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PROJECT ABSTRACT

3D Printer Enclosure Air Quality Monitor with Ventilation Fan Control

An ESP32 monitor for 3D printer enclosures with BME280 climate sensing, MQ-135 air-quality trend sensing, relay-driven ventilation fan control and a thermal alarm. Delivered built-to-order with prototype, firmware, calibration notes, report, PPT and viva kit.

01. Title

3D Printer Enclosure Air Quality Monitor with Ventilation Fan Control

02. Introduction / Background

Enclosing a 3D printer improves ABS and ASA prints, but the closed box traps heat and the volatile compounds filaments release — and most hobby enclosures carry no instrumentation at all. Users discover overheating when a print warps and fumes when the room smells. The engineering answer is a monitor that watches climate and air quality and acts: venting the enclosure when temperature or the air-quality index crosses a threshold, and alarming on a thermal high limit. This project builds exactly that on an ESP32, with the report careful about what each sensor can claim — the BME280 is factory-calibrated, while the MQ-135 gives a relative index after burn-in, never certified ppm.

03. Problem Statement

Uninstrumented enclosures leave heat and fume management to guesswork, and the two sensors needed behave very differently: one is a calibrated instrument, the other a trend sensor requiring burn-in and baselining. The project addresses this by pairing them honestly — BME280 for temperature and humidity, MQ-135 for an air-quality index — driving a relay-switched ventilation fan with hysteresis on independent threshold pairs, and raising a thermal high-limit alarm independent of the fan loop, all visible on an OLED and a Wi-Fi dashboard.

04. Objectives

- Measure enclosure temperature and humidity with a BME280.
- Track air-quality trends with an MQ-135 as a relative index after burn-in.
- Drive a 12 V ventilation fan through a relay on temperature or air-quality thresholds.
- Implement hysteresis on every threshold to stop relay chattering.
- Raise a thermal high-limit alarm with buzzer, independent of the fan loop.
- Display live values and fan state on an OLED and a Wi-Fi dashboard.

05. Proposed Methodology

The system is developed in three stages. (1) Sensing: the ESP32 samples the BME280 and the MQ-135 on a fixed cycle; the MQ-135 reading is normalized against its burn-in baseline into a relative air-quality index following the documented procedure. (2) Control: temperature and the index are each compared against independent on/off threshold pairs with hysteresis; either trip energizes the fan relay, and a separate high-limit on temperature fires the buzzer alarm. (3) Interface: the OLED shows enclosure temperature, humidity, index and fan state; the Wi-Fi dashboard mirrors the values, allows threshold edits that apply immediately, and logs fan and alarm events with timestamps.

06. System Architecture / Working

Each sampling cycle refreshes temperature, humidity and the air-quality index. The control loop checks the temperature threshold pair and the air-quality threshold pair; whichever trips first switches the 2-channel relay and starts the 12 V fan, with the OLED and dashboard naming the triggering cause. Readings falling below the off-points stop the fan. The thermal high-limit sits outside the fan loop: crossing it sounds the buzzer and shows a thermal warning regardless of fan state. Warming the sensor with a hand or wafting a solvent near it demonstrates the full sense-decide-actuate loop live.

07. Hardware / Software Requirements

- ESP32 development board
- BME280 temperature/humidity/pressure sensor
- MQ-135 air-quality gas sensor
- 2-channel 5 V relay module
- 12 V DC cooling fan
- 0.96-inch OLED display (I2C)
- Piezo buzzer
- Arduino IDE (C/C++ firmware)

08. Expected Outcomes

- A working monitor that vents the enclosure on temperature or air-quality thresholds.
- A thermal high-limit alarm independent of the fan loop.
- A documented MQ-135 burn-in and baseline procedure the student performs.
- A complete report, PPT and viva Q&A; on sensor pairing, hysteresis and burn-in.

09. Applications

- Instrumentation for enclosed 3D printers in labs and maker spaces.
- Teaching the difference between calibrated sensors and trend sensors.
- Demonstrating hysteresis control in embedded actuation loops.

10. Future Scope

- Ducted fume extraction to outdoors instead of recirculation.
- Filter-life tracking on the ventilation path.
- Multi-enclosure monitoring from one dashboard.

- Particulate sensing with a PM sensor as an added channel.