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Industrial Applications of Microcontrollers - A Practice Based Approach

Industrial Fire Safety System

Submitted by:

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Problem Statement

Industries are vulnerable to fire and gas leaks, which can lead to disastrous outcomes if not addressed in time. Conventional systems are either manual, expensive, or lack automation. The absence of real-time, automatic alert mechanisms increases risk. Hence, there is a strong need for a low-cost, smart system that can automatically detect such hazards and alert personnel without delay.

Objectives

- To build an automated fire and gas detection system using Arduino.
- To integrate sensors (MQ2 and ambient light sensor) for real-time hazard monitoring.
- To activate alerts through a buzzer and LCD display when dangerous conditions are detected.
- To simulate and validate the system using Tinkercad Circuits.
- To provide a reliable and cost-effective safety system suitable for industries.

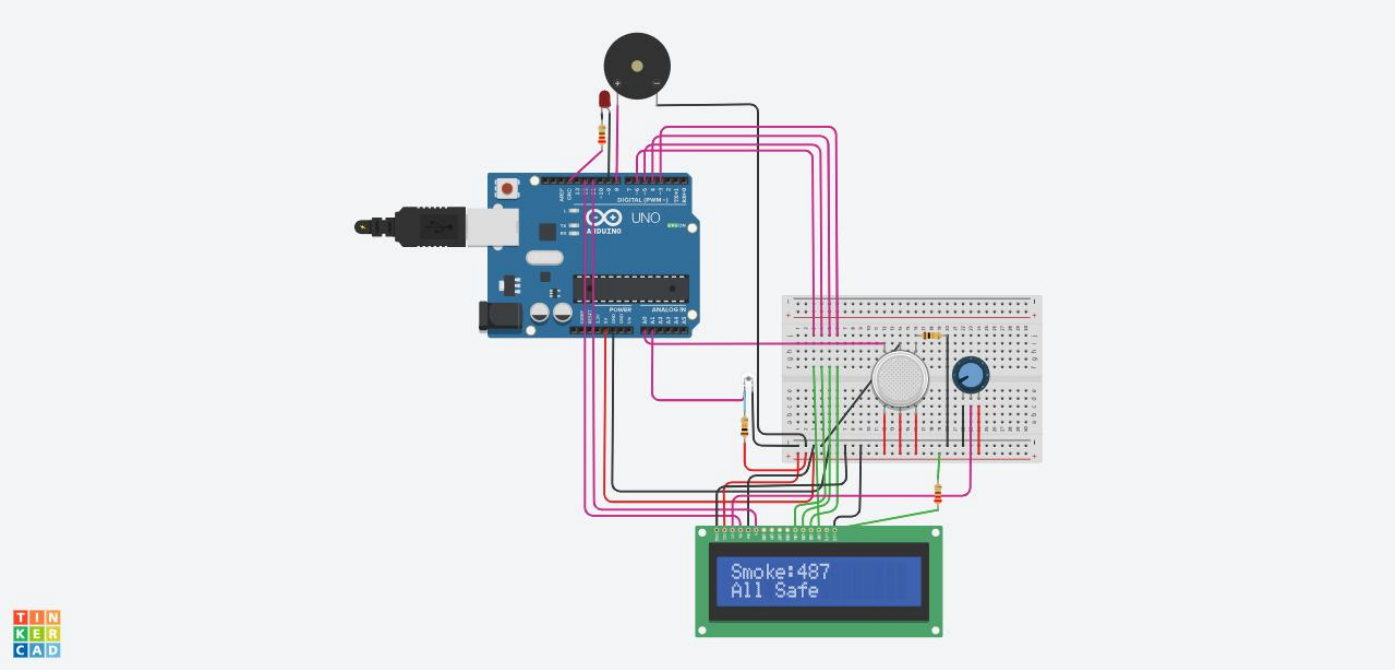
Components Description

S.No	Hardware Component
1.	Arduino Uno R3
2.	MQ2 Sensor
3.	Ambient Light Sensor
4.	16x2 LCD Display
5.	Buzzer
6.	Potentiometer(10kΩ)
7.	Breadboard

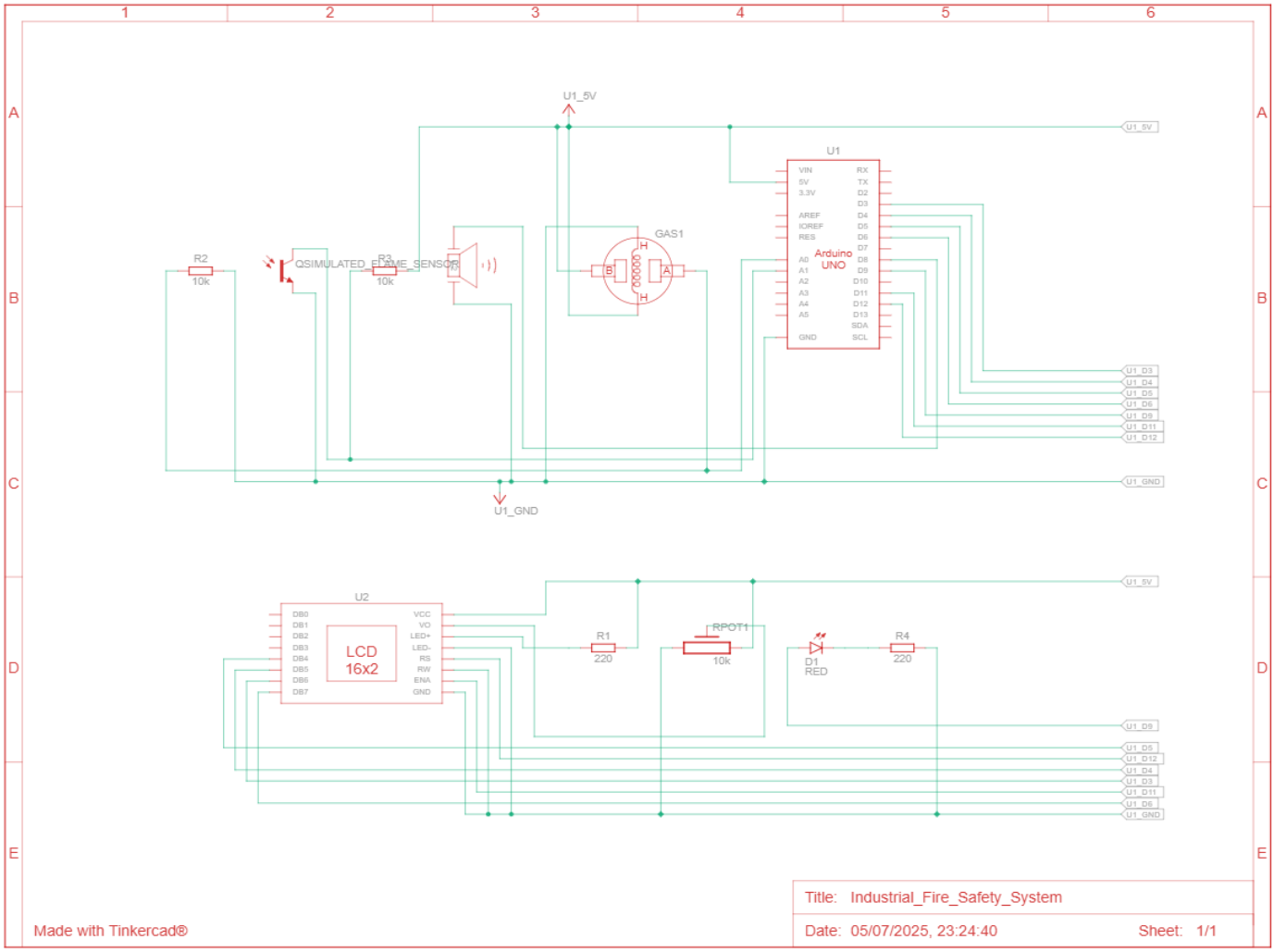
S.No	Software Component
1.	Arduino IDE
2.	Tinkercad Circuits

Simulated Circuit/Circuit Diagram

Circuit Diagram:



Schematic view:



Circuit Connections

1. MQ2 Gas Sensor (GAS1)
    - .Connected to analog pin A0 of the Arduino.
    - Powered by 5V and GND.
    - Outputs analog voltage proportional to gas concentration.

2. Ambient Light Sensor (simulated as a flame sensor)
    - Connected to analog pin A1.
    - Uses a voltage divider with resistors R2 and R3 (10k each).

3. Buzzer and Indicator LED
    - LED (D1) is connected via R4 (220Ω) to digital pin D9.
    - Buzzer is connected to digital pin D8.

4. 16x2 LCD Display (U2)
    - RS → D12
    - E → D11
    - D4–D7 → D5 to D2 respectively
    - Contrast adjusted using a 10k potentiometer (RPOT1) connected to VO pin.

5. Power Supply
    - All modules are powered from Arduino's 5V and GND lines.
    - Circuit powered via Arduino USB or external 5V source in simulation.

Video of the Demo

The video of the demo for this project has been shared in the google drive link given below:

https://drive.google.com/file/d/1xjMqNlr-fg3ck-SjrcaTHwm4U2UuRilz/view?usp=drive_link

Gerber File

A Gerber file is not applicable in this project.

Code for the Solution

```
#include <LiquidCrystal.h>

// Initialize LCD with Arduino pins: RS, EN, D4, D5, D6, D7
LiquidCrystal lcd(12, 11, 5, 4, 3, 6);

// Define sensor and actuator pins
const int smokeSensorPin = A0;      // MQ2 gas sensor
const int lightSensorPin = A1;      // Ambient light sensor (flame substitute)
const int buzzerPin = 8;
const int ledPin = 9;

// Sensor threshold values
const int smokeThreshold = 500;     // Adjust as needed
const int flameThreshold = 300;     // Lower = darker = flame detected
```

```
void setup() {
  pinMode(buzzerPin, OUTPUT);
  pinMode(ledPin, OUTPUT);

  lcd.begin(16, 2);               // Initialize 16x2 LCD
  Serial.begin(9600);             // For debug via Serial Monitor

  lcd.setCursor(0, 0);
  lcd.print("Fire Safety Sys");
  delay(2000);
  lcd.clear();
}

void loop() {
  int smokeValue = analogRead(smokeSensorPin);
  int lightValue = analogRead(lightSensorPin);

  // Debugging to Serial Monitor
  Serial.print("Smoke: ");
  Serial.print(smokeValue);
  Serial.print(" | Light: ");
  Serial.println(lightValue);

  // Display smoke value
```

```
  lcd.setCursor(0, 0);
  lcd.print("Smoke:");
  lcd.print(smokeValue);
  lcd.print("   "); // clear tail digits

  // Fire or Smoke Alert Conditions
  if (lightValue < flameThreshold) {
    lcd.setCursor(0, 1);
    lcd.print("FIRE Detected!  ");
    digitalWrite(buzzerPin, HIGH);
    digitalWrite(ledPin, HIGH);
  } else if (smokeValue > smokeThreshold) {
    lcd.setCursor(0, 1);
    lcd.print("Smoke Detected! ");
    digitalWrite(buzzerPin, HIGH);
    digitalWrite(ledPin, HIGH);
  } else {
    lcd.setCursor(0, 1);
    lcd.print("All Safe        ");
    digitalWrite(buzzerPin, LOW);
    digitalWrite(ledPin, LOW);
  }
  delay(500);
}
```

Results

- The Industrial Fire Safety System was tested using the Arduino simulation.
- Sensor Thresholds defined in the code:
  - Smoke Threshold: > 500 – for MQ2 gas sensor.
  - Flame Threshold: < 300 – for ambient light sensor (flame substitute).
- During simulation:
  - When light sensor value dropped below 300, the LCD displayed FIRE Detected!, and both the buzzer and LED turned ON.
  - When smoke sensor value exceeded 500, the LCD displayed Smoke Detected!, and the buzzer and LED were activated.
  - When neither threshold was crossed, the LCD showed All Safe, and both buzzer and LED were OFF.
- Serial Monitor output was used for debugging and confirmed the sensor readings accurately.
- LCD clearly displayed both sensor readings and system status in real time.
- The delay of 500ms made the system responsive without being too jittery.

Conclusion

- The project successfully demonstrates a low-cost, microcontroller-based fire and smoke detection system using Arduino Uno.
- The integration of MQ2 and ambient light sensor provides a basic yet effective fire safety mechanism.
- Real-time alerts via LCD display, buzzer, and LED ensure visibility and audibility in critical situations.
- The system is easy to replicate, simple to simulate using Tinkercad, and suitable for educational or prototyping use.
- The project achieves all intended goals, with correct thresholding, output behavior, and sensor logic as seen in the working code.

Applications

- Small Industrial Units: Detect smoke and early fire signs in machine rooms or factories.
- Server Rooms: Monitor for electrical overheating or smoldering.
- Warehouses: Detect sudden gas leaks or flame presence during off hours.
- Laboratories: Monitor for chemical fumes or accidental ignition.
- Educational Projects: Demonstrates sensor interfacing, condition-based logic, and output handling in embedded systems.

References

Tinkercad Simulation Link:

https://www.tinkercad.com/things/6sHdZE2y8TN-industrialfiresafetysystem?sharecode=icJgt7X_KQfC5QQJaEjwOgaDkxP9XSXxMrI6fMNemxc

Demo Video Link:

https://drive.google.com/file/d/1xjMqNlr-fg3ck-SjrcaTHwm4U2UuRilz/view?usp=drive_link

GitHub Repository Link:

https://github.com/Nikhil-27-lab/Industrial_Fire_Safety_System_Nikhil-Vasanth.git