# Smart Garbage Fill Level Using an Ultrasonic Sensor

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***Abstract*—The Smart Garbage Monitoring System is an innovative solution designed to automate and enhance waste management processes. By integrating modern sensors and microcontroller technology, the system monitors the status of garbage bins in real- time and provides data such as: Gas emissions using a gas sensor (e.g., MQ-135) to detect harmful gases from decaying waste Tampering or movement using a vibration sensor Status display on an I2C LCD screen The core of the system is the ESP32 microcontroller, which processes sensor data and can optionally transmit it wirelessly to a central server or mobile app for further action. This helps city corporations, waste management companies, and communities to optimize garbage collection schedules, reduce fuel usage, and promote a cleaner, smarter environment.**

***Index Terms*—the ESP32 microcontroller, an I2C LCD screen, central server, reduce fuel usage.**

## I. INTRODUCTION

The significance of effective waste management and the requirement for real-time garbage bin monitoring would normally be the first points made in an introduction to a project on garbage fill level monitoring utilizing an ultrasonic sensor. The idea of employing ultrasonic sensors to gauge the amount of waste in bins would then be presented, along with an explanation of how these sensors operate by sending out and receiving sound waves to gauge the distance to the trash.

## II. PROJECT OBJECTIVES

1.Automate Garbage Monitoring:

- To design a system that continuously monitors the fill level of garbage bins using an ultrasonic sensor.

2.Enhance Hygiene and Safety:

- To detect the presence of harmful gases using a gas sensor, thereby preventing health hazards caused by decomposing waste.

3.Detect Tampering or Misuse:

- To identify any unauthorized movement or tampering of bins using a vibration sensor.

4.Real-Time Status Display:

- To display the status of the bin (e.g., full/empty, gas level, vibrations) on an LCD screen for local monitoring.

5.Enable Smart Waste Management:

- To optimize waste collection schedules by providing timely data, potentially through wireless transmission using ESP32

6.Reduce Operational Costs:

- To reduce unnecessary trips by garbage collection vehicles, saving fuel and labor.

7.Promote Clean Cities:

- To help maintain cleanliness in public areas by ensuring bins are not overflowing and are serviced efficiently.

## III. PRODUCT FEATURES

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules include ultrasonic transmitters, receiver and control circuit. The basic principle of work:

1.Using IO trigger for at least 10us high level signal,

2.The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
3.IF the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.
Test distance = (high level time×velocity of sound (340M/S) / 2
3.1Wire connecting direct as following:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

3.2 Electric Parameter

| | |
|---|---|
| Working Voltage | DC 5 V |
| Working Current | 15mA |
| Working Frequency | 40Hz |
| Max Range | 4m |
| Min Range | 2cm |
| MeasuringAngle | 15 degree |
| Trigger Input Signal | 10uS TTL pulse |
| Echo Output Signal | Input TTL lever signal and the range in proportion |
| Dimension | 45*20*15mm |

## IV. FUNCTION OF BLOCK DIAGRAM

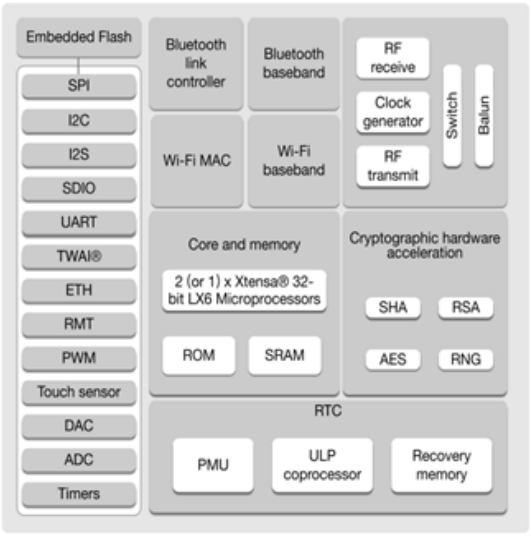


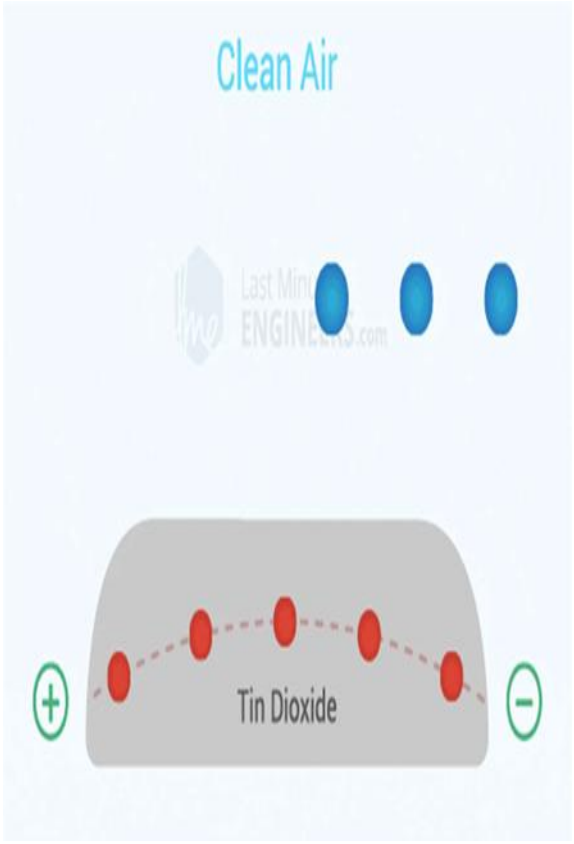

Figure 1: Functional Block Diagram

## V. FEATURES

- Wi-Fi
- CPU AND MEMORY
- ARDUINO
- LIQUID CRYSTAL DISPLAYS (LCD) WITH ARDUINO
- PCF8574 12C MODULE

## VI. GAS SENSOR WORK

When you turn on an MQ2 gas sensor, it starts heating up its internal Tin Dioxide ($SnO_2$) semiconductor layer to a high temperature. At this high temperature, oxygen molecules from the air stick (or adsorb, if you




prefer the technical term) to the surface of the Tin Dioxide. These adsorbed oxygen molecules pull free electrons away from the Tin Dioxide, which creates an "electron depletion region" near the surface. This makes the Tin Dioxide highly resistant to electrical flow, so only a small amount of electric current can pass through it.

When combustible gases enter the sensor, they react with the oxygen molecules that are stuck to the Tin Dioxide surface. This chemical reaction releases the

electrons that were being held by the oxygen. As these electrons return to the Tin Dioxide, the electron depletion region gets smaller. This reduces the resistance, allowing electricity to flow much more easily through the sensor.

## VII. GPS MODULE WITH PATCH ANTENNA WORK


This is a third generation POT (Patch Antenna on Top) GPS module. This POT GPS receiver providing a solution that high position and speed accuracy performances as well as high sensitivity and tracking capabilities in urban conditions & provides standard NMEA0183 strings in "raw" mode for any microcontroller. The module provides current time, date, latitude, longitude, speed, altitude and travel direction / heading among other data, and can be used in a host of applications, including navigation, tracking systems, fleet management, mapping and robotics.

This is a standalone GPS Module and requires no external components except power supply decoupling capacitors. It is built with internal RTC Back up battery. It can be directly connected to Microcontroller's USART. The module is having option for connecting external active antenna if necessary. The GPS chipsets inside the module are designed by MediaTek Inc., which is the world's leading digital media solution provider and largest fab-less IC company in Taiwan. The module can support up to 51 channels. The GPS solution enables small form factor devices. They deliver major advancements in GPS performances, accuracy, integration, computing power and flexibility. They are designed to simplify the embedded system integration process.

## VIII. WORKING PRINCIPLE

The PCF8574 communicates with microcontrollers (like Arduino, Raspberry Pi, etc.) using the I2C protocol. The I2C bus requires only two lines: SDA (Serial Data) and SCL (Serial Clock). The microcontroller sends data to the PCF8574, which then controls the individual I/O pins.

- I2C Communication: The I2C address of the PCF8574 is set using the address pins (A0, A1, A2). The microcontroller writes data to the PCF8574 via the I2C bus, and the module updates the state of the I/O pins accordingly.
- GPIO Pins: The module can read inputs or control outputs. For output, the PCF8574 sinks current through the I/O pins (since the output is open-drain).
- Push-Pull Output Mode: The pins are in open-drain configuration, so pull-up resistors are required for each pin to read a high state.

## IX. CIRCUIT DIAGRAM

Here's a basic schematic showing how the PCF8574 I2C module connects to an Arduino:

Components Used:

- PCF8574 I2C Module Arduino (e.g., Arduino Uno)
- Pull-up Resistors (4.7k recommended) for the I2C bus lines (SDA and SCL) Connections:
- VCC of PCF8574 to 5V of Arduino.
- GND of PCF8574 to GND of Arduino.
- SDA of PCF8574 to SDA (A4 on Arduino Uno).
- SCL of PCF8574 to SCL (A5 on Arduino Uno).
- The I2C Address Pins (A0, A1, A2) can be connected to GND or VCC to change the address.

2. Example Code (Arduino)
The following Arduino code demonstrates how to use the PCF8574 I2C module to control LEDs connected to the I/O pins.

```
#include <Wire.h>
#define PCF8574 ADDRESS 0x20 // Default I2C address void setup () {
Wire.begin(); // Initialize I2C communication
Serial.begin(9600);
```

```
// Set up I/O pins pinMode (0, OUTPUT); pinMode
(1, OUTPUT);
// Start serial communication pinMode (2, OUTPUT);
}
void loop () {
}
// Turn on LEDs connected to I/O pins
Wire.beginTransmission (PCF8574_ADDRESS);
Wire.write (0xFF); // Set all pins high
Wire.endTransmission ();
delay (1000); // Wait for 1 second
// Turn off LEDs
Wire.beginTransmission (PCF8574_ADDRESS);
Wire.write(0x00); // Set all pins low
Wire.endTransmission ();
delay(1000); // Wait for 1 second
```

Explanation:

- The code initializes the I2C communication with wire.begin(). The PCF8574 ADDRESS is the I2C address of the PCF8574 module (default is 0x20).
- In the loop (), the code sends data to turn the LEDs on and off.

## X. SIMILATION PROGRAM

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
// Pin Definitions
#define GAS_SENSOR_PIN 34
#define VIBRATION_SENSOR_PIN 35
#define TRIG_PIN 18
#define ECHO_PIN 19
// LCD setup
LiquidCrystal_I2C lcd (0x27, 16, 2); // Change to
    0x3F if needed
void setup () {Serial.begin(115200);
pinMode(GAS_SENSOR_PIN, INPUT);
    pinMode(VIBRATION_SENSOR_PIN, INPUT);
    pinMode(TRIG_PIN, OUTPUT);
    pinMode(ECHO_PIN, INPUT);
lcd.init(); lcd.backlight();
lcd.print("Initializing..."); delay (2000);
lcd.clear();
}
float readDistanceCM() {digitalWrite(TRIG_PIN,
    LOW); delayMicroseconds(2);
    digitalWrite(TRIG_PIN, HIGH);
    delayMicroseconds(10); digitalWrite(TRIG_PIN,
    LOW);
 long duration = pulseIn(ECHO_PIN, HIGH); float
    distanceCM = duration * 0.034 / 2; return
    distanceCM;
}
void loop() {
int gasValue = analogRead(GAS_SENSOR_PIN);
int vibration =
    digitalRead(VIBRATION_SENSOR_PIN); float
    distance = readDistanceCM();
lcd.setCursor(0, 0); lcd.print("Gas:");
    lcd.print(gasValue); lcd.print(" ");
lcd.setCursor(0, 1); if (distance < 10) {
lcd.print("Bin: Full ");
} else { lcd.print("Bin: ");
lcd.print((int)distance); lcd.print("cm ");
}
// Debug output Serial.print("Gas: ");
    Serial.print(gasValue); Serial.print(" | Vibration:
    ");
Serial.print(vibration == HIGH? "YES": "NO");
    Serial.print(" | Distance: "); Serial.print(distance);
Serial.println(" cm"); \ delay (1000);
}
```

## XI. KIT IMAGE

## XII. CONCLUSION AND FUTURE ENHANCEMENTS

CONCLUSION

The Smart Garbage Monitoring System successfully demonstrates how sensor- based automation can

revolutionize waste management. By integrating gas sensors, ultrasonic sensors, and vibration sensors with an ESP32 microcontroller, the system provides real-time information about the bin's status, improving efficiency and promoting hygiene. The use of an LCD display ensures local visibility of bin conditions, reducing the chances of overflow and unsanitary conditions. This project not only simplifies monitoring but also contributes to a cleaner and smarter urban environment.

## XIII. FUTURE ENHANCEMENTS:

1. IOT Integration:

Connect the system to the internet using Wi-Fi or GSM to transmit real-time data to a centralized dashboard or mobile app.

2. Mobile App Notification:

Develop an app that notifies waste collectors when bins are full or emitting harmful gases.

3. Solar Power Support:

Add solar panels to make the system energy-independent and eco-friendly.

4. AI-Based Route Optimization:

Integrate AI to optimize garbage truck routes based on real-time data from multiple bins.

5. Camera Integration:

Use a camera module to capture and analyze images for non-biodegradable waste identification.

6. Smart Lock Mechanism:

Implement a lock/unlock system based on authorized access to prevent unauthorized use or vandalism.