# Gas Detector - System Specification

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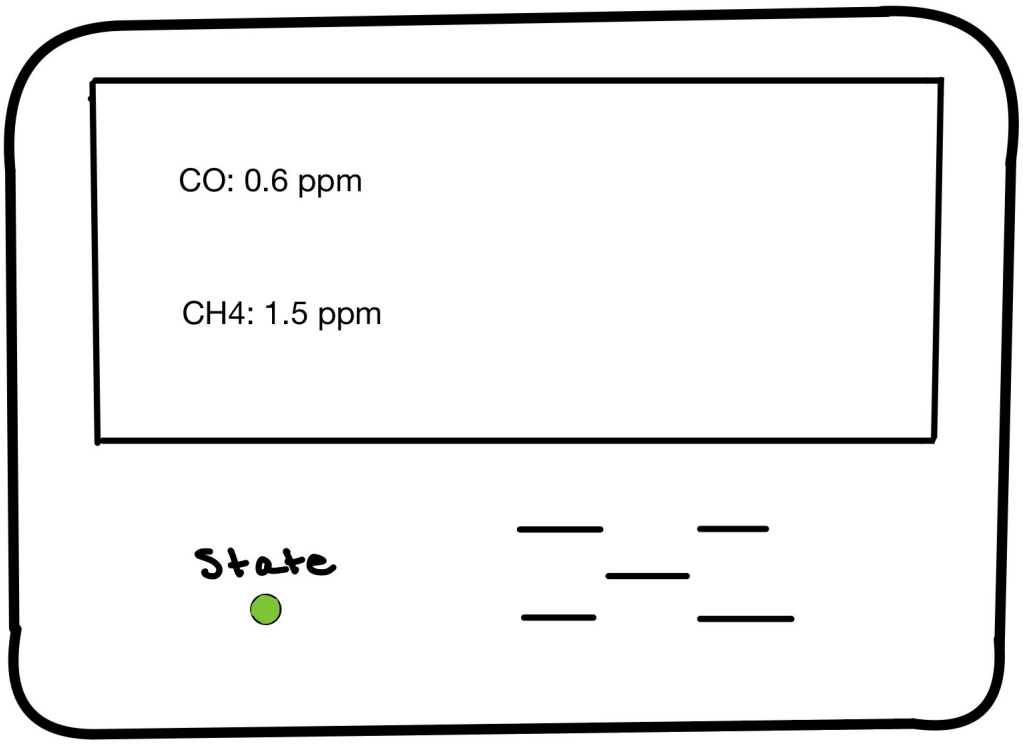


# Contents

# 1 The Concept

My gas detector combines advanced gas sensing, real-time alerts and automated ventilation into an all-in-one safety system providing homeowners with peace of mind by detecting hazardous leaks before they become life-threatening. This device helps prevent carbon monoxide (CO) and methane (CH4) poisoning, a leading cause of accidental home fatalities—while also reducing fire and explosion risks.

The detector integrates multiple components connected to an STM32F446RE microcontroller for sensor processing, alert logic, and system control. The system consists of an MQ-9 Gas Sensor which detects carbon monoxide and methane levels in real time. RGB LED for visual warning system (green = safe, yellow = caution, red = danger). An alarm Buzzer that is used for audible alerts for immediate hazard notification. An LCD display which will show gas concentration (ppm), system status and warnings. Intake/Exhaust fans that automatically ventilates the area if gas levels are unsafe.

The MQ-9 sensor continuously monitors air quality, ensuring early detection of leaks from faulty heaters, stoves, or gas lines. If dangerous levels are detected the system triggers the RGB LED by immediately changing colors for quick status checks and the buzzer by sounding a loud alarm that ensures awareness even if the user isn't near the display.

Initially, I considered using separate carbon monoxide and methane sensors, but the MQ-9 provides a cost-effective, dual-function solution. We also explored voice alerts, but due to power and complexity constraints, we prioritized a high-decibel buzzer for universal effectiveness. Early testing showed sensitivity to smoke or humidity, so we implemented calibration and threshold adjustments to improve accuracy and added intake/exhaust fan to improve the sensor readings.

In the future, I will aim for full AI-based predictive alerts and also focus on real-time detection with optional IoT expansion for future updates. This system prevents gas-related accidents, protecting families and reducing emergency incidents. Future enhancements could include predicting leaks based on historical sensor data and integrating with smart valves to cut supply during leaks. By combining reliability, automation and user-friendly alerts my MQ-9 Gas Detector delivers a smarter and safer way to protect homes from invisible threats.

# 2 Inputs/Outputs and Block Diagram

**Central block: Sensor processing/ System control/ Storage**

- Description: The STM32F446RE is the main microcontroller unit that handles sensor processing by converting analog gas sensor data to digital and processes it, system control by managing warnings, display, and relay logic. While also storing optionally logs sensor readings (e.g., to EEPROM or SD card).
- Input: The inputs are the analog sensor readings from the MQ-9 sensor
- Output: Control signals (GPIO) to LCD display, visual warning, alarm buzzer, relay module

**Gas Detection block**

- Description: This block represents the MQ-9 gas sensor which detects gases such as carbon monoxide (CO) or methane (CH4).
- Input: Voltage common collector (VCC) and ground (GND)
- Output: Analog output (AO) to the microcontroller for processing

**LCD Display block**

- Description: A character or graphic LCD module that shows gas concentration, system status, etc.
- Input: VCC, GND and GPIO (Data/Command signals from the microcontroller unit)
- Output: Printout text from the screen

**Visual Warning block**

- Description: An RGB LED to indicate warning states (green = safe, yellow = caution, red = danger).
- Input: VCC and GPIO for red, green and blue pins.
- Output: Emmits one of three color to represent the safety status.

**Alarm Buzzer block**

- Description: Emits sound in case of gas detection exceeding threshold.
- Input: VCC and GND
- Output: Audible alert

**5V Relay Module block**

- Description: Used to control high-power devices based on gas level detection.
- Input: VCC, GND and GPIO (Trigger signal from MCU).
- Output: COM line connects/disconnects Intake/Exhaust Fans and acts as a switch using 12V from External Power Supply.

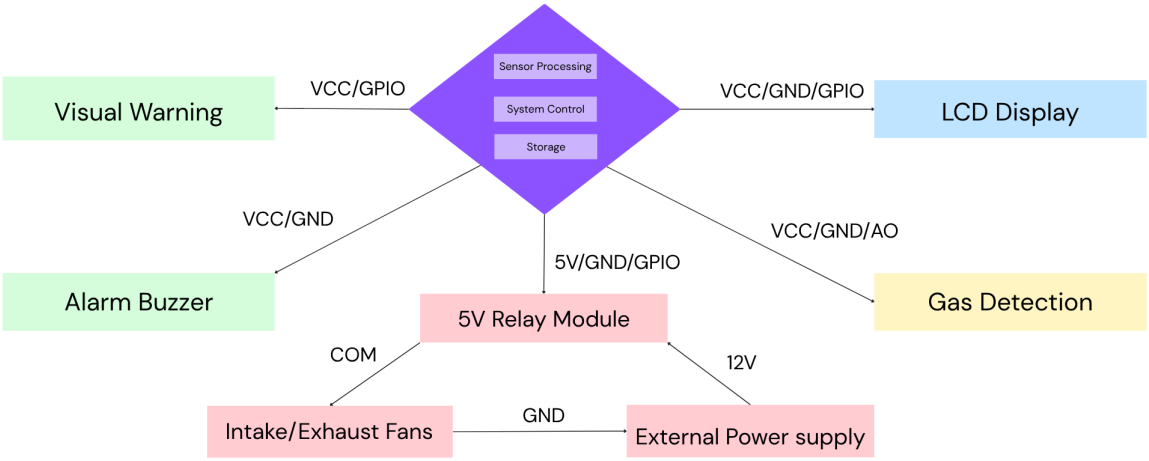
**Intake/Exhuast Fans block**

- Description: Controls the airflow from with the device to improve the gas detection
- Input: Power through COM line of Relay (connected to 12V via relay control)
- Output: Physical air movement

**External Power Supply block**

- Description: Used to supply 12V to the system in order to support the fans.
- Input: 12V and GND
- Output: N/A

# Block Diagram



# 3 Specification of the blocks

**STM32F446RE:**

The core of the gas detection system is an STM32F446RE microcontroller which handles sensor input, system control, output signals, and data management. The functionality reads analog signals from the gas sensor, processes concentration levels, and triggers actions like alarms, display updates, and fan control. It also manages timing, logic decisions, and peripheral coordination.

The technical specifications include ADC for reading analog signals, GPIO for interfacing with buzzer, relay, display, LEDs. Timer modules for delay and scheduling and flash storage or external EEPROM for logging historical data.

It's input is the analog output from the sensor itself and it's outputs are GPIO signals for visual warnings, buzzer, LCD, and relay module.

**5V Relay Module:**

The 5V relay module's functionality acts as an interface for controlling high system voltages. It has two contacts, normally open (NO) and normally closed (NC). The NO contact closes and the current flows through the voltage device. The NC contact opens, interrupting the connected device.

Its technical specifications include sending a 3.3V signal to the GPIO pin activating the coil inside the module. The coil creates a magnetic field and opens or closes the contacts. In addition, when the STM32 deactivates the delay low signal and the contacts NO and NC return to their default state.

It's output is the fans are controlled by the STM32 using pins connected to a 5V Relay module. The relay allows a low-voltage signal from the STM32 to maintain a higher voltage needed for the fans. A 12V supply is needed to power the 5V relay module and the fans.

**Alarm Buzzer:**

The alarm buzzer's functionality is a sound-emitting device that makes a beep when an electrical signal is applied. For my gas detector, it will be necessary to generate alerts with sound effects to people.

It's technical specifications include the positive and negative terminals will be connected to the STM32's 5V and GND pins. It interacts with the STM32 through GPIO to output signals.

**MQ-9 Gas Sensor:**

The MQ-9 gas sensor detects combustible gases like CO and CH4 through a sensitive material that changes resistance based on gas concentration. It's Functionality is it provides an analog voltage corresponding to gas concentration. This voltage is interpreted by the microcontroller to determine the level of hazard.

The technical specifications include the operating voltage which is 5V, the analog output (AO) voltage, sensitivity to CO, CH4, LPG; preheat time which is around 60 seconds.

The inputs are VCC, GND and output is the data collected from the sensor in analog siganls (AO).

**LCD Display:**

The LCD display functionality is displaying real-time data such as gas concentration levels and system alerts that will be used to give the user visual feedback about system status and detected gas levels. It improves usability and monitoring.

The technical specifications include the interface which in this case is a 4-bit parallel communication where the pins are D0-D3 of the LCD module.

The inputs are GPIO signals for data and control lines. The outputs is the display text visible to user.

**RGB LED**

The RGB LED's functionality provides a visual warning using light colors. It will use a tri-color (RGB) LED for indicating the system's status: normal (green), warning (yellow), danger (red).

The technical specifications include the voltage where it will be 5V depending and forward

current which is typically 20mA.

**Intake/Exhaust Fans**

The functionality of the intake/exhaust fans are responsible for circulating air to reduce gas concentration in hazardous situations. They ventilate the enclosed space.

The technical specifications include the voltage which is 12V DC and is controlled via relay, the current draw varies (typically 0.1A to 0.5A). Its inputs are power from 12V line (controlled via relay's NO contact) and its output is the airflow with the case.

**12V Power Supply**

The functionality of the external power supply is to provide a higher voltage needed to operate fans and the relay module; It powers the high voltage components separately from the STM32's 3.3V or 5V logic lines.

The technical specifications include the current which must math or exceed fan and relay current draw. The output is 12V DC to the fans and relay module.

# 4 System Description

This system is a comprehensive security solution centered around a STM32 and can be split into three different categories, the alarm system, the fan control and gas concentration monitoring. The alarm system consist of the RGB LED and a 3-12V DC buzzer to provide visual and sound indication if there is dangerous concentrations of methane or carbon monoxide. In this case the RGB LED will be connected to three GPIO pins (PB1, PB2, PB3) with a 1k ohm resistor for there respective color pins and its fourth pin will be connected to ground and the buzzer will be connected to 5V and ground. The fan control, will consists of an external power supply, two fans for intake and exhaust and a 5V relay module. The system utilizes a 12V power supply to power both the fans and a 5V relay module which controls the fans. The relay module, which is controlled by one of the STM32's GPIO pins (PB0) activates the fans by closing the circuit which allows the lock to engage or disengage. The relay is connected to the lock via its COM and NO terminals with the fans receiving power from the 12V supply when triggered by the relay. For gas concentration monitoring, the component will just be the MQ-9 gas sensor which will connected to 5V, ground and an ADC pin (PA4) in order for the microcontroller to interpret the analog data coming from the sensor. The configuration of the MQ-9 is based of this datasheet which was used for calibrating the sensor based on the data points from the Rs/R0 vs ppm log-log curves for CO and CH4. The graphs on page 5 (Figure 2) show a log-log plot of Rs/R0 vs ppm for several gases, including: CO (Carbon Monoxide), CH4 (Methane), LPG, Alcohol, etc. Using two points from the curves per gas, we can get the slope for each. For carbon monoxide based on the graph,

At 10 ppm $\rightarrow Rs/R_o \approx 3.7$
At 200 ppm $\rightarrow Rs/R_o \approx 0.5$

Now we can compute slope m and intercept b:

x1 = log10(10) = 1 y1 = log10(3.7) 0.57
x2 = log10(200) = 2.3 y2 = log10(0.5) -0.30

$m_{CO}$ = (y2 - y1) / (x2 - x1) $\approx (-0.30 - 0.57)/(2.3 - 1) \approx$ **-0.67**
$b_{CO}$ = y1 - $m_{CO}$ * x1 $\approx 0.57 - (-0.67) * 1 \approx$ **1.24**

For methane based on the graph,

At 200 ppm $\rightarrow Rs/R_o \approx 2.7$
At 10000 ppm $\rightarrow Rs/R_o \approx 0.4$

x1 = log10(200) $\approx 2.3$ $y1 = log10(2.7) \approx 0.43$
$x2 = log10(10000) = 4$ $y2 = log10(0.4) \approx -0.40$

$m_{CH_4}$ = (y2 - y1) / (x2 - x1) $\approx (-0.40 - 0.43)/(4 - 2.3) \approx$ **-0.49**
$b_{CH_4}$ = y1 - $m_{CH_4}$ * x1 $\approx 0.43 - (-0.49 * 2.3) \approx$ **1.56**

Using these slopes, we can calculate the gas concentrations for both carbon monoxide and methane in parts per million(PPM).

Overall, this system combines advanced gas sensing, real-time alerts and automated ventilation to create a robust interconnected security solution managed and monitored by the STM32. The following figure is my schematic (Figure 1):

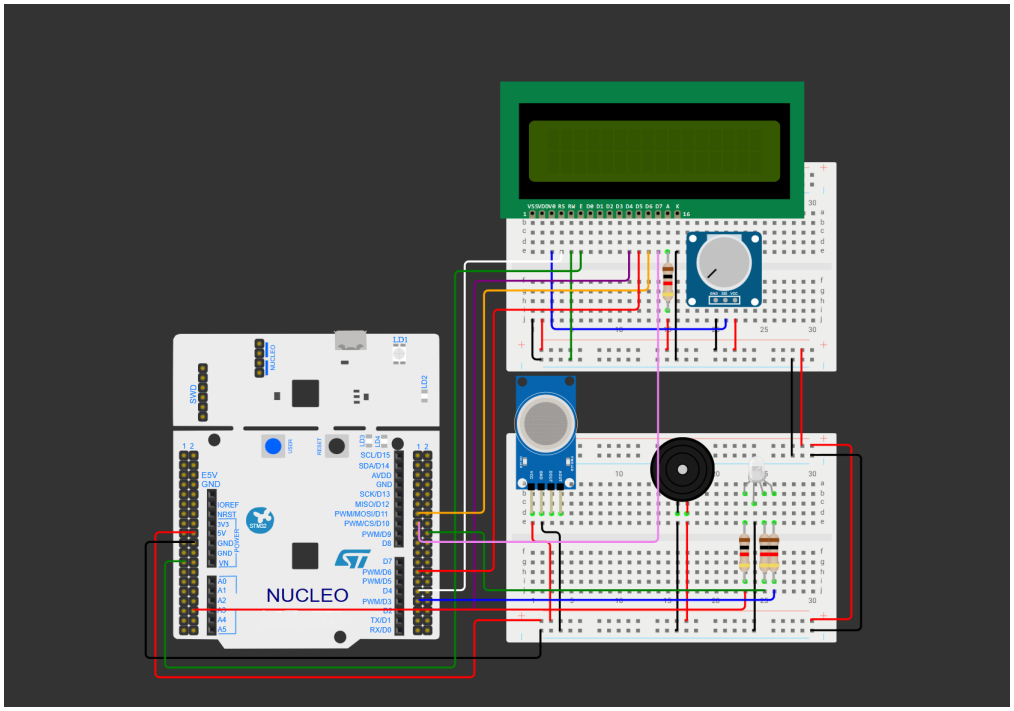



Figure 1: Schematic of the gas detector circuit