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Hardware Interface Design Report
On

“FIRE EXTINGUISHER ROBOT”

Submitted by

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Under the Guidance of
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ASSISTANT PROFESSOR

in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING
(IOT & CYBERSECURITY INCLUDING BLOCKCHAIN)

B.M.S. COLLEGE OF ENGINEERING
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B. M. S. College of Engineering,
Bull Temple Road, Bengaluru 560019
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Department of Computer Science and Engineering
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CERTIFICATE

This is to certify that the project work entitled **"AGNI 2.0.2.5"** carried out by **Rohith S (1BM23IC057), Dadapir (1BM24IC400), Gaurav G (1BM23IC077), OV Yogeswar Reddy (1BM23IC045)** who are bonafide students of **B. M. S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering (IoT & Cybersecurity including Blockchain)** of the Visvesvaraya Technological University, Belagavi during the year 2023-24. The project report has been approved as it satisfies the academic requirements in respect of **Hardware Interface Design (23IC4AEHID)** work prescribed for the said degree.

Signature of the Guide	Signature of the HOD
Mrs. Medha Gourayya Assistant Professor Dept. of CSE(ICB) BMSCE, Bengaluru	Dr. Prasad GR Professor & Head Dept. of CSE(ICB) BMSCE, Bengaluru

External Viva

Name of the Examiner	Signature with date

B.M.S. COLLEGE OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(IoT & CYBERSECURITY INCLUDING BLOCKCHAIN)

DECALARATION

We, **Rohith S (1BM23IC057), Dadapir (1BM24IC400), Gaurav g (1BM23IC077), OV Yogeswar reddy (1BM23IC045)** students of 4th Semester, B.E, Department of Computer Science and Engineering (IoT & Cybersecurity including Blockchain), BMS College of Engineering, Bengaluru, hereby declare that, this Hardware Interface Design project entitled **" FIRE EXTINGUISHER ROBOT "** has been carried out by us under the guidance of Mrs. Medha Gourayya Assistant Professor Department of CSE(ICB), BMS College of Engineering, Bengaluru during the academic semester February 2025 - June 2025. We also declare to the best of our knowledge and belief that the development reported here is not from part of any other report by any other students.

Name		**Signature**
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INTRODUCTION

1.1 Overview

Fire safety is a fundamental concern in residential, commercial, and industrial settings. Delayed detection and response to fire outbreaks can lead to significant loss of life, destruction of property, and disruption of services. Conventional fire suppression systems, such as sprinkler systems and fire alarms, are effective to an extent, but they rely heavily on human intervention or fixed installation points, which may not be sufficient during critical situations, especially in large or complex environments. This project focuses on the development of a **Fire Extinguisher Robot**, an autonomous robotic system capable of detecting and extinguishing fires without human involvement. The robot is designed to monitor its environment continuously using a combination of flame, smoke, temperature, and gas sensors. Upon detecting a fire, it activates a mobility mechanism—such as wheels or tracks—to navigate toward the fire source. Once in range, the robot deploys its onboard fire suppression system, which may include CO_2, dry powder, or water mist, to extinguish the flames effectively.

The system is built around a microcontroller platform (e.g., Arduino or Raspberry Pi), which processes input from sensors, controls motion, and activates the extinguisher unit. Additionally, wireless communication modules such as Wi-Fi, Bluetooth, or RF can be used to enable real-time alerts and remote control capabilities. The robot may also be enhanced with a camera module for live video streaming and advanced navigation algorithms using line-following or obstacle-avoidance techniques.

The ultimate aim is to provide a robust, reliable, and cost-effective solution that can respond quickly to fire emergencies—especially in locations where human access is difficult or dangerous. These environments may include chemical factories, warehouses, server rooms, high-rise buildings, and other areas with elevated fire risk.

1.2 Motivation

Fires are unpredictable and can escalate rapidly, leaving minimal time for response. In many incidents, the delay in detecting the fire or the inability of first responders to reach the site promptly results in severe consequences. While fire alarms and sprinkler systems provide some level of early warning and mitigation, they often lack mobility, adaptability, and real-time decision-making abilities.

Human intervention in fire situations can be risky, especially when dealing with electrical fires, chemical reactions, or toxic environments. The rising number of such incidents has highlighted the urgent need for an **automated fire-fighting system** that can act immediately and intelligently without waiting for external intervention.

This project is motivated by the desire to bridge this gap by introducing an autonomous robot that can not only detect fire at its source but also take immediate action to suppress it. By doing so, we aim to reduce response time, minimize risks to human life, and prevent fire damage more effectively. The robot's ability to reach confined or hazardous areas makes it a valuable tool for early-stage fire suppression and disaster management.

Moreover, this project aligns with the growing trend toward smart systems and automation in safety-critical applications. It also provides a hands-on implementation of key engineering concepts such as embedded systems, sensor integration, robotics, wireless communication, and real-time control—making it both practically valuable and educationally enriching.

1.3 Objectives

The key objectives of this project are as follows:

Autonomous Fire Detection: Design a multi-sensor system that can detect the presence of fire accurately using flame sensors, smoke detectors, gas sensors, and temperature sensors. The system should be capable of distinguishing between false alarms and actual fire events.

Fire Suppression Mechanism: Develop an integrated fire extinguishing module that can effectively neutralize flames. Depending on the type of fire expected, the robot can be equipped with a CO_2 canister, water spray system, or dry chemical extinguisher.

Mobility and Navigation: Implement a motorized mobility system to allow the robot to move towards the fire. This may involve using obstacle-avoidance sensors, line-following technology, or mapping systems to navigate within the environment.

Real-Time Monitoring and Alerts: Enable wireless communication features for sending alerts to a central monitoring system or mobile device. Optional camera integration can allow real-time video streaming for remote operators.

Safety and Reliability: Ensure the robot can operate safely in harsh environments without posing any risk to humans or itself. Include features such as battery monitoring, thermal shutdown, and robust enclosure design.

Scalability and Cost-Effectiveness: Design the system to be scalable for larger environments and cost-effective for practical deployment in schools, offices, factories, and public spaces.

By accomplishing these objectives, this project aims to deliver a fully functional, autonomous fire extinguisher robot that enhances fire safety standards, reduces the need for human intervention in emergencies, and demonstrates the powerful potential of robotics and embedded systems in life-saving applications.

REQUIREMENT SPECIFICATIONS

2.1 Hardware Requirements:

- A PC with the following or greater specifications:
  - Intel Core i3 or higher
  - 16 GB RAM
  - 500 GB Hard Drive
- A stable internet connection (2Mbps or higher)
- ESP32
- FIRE senser
- Jumper Wires
- LED
- Buzzer
- Power Supply
- Motor driver
- Dc motors
- Wheels
- Water pump

2.2 Software Requirements:

- Operating system : Windows, Linux, arduni uno
- Front end technologies are : HTML, CSS, JavaScript, Flutter, Dart
- IDE : VS Code, Sublime text
- Back end requirement : Firebase Cloud Database, Firebase Authentication, Python
- Server : Firebase, Dart

DESIGN

3.1 Block Diagram

The block diagram illustrates the overall architecture of the Fire Extinguisher Robot. It demonstrates the interaction between various components including the flame sensor, gas sensor, temperature sensor, obstacle detection module, motor driver, and microcontroller (Arduino or Raspberry Pi). The sensors continuously monitor environmental conditions and relay real-time data to the microcontroller. Upon detecting fire or abnormal gas levels, the microcontroller activates the motor driver to move the robot toward the fire source. The obstacle detection module assists in navigation by avoiding collisions. Once the robot reaches the target location, the fire extinguishing mechanism—controlled by a relay module—is triggered to suppress the fire using CO_2, water spray, or a similar extinguishing agent. The system may also include a wireless module (Wi-Fi/Bluetooth) for real-time alerts or remote control. Optionally, a camera module can be integrated for live monitoring. This architecture enables the robot to operate autonomously or semi-autonomously in detecting and extinguishing fires, ensuring rapid response and enhanced fire safety in high-risk environments.

Figure 3.1 shows the block diagram of the project.

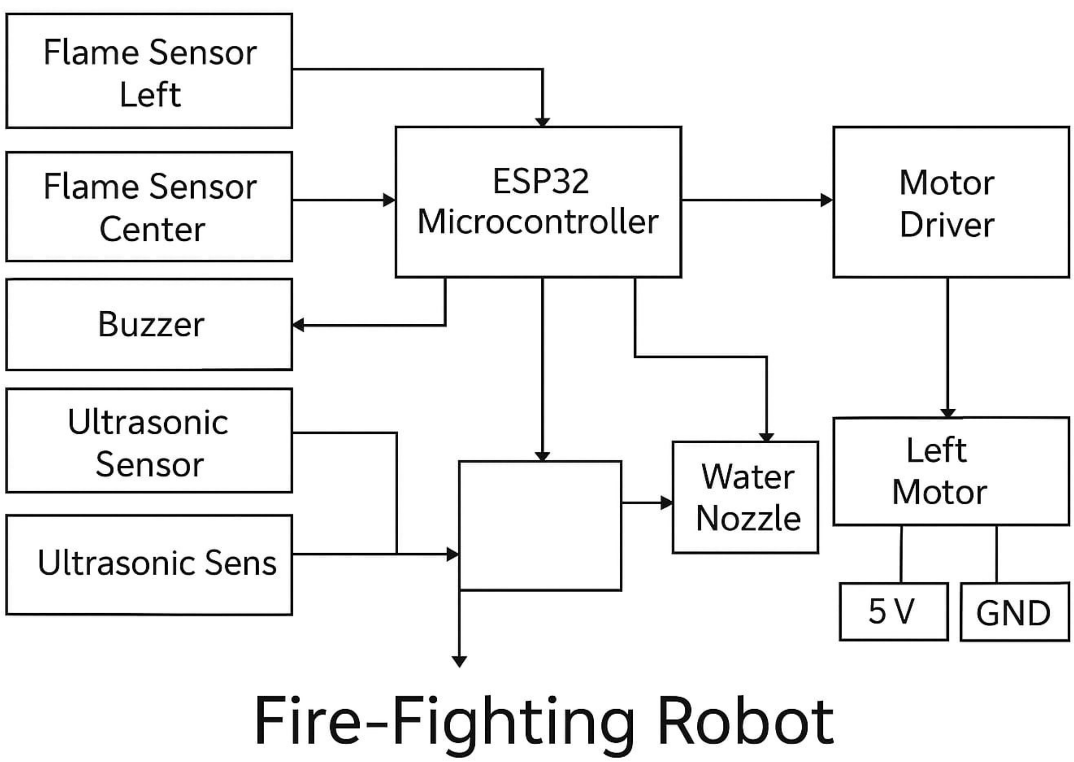

Figure 3.1: Applicability of the system

3.2 Circuit Diagram

The circuit diagram of the Fire Extinguisher Robot includes essential components connected to a central microcontroller such as an Arduino Uno or Raspberry Pi. Flame, gas, and temperature sensors detect fire-related conditions and send signals to the controller. An ultrasonic sensor is used for obstacle detection to help the robot navigate safely. The motor driver module (L298N) controls the movement of the robot's wheels based on sensor inputs. When fire is detected, the controller activates a relay module that triggers a water pump or CO_2 spray to extinguish the fire. The entire system is powered by a rechargeable battery, and optional modules like a camera or Wi-Fi can be added for live monitoring and remote control. This smart integration enables the robot to autonomously detect and suppress fire while avoiding obstacles.

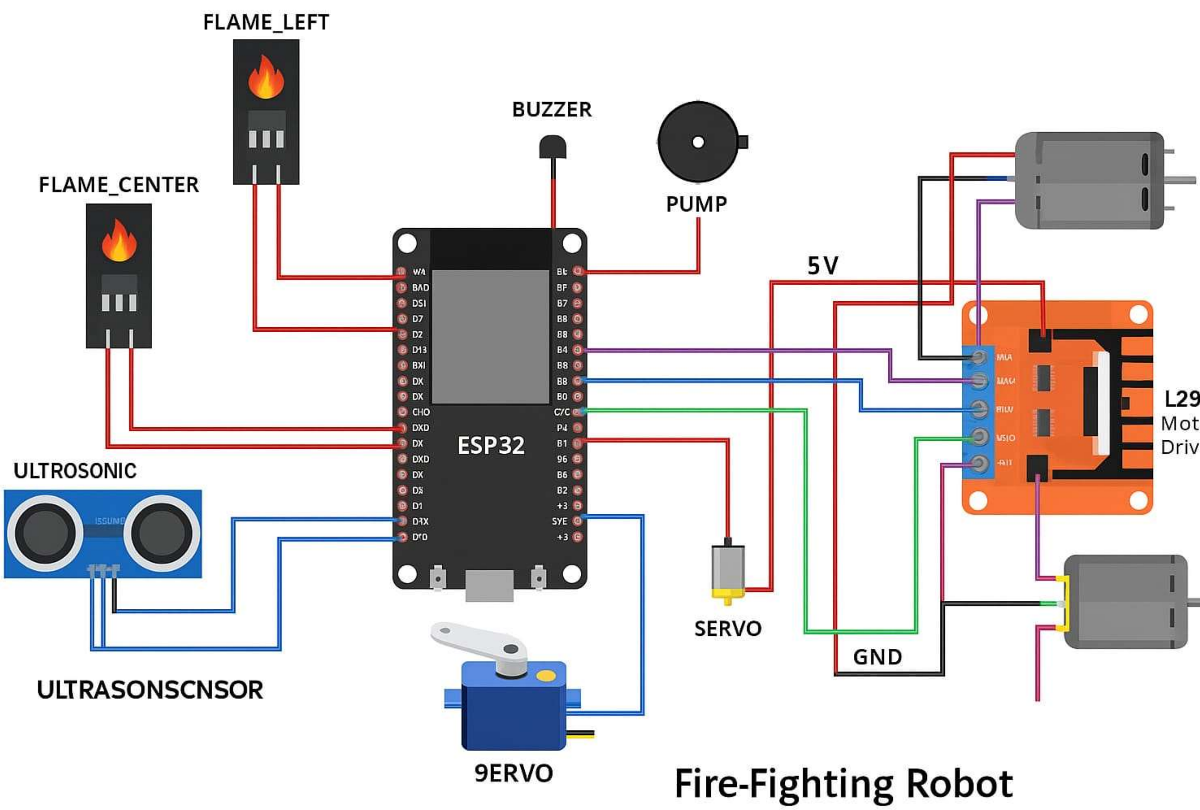

Figure 3.2: Circuit Diagram

IMPLEMENTATION

4.1 Source Codes

This section presents the source code for various components of the automated attendance system's mobile application. It includes the initialization of the app, Firebase setup and the implementation of different screens and functionalities using Flutter and Dart.

```
#include <Arduino.h>
#include <ESP32Servo.h>
#include "BluetoothSerial.h"

// ----- Flame Sensor Pins -----
#define FLAME_LEFT    36
#define FLAME_CENTER  34
#define FLAME_RIGHT   39

// ----- Motor Pins -----
#define LEFT_MOTOR_IN1   26
#define LEFT_MOTOR_IN2   27
#define RIGHT_MOTOR_IN1  25
#define RIGHT_MOTOR_IN2  33

// ----- Other Components -----
#define BUZZER_PIN    14
#define PUMP_PIN      13
#define SERVO_PIN     15

// ----- Ultrasonic -----
#define TRIG_PIN      4
#define ECHO_PIN      2

#define FIRE_APPROACH_DISTANCE  15.0

BluetoothSerial SerialBT;
Servo flameServo;

bool autoMode = true;

void setup() {
  Serial.begin(115200);
```

```
  SerialBT.begin("FireFighterBot");

  pinMode(FLAME_LEFT,   INPUT);
  pinMode(FLAME_CENTER, INPUT);
  pinMode(FLAME_RIGHT,  INPUT);

  pinMode(LEFT_MOTOR_IN1,  OUTPUT);
  pinMode(LEFT_MOTOR_IN2,  OUTPUT);
  pinMode(RIGHT_MOTOR_IN1, OUTPUT);
  pinMode(RIGHT_MOTOR_IN2, OUTPUT);

  pinMode(BUZZER_PIN, OUTPUT);
  pinMode(PUMP_PIN,   OUTPUT);
  flameServo.attach(SERVO_PIN);
  flameServo.write(90);

  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);

  SerialBT.println("□ Voice-Control Firefighter Ready!");
}

void loop() {
  if (SerialBT.available()) {
    String cmd = SerialBT.readStringUntil('\n');
    cmd.trim();
    cmd.toLowerCase();
    SerialBT.println("□ CMD: " + cmd);

    if (cmd == "manual mode") {
      autoMode = false;
      stopMotors();
      digitalWrite(PUMP_PIN, LOW);
      SerialBT.println("Switched to □ Manual Mode");
    } else if (cmd == "fire mode") {
      autoMode = true;
      SerialBT.println("Switched to □ Auto Fire Mode");
    }

    if (!autoMode) {
```

```
    // Manual voice commands
    if (cmd == "forward")      moveForward();
    else if (cmd == "backward") moveBackward();
    else if (cmd == "left")     turnLeft();
    else if (cmd == "right")    turnRight();
    else if (cmd == "stop")     stopMotors();
    else if (cmd == "spray")    digitalWrite(PUMP_PIN, HIGH);
    else if (cmd == "off")      digitalWrite(PUMP_PIN, LOW);
  }
}

if (autoMode) {
  // --- Auto Fire Mode ---
  bool L = (digitalRead(FLAME_LEFT) == LOW);
  bool C = (digitalRead(FLAME_CENTER) == LOW);
  bool R = (digitalRead(FLAME_RIGHT) == LOW);
  bool fireDetected = L || C || R;
  float dist = getDistance();

  digitalWrite(BUZZER_PIN, fireDetected ? HIGH : LOW);

  if (L && !C && !R) flameServo.write(135);
  else if (R && !C && !L) flameServo.write(45);
  else flameServo.write(90);

  if (fireDetected && dist > FIRE_APPROACH_DISTANCE) {
    SerialBT.println("□ Fire Detected → Moving Forward");
    moveForward();
    digitalWrite(PUMP_PIN, LOW);
  } else if (fireDetected && dist <= FIRE_APPROACH_DISTANCE) {
    SerialBT.println("□ Close to fire → Stopping & Spraying");
    stopMotors();
    digitalWrite(PUMP_PIN, HIGH);
  } else {
    stopMotors();
    digitalWrite(PUMP_PIN, LOW);
    flameServo.write(90);
  }
  delay(300);
}
```

```
}

// --- Ultrasonic Distance ---
float getDistance() {
  digitalWrite(TRIG_PIN, LOW); delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH); delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);
  long duration = pulseIn(ECHO_PIN, HIGH, 30000);
  return duration * 0.034 / 2;
}

// --- Motor Functions ---
void moveForward() {
  digitalWrite(LEFT_MOTOR_IN1, HIGH); digitalWrite(LEFT_MOTOR_IN2, LOW);
  digitalWrite(RIGHT_MOTOR_IN1, HIGH); digitalWrite(RIGHT_MOTOR_IN2, LOW);
}
void moveBackward() {
  digitalWrite(LEFT_MOTOR_IN1, LOW); digitalWrite(LEFT_MOTOR_IN2, HIGH);
  digitalWrite(RIGHT_MOTOR_IN1, LOW); digitalWrite(RIGHT_MOTOR_IN2, HIGH);
}
void turnLeft() {
  digitalWrite(LEFT_MOTOR_IN1, LOW); digitalWrite(LEFT_MOTOR_IN2, HIGH);
  digitalWrite(RIGHT_MOTOR_IN1, HIGH); digitalWrite(RIGHT_MOTOR_IN2, LOW);
}
void turnRight() {
  digitalWrite(LEFT_MOTOR_IN1, HIGH); digitalWrite(LEFT_MOTOR_IN2, LOW);
  digitalWrite(RIGHT_MOTOR_IN1, LOW); digitalWrite(RIGHT_MOTOR_IN2, HIGH);
}
void stopMotors() {
  digitalWrite(LEFT_MOTOR_IN1, LOW); digitalWrite(LEFT_MOTOR_IN2, LOW);
  digitalWrite(RIGHT_MOTOR_IN1, LOW); digitalWrite(RIGHT_MOTOR_IN2, LOW);
}
```

RESULTS

The image shows a Fire Extinguisher Robot built on a chassis, with a microcontroller (such as an Arduino Uno or Raspberry Pi) mounted securely and connected to various sensors through a breadboard. Flame sensors are positioned on the front of the robot to detect fire direction, while a gas sensor and temperature sensor are placed to monitor hazardous conditions in the surrounding environment. Multiple jumper wires connect these sensors to the GPIO pins of the microcontroller. A motor driver module (L298N) controls the two DC motors responsible for robot movement, powered by a rechargeable battery pack. An ultrasonic sensor is also attached to the front, helping the robot detect and avoid obstacles while navigating toward a fire source.

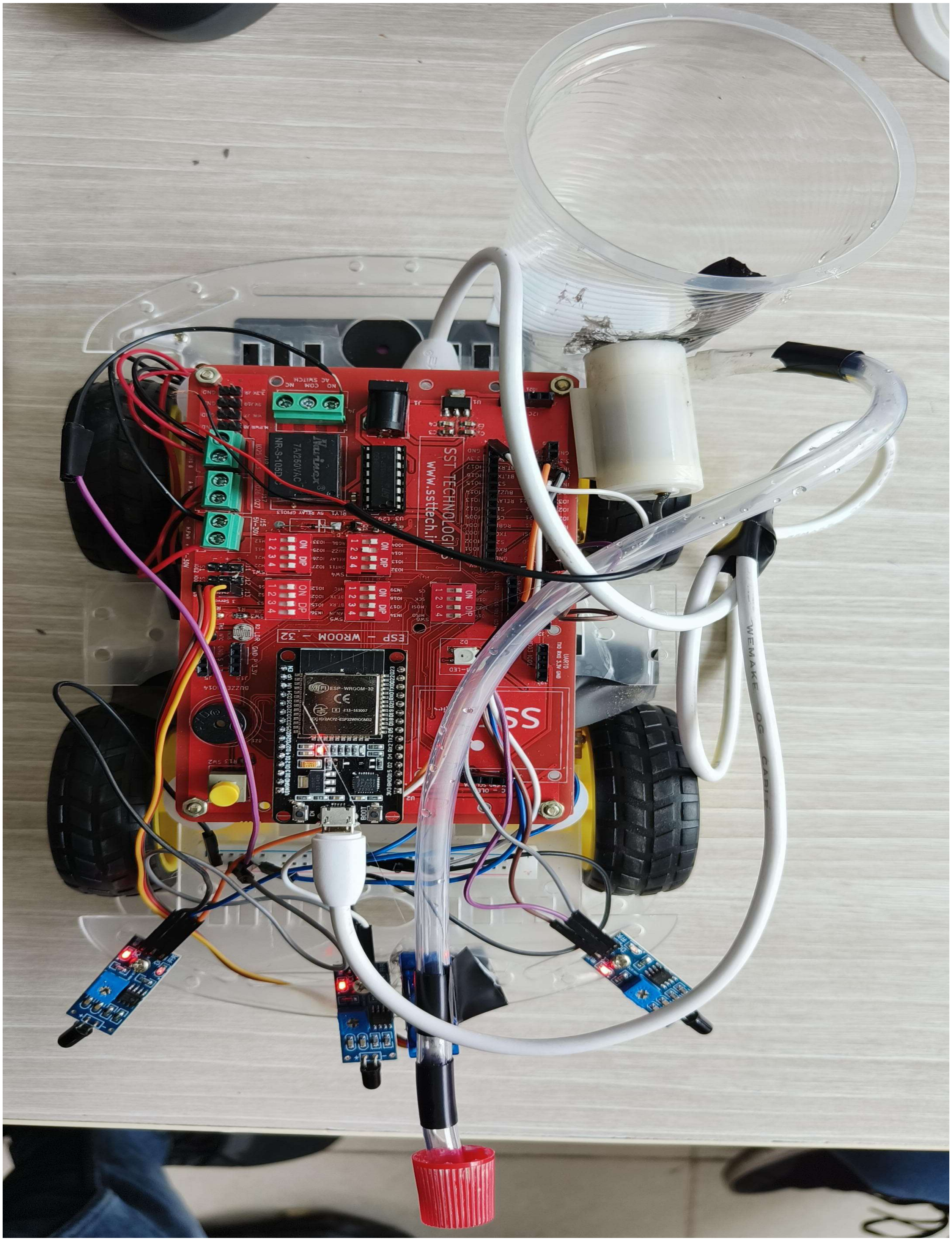

Figure 5.1: Circuit Diagram (Non – Working State)

An extinguishing system—either a mini water pump or a CO_2-based mechanism—is connected through a relay module, allowing the robot to automatically suppress the fire upon detection. A red LED on the board indicates system activity, and a buzzer alerts users when fire is detected. The entire setup is wirelessly connected to a smartphone via Bluetooth or Wi-Fi. A mobile application, built using Flutter and connected to Firebase, displays real-time sensor readings such as flame detection status, gas levels, and temperature. Upon detecting a fire, the app receives an alert notification and logs the incident in the Firebase database. The interface also provides manual override options, allowing users to control the robot's movement or activate the extinguishing system directly from the smartphone.

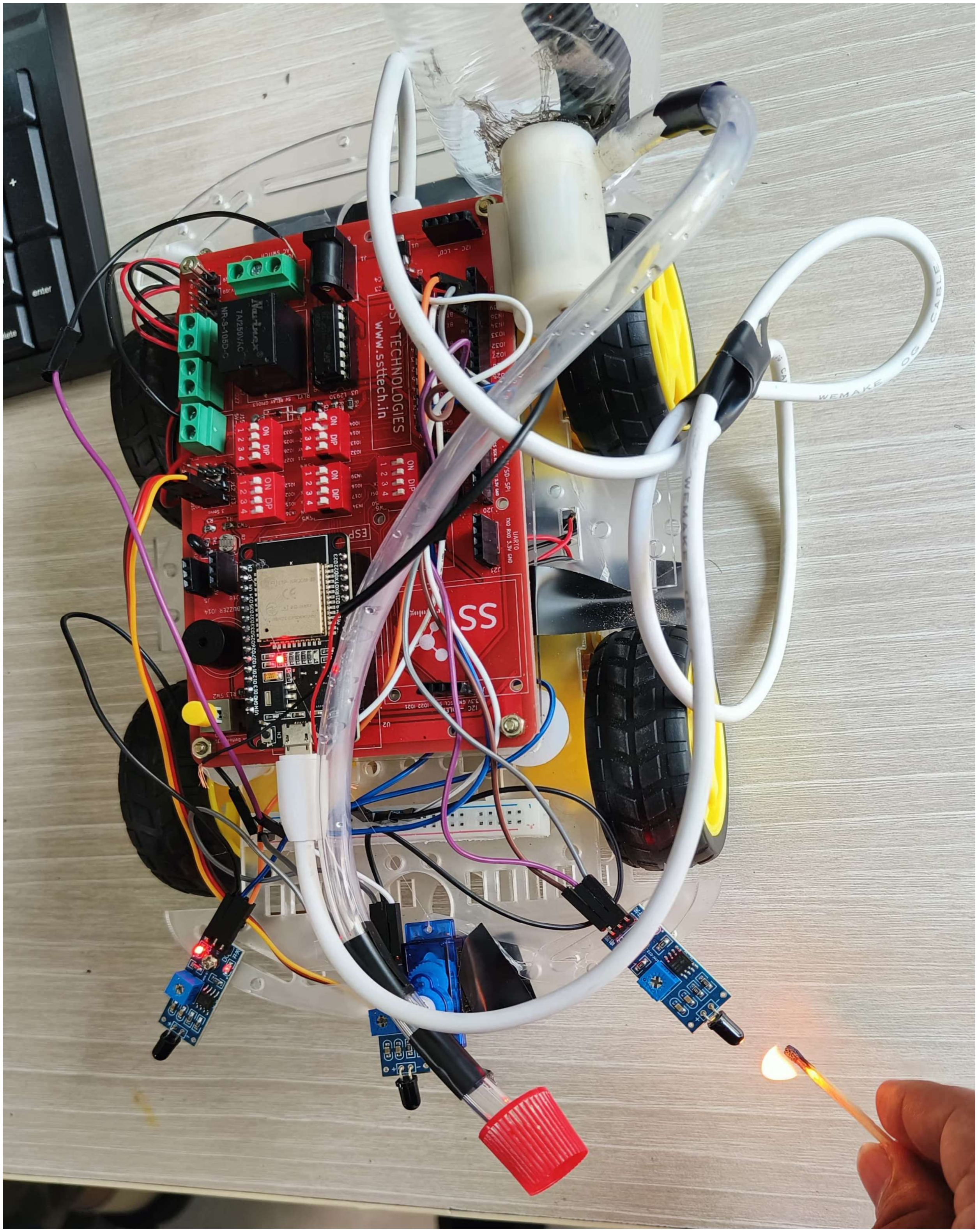

Figure 5.2: Circuit Diagram (Working State)

The **mobile application** displays key readings from the sensors, such as gas concentration, temperature, and flame status. It also provides **push notifications** in case of fire detection, ensuring the user is immediately alerted. Moreover, the app includes **manual controls**, allowing users to remotely drive the robot, activate or deactivate the extinguisher, and monitor the robot's status. All events, such as fire detection time, extinguishing action, and environmental readings, are automatically logged and synced to the **Firebase backend**, providing a reliable record for future reference or safety audits.database

Figure 5.3: output screen

CONCLUSION

The **Fire Extinguisher Robot** is a successful demonstration of how robotics, embedded systems, and Internet of Things (IoT) technologies can be combined to create an intelligent, autonomous fire safety solution. Through the integration of various sensors—including flame, gas, temperature, and ultrasonic modules—the robot is capable of accurately detecting hazardous fire-related conditions, navigating its environment to avoid obstacles, and effectively extinguishing small fires using an automated suppression system. The inclusion of a motor driver module and a programmable microcontroller allows for smooth, responsive movement, making the robot suitable for operation in dynamic and unpredictable settings.

One of the standout features of this project is the **real-time wireless communication** between the robot and a smartphone application. This enables remote monitoring and control, allowing users to receive live updates, sensor readings, and emergency alerts through push notifications. Using **Firebase Cloud Database**, all activity and sensor data are logged in the cloud, providing a comprehensive and accessible record of fire events and robot actions. This cloud-based integration enhances the reliability and usability of the system, making it practical for use in both domestic and industrial environments.

In terms of real-world application, the Fire Extinguisher Robot offers a **cost-effective and scalable** solution for fire prevention and response. It is especially useful in environments where human access is dangerous, such as chemical storage areas, electrical rooms, warehouses, and confined spaces. Its autonomous nature ensures that fires can be detected and addressed without delay, significantly reducing the chances of escalation and potential damage.

From a technical perspective, this project showcases the effective use of microcontroller programming, sensor interfacing, wireless communication, and real-time data handling. It also encourages interdisciplinary learning, combining elements of electronics, software development, mechanical design, and automation.

Looking ahead, the robot can be further improved by integrating **machine learning algorithms** for better fire detection, **thermal imaging cameras** for enhanced accuracy, and **GPS modules** for location tracking in outdoor environments. It could also be connected to larger **smart building management systems**, allowing for a network of robots to monitor and protect larger areas collaboratively.

In conclusion, the Fire Extinguisher Robot not only addresses a critical safety need but also exemplifies the potential of modern technology to create autonomous systems that improve emergency response, minimize human risk, and pave the way for smarter, safer environments. It serves as a strong foundation for future innovation in robotic fire safety and IoT-enabled emergency systems.

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