1. Introduction

This document describes the hardware interconnections between the ESP32 microcontroller and the sensing/actuation components used in the Smart Waste Bin system. The connections are designed to support fill-level monitoring, object detection, waste classification, and bin lid actuation.

The hardware configuration was validated using Wokwi simulation and follows ESP32 GPIO best practices.

2. Hardware Components Used

- ESP32 Dev Module
- Ultrasonic Distance Sensor (HC-SR04)
- PIR Motion Sensor
- Potentiometer (used as moisture sensor simulation)
- Servo Motor (Dry Waste Bin)
- Servo Motor (Wet Waste Bin)

3. ESP32 Pin Overview

Pin Type	Description
GPIO	Digital input/output pins
ADC	Analog input pins
PWM	Servo motor control
3.3V / 5V	Power supply
GND	Common ground

4. Ultrasonic Sensor (HC-SR04) Connections

Purpose: Measure the fill level of the waste bin.

HC-SR04 Pin	ESP32 Pin	Description
VCC	3.3V	Power supply
GND	GND	Ground
TRIG	GPIO 5	Trigger pulse
ECHO	GPIO 18	Echo response

Working:
Distance is calculated based on echo time and converted into bin fill percentage using calibrated bin depth.

5. PIR Motion Sensor Connections

Purpose: Detect object presence near bin opening.

PIR Pin	ESP32 Pin	Description
VCC	5V	Power supply
GND	GND	Ground
OUT	GPIO 26	Motion detection signal

Working:
When motion is detected, the ESP32 enables waste classification logic.

6. Potentiometer (Moisture Simulation) Connections

Purpose: Simulate moisture level for DRY/WET waste classification.

Potentiometer Pin	ESP32 Pin	Description
VCC	3.3V	Power supply
GND	GND	Ground
SIG	GPIO 15 (ADC)	Analog moisture value

ADC Range: 0 – 4095
Threshold: ~2000 (configurable)

7. Servo Motor – Dry Waste Bin

Purpose: Open and close the dry waste bin lid.

Servo Pin	ESP32 Pin	Description
VCC	5V	Power supply
GND	GND	Ground
PWM	GPIO 14	Control signal

8. Servo Motor – Wet Waste Bin

Purpose: Open and close the wet waste bin lid.

Servo Pin	ESP32 Pin	Description
VCC	5V	Power supply
GND	GND	Ground
PWM	GPIO 27	Control signal

9. Power & Grounding Notes

- All GND pins are connected to a common ground.
- Servo motors require higher current; in real deployments, an external power source is recommended.
- ESP32 operates at 3.3V logic levels.

10. Simulation Note

In the Wokwi simulation environment:

- Potentiometer replaces an actual moisture sensor.
- Servo motors represent bin lid movement.
- Network communication is simulated via MQTT over Wi-Fi.

11. Summary

This sensor connection configuration ensures reliable sensing, correct waste classification, and actuator control. The modular design allows easy replacement of simulated components with real sensors in physical deployment.