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Smoke Sensor Based Flame Detection and Alert System

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Abstract : A flame surveillance device combines concurrent readings for fumes, gases such as carbon monoxide as well as dioxide in order to strengthen campus security against unwanted entry in locations like labs, classrooms, staff rooms, or washrooms. Comprising fire detectors, control units, and alarm systems, the system incorporates numerous detectors, including smoke detectors, heat sensors, and Infra-Red detectors. An new flame detector is developed, using simultaneous thermal and fume readings. The alert algorithm implemented in the system effectively detects fires not detected by solo smoke sensors and delivers quicker reaction times. Unlike prior algorithms relying on data from warmth, fumes, along with combustible product sensors, this approach shows successful in identifying and warning in a more timely way. The emissions detector activates an alert whenever analogue signal that it emits reaches or matches the specified threshold value. Utilizing analog sensors, the system detects fumes, gaseous carbon monoxide (CO), as well as warmth. The fundamental purpose of a fire detection technology is to rapidly and reliably notify occupants of buildings to possible fire threats, including fumes or temperatures that are rising. The components that make up this system are Arduino UNO, GSM Module, MQ2 Gas Sensor, DH-11 sensor, Buzzer and LCD.

***IndexTerms* - Sensors, MQ2 sensor, IoT, buzzer, Exhaust fan, Blynk platform, Sensitivity.**
exhaust fan, Blynk platform, sensitivity.

I. INTRODUCTION

Flame plus fumes monitoring Alert devices serve a key role in guaranteeing the safety of numerous surroundings, including houses, workplaces, marketplaces, and other locations. The fundamental purpose of a well-designed flame including gas technology is to detect and, in certain situations, automatically minimize the dangers associated with fire, flammable gasses, and poisonous gases. The strategic arrangement of sensors is crucial in system design to ensure proper coverage, allowing the identification of possible dangers at their earlier stages and limiting their escalation. The flame alert mechanism depends on the ratios of rise of fire, flammable gas, and poisonous gas components to establish the existence of a flame. The fumes detector acts as a mechanism to detect smoke, offering an early warning of a possible fire. Heat detectors, considered the earliest kind of automated fire detection equipment, activate either as a sensing component exceeds a predefined preset thermal or in response with a particular pace of thermal variation. In the case of a fire, these systems may be coupled to extinguishing devices, sheltering adjacent places from the fire's influence. Typically, fire detection and gas detection systems are combined into a single fire and gas system. However, a possible divide may be created, with one system devoted to areas of processing as well as other sub-system primarily handling utility, office, or accommodation spaces. This segmentation allows for a more customized strategy to flame along with gaseous safety precautions in various working zones.

II. SYSTEM REQUIREMENTS

This framework operates for to assist with gas and fire monitoring plus alert. This comprises mainly several elements for incorporating the framework's objective: Arduino UNO [1, 2], . Gas sensor MQ-2, Temperature and Humidity sensor,GSM module SIM900 , DH-11, LCD and Buzzer.

2.1 Arduino UNO

The Uno version of the Arduino is a type of microcontroller board utilizing Atmel's ATmega328 microprocessor at its heart. The moniker "Uno," meaning one in Italian, symbolizes its position as the newest version among an ongoing series created with the help of the USB interface. This versatile board boasts essential components, including a ceramic resonator with a frequency of 16 MHz an external USB association, an AC power a connector, an In-Circuit Serial Programming (ICSP) a header, the reset switch, six inputs for analog signals, and fourteen pins for digital input and output, with 6 of them capable of functioning as Pulse Width Modulation (PWM) outputs. The proposed board's technical characteristics include 32 KB of flash memory (with 0.5 KB devoted to the bootloader), a total of 2 KB of Static Random-Access Memory (SRAM), a single KB of Electrically Erasable Programmable Read-Only Memory (EEPROM), and a clock speed of 16 MHz. These qualities together add to the Uno's capabilities to manage an assortment of jobs and projects. One of the primary benefits of the Arduino board Uno resides in its flexibility and integration possibilities. With 6 analog with 14-computational pins, it may be effortlessly integrated into numerous boards and circuits, each performing diverse tasks within a design. The USB serial connection port permits the loading of programs from a computer, boosting the board's accessibility and simplicity of programming. To expedite the programming process, Arduino includes its very own programming known as the integrated developmental environment (IDE). This IDE is especially engineered to handle the programming languages C++ and C, enabling a user-friendly environment for code creation and uploading onto the Uno board of Arduino [1, 2].

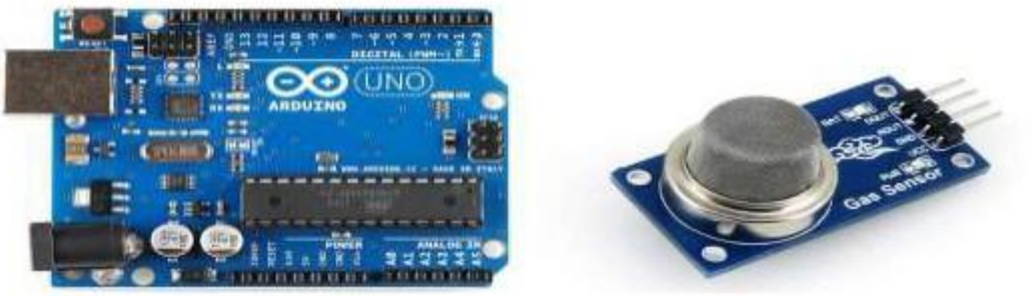

Figure1. Arduino UNO microcontroller and MQ-6 Sensor

2.2 MQ-6 Smoke and Gas Sensor

The previously MQ range of sensors for gases employs a tiny internal heater paired with a separate electro-chemical instrument, as indicated in the first illustration. These sensors are designed to sensitivity across a variety of gases and find uses inside at ambient temperature. The data that comes from the MQ sensors is in the format of a signal that is analog, which may be simply read using the analog input of a microcontroller such as a PIC. The MQ-6 Gas Detector module, a component of the MQ series, is especially beneficial for detecting gas leaks in both household and industrial environments. It demonstrates great sensitivity to many gases, including LPG, butane, propane, methane, alcohol, hydrogen, and smoke. Some modules are equipped with an integrated programmable resistor, which permits a modification of sensor sensitivity. In the course of this study endeavor, the MQ-6 sensor was deployed for identifying the presence of liquefied petroleum and haze inside an organization. The amount of resistance of the MQ-6 sensor differs based on what kind of gas it detects. For smoke detection, a built-in potentiometer is available, allowing users to fine-tune the sensor's sensitivity based upon the required degree of accuracy [5, 7]. The code sample supplied below illustrates the programming logic for identifying smoke using the MQ-6 sensor:

```
const int buzzer = 9;
const int smokeA0 = A0;

void setup() {
  pinMode(buzzer, OUTPUT);
  pinMode(smokeA0, INPUT);
  Serial.begin(9600);
}

void loop() {
  int analogSensor = analogRead(smokeA0);
  Serial.print("Analog Sensor Value: ");
  Serial.println(analogSensor);

  if (analogSensor > 400) {
    activateBuzzer();
  } else {
    deactivateBuzzer();
  }

  delay(1000); // Move this line inside the loop
}

void activateBuzzer() {
  tone(buzzer, 1000, 200);
}

void deactivateBuzzer() {
  noTone(buzzer);
}
```

This Arduino code initializes the system by setting up the pin modes for the buzzer and smoke sensor. In the main loop, it receives the analog value from the flame detector (attached to pin A0). If the analog value crosses a particular threshold (in this example, 400), the system activates the buzzer to create a sound, signaling the existence for smoke. The delay function is added for regulating the rate of readings [5, 7].

2.3 Temperature and Humidity Detection

Moisture as an important element in fire detection, since flames typically lead to dry air and a subsequent fall in humidity. This reduction in humidity could serve like a warning indicator of disasters such as forest fires. The DHT-11 detector proves important in measuring humidity ithin an acceptable range of 20-90% RH with a precision of ±5% RH. Employing a resistive-type humidity measuring component, the DHT- 11 and its counterpart, DHT22, are uncomplicated to connect, comprising a total of four rivets: the VCC, the Data, NC, and Gnd [5, 6, 7]. Figure 2 depicts the the DH-11 detector, A beeper, GSM modem, and LCD.

The Voltage Control Circuit (VCC) port gives power to the sensor, supporting a voltage range between 3.3V and 5.5V, with a suggested 5V supply. With a 5V power source, the sensor may be positioned up to 20 meters away. However, with a 3.3V supply, the wire length should not exceed 1 meter. The Data pin permits interaction among the sensor's circuit and the micro controller.

Internally, the sensor contains a humidity measuring component and an NTC sensor for temperature . The humidity sensor component contains a pair of electrodes that have a moisture-holding substrate (typically composed of salt or conductance polymeric polymers) layered among it. Increased humidity levels reduces the amount of resistance between the the electrodes, whereas a lower humidity level raises the resistance. In the IDE for Arduino, the following code is built to read and show heat and humidity ratio readings of the liquid crystal display:

Figure2. DH-11 sensor, Buzzer, GSM modem (Sim900), Liquid crystal display unit (LCD)

2.4 GSM Module

The Global System for Mobile Phones Component incorporated in the framework is a Quad-band mobile phone module with compatibility for GSM/GPRS, running on frequencies of 850/900/1800/1900MHz. Its functions extend beyond internet access, covering vocal communication when connected with a mic and a tiny loudspeaker, as well as managing Short Message Service (SMS). The component is under the supervision of an AMR926EJ-S CPU, responsible for handling cellular interaction, transmitting information via a built-in TCP and IP, stack, and interaction with the linked circuit via a UART and TTL serial interface. The AMR926EJ-S CPU also controls a single SIM chip (3 or 1.8V), which is physically linked to the module. The Global System for Mobile Communications (Sim900) gadget combines numerous extra functions, including a standard analog user interface a digital to analog converter, a Real-Time Clock (RTC), a Serial Programming Interface (SPI) bus, an Integrated Circuit (IC), and a Pulse Width Modulation (PWM) module. These components jointly give rise to module's adaptability and its capacity to ease interactions between the system with an external mobile phone network [3, 4].

2.5 The Liquid Crystal Display Unit

The liquid-crystalline display (LCD) unit of the entire system comprises with a 16×2 Characters Display. It is con via with an external resistor (10kΩ) responsible for altering the LCD's brightness. This display device acts as the visual interface for transmitting the system's condition, signaling gas or flame detection via the different installed sensors.

```
#include <LiquidCrystal.h>
#include <dht.h>

LiquidCrystal lcd(12, 11, 5, 4, 3, 2); // Creates an LCD object.
dht DHT;
bool showCelsiusOrFahrenheit = false;

void setup() {
  lcd.begin(16, 2); // Initialize the LCD with 16 columns and 2 rows
}

void loop() {
  int dataPin = 7;  // Replace 7 with the actual data pin connected to the DHT sensor
  int readData = DHT.read11(dataPin);

  float t = DHT.temperature;
  float h = DHT.humidity;
```

```
  lcd.setCursor(0, 0);
  lcd.print("Temp.: ");
  if (showCelsiusOrFahrenheit) {
    lcd.print(t);
    lcd.print((char)223); // shows degrees character
    lcd.print("C");
    showCelsiusOrFahrenheit = false;
  } else {
    lcd.print((t * 9.0) / 5.0 + 32.0);
    lcd.print((char)223); // shows degrees character
    lcd.print("F");
    showCelsiusOrFahrenheit = true;
  }

  lcd.setCursor(0, 1);
  lcd.print("Humi.: ");
  lcd.print(h);
  lcd.print(" %");

  delay(2000);  // Delay should be inside the loop
}
```

In this Arduino code, a liquid crystal display device is created, and the display's settings are specified. The loop function constantly reads the humidity and temperature readings from the DHT sensor and shows them via the Display. This ambient temperature may be shown in either Celsius or Fahrenheit, flipping distinction of the two units with each iteration of the loop [8].

2.6 Buzzer

A buzzer, is an auditory signaling device which might be considered mechanical, electromechanical, magnetic, electromagnetic, electro-acoustic, or piezoelectric. Specifically, a piezo-electric buzzer is deployed, which may be powered through a fluctuating electrical circuit or another sound indicate origin. The buzzer functions as an indication, delivering audible signals such as clicks, beeps, or rings to transmit information. the context of such framework, it plays a critical function in signaling the identification of gases or flame via the numerous sensors. When triggered, the buzzer generates constant or sporadic ringing or buzzing noises, delivering an aural warning to bring attention to the system's state. This audio communication technique is vital for rapidly informing persons of possible threats and urging appropriate responses. In summary, the buzzer within this structure works as an important component of the alarm system, complementing visual signs like an LCD demonstrate for overall efficacy of safety measures in place [8].

III. FLAME DETECTION AND ALERT SYSTEMS

Flame detection with so monitoring technologies play a key role in protecting life and property. The various types of fire alarm systems, each catering to distinct needs:

3.1 Traditional Gas Detection System:

Traditional systems that split a structure into zones, everyone using the unique network. Alarms offer a 8 broad co-ordinates of the fire inside a zone. Traditional systems that split a structure into zones, each with its own circuit. Alarms offer a broad locative co-ordinates of the fire inside a zone.

3.2 Addressable Fire Alarm System:

Allows each device (smoke detector, heat detector, etc.) that maintain their unique address. This permits determining the precise location in each alert.

3.3 Analogue Addressable Fire Alarm System:

Similar to addressable systems but offers more precise in state of each unit, resulting in rapid response.

3.4 Wireless Fire Alarm System:

Offers a cable-free alternative to wired systems, allowing flexibility and convenience of installation. Utilizes wireless communication for data delivery. Remote flames sensor systems, in particular, have gained appeal since they reduce a necessity for extensive wiring. These systems work as complete digital addressing flame detection technologies beyond any limits of physical connections. They perform numerous roles, including automated fire detection depending on smoke with so gaseous concentration, notifying building occupants, providing alarm signals to emergency response organizations, and managing equipment and operations. In the framework of the proposed flame detection and monitoring system, an Arduino device is deployed, developed using Android Studio. The Arduino gets information from gas, smoke, temperature, with so humid sensors. These components are linked to the Arduino input via connecting cords. The output of the device is connected with a buzzer, delivering an audible indication when gases or fumes is detected. Atmospheric delay duration of the power source buzz may can be modify the sound, making it flexible for detecting various gasses. The MQ2 sensor, connected with Arduino, permits direct monitoring about numerous gases. The system's simplicity and ease of software upload make Arduino a perfect option. The Arduino interpreter is employed for programming, making the integration of the MQ2 sensor uncomplicated. The Display screen reveals the system's condition when there exists a concentration about gases or smoke, offering a visual picture of possible fire breakouts. This integrated system, with its numerous sensor capabilities and Arduino's programmability, provides a holistic approach to fire detection, assuring timely alarms and possible preventative measures in response to changing environmental circumstances [6].

3.4.1 Hardware Components

Coming to the components of this fire and smoke detection system, an Arduino controller acts as the key component. The Arduino controller works as the primary controller of the system, managing components of numerous sensors and communication components. The essential components of the hardware design include:

1. Arduino Controller:

The Arduino controller acts as the brain of the system, responsible for analyzing input from numerous sensors and performing suitable actions with observed circumstances.

2. Temperature and Humidity Sensor:

This sensor is applied to monitor variations in temperature and humidity levels. It gives vital data for recognizing probable fire conditions, particularly when there's a spike in temperature.

3. Smoke Sensor:

The gas detector is employed to detect the presence of smoke, a critical sign of a possible fire. It contributes to the early identification of fire threats.

4. Buzzer:

The buzzer works as an alarm, delivering aural notifications when the system detects indicators of fire or smoke. It acts as a critical component for informing inhabitants of possible threats.

5. WiFi Module:

The WiFi module permits wireless connectivity between the Arduino controller and an Android phone. This wireless link boosts the system's versatility and enables for remote monitoring.

6. GSM Module:

The GSM module permits connection between the Arduino controller and an Android phone via the virtual terminal. It enables the controller to deliver orders and alerts about fire and smoke detection. The overall fire detection and alarm system, together with the block diagram, is represented in Figures 3 and 4, respectively. These visualizations offer an overview of the hardware components and their relationships inside the system. The combination of sensors, communication modules, and the Arduino controller demonstrates a holistic approach to fire and smoke detection, offering a sturdy and effective system for boosting safety.

Figure3. Fire Detection and Alarm Systems

3.4.2 Software Design

The Arduino flame detector device provides an essential part for both industrial and domestic safety. This technology, upon sensing fire or smoke, instantly warns the user using the GSM module in turn. The software architecture of this a fire detector device is represented in Picture 5.

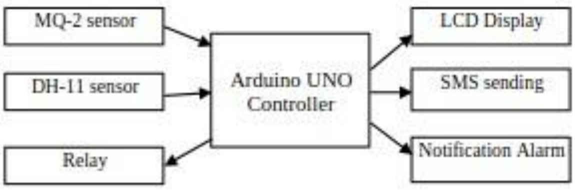

Figure4. Block Diagram

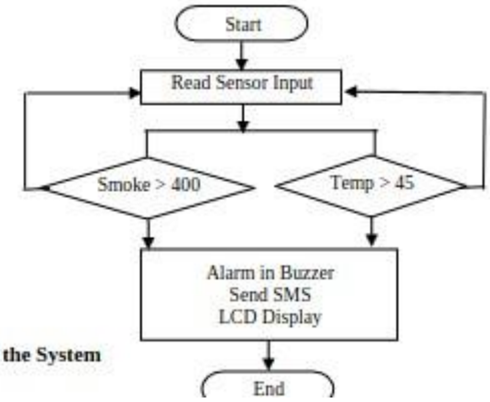

Figure5. Flow chat of the System

IV IMPLEMENTATION:

The hardware implementation of this system requires many critical components working together to enable excellent fire and smoke detection. The hardware components include:

1. **Gas Sensor**
2. **Temperature and Humidity Sensor**
3. **Arduino Microcontroller**
4. **GSM SIM-900A Module**
5. **Relay Module**

These components are integrated to produce a fire alarm system that can detect and notify humans in the presence of smoke, fire, carbon monoxide, or other problems. The implementation seeks to handle elements such as the building's geometry, size, layout, and use, which might impact the spread of fire and smoke inside a structure.

The system's functioning is as follows:

• The gas sensor is responsible for detecting the presence of gases, notably those connected with fires.

• Temperature and humidity sensor monitors changes in temperature and humidity, giving extra data for fire detection.

• The Arduino microcontroller acts as the central processing unit, coordinating the inputs from the sensors and triggering relevant actions.

• The GSM SIM-900A module provides connection between the system and external devices, such as an Android phone.

• The relay module supports the control of the GSM module, enabling the system to send warnings and messages when flames or fumes is detected.

When the system monitors flame or temperatures or when someone triggers a broken acrylic device, alarm sounders are activated.These sounders act as audio alerts, alerting persons inside the building to the probable existence of a flame as well as initiating evacuation measures.

The effective deployment of this hardware arrangement guarantees a dependable and rapid fire monitoring and alert system, leading to better safety in both industrial and domestic settings.

V CONCLUSION:

By the end, the present research demonstrates the conceptualization and effective implementation of an automated GSM-based alarm system for fires. The system is meant to be cost-effective and dependable, employing multiple sensors, including a fume sensor, and both moisture and temperature detectors. The major components of the system, including the sensors, Arduino controller, LCD display, Buzzer, and GSM module, work in unison to enable efficient detection of fires along with alerting.

The key characteristics and contributions of the framework include:

1. Sensor Integration:

Utilizing smoke, temperature, and humidity sensors to offer complete data for fire detection.

2. Arduino Controller:

Serving as the central processing unit, the Arduino controller processes sensor inputs and regulates the system's outputs.

3. Output Devices:

The Buzzer provides auditory notifications for fire alarms, while the LCD display graphically displays the fire detection status.

4. GSM Module:

Enabling contact with other devices, such as an Android phone, to warn particular people about the detected fire and avoid possible harm. The application of this technology extends to residential locations, workplaces, and hotels, leading to better safety and security. Multiple smoke detectors are advised, with installations on each story of a structure for thorough coverage.

The benefits of this technology lay in its capacity to give early detection, thereby preserving lives as well as properties. The quick notification capabilities of its GSM module give an added layer of safety, enabling users to take immediate action in reaction to fire situations. Overall, the system serves as a vital instrument for safeguarding the protection of persons and their houses.

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