Demand Controlled Ventilation using CO2 Sensors in a Wireless Sensor Network

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RET Program - Summer 2013

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Abstract: The focus of this research project was to investigate Indoor Air Quality (IAQ) monitoring technologies, government regulations and policies, and best practices to improve IAQ. The goal being to minimize the adverse effect of poor IAQ in direct relation to CO2, specifically in the classroom environment and test demand controlled ventilation applications. The investigation involved: development of a cost effective indoor air quality prototype unit for CO2 levels, the testing of the unit in a simulated room environment; and collection of data from testing. The data from the simulations was then compiled and analyzed. Additionally, literature research was instrumental in determining testing parameters and conducting experiments. This provided valuable experiences which will be shared with the educational community.

INTRODUCTION

In recent decades much research has gone into the concept of improving indoor air quality, specifically its importance as a public health issue. Research has shown that both short term and long term health conditions can be linked to the indoor characteristics of buildings. According to ASHRAE, “providing superior IAQ can improve health, work performance and school performance, as well as reduce health care costs, and consequently be a source of substantial economic benefit.”

Project Goals
- Build experimental IAQ CO2 monitoring system with “Demand Controlled Ventilation” capabilities using Arduino technology
- Compare the performance of the prototype with the professional grade Gray Wolf IAQ measurement system
- Test IAQ CO2 wireless sensors in simulated room environments to collect IAQ data
- Analyze effects of building materials on CO2 levels
- Develop a lesson plan and prepare hardware and software for inclusion in a high school classroom

Indoor Air Quality Room Simulation Project

Readings were taken from 6 simulations:

Simulation 1: Dry Wall, unpainted (2 pcs. 5” x 26”)
Simulation 2: Cinder Block, unpainted (16”x 7.5”x 3.5”)
Simulation 3: Bricks (3 ea. 7.5”x 3.5”x 2”)
Simulation 4: Ceiling Tile (2 ea. - 1 sq. ft. each)
Simulation 5: Linoleum Floor Tile (1 sq. ft.)
Simulation 6: Plants (1 Fern & 1 Caladium)
- Each simulation was monitored using our IAQ prototype, the Gray Wolf, and a Dell computer.
- Each simulation was tested to see if the building materials had any effect on the CO2 level
- We then analyzed the data to identify certain trends based upon each simulation

Comparison of Prototype Unit and GrayWolf Sensor

To be able to use the CO2 Arduino prototype, a calibration had to be done by use of a professional IAQ sensor, the GrayWolf. The ppm from the GrayWolf were correlated with the voltage output from the prototype. Voltage measurements from the CO2 sensor readings correspond to levels of CO2 as the graph on the left shows. Getting the Arduino to turn on a fan at a minimum threshold level and ramp up its speed with more CO2 was accomplished with programming skill and panache.

Prototype Design

Our “On Demand” CO2 Sensor and Ventilation prototype incorporates two distinct designs using Arduino and Zigbee technology. The first is a CO2 sensing unit that has an additional filter/amplifier board. This assembly wirelessly sends CO2 levels to the second assembly which is an Arduino fan control unit that turns on a ventilation fan when the CO2 reaches predetermined levels. The fan speed is determined by the CO2 levels. Higher levels require faster fan speeds to evacuate CO2 from the room to improve IAQ.

Results

Comparison of Prototype Unit and GrayWolf Sensor

Fan vs. Gravity Driven Ventilation

With a 20 second response time, the fan driven exhaust system evacuated the CO2 at a far greater rate than that of gravity and kinetic motion alone, bringing the enclosure from a ridiculously high CO2 level to a safe one in under 2 minutes.

Amusing Discovery

One peculiarity the group uncovered was the fact that cinder blocks absorb CO2. Much more time and effort could be expended in investigating this phenomena, but time and budget excluded the group from further pursuit.