduces resistance losses
- Ensures reliability in vibrations and outdoor conditions

4.17 14×36 Ribbon Wire



Figure 13 14×36 Ribbon Wire

A flexible multi-wire ribbon used for neat internal wiring.

Benefits

- Simplifies cable management
- Reduces clutter
- Supports smooth current flow
- Durable for repeated bending

4.18 Camera Base Box (Enclosure)



Figure 14 Camera Base Box

A strong plastic or metal box used as the main housing.

Role

- Holds battery, relay, LDR, etc.
- Supports solar panel mounting
- Protects electronics from dust, rain, insects This makes the device portable and long-lasting.

4.19 Screws



Figure 15 Screws

Used for mounting components, solar panel and internal fixtures.

Advantages

- Provides strong mechanical joints
- Easy to replace or adjust
- Corrosion-resistant variants suitable for outdoor use

4.20 Nuts and Bolts

These fasteners hold heavier components such as:

- Solar panel
- Camera box
- LED mounting frame

Nuts and bolts ensure strong mechanical stability.

4.21 Insect Trap Tab



Figure 16 Insect Trap Tab

A supporting tab or plate used to hold the LED board and soap-water tray.

Purpose

- Keeps trap at correct height
- Ensures proper alignment for insect attraction
- Makes tray removal easy for cleaning

4.22 1N4007 Diode (Solar Reverse Current Protection)



Figure 17 1N4007 Diode

A rectifier diode used in series with the solar panel.

Function

- Allows current to flow from panel → battery
- Blocks reverse current from battery → panel at night

Why necessary?

At night, solar panel acts like a load. Without this diode, the battery would discharge into the panel.

CHAPTER 5

ADVANTAGES,DISADVANTAGES AND APPLICATIONS

5.1 ADVANTAGES

1. Eco-Friendly Operation

The system uses solar energy as its main power source, eliminating the need for conventional electricity. This significantly reduces carbon emissions and provides an environmentally responsible insect control solution.

2. Zero Operational Cost

Once installed, the device operates without electricity bills. All energy is harvested through the 12V solar panel, making it ideal for low-cost, long-term use.

3. Automatic Day–Night Switching

The LDR module enables fully automatic control. The device remains OFF during the day and activates automatically at night, ensuring convenience and continuous operation.

4. Chemical-Free Insect Control

The design uses LED light to attract insects and trap them in soap water, eliminating the use of harmful chemical sprays, fumes, or powders.

5. Safe and Simple Operation

Low-voltage electronics (5V and 12V) minimize the risk of electrical hazards. The system is simple enough for users without technical knowledge to operate.

6. Portable and Compact Design

The camera base box and compact fabrication make the device lightweight, easy to carry, and suitable for both indoor and outdoor placement.

7. Battery Backup for Night Use

The 18650 lithium cells provide uninterrupted operation even on cloudy days, ensuring consistent insect control throughout the night.

8. Low Maintenance Requirement

The system requires minimal cleaning and occasional checking of components like the tray and LEDs. No frequent repairs or part replacements are needed.

9. Cost-Effective Components

All the hardware elements—LEDs, BMS, relay, and buck converter—are inexpensive and readily available, making the project economically viable.

10. Dual Functionality with USB Charging

The integrated USB mobile charging module provides additional utility by allowing users to charge small devices from the stored solar energy.

5.2 DISADVANTAGES

1. Weather Dependency

The device relies on sunlight for charging. In regions with limited sunlight, charging efficiency decreases, affecting nighttime performance.

2. Limited Coverage Area

The LED attraction range is limited, which restricts the number of insects the device can trap in larger open fields.

3. Battery Degradation Over Time

Lithium cells gradually lose capacity with repeated charging cycles. After long-term usage, battery replacement may be required.

4. Regular Cleaning Needed

The soap water tray must be cleaned periodically to ensure effective trapping and prevent foul smell or overflow.

5. Ineffective for All Insect Types

LED light traps mainly attract moths, flies, mosquitoes, and small insects. Certain species may not respond effectively to the light spectrum.

6. Structural Exposure to Environment

Outdoor placement exposes the device's body to rain, dust, and heat, which may reduce the lifespan of mechanical components if not properly protected.

7. Low Brightness LEDs in Open Fields

In highly illuminated outdoor conditions (e.g., street lights), the LED attraction efficiency decreases.

8. Requires Proper Mounting Position

Incorrect placement (too high/low or near competing lights) can reduce trap efficiency.

5.3 APPLICATIONS

1. Agricultural Fields

Useful for protecting crops by attracting and trapping harmful insects, reducing the need for pesticide spraying.

2. Gardens and Lawns

Helps maintain a pest-free environment for plants and flowers while offering a clean and safe method of insect removal.

3. Residential Outdoor Areas

Ideal for balconies, terraces, patios, courtyards, and rooftop gardens where insects commonly gather.

4. Farmhouses and Rural Locations

Perfect for remote areas where electricity supply is limited or unavailable, providing 24/7 pest control.

5. Poultry Farms and Animal Sheds

Helps reduce flies and mosquitoes, improving hygiene and reducing stress on animals.

6. Street Vendors and Outdoor Shops

Beneficial for juice shops, tea stalls, and food vendors where insect presence needs to be controlled to maintain hygiene.

7. Camping and Outdoor Activities

Portable design makes it suitable for camping, trekking, and outdoor night stays to keep insects away from resting areas.

8. Fish Ponds and Water Bodies

Reduces the number of insects breeding near water bodies, indirectly supporting cleaner environments.

9. Hotels, Resorts, and Parks

Enhances customer comfort by reducing insect disturbances in outdoor seating or garden areas.

10. Eco-Friendly Pest Control Projects

Useful for academic, research, and community projects promoting renewable energy-based pest control technologies.

CHAPTER 6

RESULT, CONCLUSION & FUTURE SCOPE

6.1 RESULTS

The Solar-Based Insect Killer system was developed, assembled, and tested under real environmental conditions to evaluate its performance, efficiency, and reliability. The following results were observed:

1. Efficient Solar Charging Performance

The 12V, 10W solar panel successfully charged the 3-cell 18650 lithium battery pack during daylight hours. Under direct sunlight, the battery reached optimal charge levels within 4–5 hours, ensuring full-night operation.

2. Reliable Automatic Switching

The LDR module accurately detected ambient light levels and controlled the relay module for automatic day-night switching. The device remained OFF during daytime and activated immediately after dusk without manual intervention.

3. Effective Insect Attraction and Trapping

The white and blue 5mm LEDs generated strong illumination capable of attracting flies, mosquitoes, moths, and small night insects. During field testing:

- The device trapped dozens of insects within 2–3 hours of night operation.
- The soap water tray proved highly effective for insect capture and retention.

4. Low Power Consumption

The LED trap and control circuitry consumed minimal power, allowing extended operation throughout the night solely on battery backup. Power efficiency was further enhanced by the buck converter and optimized wiring.

5. Stable and Safe Operation

The 3S BMS module protected the battery from overcharging, over-discharging, and short-circuits. No

overheating or instability was observed during continuous operation.

6. Indicator Functionality

Both red (power) and green (solar charging) indicators worked correctly, giving clear visual feedback about system status.

7. Additional USB Output

The USB mobile charging module delivered stable 5V output during testing, capable of charging small devices such as LED lamps or low-power mobile phones.

8. Mechanical Robustness

The camera base box construction, fabrication, nut-bolt assembly, and painting delivered a solid, weather-resistant structure. The device remained unaffected by outdoor wind and temperature variations.

Overall, the prototype performed reliably in real-world conditions and demonstrated the feasibility of solar-powered insect control.



Working Model

6.2 CONCLUSION

The Solar-Based Insect Killer system successfully demonstrates the integration of renewable energy technology with practical pest control methods. The project highlights the effective use of a solar panel, battery management system,

LEDs, and simple electronics to create a reliable, cost-effective, and eco-friendly insect-killing device.

The design enhances sustainability by eliminating the need for chemical insect repellents, thereby reducing environmental pollution and human health hazards. The automatic LDR-based switching mechanism improves usability and ensures uninterrupted nighttime operation without manual intervention.

From the testing outcomes, the system proved capable of attracting and trapping a significant number of insects in a short duration, making it suitable for agricultural, residential, and commercial environments. The low maintenance requirements, portable structure, and secondary utility of USB charging add further value to the project.

Overall, the project fulfills its objective of providing an affordable, renewable-energy-driven solution to insect control, demonstrating strong potential for real-life implementation.

6.3 FUTURE SCOPE

The Solar-Based Insect Killer has significant potential for further improvements, advancements, and commercial expansion. The following future enhancements can be implemented:

1. Use of Higher Watt Solar Panel

Increasing solar panel wattage (20W or 30W) can improve charging efficiency and support more LEDs or additional features.

2. Integration of High-Efficiency LED Arrays

Super-bright UV LEDs or UV tubes can be added to increase insect attraction, especially for mosquitoes and moth species.

3. Smart Monitoring via IoT

Adding ESP8266/ESP32 modules can enable:

- Live battery status monitoring
- Trap count monitoring
- Remote ON/OFF control
- Daily performance reports

4. Automatic Cleaning Mechanism

A mechanical or motorized trap cleaning system can be introduced to reduce manual maintenance.

5. Rechargeable Water Pump for Soap Tray Refreshing

A small solar-powered pump can automatically maintain soap solution freshness.

6. Weatherproof Enclosure Upgrades

An IP65 or IP67-rated casing would allow stable performance in rain, dust, and extreme climates.

7. Larger Capacity Battery Pack

Increasing battery capacity can extend operation during cloudy days or low-sunlight seasons.

8. Use of Motion Sensors

PIR sensors can be used to detect insect activity and adjust LED brightness dynamically to save power.

9. Commercial Product Design

The model can be redesigned into a compact, aesthetically appealing unit suitable for:

- Home users
- Garden centers
- Resorts and hotels
- Agricultural markets

10. Hybrid Power Support

Apart from solar charging, AC charging or wind turbine integration can make the system functional during rainy or foggy seasons.

11. Insect Collection Analysis System

Sensor-based insect counting can help farmers analyze insect density for better crop management.

12. Biodegradable Fluid Traps

Future systems can use natural attractants or biodegradable fluids to enhance insect catch rate while being environmentally safe.

CHAPTER 7

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