Design and Development of an Automated Carbon Monoxide Detection with Emergency Alert for Vehicle Safety

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ABSTRACT

This study proposes a compact, real-time carbon monoxide (CO) detection system for in- vehicle environments using the MQ-7 sensor and Raspberry Pi 4 integrated with a SIM7600X GSM module. The system is designed to monitor CO levels and automatically alert emergency contacts via SMS when dangerous thresholds are detected. Testing was conducted in a vehicle at five distinct locations to evaluate sensor placement and communication response. Results show that dashboard placement yields the fastest detection (5 seconds) and consistent GSM message delivery within 2–3 seconds. This system addresses the limitations of standalone CO detectors by introducing emergency communication capabilities. The solution is compact, cost-effective, and suitable forretrofitting into existing vehicles. Findings suggest the system's potential for improving automotive safety and offer a scalable model for real-time hazardous gas alert systems.

Keywords: Carbon Monoxide, GSM, Raspberry Pi, MQ-7, Vehicle Safety, IoT.

INTRODUCTION

Carbon monoxide (CO) is a highly toxic, colorless, and odorless gas generated from incomplete combustion, commonly found in vehicle exhaust systems. In enclosed environments such as vehicle cabins, CO accumulation poses a serious health risk that can lead to unconsciousness or death. Despite the advent of numerous in-vehicle safety systems, CO detection is not widely integrated into commercial vehicles. Current systems are often standalone units intended for residential use, offering limited emergency communication functionality.

This research addresses that gap by developing a lightweight, GSM-enabled system capable of real-time CO monitoring and emergency alerting. The primary objective is to provide occupants with immediate warning through SMS alerts when dangerous CO levels are detected, especially in situations where the victims may be incapacitated.

METHODOLOGY

This project adopts a structured approach to designing and validating a real-time carbon monoxide detection and alert system tailored for vehicle environments. The system integrates digital gas sensing with embedded processing and GSM-based communication to ensure timely response during hazardous conditions. The methodology involves selecting appropriate hardware components, developing control logic via Python, and evaluating the system under realistic conditions inside a vehicle. Both hardware integration and software development are optimized for minimal footprint, reliability, and ease of deployment in enclosed automotive spaces. Testing includes simulated CO exposure and performance analysis of alert timings and sensor responsiveness across multiple in-vehiclelocations.

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Hardware Architecture

The system consists of three main components:

- MQ-7 Sensor: For digital CO detection.
- Raspberry Pi 4: Main controller, processing sensor input.
- SIM7600X GSM Module: Sends SMS alerts upon detection.

The MQ-7's digital output is connected to GPIO17 on the Raspberry Pi. The SIM7600X is interfaced via USB (ttyUSB2). Power is supplied via a 5V adapter.

Software Setup

The Python code uses RPi.GPIO for sensor input and pyserial for AT command communication with the GSM module. When CO is detected (LOW signal), the Raspberry Pi executes AT commands to send a predefined SMS alert.

Table 1: System parameters and configuration values

Parameter	Value/Description
Sensor Model	MQ-7 Carbon Monoxide Sensor
Sensor Output Type	Digital (DO pin used)
Controller Unit	Raspberry Pi 4 Model B
GPIO Pin for CO Detection	GPIO17 (Pin 11)
GSM Module	SIM7600X 4G HAT
Communication Port	/dev/ttyUSB2 (via USB interface)
Baud Rate	115200 bps
Power Supply	5V, 3A USB-C Adapter
Average CO Detection Time	5–12 seconds (based on in-car location)
Average SMS Delivery Time	2.3 – 2.7 seconds
Emergency Contact Format	+60XXXXXXXXX (international format for SMS delivery)
Programming Language	Python 3 (using RPi.GPIO and pyserial libraries)
Trigger Threshold (Digital)	LOW signal from MQ-7 DO pin indicates CO presence

EXPERIMENTAL SETUP AND VALIDATION

Test Locations

The device was installed in a real vehicle, powered via the Raspberry Pi's 5V adapter. A cigarette lighter was used to simulate CO presence in a controlled, non-hazardous way.

Five locations were selected within a car:

1. Dashboard
2. Center Console
3. Under Front Seat
4. Passenger Footwell
5. Rear Seat Backrest

Each location was tested for CO detection. Readings were recorded for detection delay and SMS delivery time.

(a)

(b)

(c)

(d)

(e)

Results Summary

Location	Avg. DetectionTime (s)	SMS Delivery Time (s)	Notes
Dashboard	5	2.5	Fastest response due to airflow
Center Console	7	2.3	Balanced response andprotection
Under Front Seat	12	2.7	Delayed due to air stagnation
Passenger Footwell	10	2.4	Adequate butless ideal placement
Rear Seat Backrest	9	2.6	Slower due to distance from airflow sources

RESULTS AND DISCUSSION

Detection Timing by Location

Location	Average Detection Time (s)	Average SMS Delivery Time(s)	Notes
Dashboard	5	2.5	Fastest response due to direct airflow from front vents.
Center Console	7	2.3	Balanced response, protected and easy to install.
Under Front Seat	12	2.7	Delayed response due toreduced air circulation.
PassengerFootwell	10	2.4	Response time fair, butphysical space is limited.
Rear Seat Backrest	9	2.6	Detection slower than frontcabin positions.

This data revealed that the dashboard location produced the fastest CO detection time (5 seconds), due to its proximity to incoming airflow. The center console was also effective, offering both fast detection and practical installation.

GSM Alert Timing

SMS alerts were consistently delivered within 2–3 seconds. The system performedreliably under varying signal conditions with CSQ values between 15 and 24

Overall Discussion.

The results validate the system's ability to detect CO exposure and respond effectively through communication. Unlike commercial CO detectors that only produce a sound alarm, this prototype initiates remote alerts, critical in cases where occupants are unableto act.

The center console location is the most practical compromise between performance and installation convenience. The digital-only MQ-7 implementation simplifies the circuit but lacks ppm resolution, which could be improved using ADCs in future versions.

The SIM7600X module, while reliable, required USB-based activation to start GSM functionality, which may pose challenges in compact casing designs. However, once powered and initialized, communication was stable and fast.

CONCLUSION

The study successfully demonstrates a lightweight, effective CO monitoring system using the MQ-7 and Raspberry Pi with GSM communication. The proposed device fills the gap in existing vehicle safety technology by adding automated alerts. It can be implemented in a variety of vehicle models with minimal integration cost. Future work may include analogreadings with ADCs and AI-based predictive alerts.

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