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IoT-Based Indoor AQI Emulation System

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Abstract: *With the acceleration of urban lifestyles and the proliferation of ambient contaminants, monitoring and maintaining indoor air hygiene has become a critical pillar of smart home automation. However, developing and testing adaptive domestic utility platforms within a clean laboratory environment remains a significant challenge due to the difficulty of safely generating precise, controlled levels of localized atmospheric pollution. This paper introduces an IoT-Based Indoor Air Quality Index (AQI) Emulation System designed to bridge the gap between software simulation and physical mechatronic response. Built around an open-source microcontroller architecture, the system leverages a dual-voltage topology (12V/5V) to isolate low-power logic from high-draw components, incorporating real-time environmental data acquisition from gas and particulate matter (PM2.5) sensor arrays.*

To overcome the testing constraints of pristine testing environments, we developed a state-machine calibration loop capable of generating synthetic atmospheric telemetry. This dynamic emulator allows developers to safely inject complex pollution scenarios into the system logic, verifying that the hardware can autonomously pivot from surface maintenance routines to active air purification protocols without endangering workshop safety. Interfaced wirelessly over a low-overhead Bluetooth Classic (UART) serial bridge, users can monitor localized environmental analytics and trigger manual operation profiles directly via a custom Smartphone interface.

Experimental validation indicates that the emulation layer accurately mirrors physical sensor tracking behaviors with minimal latency. By stripping away the need for costly industrial mapping assets or hazardous pollutant deployment, this frugal engineering framework provides a highly modular, open-source, and cost-effective test bed. Ultimately, this research democratizes the development of smart, environmentally responsive appliances, offering an accessible architecture for the next generation of hybrid domestic utility robotics.

Keywords: Air Quality Index (AQI), Emulation System, Internet of Things (IoT), Arduino, Mobile Robotics, Frugal Engineering, Smart Home Automation.