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Solar Powered Remote Controlled Pesticide Sprayer

Dr. Sunil R. Patil
AISSMS College of Engineering
srpatil@aissmscoe.com

Prajwal P. More
AISSMS College of Engineering
moreprajwal53@gmail.com

Atharva P. Gore
AISSMS College of Engineering
atharvagore1354@gmail.com

Swapnil S. Kadam
AISSMS College of Engineering
Swapnil.s.kadam001@gmail.com

Rohan S. Ghodge
AISSMS College of Engineering
rohanghodge9898@gmail.com

1. Abstract

This paper presents the design and development of a solar-powered, remote-controlled pesticide sprayer aimed at reducing the physical strain and health risks associated with traditional manual spraying methods in agriculture. This system uses the sun's energy to power a motorized sprayer, which has been developed as an autonomous spraying system that is wirelessly controlled to optimize productivity and mitigate operator exposure to harmful chemicals. The system comprises a solar panel, battery, less than 1A Arduino microcontroller, a Bluetooth module, and a motorized sprayer. This paper describes the system's design considerations, component selection, calculations, and implementation of the initial phase.

Index Terms – Solar Power, Remote Control, Pesticide Sprayer, Agriculture, Arduino, Bluetooth Module, Mechanization, Sustainable Agriculture.

2. Introduction

Being a farmer is the main occupation for a sizeable quantity of the Indian population, of which 73% rely on agriculture [1]. Traditional farming reduces productivity in agriculture because of unreliable power supply, agricultural mechanization, and labour dependency. Spraying pesticides is one task that can be arduous [2]. Manual backpack sprayers cause operator fatigue, while hand sprayers need constant pressure that can strain the operators body, and harmful pesticides and chemicals can adversely affect farmers' health [3] .

This project proposes a solar powered, remote controlled pesticide sprayer to alleviate the burden on farmers. The main purpose of the project is to create an environmentally friendly and sustainable alternative that decreases labour costs, improves health safety, and increases efficiency and productivity in agricultural activities through a combination of solar power and remote-control technology that provides modern alternatives to manual spraying [4].

3. Literature Review

Modern pesticide spraying systems range from hand-powered to engine-powered and electric motorized systems. Hand-powered systems are cheap but cause excessive physical fatigue. Engine powered sprayers produce contaminates in noisy conditions. Electric motors are somewhere in between; however, they may be limited by the amount of public supply electricity needed [5].

Technology development has offered new mechanized, ergonomic and ecological sustainable spraying technologies to leverage the power of technology for moving forward with sustainable agriculture [6]. Solar powered technology is becoming an option because it provides independence and reduces costs. This project integrates solar energy and remote control and aims to provide a lightweight and simple design to reduce physical strain on farmers [7].

4. Problem Identification

The project addresses several key issues prevalent in Indian agriculture:

1. **Pest Damage:** Pests cause significant harm to crops, impacting yields and farmer livelihoods.
2. **Low Mechanization:** Small-scale farmers often lack access to and resources for advanced machinery.
3. **Unreliable Power Supply:** Rural areas frequently experience power outages, hindering the use of electric-powered equipment.
4. **Ergonomic Challenges:** Traditional sprayers impose physical strain and health risks on operators.

5. Objectives

The main objective of this project is to develop and implement a solar-powered pesticide sprayer. The sub-objectives include:

1. **Reduce Costs:** Lower operational and labor costs associated with pesticide application.
2. **Ensure Continuous Operation:** Enable year-round spraying operations, independent of grid electricity.
3. **Minimize Human Effort:** Reduce physical exertion through remote control functionality.

6. System Design and Components

The system comprises the following key components:

- **Solar Panel (12V, 20-50W):** Converts solar energy into electricity to charge the battery and power the system.
- **Battery (12V, 10Ah):** Stores solar energy to ensure continuous operation.
- **DC Motor (100 RPM):** Provides controlled movement and consistent spraying.
- **Microcontroller (Arduino Uno/Nano):** Acts as the central control unit for motor operation and wireless communication.
- **Wireless Control Module (HC-05 Bluetooth):** Enables remote control of the sprayer.
- **Motor Driver (L298N):** Controls the speed and direction of the DC motor.
- **Relay Module (5V):** Used for switching circuits.
- **DC-DC Buck Converter (LM2596S):** Regulates voltage levels within the system.
- **Water Tank (10 Liters):** Stores the pesticide solution.
- **Frame:** Provides structural support for the system.

6.1 Circuit Design

The circuit design integrates the solar panel, battery, microcontroller, motor driver, and wireless control module to enable automated and remote-controlled spraying. (See Figures 1 & 2)

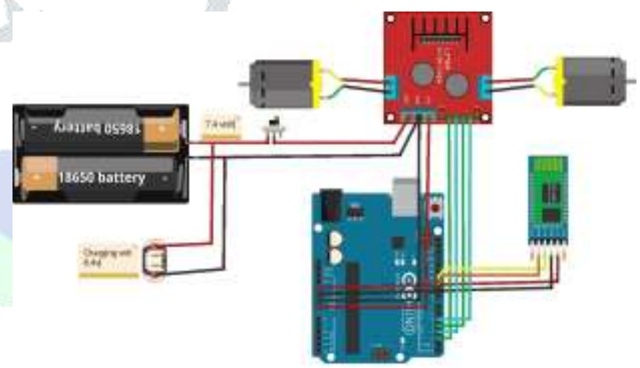

Figure 1: Initial Circuit Diagram

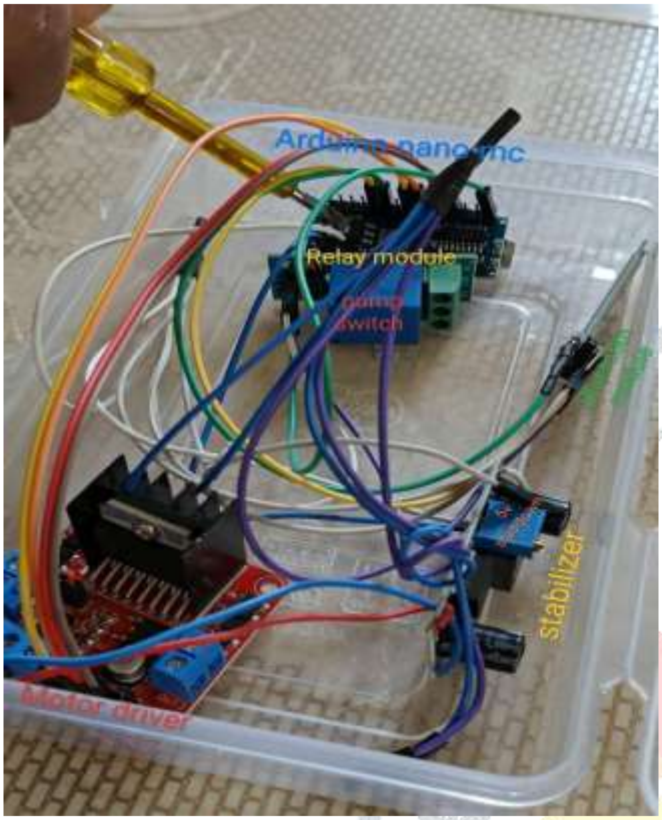

Figure 2: Completed Circuit

6.2 Frame Design

The frame provides the structural support for the entire pesticide sprayer system. To minimize the overall weight of the system, an H-type frame design was adopted. The H-frame offers a good balance between structural integrity and weight reduction compared to a solid or fully enclosed frame. The design strategically uses structural members to support the components while minimizing the amount of material used.

(a)

(b)

(c)

Figure 3: H-type frame design..

7. Working

The solar-powered, remote-controlled pesticide sprayer operates through a combination of solar energy conversion, electronic control, and mechanical spraying.

1. **Solar Energy Conversion and Storage:** The solar panel converts sunlight into electrical energy, which is used to charge the 12V battery. The battery stores the energy, providing a continuous power source for the system's operation, even in the absence of direct sunlight.
2. **Remote Control and Signal Processing:** The operator controls the sprayer wirelessly using a Bluetooth module (HC-05). The Arduino microcontroller receives the control signals from the Bluetooth module. These signals correspond to specific actions, such as moving forward, backward, turning, or activating/deactivating the spraying mechanism.
3. **Motor Control and Movement:** The Arduino microcontroller sends signals to the motor driver (L298N), which controls the speed and direction of the DC motors. The DC motors are mechanically linked to the wheels, enabling the sprayer to move in the desired direction. The code specifies the logic for forward, backward, left, and right movements by controlling the rotation of the motors.
4. **Spraying Mechanism:** The system includes a water tank that stores the pesticide solution. A pump, powered by the battery, is used to spray the pesticide through the spray nozzles. The activation of the pump is also controlled by the Arduino via a relay module.

8. Calculations

8.1 Motor Selection

The motor selection is critical to ensure sufficient torque to drive the system. A Johnson geared DC motor with the following specifications was chosen:

- Rated Speed: 60 rpm
- Stall Torque: 7 N-m

The required driving torque must exceed the frictional torque. The selected motor meets this requirement.

8.2 Battery and Solar Panel Sizing

- **Current Consumption:**
  - DC Motors (4 motors * 0.8A) = 3.2 A
  - Pump = 0.3 A
  - Arduino = 0.02 A
  - Total current draw = 3.2 A + 0.3 A + 0.02 A = 3.52 A
- **Battery Backup:**
  A 10 Ah battery is used, providing an estimated backup time of:
  - Battery Backup = Battery Capacity / Total Current Draw = 10 Ah / 3.52 A = 2.84 hours
- **Solar Panel Sizing:**
  - A 50W solar panel with a 12V output is used.
  - Current supplied by the solar panel: I = P / V = 50 W / 12 V = 4.16 A
- **Charging Time:** The time required to charge the 10Ah battery is:
  Charging Time = Battery Capacity / Current Supplied = 10 Ah / 4.16 A = 2.4 hours

9. CAD Model

The CAD model (Figure 4) illustrates the physical structure and arrangement of the components. The design was modified to reduce the weight of the system.

Figure 4: CAD Model

10. Components and Specifications

Table 1 provides a summary of the key components and their specifications.

Table 1: Components and Specifications

Sr. No.	Component	Specification	Function
1	Solar Panel	12V, 20-50W	Charges the battery and powers the system
2	DC Motor	12V, 100 RPM	Provides controlled movement for spraying
3	Arduino Uno/Nano	Microcontroller	Controls motor operation and wireless communication
4	Bluetooth Module (HC-05)	Wireless communication	Enables remote control of the sprayer
5	Battery	12V, 10Ah	Stores solar energy for continuous operation
6	Water Tank	10 Liters	Stores pesticide solution
7	Motor Driver (L298N)	Controls DC motor	Drives the DC motor
8	Relay Module	5V	Switching circuits
9	Frame	Mild Steel	Provides structural support
10	Pump	12V DC	Sprays Pesticide
11	Wheels	6 inch diameter, 2 inch width	Provides mobility to the system
12	Spray Nozzles	Adjustable nozzles	Controls the spray pattern and flow rate

			of the pesticide

11. Arduino Code

```
#include <SoftwareSerial.h>
SoftwareSerial BT(2, 3);


int motor_r2 = 5;
int motor_r1 = 6;

int motor_l2 = 8;
int motor_l1 = 9;

int state;
int speed = 130;

int viper = 11;
int og_555 = 12;

void setup(){


pinMode(motor_l1, OUTPUT);
pinMode(motor_l2, OUTPUT);
pinMode(motor_r1, OUTPUT);
pinMode(motor_r2, OUTPUT);

pinMode(viper, OUTPUT);
digitalWrite(viper, HIGH);
pinMode(og_555, OUTPUT);
digitalWrite(og_555, HIGH);

// initialize serial communication at 9600 bits per second:
Serial.begin(9600);
BT.begin(9600); // Setting the baud rate of Software Serial Library

 delay(1000);
 }

void loop(){
//if some date is sent, reads it and saves in state
if(BT.available() > 0){
state = BT.read();
Serial.println(state);
if(state > 15){speed = state;}
}

  // if the state is '1' the DC motor will go forward
   if (state == 1){forword();Serial.println("Forward!");}

// if the state is '2' the motor will Backword
else if (state == 2){backword();Serial.println("Backword!");}

// if the state is '3' the motor will turn left
else if (state == 3){turnLeft();Serial.println("Turn LEFT");}

// if the state is '4' the motor will turn right
else if (state == 4){turnRight();Serial.println("Turn RIGHT");}

// if the state is '5' the motor will Stop
else if (state == 5) {stop();Serial.println("STOP!");}

//else if (state == 6) {Serial.println("lift"); if(pos1<180){pos1 = pos1+1;}}
//else if (state == 7) {Serial.println("right"); if(pos1>0){pos1 = pos1-1;}}
else if (state == 8) {Serial.println("up");  digitalWrite(viper, LOW);  }
else if (state == 9) {Serial.println("down"); digitalWrite(viper, HIGH);}

else if (state == 10){Serial.println("pump on");digitalWrite(og_555, LOW);}
else if (state == 11){Serial.println("pump off");digitalWrite(og_555, HIGH);}


delay(30);
}



void stop(){
   digitalWrite(motor_l1, LOW);
   digitalWrite(motor_l2, LOW);
   digitalWrite(motor_r1, LOW);
   digitalWrite(motor_r2, LOW);

}

void forword(){
   digitalWrite(motor_l1, LOW);
   digitalWrite(motor_l2, HIGH);
   digitalWrite(motor_r1, HIGH);
   digitalWrite(motor_r2, LOW);
}

void backword(){
   digitalWrite(motor_l1, HIGH);
   digitalWrite(motor_l2, LOW);
```

```
    digitalWrite(motor_r1, LOW);
    digitalWrite(motor_r2, HIGH);
}


void turnRight(){
      digitalWrite(motor_l1, HIGH);
    digitalWrite(motor_l2, LOW);
    digitalWrite(motor_r1, HIGH);
    digitalWrite(motor_r2, LOW);
}

void turnLeft(){
digitalWrite(motor_l1, LOW);
    digitalWrite(motor_l2, HIGH);
    digitalWrite(motor_r1, LOW);
    digitalWrite(motor_r2, HIGH);

}
```

12. Block Diagram

The block diagram (Figure 5) illustrates the functional relationships between the system's components.

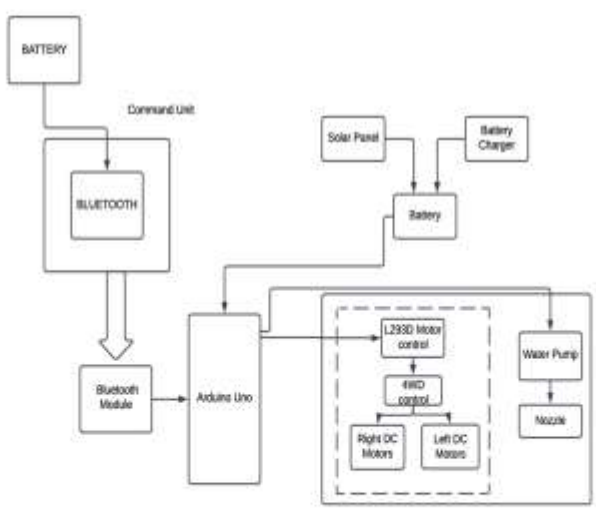

Figure 5: Block Diagram

13. Final model

The Final model (Figure 6) illustrates the physical structure and arrangement of the components

(a)

(b)

Figure 6: Physical structure

14. Applications

The solar-powered pesticide sprayer has diverse applications:

- Agriculture
- Greenhouses
- Sanitization
- Commercial settings
- Public parks and gardens

15. Conclusion

The development of a solar-powered, remote-controlled pesticide sprayer offers a promising solution to address the challenges associated with traditional spraying methods. By reducing physical strain, minimizing health risks, and improving efficiency, this technology can contribute to more sustainable and productive agricultural practices. The project's progress demonstrates the feasibility of the design, and the planned next steps will lead to a fully functional and deployable system.

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