Department of Electronic and Telecommunication Engineering

University of Moratuwa

EN2160 – Electronic Design Realization

Final Report – Smart Dustbin

Name: Kavinda W.M.C.

Index Number: 200301D

25th of July 2023

Table of Contents

Abstract

The Smart Dustbin project introduces an innovative waste management solution designed to enhance convenience, hygiene, and sustainability. This project focuses on creating a dustbin with automatic opening and a level sensor, revolutionizing the traditional waste disposal process. By incorporating ultrasonic sensor technology, the smart dustbin can detect proximity and trigger the lid to open automatically when someone approaches, reducing physical contact and promoting sanitation. Additionally, the bin utilizes a level sensor to continually monitor the garbage level and indicate to the user when it approaches full capacity, preventing overfilling. This report presents the development and features of the smart dustbin, highlighting its contributions to a cleaner and healthier environment while making waste disposal an efficient and hands-free experience.

Introduction

In a world increasingly focused on sustainability and improved quality of life, waste management emerges as a crucial challenge. Traditional waste disposal methods and conventional dustbins have long served their purpose, but they lack the efficiency and convenience required for modern living. To address this need, the Smart Dustbin project introduces an innovative solution that elevates waste management to new heights.

The primary goal of this project is to develop a smart dustbin that offers a hands-free, hygienic, and sustainable approach to waste disposal. By incorporating advanced sensor technology, the smart dustbin opens automatically when a user approaches, reducing physical contact and minimizing the risk of contamination. An ultrasonic sensor serves as the key element for detecting proximity and triggering the lid's smooth and gradual opening.

Furthermore, the smart dustbin boasts a level sensor that constantly monitors the garbage fill level with remarkable accuracy and reliability. LED indicators change color as the garbage level increases, providing users with a visual cue for timely waste disposal and preventing overfilling.

This report delves into the design, development, and features of the smart dustbin, highlighting its potential to transform waste management practices. By promoting touchless interaction, reducing waste overflow, and encouraging responsible waste disposal habits, the smart dustbin takes a significant step toward a cleaner, healthier, and more sustainable future.

1. Product Description and Specifications

The Smart Dustbin is a revolutionary waste management solution designed to offer convenience, hygiene, and sustainability in disposing of garbage. This innovative dustbin incorporates advanced sensor technology to create a touchless and efficient waste disposal experience. It is constructed using plastic material, ensuring durability and longevity. The smart dustbin has a compact size, measuring 20cm x 15cm x 35cm, and features a capacity of 10 liters, making it suitable for home use and other settings with frequent waste generation.

1.1. Specifications

- Material: HDPE (High-density polyethylene)
- Size: 20cm x 15cm x 35cm
- Capacity: 10 liters
- Shape: Square Dustbin
- Color: Blue, green, and yellow
- Power Source: 5V 1A power adapter

1.2. Key Features

- **Automatic Opening Mechanism**: The Smart Dustbin is equipped with an ultrasonic sensor that detects the presence of a person near the bin. When someone approaches, the sensor triggers the automatic lid opening mechanism, allowing for a hands-free waste disposal experience. This feature minimizes physical contact with the dustbin, promoting hygiene and sanitation.
- **Level Sensor with LED Indicators**: The dustbin is integrated with a level sensor that employs ultrasonic technology to continuously measure the garbage fill level. LED indicators on the dustbin's exterior change colors as the garbage level increases. The LED lights switch from green to yellow and eventually red, providing a visual cue to the user about the current fill level. This real-time monitoring prevents overfilling and helps users know when it's time to empty the dustbin.
- **Smooth and Gradual Lid Closure**: The lid of the smart dustbin is designed to open smoothly and close gradually. This ensures user safety during operation and prevents any abrupt lid movements.
- **Manual Override Feature**: While the smart dustbin offers automatic opening, it also includes a manual override feature. Users can open the lid manually, providing flexibility and control when needed.
- **Application**: The Smart Dustbin is ideal for both household and public use. In homes, it provides a convenient and hygienic solution for waste disposal, especially in kitchens and common areas. In public places such as offices, shopping centers, and parks, the smart dustbin ensures a touchless and efficient waste management system for many users.

2. Implementation

2.1. Component Selection

To bring the Smart Dustbin project to life, specific components were carefully chosen based on their performance, compatibility, and cost-effectiveness. The selected components are as follows

1. Ultrasonic Sensor (HC-SR04):

The HC-SR04 Ultrasonic sensor is utilized as the primary component for both the automatic opening mechanism and the level sensor. It accurately detects the distance between the sensor and an object by measuring the time taken for sound waves to bounce back. This information is crucial for triggering the lid's automatic opening when someone approaches the dustbin and for monitoring the garbage fill level inside the bin.

2. Microcontroller Unit (MCU) - ATmega328P:

The ATmega328P microcontroller unit serves as the brain of the smart dustbin. It receives and processes data from the ultrasonic sensors, controls the actuator for the lid mechanism, and manages the LED indicators based on the garbage fill level. The ATmega328P was chosen for its versatility, performance, and compatibility with the selected components.

3. LED Indicators - One RGB LED:

A single RGB (Red, Green, Blue) LED is chosen as the indicator for the garbage fill level. By controlling the intensity of the three colors, the LED can display various colors, each corresponding to a different fill level. Green indicates a low fill level, yellow indicates a medium fill level, and red indicates a high fill level, prompting users to empty the bin.

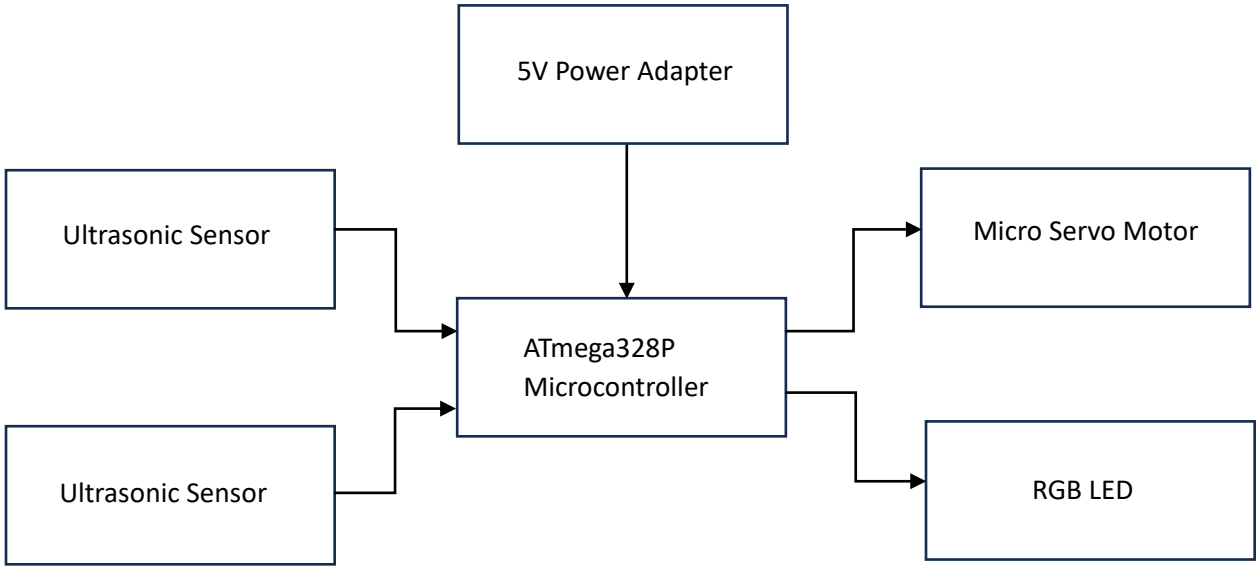
4. Actuator - SG90 9g Micro Servo Motor:

The SG90 9g Micro Servo Motor is the actuator responsible for opening and closing the dustbin lid. When triggered by the MCU, the servo motor rotates to lift the lid, providing a smooth and gradual opening. The servo motor is suitable for this application due to its compact size, precise control, and sufficient torque to handle the lid's weight.

5. Power Supply Unit:

To power the smart dustbin and its components, a 5V 1A power adapter has been chosen. This power supply unit provides stable voltage and sufficient current to ensure the proper operation of all the selected components without any performance issues.

2.2. Block Diagram



2.3. Schematic Design

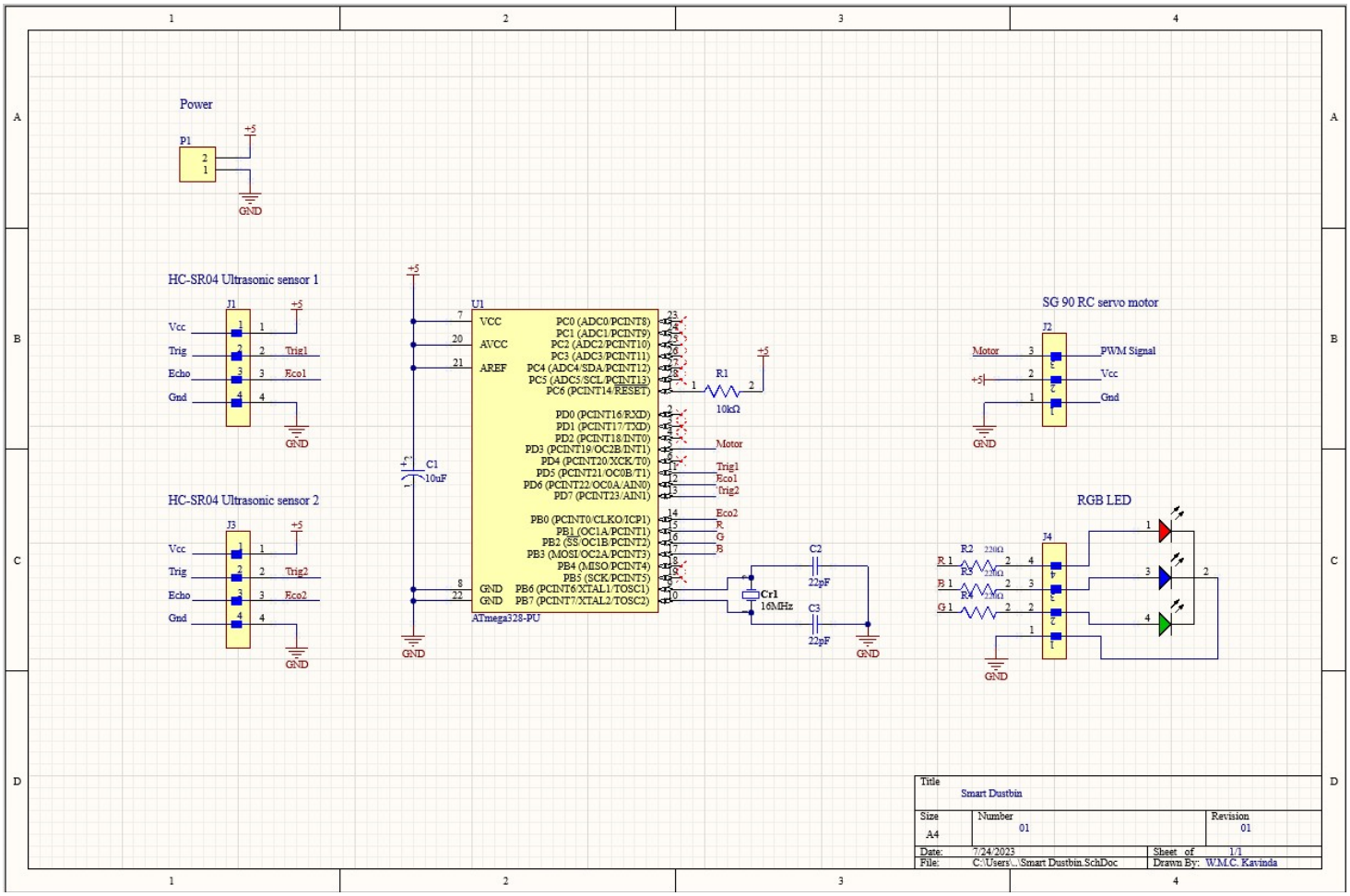


Figure 1: Schematic Design

2.4. PCB Design

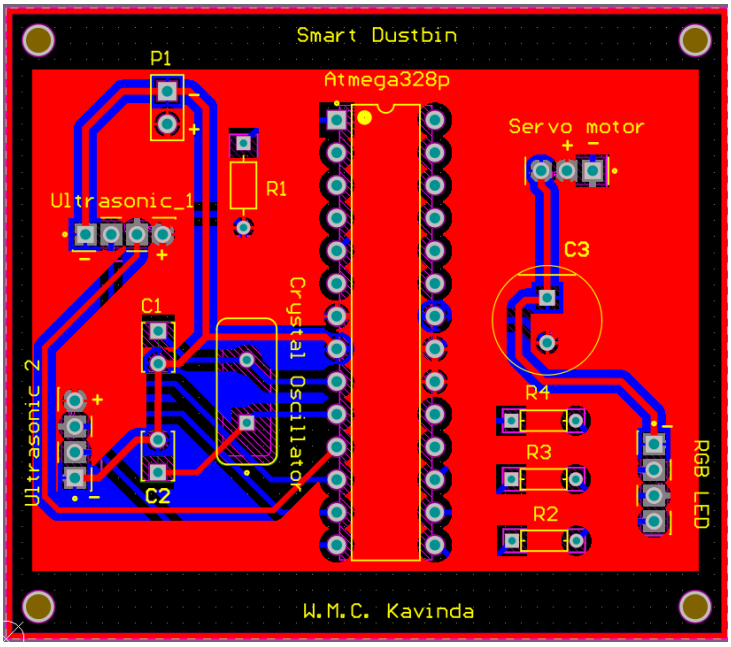


Figure 2: PCB Design

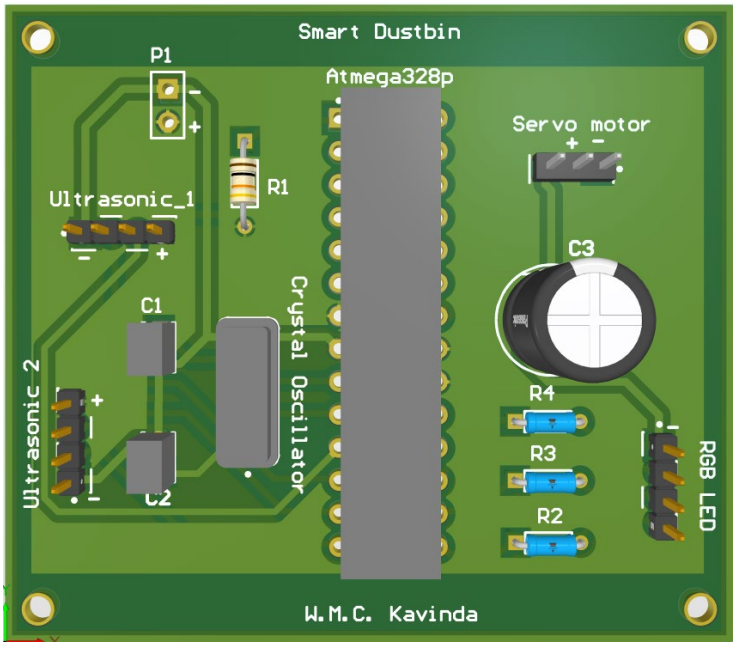


Figure 3: PCB 3D view

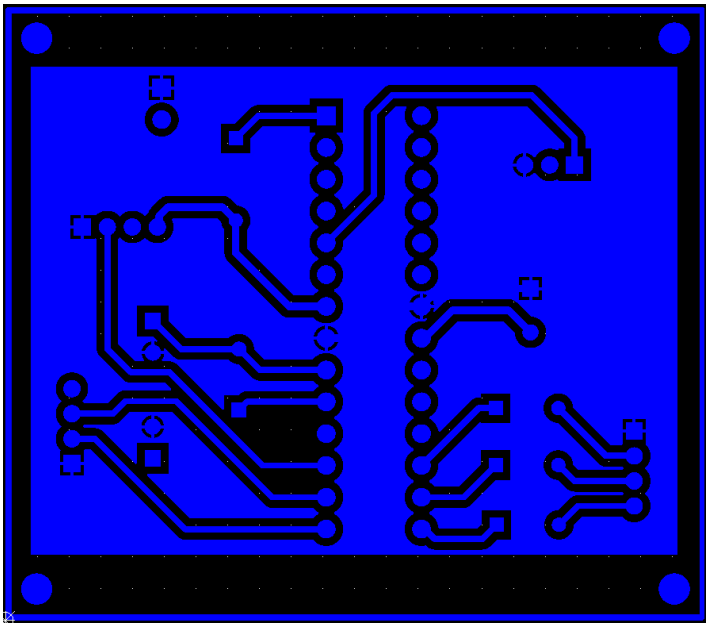


Figure 4: PCB Bottom layer

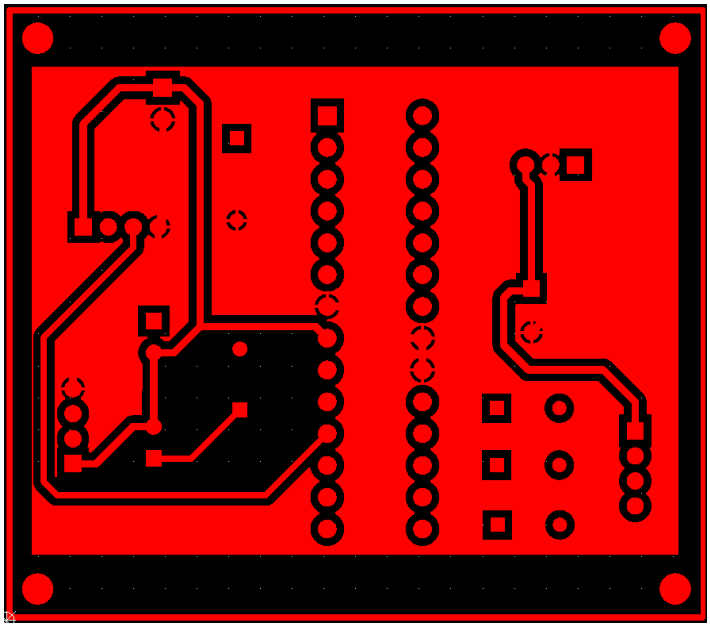


Figure 5: PCB Top layer

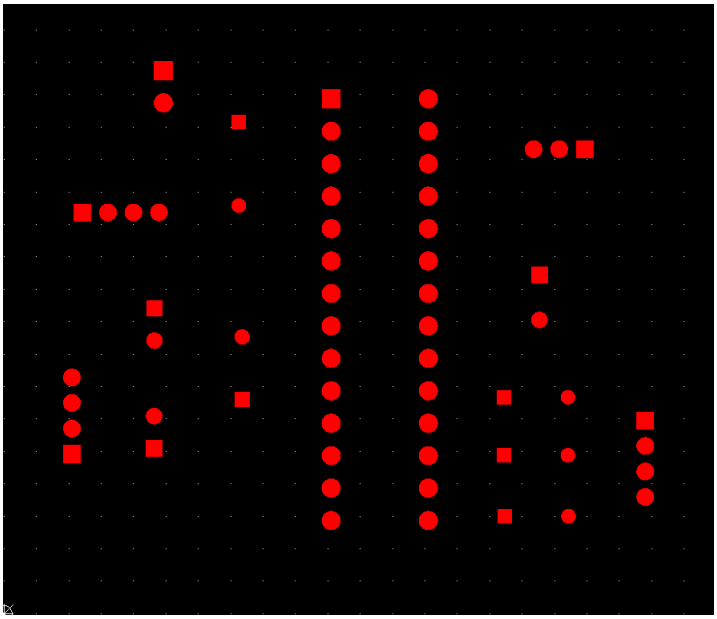


Figure 6: Pads bottom

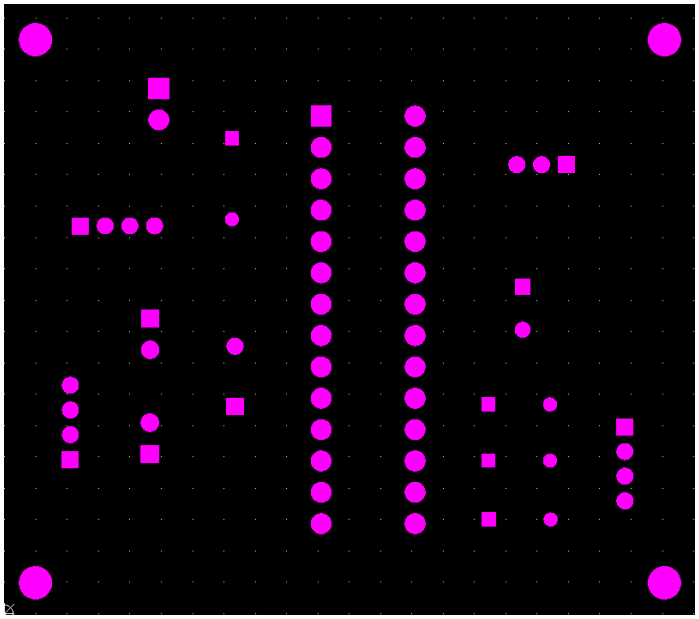


Figure 7: Solder mask bottom

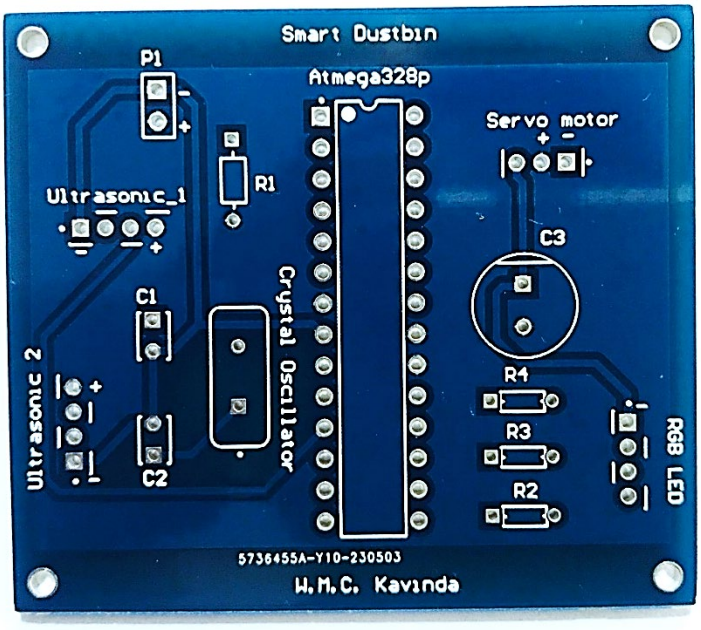


Figure 8: Printed Circuit Board top view

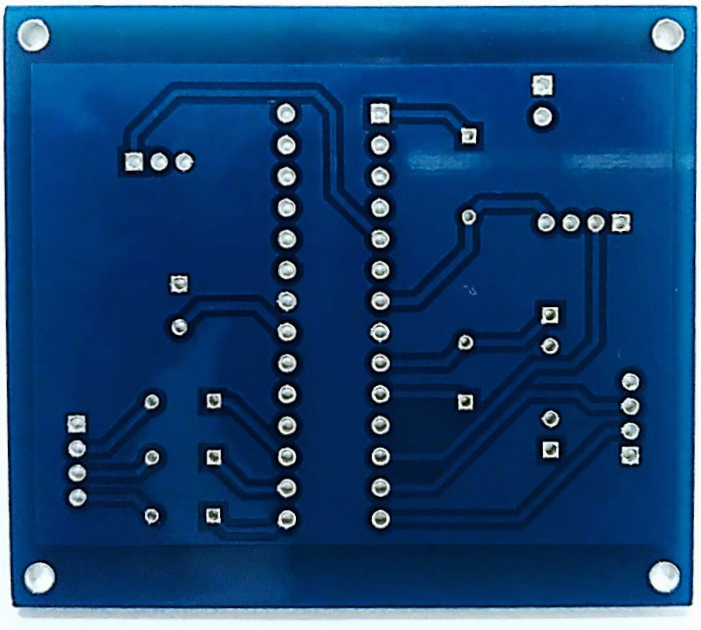


Figure 9: Printed Circuit Board bottom view

2.5. Enclosure Design

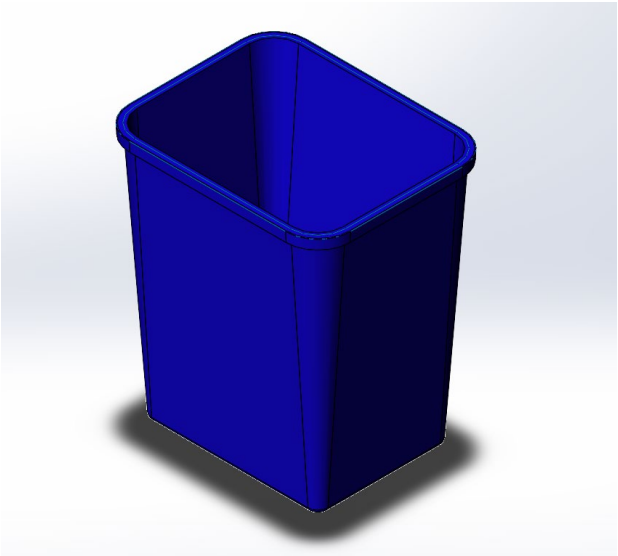


Figure 10: Dustbin Body

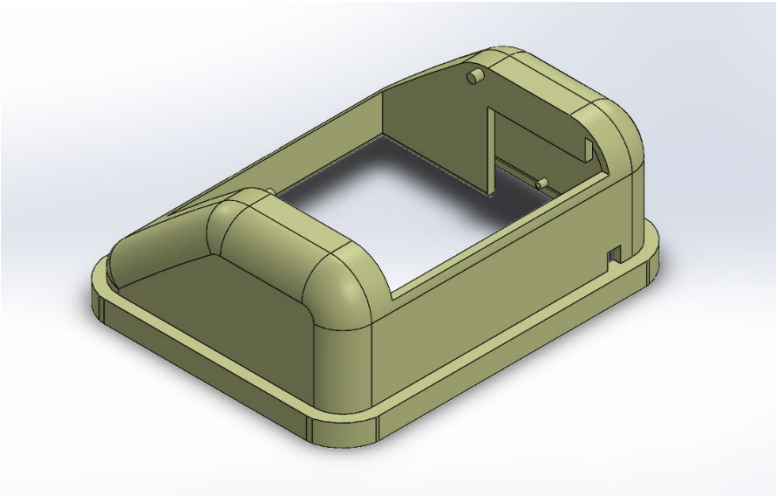


Figure 11: Dustbin Lid part 1

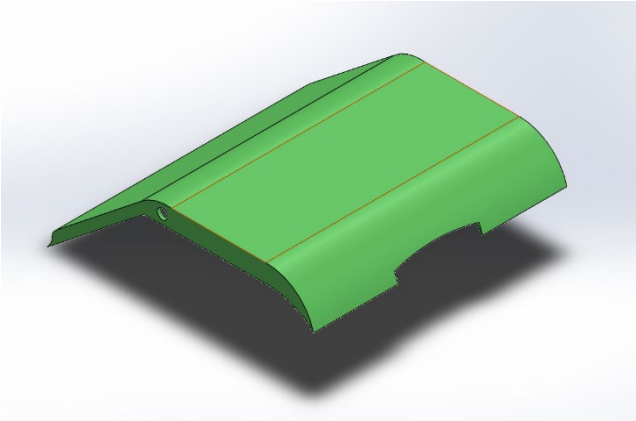


Figure 12: Dustbin Lid part 2

Figure 13: Assembly Front View

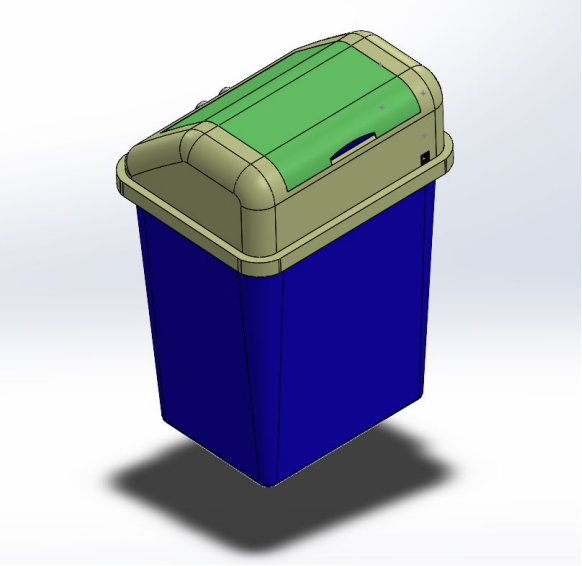


Figure 14: Assembly Bottom View

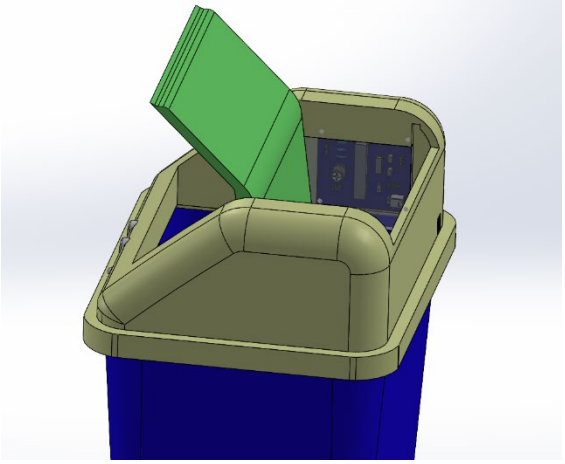


Figure 15: Assembly Top View

2.6. Software Implementation

```
#include <Servo.h>

// constants won't change
const int TRIG_PIN1 = 7;  // Arduino pin connected to Ultrasonic Sensor's TRIG pin
const int ECHO_PIN1 = 8;  // Arduino pin connected to Ultrasonic Sensor's ECHO pin
const int TRIG_PIN2 = 5;  // Arduino pin connected to Ultrasonic Sensor's TRIG pin
const int ECHO_PIN2 = 6;  // Arduino pin connected to Ultrasonic Sensor's ECHO pin
const int SERVO_PIN = 3;  // Arduino pin connected to Servo Motor's pin
const int DISTANCE_THRESHOLD = 20; // centimeters

Servo servo; // create servo object to control a servo

// variables will change:
float duration_1, distance_1;
float duration_2, distance_2;
int red_LED = 10;
int green_LED = 11;
int blue_LED = 9;

void setup() {
    Serial.begin(9600);       // initialize serial port
    pinMode(TRIG_PIN1, OUTPUT); // set arduino pin to output mode
    pinMode(ECHO_PIN1, INPUT);  // set arduino pin to input mode
    pinMode(TRIG_PIN2, OUTPUT); // set arduino pin to output mode
    pinMode(ECHO_PIN2, INPUT);  // set arduino pin to input mode
    pinMode(red_LED, OUTPUT);
    pinMode(green_LED, OUTPUT);
    pinMode(blue_LED, OUTPUT);
    servo.attach(SERVO_PIN);   // attaches the servo on pin 9 to the servo object
    servo.write(0);
    analogWrite(red_LED, 0);
    analogWrite(green_LED, 255);
    analogWrite(blue_LED, 0);
}

void loop() {
    // generate 10-microsecond pulse to TRIG pin
    digitalWrite(TRIG_PIN1, HIGH);
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN1, LOW);

    duration_1 = pulseIn(ECHO_PIN1, HIGH);
    // calculate the distance
    distance_1 = 0.017 * duration_1;

    digitalWrite(TRIG_PIN2, HIGH);
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN2, LOW);

    duration_2 = pulseIn(ECHO_PIN2, HIGH);
    // calculate the distance
    distance_2 = 0.017 * duration_2;

    if (distance_1 < DISTANCE_THRESHOLD) {
        servo.write(90); // rotate servo motor to 90 degree
```

```
            analogWrite(red_LED, 0);
            analogWrite(green_LED, 0);
            analogWrite(blue_LED, 255);
            delay(3000);
        }
        else {
            servo.write(0);  // rotate servo motor to 0 degree
            if (distance_2 < 10) {
                analogWrite(red_LED, 255);
                analogWrite(green_LED, 0);
                analogWrite(blue_LED, 0);
            }
            else if (distance_2 < 20) {
                analogWrite(red_LED, 255);
                analogWrite(green_LED, 200);
                analogWrite(blue_LED, 0);
            }
            else {
                analogWrite(green_LED, 255);
                analogWrite(red_LED, 0);
                analogWrite(blue_LED, 0);
            }
        }
        delay(300);
    }
```

3. Instructions for Assembly

Assembling the Smart Dustbin requires careful handling of the components and systematic integration of the circuit. Follow the step-by-step instructions below to ensure a successful assembly.

Step 1: Gather Components

Gather all the necessary components for the smart dustbin assembly, including the Smart Dustbin enclosure, PCB with soldered MCU (ATmega328P) and other supporting components, two HCSR04 Ultrasonic Sensors, RGB LED, SG90 9g Micro Servo Motor, wires, and the 5V 1A power adapter.

Step 2: Prepare the PCB

Ensure that the MCU (ATmega328P) is properly soldered onto the PCB board, with all necessary supporting components like capacitors and resistors in place.

Step 3: Connect the Ultrasonic Sensors

Mount the HC-SR04 Ultrasonic Sensors inside the Smart Dustbin enclosure at an appropriate position for detecting proximity. Connect the ultrasonic sensor's wires (VCC, GND, Trig, and Echo) to the corresponding pins on the MCU board. Use wires for this purpose.

Step 4: Connect the RGB LED

Place the RGB LED inside the Smart Dustbin enclosure at a visible location. Connect the RGB LED's wires (R, G, and B pins) to the three 220Ω resistors on the PCB board to limit the current flow, and then connect the resistors to the corresponding digital output pins on the MCU board using wires.

Step 5: Connect the Servo Motor

Mount the SG90 9g Micro Servo Motor inside the Smart Dustbin enclosure in such a way that it can open and close the lid effectively. Connect the servo motor's wires (VCC, GND, and Signal) to the corresponding pins on the MCU board. Use wires for this connection.

Step 6: Power Supply

Connect the 5V 1A power adapter to the power input of the PCB board.

Step 7: Test the Smart Dustbin

Power up the smart dustbin by plugging in the 5V 1A power adapter. Test the functionality of the smart dustbin,

- Approach the dustbin, and the ultrasonic sensor should trigger the servo motor to open the lid automatically.
- The RGB LED should display different colors based on the garbage fill level (green for low, yellow for medium, and red for high).

Step 8: Assemble the Enclosure

Once the functionality testing is successful, securely attach the Smart Dustbin enclosure to the PCB board with all components inside. Ensure all wires and connections are properly managed to avoid any interference or damage.

By following these assembly steps, you will have successfully created the Smart Dustbin with an automatic opening mechanism and a level sensor. The soldered MCU and resistors on the PCB ensure a neat and compact design, making the dustbin both efficient and user-friendly.

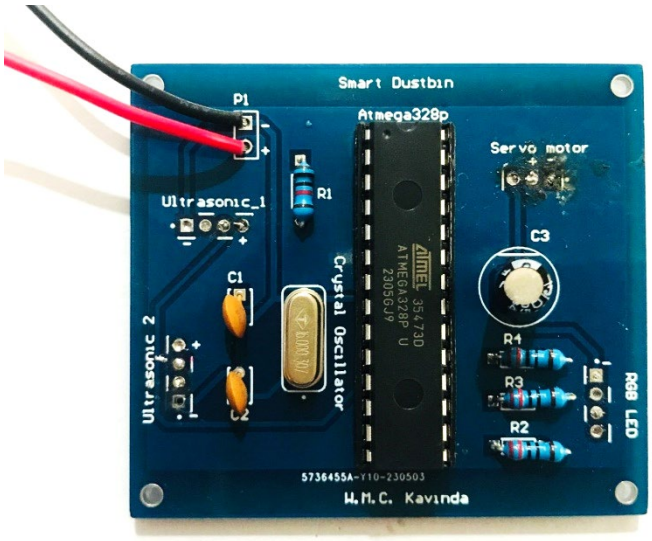


Figure 16: Soldered PCB

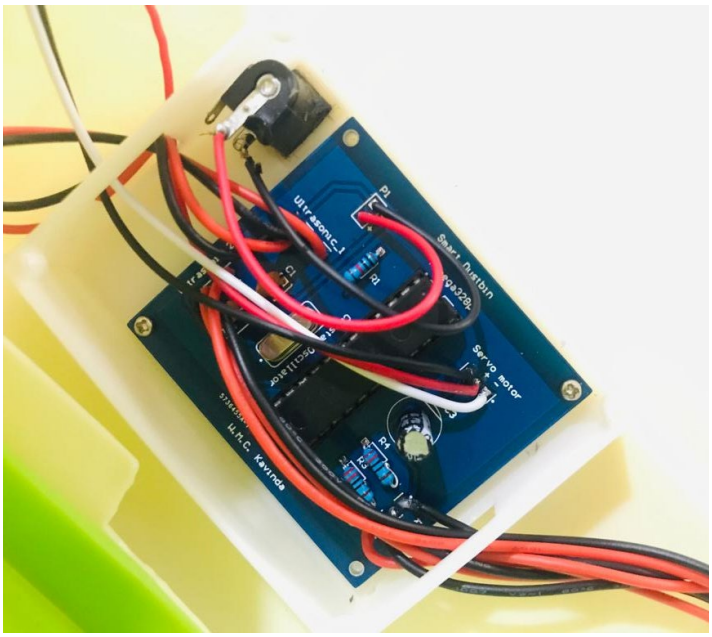


Figure 17: Mounted PCB

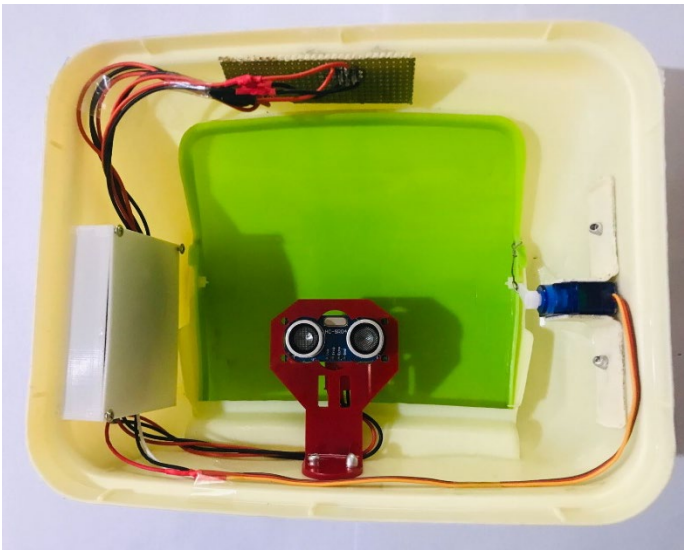


Figure 18: Mounted all components.

Figure 19: Final product

4. Testing the Product Functionality

To test the functionality of the Smart Dustbin, follow these steps.

Step 1: Power On
Connect the 5V 1A power adapter to the power input of the PCB board.
Power on the Smart Dustbin by plugging in the power adapter.

Step 2: Automatic Lid Opening
Approach the Smart Dustbin closely, ensuring that the Ultrasonic Sensor can detect your presence.
The Ultrasonic Sensor should trigger the Servo Motor, causing the lid to open automatically.
Verify that the lid opens smoothly and gradually in response to your proximity.

Step 3: Lid Closing
Once you have tested the automatic lid opening and manual override, ensure that the lid closes smoothly and securely.
Test the responsiveness of the lid closing action, ensuring it does not close too quickly or forcefully.

Step 4: Garbage Fill Level Indication
Observe the RGB LED indicators on the Smart Dustbin enclosure.
The LED should display a green light when the garbage fill level is low, indicating sufficient capacity.
As you gradually add garbage or block the Ultrasonic Sensor's path, the LED should change to yellow and then red as the garbage level increases.

Step 5: Repeat Testing
Repeat the above steps multiple times to ensure consistent and reliable functionality.
Pay attention to any anomalies, such as incorrect LED indications or lid malfunction.

By performing these functionality tests, you can ensure that the Smart Dustbin operates smoothly, providing an efficient, hygienic, and user-friendly waste management experience. If any issues or inconsistencies are detected during testing, carefully review the circuit connections and programming to rectify the problems. Once the Smart Dustbin passes all tests successfully, it is ready for use and can offer a seamless solution for waste disposal in your home or public spaces.

5. Bill of Materials

5.1. Foreign Market

Item	Manufacture	Supplier	Unit price (US$)	Qty.	Total amount (US$)
ATMEGA328P-PU	Microchip Tech	LCSC	4.25	1	4.25
28 pin IC socket	ZHOURI	LCSC	0.0442	1	0.0442
16MHz crystal oscillator	TAITIEN Elec	LCSC	0.1	1	0.1
10 uF 50V capacitor	Nantong Jianghai	LCSC	0.038	1	0.038
22 pF capacitor	Dersonic	LCSC	0.0095	2	0.019
10kΩ 250mW resistor	TyoHM	LCSC	0.0088	1	0.0088
220Ω 250mW resistor	TyoHM	LCSC	0.0086	3	0.0258
RGB 5mm LED	TOGIALED	LCSC	0.1319	1	0.1319
PCB	JLCPCB	JLCPCB	0.8	1	0.8
Shipping cost + tax					6.5
Total cost					**11.92**

5.2. Local Market

Item	Supplier	Unit price (Rs)	Qty.	Total amount (Rs)
HC-SR04 Ultrasonic Sensor	Tronic.lk	300	2	600
Micro Servo Motor SG90	Tronic.lk	410	1	410
5V 1A SMPS Power Adapter	Tronic.lk	500	1	500
Connectors & wires	Tronic.lk	-	-	250
Enclosure for PCB	Xydder	900	1	900
Dustbin	Arpico	850	1	850
Total cost				**3510**

Total cost (Rs) = 3960.23 + 3510.00

= 7470.23

6. Future Developments

As technology and innovation continue to advance, the Smart Dustbin can undergo further developments to enhance its capabilities and address emerging needs in waste management. Some potential future developments for the Smart Dustbin include:

1. Internet of Things (IoT) Integration:
Integrating the Smart Dustbin with IoT technology could enable remote monitoring and control. Users can receive real-time notifications about the garbage fill level, lid status, and even schedule waste collection services automatically when the bin reaches a certain capacity.

2. Smart Sorting and Recycling:
Future iterations of the Smart Dustbin could incorporate smart sorting mechanisms that use artificial intelligence (AI) to identify recyclable materials. It could separate recyclable waste from non-recyclable waste, making recycling more efficient and reducing the environmental impact.

3. Solar-Powered Operation:
Implementing solar panels on the Smart Dustbin could enable it to harness renewable energy, reducing its dependency on the electrical grid and making it more sustainable and eco-friendlier.

4. Collaborative Waste Management System:
Smart Dustbins could be connected in a network, forming a collaborative waste management system. They can share data about waste levels, collection schedules, and optimize waste collection routes, leading to more efficient waste management practices.

5. Smart Waste Composting:
Integrating composting features into the Smart Dustbin could facilitate the conversion of organic waste into nutrient-rich compost, promoting sustainable waste management practices.

As technology evolves and societal awareness about waste management increases, the Smart Dustbin has the potential to evolve into a comprehensive waste management solution, contributing to a cleaner and more sustainable future.

7. Acknowledgment

I would like to express my heartfelt gratitude to all those who contributed to the successful completion of the Smart Dustbin project and the preparation of this project report. Special thanks to my project supervisors Prof. J.A.K.S. Jayasinghe and Dr. Jayathu Samarawickrama for their valuable guidance and support. I am also thankful to my friends for their collaboration and dedication. Lastly, I am grateful to my family for their unwavering encouragement throughout this endeavor. Your contributions have been invaluable, and I am truly grateful for your assistance.

8. References

ATmega328P - https://datasheet.lcsc.com/lcsc/Microchip-Tech-ATMEGA328P-PU.pdf

HC-SR04 Ultrasonic sensor - https://datasheetspdf.com/pdf-file/1380136/ETC/HC-SR04/1

SG90 Micro Servo motor - https://datasheetspdf.com/pdf-file/791970/TowerPro/SG90/1

RGB LED - https://datasheet.lcsc.com/lcsc/1912111437_TOGIALED-TJ-L5FYTXHTCYLCRGB.pdf

PCB Design - From Zero to PCB | using Altium Designer - YouTube

9. Appendix (User Manual)

9.1. Introduction

Thank you for choosing the Smart Dustbin, an innovative waste management solution that brings convenience, hygiene, and sustainability to your daily life. This user manual provides essential information on how to use and maintain your Smart Dustbin effectively. Please read this manual carefully before operating the product.

9.2. Product Overview

The Smart Dustbin is equipped with an automatic opening mechanism triggered by an ultrasonic sensor and a level sensor to monitor the garbage fill level continuously. The key features of the Smart Dustbin include:

Automatic Opening: The lid opens automatically when someone approaches the dustbin, reducing the need for physical contact and promoting hygiene.

Level Sensor: The Smart Dustbin employs a level sensor that continuously monitors the garbage fill level. LED indicators change color (green, yellow, and red) based on the fill level, indicating when it's time to empty the bin.

9.3. Operating Instructions

9.3.1. Automatic Lid Opening

- Approach the Smart Dustbin closely, within the detection range of the ultrasonic sensor.
- The lid will open automatically, allowing you to dispose of garbage without touching the dustbin.

9.3.2. Garbage Fill Level Indication

- Observe the LED indicators on the Smart Dustbin enclosure.
- Green Light: Indicates a low garbage fill level, implying sufficient capacity.
- Yellow Light: Indicates a medium garbage fill level, reminding you that the dustbin will need emptying soon.
- Red Light: Indicates a high garbage fill level, prompting you to empty the dustbin immediately.

9.4. Maintenance

9.4.1. Cleaning

- Regularly clean the Smart Dustbin's exterior with a mild detergent and a soft cloth.
- Ensure to clean the inner bucket regularly to maintain hygiene.

9.4.2. Garbage Disposal

- When the garbage fill level reaches the red LED indication, empty the dustbin promptly to prevent overflow.
- Use standard garbage bags or liners inside the inner bucket for easy disposal.

9.5. Safety Precautions

- Do not disassemble or modify the Smart Dustbin, as it may damage the product and void the warranty.
- Keep the Smart Dustbin away from water, moisture, and extreme heat sources.
- Avoid overloading the dustbin with excessively heavy or bulky items.

9.6. Troubleshooting

In case of any issues or concerns with the Smart Dustbin's functionality, refer to the troubleshooting section in this manual or contact our customer support for assistance.

9.7. Warranty and Support

The Smart Dustbin comes with a limited warranty period. For warranty details and customer support, refer to the warranty card provided with the product.

9.8. Conclusion

The Smart Dustbin is designed to provide a convenient, hygienic, and sustainable waste management solution. By following this user manual and taking proper care of the product, you can enjoy an efficient and pleasant waste disposal experience. Thank you for choosing the Smart Dustbin, and we hope it enhances your daily life while contributing to a cleaner and healthier environment.