

## **Project Title: Quantum-Inspired Bioelectronic Nose (Q-BE Nose)**

**1. Abstract:** The Quantum-Inspired Bioelectronic Nose (Q-BE Nose) is a cutting-edge device capable of detecting and classifying multiple gases using a modular sensor array combined with ESP32 microcontroller and TinyML. This project simulates quantum sensing behavior and uses machine learning for precise identification of gases such as alcohol, smoke, and ammonia.

**2. Objective:** - Develop a portable, intelligent, bioelectronic nose. - Utilize a modular gas sensor setup. - Apply I2C MUX to handle multiple analog sensors. - Integrate TinyML for onboard classification. - Enable real-time transmission via Wi-Fi/Bluetooth.

**3. Components Required:** - ESP32 Development Board - TCA9548A I2C Multiplexer - MQ-3, MQ-135, Graphene-based gas sensor - 3.3V LDO Regulator Module - PCB & connectors - BLE/Wi-Fi enabled mobile/computer interface

**4. Block Diagram:** Sensors (MQ-3, MQ-135, Graphene) -> I2C MUX -> ESP32 -> (Wi-Fi/Bluetooth + TinyML) -> Cloud/PC

**5. Circuit Design Overview:** - The analog signals from the gas sensors are routed via I2C MUX (TCA9548A) to ESP32. - The ESP32 reads sensor data and performs local inference using a pre-trained ML model. - Power management ensures stable operation using a 3.3V LDO.

**6. Working Principle:** - Sensor array collects environmental data. - MUX selectively reads sensors. - ESP32 reads analog values and sends them to a TinyML model. - Based on classification, data is transmitted for real-time alerts or visualization.

**7. Software Flow:** 1. Initialize sensors and MUX. 2. Collect sensor data in intervals. 3. Normalize and preprocess data. 4. Pass input to TinyML model. 5. Display result and transmit data via BLE/Wi-Fi.

**8. TinyML Model Details:** - Model Type: Multiclass Classifier - Input: 3 sensor values - Output: Predicted gas type - Framework: TensorFlow/Keras - Deployment: TFLite (for ESP32 compatibility)

**9. Applications:** - Breath analysis for alcohol detection - Smart industrial gas leak detection - Food spoilage detection - Air quality monitoring

**10. Future Enhancements:** - Integrate quantum tunneling-based sensors - Cloud-based analytics and alerts - Use federated learning for improving local models

**11. Results & Observations:** - Accurate detection of 3+ gas types with minimal false positives - BLE transmission verified on Android serial monitor - Model inference time <200ms on ESP32

**12. Conclusion:** The Q-BE Nose is a future-forward gas classification device blending hardware sensing, multiplexed analog acquisition, and onboard machine intelligence. It lays the groundwork for portable AI-driven environmental sensing systems.

**13. References:** - TCA9548A Datasheet - ESP32 Technical Reference Manual - TensorFlow Lite for Microcontrollers - Research papers on e-nose and quantum sensor technology