PROJECT ABSTRACT

IoT Smart Manhole Cover Monitor with Displacement and Gas Alerts

An ESP32-based monitor that bolts under a manhole cover to detect cover displacement and dangerous sewer gas build-up (methane, hydrogen sulfide), raising local and Wi-Fi alerts with the cover's location.

01. Title

IoT Smart Manhole Cover Monitor with Displacement and Gas Alerts

02. Introduction / Background

Open or displaced manhole covers cause fatal accidents every year, and sewer gas build-up — methane and hydrogen sulfide — kills sanitation workers silently. Municipal monitoring of covers is practically nonexistent in most Indian cities: inspections are manual and infrequent. This project builds the missing sensing layer as a student-buildable prototype: a monitor box fixed to the underside of the cover detects tilt and displacement with an accelerometer/tilt switch, sniffs gases with MQ-series sensors, and reports over Wi-Fi with a local buzzer and LCD for on-site status. The engineering substance is in the threshold logic — distinguishing a real gas hazard from sensor drift, and real cover movement from vibration — plus the low-power design thinking for a device that must live in the field.

03. Problem Statement

Civic-safety IoT projects often demonstrate a sensor on a bench without addressing the actual deployment questions: how thresholds are set, how false alarms are suppressed, how the device is powered and mounted, and how alerts reach someone who can act. The project addresses this by building the complete monitor — sensing, threshold logic, local alarm, Wi-Fi alerts with location tags, event logging, enclosure and mounting design, and a buyer-run calibration procedure — around the genuine hazards of displaced covers and sewer gas.

04. Objectives

- Detect cover displacement/opening with tilt/shock sensing and a configurable threshold angle.
- Sense methane (MQ-4) and hydrogen sulfide (MQ-136) with calibrated, drift-aware alert thresholds.
- Raise local alarms (buzzer + LCD) and push Wi-Fi alerts with the cover's location tag.
- Log all displacement, gas and baseline events with timestamps for the monitoring view.
- Design for the field: sleep scheduling, solar-charging provision, IP-rated enclosure and mounting.

- Deliver the buyer-run calibration procedure plus the complete student kit.

05. Proposed Methodology

The system is developed in three stages. (1) Sensing: the MQ-4 and MQ-136 are characterized (warm-up behavior, baseline in clean air) and the tilt sensor's baseline orientation is recorded at installation. (2) Firmware: the ESP32 samples gas levels on a schedule between deep sleeps, applies persistence filtering (an alert needs the threshold crossed for a confirmed duration, not a single spike), watches tilt against the configured angle, drives the buzzer/LCD locally and pushes alerts over Wi-Fi (HTTP/MQTT) with the device ID and location tag. (3) Deployment design: the power budget is calculated from the sampling schedule, the enclosure and under-cover mounting are documented, and the calibration procedure lets the buyer set baselines and thresholds on their own build.

06. System Architecture / Working

The monitor unit is fixed to the underside of the manhole cover. On power-up the gas sensors warm up and the ESP32 establishes baselines. An accelerometer/tilt switch watches orientation; gas sensors are sampled on schedule between low-power sleeps. Tilt beyond the configured threshold (design target ±10°) raises a displacement alert; gas readings crossing their thresholds for the confirmed duration raise a gas-hazard alert with the measured levels. Both fire the buzzer, update the LCD (live gas levels + cover status for on-site crews), and push a timestamped event with the location tag to the monitoring endpoint.

07. Hardware / Software Requirements

- ESP32 dev board (Wi-Fi, deep-sleep) with Arduino-framework firmware
- MQ-4 methane sensor (300–10,000 ppm per datasheet), MQ-136 hydrogen sulfide sensor
- Tilt switch / accelerometer for displacement sensing; 16×2 LCD; buzzer
- Battery pack with sleep scheduling; solar-charging provision (documented)
- HTTP/MQTT alert endpoint with event-log dashboard; IP-rated enclosure

08. Expected Outcomes

The project delivers an assembled monitor prototype that detects cover displacement and gas build-up, alarms locally and pushes located alerts over Wi-Fi, with all events timestamp-logged. Alert thresholds are design targets set during the buyer's own calibration — no measured detection figures are claimed before that run. Deliverables: the prototype, firmware source, wiring diagrams and BOM with exact part numbers, the calibration and mounting documentation, power-budget calculation, project report PDF, PPT and viva Q&A; document.

09. Applications

Municipal manhole safety monitoring; sanitation-worker protection; smart-city infrastructure sensing; industrial confined-space gas indication; campus utility-cover monitoring.

10. Future Scope

- MQ readings are indicative, not lab-grade — they drift with temperature/humidity, hence the calibration procedure.
- Alert thresholds are design targets set in the buyer's calibration; nothing is claimed as measured before that.
- Wi-Fi range limits underground deployment; LoRa is documented as the upgrade path (future scope).
- Battery life follows the sampling schedule and solar input — the report gives the calculation, not a measured figure.
- A hazard-indication prototype, not certified safety equipment.
- Future scope: LoRa uplink, multi-gas arrays, integration with municipal GIS dashboards.
- The project gives the student a complete civic-safety IoT build: real sensors with real drift characteristics, threshold logic that must be designed rather than assumed, wireless alerting with location context, and the power and enclosure thinking a field device demands. The buyer-run calibration procedure keeps every claim honest, and the problem it addresses is one examiners immediately recognize as real.