**Project Report - Smart Air Quality Monitoring System**

**Abstract**

Indoor air quality monitoring is essential for maintaining ambient conditions that are safe and comfortable. This project implements a smart air quality monitor using ESP32, DHT11, MQ2 gas sensor and bi-color LED indicator. It continuously tracks temperature, humidity, combustible gases and visually indicates air quality through the LED.

**Introduction**

Indoor air quality affects the health, comfort and performance of building occupants. Parameters like temperature, humidity, and hazardous gases need monitoring. This project develops an effective and low-cost air quality monitoring system using common components like sensors, ESP32 controller and simple LED indicator.

**Background**

Poor indoor air quality can cause a range of adverse health effects. Sources of pollution include smoke, cleaning chemicals, mold, allergens, and toxic gases like carbon monoxide and VOCs from furnishings or paints. Prolonged exposure can lead to respiratory illnesses, headaches, infections and long term diseases. Real-time monitoring is essential for maintaining air quality and detecting sources of pollution early.

**System Overview**

The developed system monitors temperature, humidity and combustible gases in ambient air and provides instant visual indications through a bi-color LED indicator. This gives real-time insights into air quality without needing complex outputs.

**Hardware Components**

**\*ESP32 Microcontroller**

The ESP32 is a low cost yet powerful microcontroller chip designed for IoT applications. Key features:

- 240 MHz dual core Tensilica LX6 microprocessor with 520 KB SRAM

- Integrated 802.11 BGN WiFi and Bluetooth

- Various peripherals like ADC, DAC, touch sensors, timers, UART, SPI, I2C

- Ultra low power consumption

- Can operate standalone or integrate with cloud platforms

The ESP32 provides the processing power, wireless connectivity and I/O interfaces required for the air quality monitor system.

**\*DHT11 Temperature and Humidity Sensor**

The DHT11 is a digital humidity and temperature sensor with calibration. Key features:

- 3-5V power and I/O supply

- Humidity range of 20-90% with 5% accuracy

- Temperature range of 0-50°C with ±2°C accuracy

- Fast sampling rate

- Digital output, direct interface with microcontrollers

- Low power consumption

The DHT11 is interfaced using a single wire to the ESP32 to provide ambient temperature and humidity measurements.

**\*MQ2 Gas Sensor**

The MQ2 is an analog gas sensor capable of detecting a wide range of combustible and toxic gases like methane, butane, LPG, smoke, alcohol etc. Key features:

- Operating voltage: 5V ± 0.1V

- Detectable gas concentrations: 300 to 10000 ppm

- Fast response and high sensitivity

- Simple analog interface, output voltage proportional to gas concentration

- Heating coil to maintain sensor temperature

The MQ2 provides the combustible gas sensing capability required to monitor air quality.

**\*Bi-color LED**

A red-green bi-color LED is used as an output indicator for air quality status:

- Green indicates good air quality

- Red indicates poor air quality with high gas levels

The simple LED indicator provides live visual feedback without needing complex displays.

**\*Other Components**

- Breadboard, jumper wires and resistors are used to prototype the circuit.

- A 5V USB phone charger is used as the power supply.

**Software Implementation**

The system software is implemented on the Arduino IDE using C/C++. The ESP32 board support packages are installed to compile and upload code to the board.

Key software modules:

**\*Sensor Reading**

Dedicated functions to read the DHT11 and MQ2 sensor values. DHT11 uses proprietary library while MQ2 is read using ADC.

**\*Air Quality Assessment**

Processes MQ2 sensor value and checks it against pre-defined thresholds to quantify air quality as Good/Poor.

\*LED Control

Based on air quality, it lights up the green or red LED accordingly.

**\*Main Loop**

The core logic that runs continuously - reads sensors, processes data, controls LED output.

The modular structure allows easy extensibility and additional functionality to be built on top of the core air quality monitoring.

**Working Principle**

The DHT11 and MQ2 sensors are interfaced to the analog and digital I/O pins on the ESP32 board. The ESP32 continuously reads values from both sensors at a 2 second interval.

DHT11 directly provides digital temperature and humidity data. MQ2 output requires analog to digital conversion to get gas concentration value.

The gas concentration is compared to predefined threshold levels to determine air quality as Good or Poor. If poor, the red LED lights up, else green LED turns on. The LED indicates live status without needing any numeric display.

This sequence runs continuously to monitor any changes in air quality in real-time. The modular software architecture allows new sensors, connectivity features and data processing logic to be added.

**Advantages**

- Low cost implementation using common components

- Real-time monitoring for early hazard detection

- Simple LED indication, no complex display needed

- Minimal calibration required compared to advanced sensors

- Modular architecture allows easy extensibility

- Leverages ESP32's powerful on-board processing and wireless

**Limitations**

- Limited to monitoring gases detectable by MQ2 sensor

- Prone to sensor drifts requiring periodic calibration

- Basic data processing and threshold alerts

- Limited number of analog sensor inputs on ESP32

- WiFi connectivity not used in this implementation

**Applications**

- Gas leak detection systems for homes, factories

- Kitchen safety monitors in restaurants

- Fume hoods and air ducts in chemistry labs

- HVAC systems air quality monitoring

- Automotive LPG/CNG leakage detection

- Air pollution monitoring in cities

**Future Enhancements**

- Add WiFi connectivity to upload data to cloud platforms

- Use advanced gas sensors like CCS811 with digital output

- Detect additional gases like CO, VOCs, Ozone

- Implement smartphone apps for remote monitoring

- Add machine learning to classify gases based on patterns

- Control ventilation systems based on measured gas levels

- Solar-based power supply for outdoor sensor stations

**Conclusion**

The project demonstrated an easy to implement air quality monitoring system built around the ESP32 controller. It monitors temperature, humidity and combustible gases in ambient air and indicates real-time air quality through a simple bi-color LED indicator. The well modularized design allows extending its capabilities by adding sensors, connectivity, data analytics and more.