AIR QUALITY MONITORING ESP32 IOT SYSTEM

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Abstract:

This project presents the design and implementation of a real-time **Air Quality Monitoring System** using the **ESP32 microcontroller** integrated with multiple sensors and IoT platforms. The system utilizes a **DHT11 sensor** to monitor ambient temperature and humidity, and an **MQ-135 gas sensor** to evaluate air quality through gas concentration levels.

Data is collected at regular intervals and transmitted over Wi-Fi to the **Blynk IoT platform**, providing users with real-time visual feedback via a mobile application. Additionally, readings are logged to **Google Sheets** for historical analysis, enabling trend tracking over time. The system features **event-based alerts**, such as notifications for high temperature or dangerous gas levels.

To enhance accessibility, the system supports **WhatsApp-based queries** using **ThingESP**, allowing users to request environmental data remotely via predefined text commands. It also incorporates **Over-the-Air (OTA) updates** through OTADrive, ensuring that firmware enhancements can be deployed without physical access to the device.

The solution is low-cost, scalable, and ideal for smart homes, schools, and environmental monitoring setups, offering a practical tool for tracking indoor or outdoor air quality and promoting public health awareness.

Project Overview:

This IoT-based **Air Quality Monitoring System** is built using an **ESP32 microcontroller**, **DHT11 sensor**, **MQ-135 gas sensor**, and is integrated with **Blynk**, **ThingESP**, and **Google Sheets** to monitor environmental conditions in real-time. The system reads temperature, humidity, and air quality, sends data to mobile apps and cloud storage, and supports **OTA (Over-the-Air) firmware updates** and **WhatsApp-based queries**.

System Architecture:

1. **ESP32 Microcontroller**
   - Controls sensor readings, communication, and data processing.
2. **DHT11 Sensor**
   - Measures **temperature** and **humidity**.
3. **MQ-135 Gas Sensor**
   - Measures **air quality (gas concentration)** via:
     - **Analog Output (AOUT)** for gas level intensity.
     - **Digital Output (DOUT)** for threshold-based alerts.
4. **WiFi Connectivity**
   - Used to connect to:
     - Blynk IoT Platform
     - Google Sheets
     - OTA update server
     - ThingESP for WhatsApp integration
5. **Cloud Services**
   - **Blynk**: Real-time sensor data visualization and alerts.
   - **Google Sheets**: Logs temperature, humidity, and gas levels for historical analysis.
   - **ThingESP**: Enables WhatsApp commands to query the system remotely.
   - **OTADrive**: Firmware updates via the internet.

Sensor Data Overview

Parameters Monitored:

- Temperature (°C)
- Humidity (%)
- Gas Concentration (Analog Value)

Air Quality Classification:

Gas Level	Air Quality	Status
< 200	Good	Safe
200 – 399	Moderate	Caution
400 – 599	Poor	Unhealthy
≥ 600	Dangerous!!	Critical

Functional Flow

1. **Sensor Readings**
   - Collected every 5 seconds via a `BlynkTimer`.
2. **Status Update**
   - Sensor readings are:
     - Printed on Serial Monitor.
     - Sent to Blynk via virtual pins `V0` (temperature), `V1` (humidity), `V2` (gas), and `V3` (status).
     - Logged to Google Sheets via an HTTP POST.
3. **Alerts and Notifications**
   - **Heat Alert**: Temperature > 40°C triggers a Blynk event.
   - **Pollution Alert**: Gas Level > 600 triggers a Blynk event.
4. **User Interaction (WhatsApp via ThingESP)**
   - Valid queries:
     - `temperature` → Returns current temperature.
     - `humidity` → Returns humidity.
     - `airquality`/`air quality` → Returns gas level and status.
     - `report` → Returns full environmental status.
5. **OTA Update Handling**
   - Every 5 minutes, checks OTADrive server for updates.
   - If available, updates firmware automatically.

User Interfaces

Blynk App:

- Live display of temperature, humidity, gas levels.
- Notifications for alerts (heat, pollution).

WhatsApp (via ThingESP):

- Text-based command and response.
- Useful for users without the Blynk app.

Google Sheets:

- Logs historical data with time stamps (server-dependent).

Security & Stability

- OTA security relies on a unique **API key**.
- WhatsApp interactions are limited to defined queries, minimizing misuse.
- Built-in checks for sensor read failures (e.g., `isnan(temp)`).
- Network failure handling for HTTP and OTA.

Future Improvements

- Add **timestamping** in Google Sheets.
- Upgrade to **DHT22** for better temperature/humidity precision.
- Calibrate MQ-135 for more accurate PPM readings.
- Integrate **push notifications** via WhatsApp or Telegram.
- Include **battery power and offline logging** capability.

Sample Output:

Left panel — Air Quality M... dashboard:

- 33 (gauge 0–100)
- Temperature: 37.4 °C (gauge 0–100)
- Air Quality: 283 ppm (gauge 0–1000)

Right panel — WhatsApp chat:

humidity 7:15 PM ✓✓

💧 Humidity_iqra: 33.00% 7:15 PM

temperature 7:15 PM ✓✓

🌡️ Temperature: 37.40°C 7:15 PM

report 7:15 PM ✓✓

📊 Air Quality Report:

Temperature: 37.40°C
Humidity: 33.00%
Air Quality: Moderate ⚠️ (262)

7:15 PM