

A Study of Air Quality and development of an Air Quality sensor

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1.Introduction

This project will focus on addressing the problem of air quality in outdoor, and Indoor environments, giving a simple response to the user, to show the danger limits of harmful CO₂ levels surrounding them.

A air quality device will be created to help people in heavy air pollution countries where there is no way of measuring the quality of the air easily. This would then allow for users of the product to know when it is necessary to wear protective masks or ventilating a room.

The world is developing at an explosive rate, producing more CO₂ lever in an urban environment than ever before. Some house near the busy road can suffer from over expositor of a CO₂ levels or VOC levels every day. Research shows that people surrounded with a large amount of CO₂ levels or VOC levels can suffer from many ailments .

The overall aim of this project is to design and prototype a product that can detect CO₂ in a local environment and advice user on potentially dangerous levels. Added feature of VOC, temperature, pressure and humidity will be added to help with outdoor factors. VOCs will be added to help with home and indoor quality.

2.Outline

After reviewing different sensors and their ability to gather different data types, an appropriate sensor was chosen that’s able to measure CO₂ and VOC levels, while only need a lower power supply, and come in a tiny package. This will allow for the device to be compact and allow for better portability and will give it a better chance to be added in to daily life, without any inconvenience. The key features as identified are as following;

- A USB will also be used for Transferring data.
- One button with 3 modes will be added it will be holed for 8 seconds to turn on the device. Pressed once to show embedded readings. 8 seconds to turn off.
- This device will measure a range of things from temperature to humidity, CO₂ and VOCs, these can all play a factor in air quality and was needing to give the user more accrete data.
- Some functions for this device is to be able to collect data save it to the SD card. And use the USB slot to transmit its data to PC
- This device will also come with one button and four LED these will show the danger zone levels of your environment.
- The button will have three modes hold down mode will turn the device off and on 1 push will pause the device.
- It will read all data such as temperate, humidity, VOC, CO₂ to screen for the user.

Device Name	Type	Features	Negatives
Atmotube (Still In Development)[1]	Consumer	• Able to measure CO₂ and VOC • Bluetooth capability • Low-powered	• Only one was created, hence is not available on the market • Only ready CO₂ and VOC
Series 500 – Portable Air Quality Monitor[2]	Medical	• SD card • Can connect to external control systems • Can read, but not exclusively, NH₃, CO₂, CO, CH₂O, NO₂ and SO₂	• Expensive • Complex for the user
E-Instrument AQ VOC Air Quality Monitor [3]	Industry	• Able to measure 400 different VOC gasses • Able to measure 0-2000ppb and 0-200ppm • SD card and USB	• Bulky • High power consumption • Short runtime • Use IR detection technique

3.Background Research

CO₂

Introduce to Research into CO₂

Due to the high levels of atmospheric CO₂, carbon dioxide levels within the past decade, with a growth rate, for the years 2015 and 2016, of double that between 1990 -2000[4]. Due to this fact, there have been many proposed and implemented developments which aim to reduce our impact on the environment and hence humanity, with regards to CO₂, and in some cases, the reduction the current CO₂ levels. This section shall explore methods that have been proposed and implemented as well as policies and international agreements such as the Paris Agreement.

Indoor CO₂ levels have been increasing inside buildings, this is attributed to high-rise housing and poor air ventilation in homes. The high concentration of CO₂ can impair performance of the Health of the Occupants.

Sick Building Syndrome is on the increases in most counters. This syndrome is caused when the air quality within a building is dangerous or causes sickness. The NHS Online[5] state that “symptoms of sick building syndrome get worse the longer you’re in a particular building and get better after you leave”

Cyclists are exposed to Large Amounts of CO₂ while bike riding behind cars[6]. City Lab has done extensive research in how CO₂ effect cyclists - The study shows Bikers inhale black carbon than pedestrians do. A study led by Professor Jonathan Grigg from Bart’s and the London School of Medicine “bicycle commuters had 2.3 times more black carbon in their lungs”. Some People who go running in city climates with heavy car usage will also see an increase of Carbon levels in their lungs[6]

The United Kingdom ratified the Paris Agreement in November of 2016[7]. Nick Hurd MP, the Minister of State for Climate Change and Industry of the time, stated that intends on using the Paris Agreement as an opportunity to transform aspirations into implementations, stating that the UK has provided “secure, affordable and clean energy” to both businesses and British families. The Energy and Climate Intelligence Unit, a UK not-for-profit organisation[8], claims that the Paris agreement will have a wider impact upon 14 mains areas, these being; policy, energy, business, investors, weather, nature, security, international politics, civil society, faith, international development, farming, the media and more-so health.

VOCs

Volatile organic compounds or VOCs contain a variety of chemicals, that are emitted from solids or liquids, these chemicals in the air can be very dangerous in long term or short-term exposure, VOC are at their highest indoors, as many products contain VOCs, this combined with low airflow can create an unhealthy or deadly situation.

These Organic chemicals are used in a lot of household product, vanishes and pain, etc.

EPA’s Office of Research and Development’s “Total Exposure Assessment Methodology (TEAM) Study” (Volumes I through IV, completed in 1985) found levels of about a dozen common organic pollutants to be 2 to 5 times higher inside homes than outside, regardless of whether the homes were in rural or highly industrial areas. TEAM studies indicated that while people are using products containing organic chemicals, they can expose themselves and others to very high pollutant levels, and elevated concentrations can persist in the air long after the activity is completed.[9]

TVOC (total volatile organic compounds) is often the name give VOC that are indoors. Having an idea of the health and risks related to the measurement of this element was needing to be able to convey to the user of this product. Many different organizations have sent their own limits and health-related to them this table shows some of the originations and agency own results[10]

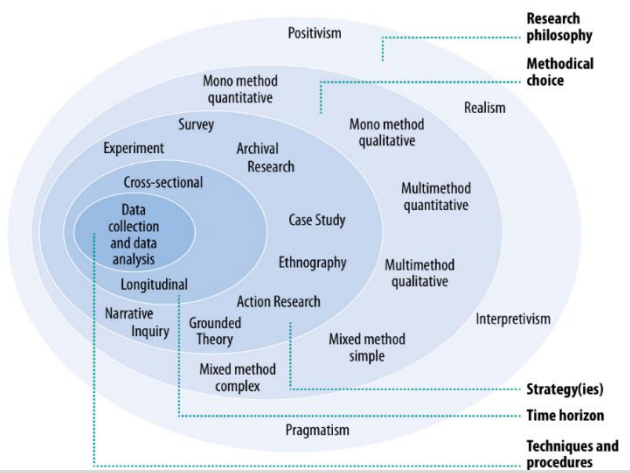
All results are related to the same measurements taken in this project TVOC parts per billion.

4.Research Methodology

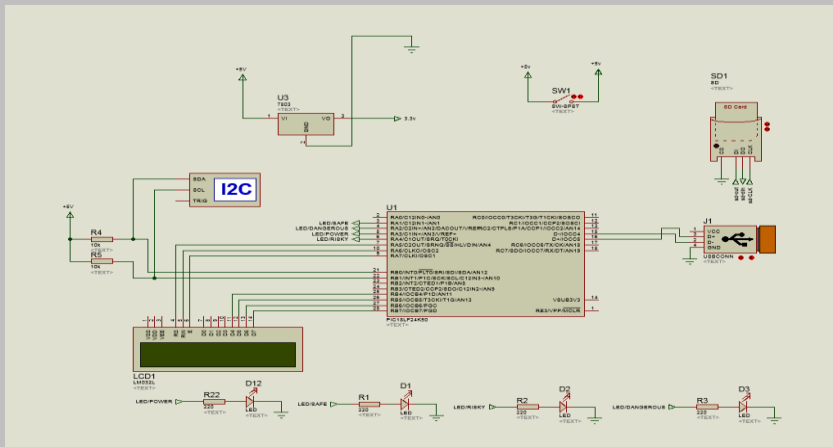
The metaphor of the Research Onion is used in order to understand the complex processes of research and its related decisions, this metaphor takes a layered approach, hence its name of Onion, these layers, in according order, being, research philosophy, methodical choice, strategies, time horizon and technique and procedures

Saunders and Tosey, 2013, state that “Most researchers design a piece of research to answer a question or address a problem”, by doing this they have less of a focus on the outer layers of the onion.

Research Philosophy	For this report, a pragmatism approach has been taken, to focus on the complexity of air quality and the impact that this has upon health.
Methodical Choice	Within the project, mixed method simple was chosen allowing for the research of the qualitative impact upon health and related legislation, as well as quantitative research regarding co2 levels and VOC levels.
Strategies	A variety of methods, for the report the main strategy was archival research, whereby journals, report and legislations are used, amongst others.
Time Horizon	This project focuses on a combination of long-term and short-term studies, hence has a both cross-sectional and longitudinal strategies.



5.Components and Design



- The IAQ sensor was chosen for this project as it fit the needed categories very easily with low power usage running on 3.3v and being Able to measure the Total CO₂ levees and VOC levels give this sensor and step up from its competitors.
- The chosen microcontroller had to have be able to handle all communication need for all components in this project doing this ultra-low power the PIC18LF25K50 this had all the communication need for this project such as I2C, SPI, analogy, rs232 and digital with 28 pin O/I this PIC would allow for the fitting of extra components
- The MOD board is the pre-mounted PCB bored contains the two sensors that are used in this project. The IAQ core and the BME280 both work of I2C so no need extra pins were needed for the PIC18F. Running on 3.3v created by embedded adventures.
- The BME260 sensor is an environmental sensor able to detect Temperature, pressure, humidity this type of data is needing to calibrate the MOS sensor these types of sensor can have their data altered by the effects of Temperature and Pressure on CO₂/VOC Measurement.

Component	Functions/Features	Why Chosen
BME280	Environmental sensor - Measures temperature (-40 – 85 °C), pressure (300-1100 hPa), humidity	Small Low Powered – 3.3v Need to apply molecular density of gas laws
IAQ-Core	Metal Oxide Semiconductor - Measures CO ₂ and VOCs	Compacted Low Powered Measures both CO ₂ and VOC
PIC18LF25K50	Embedded Microcontroller	
MOD1023	Pre-mounted PCB board	

6.Implementation

Implementing

Issues arose with false data being read or no data at all be shown on LCD, all other Bit of code seemed to be run as simulated, the issue was due to the fact that the addresses that were needed for this project was the 00x85, which not being used here.

Another issue that was only found out in implantation was the need for a slow clock speed on the PIC18 this was needed to function with the I2C. Invalid BME280 Data readings was an issue once loading simulated program, after researching the BME sensor it was found that it was in sleep mode , meaning that the BME was working correctly but was just set in a sleep mode, this was not able to be programmed as a time restraint .

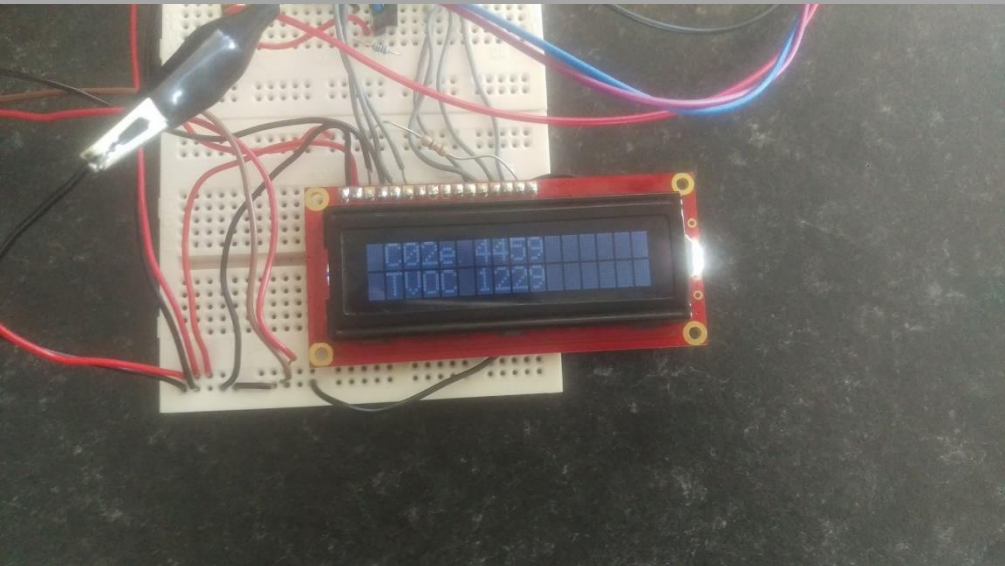
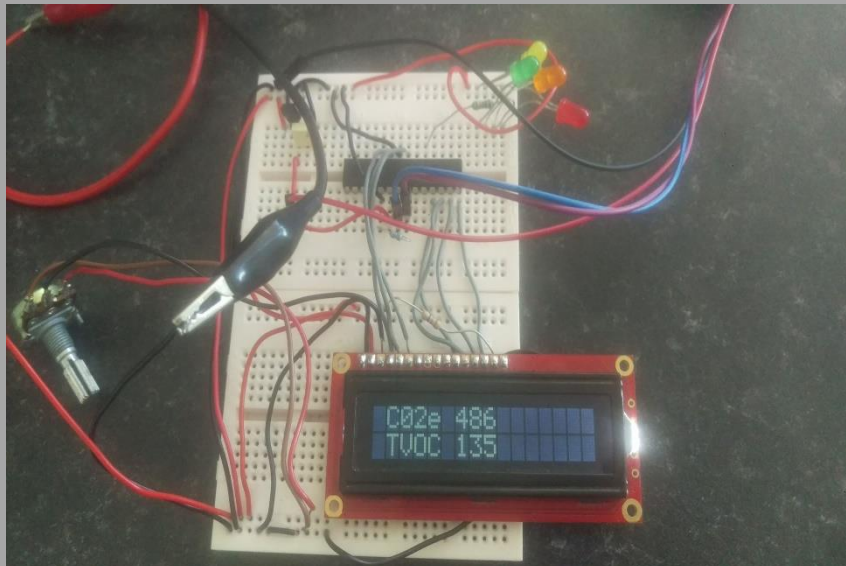
Prototyping

The simulation shows that this project can effectively read I2C results from an I2C device. Effective aids such as an I2C debugger and I2C registry reader advanced the observation of I2C infecting. The BME280 and IAQ core were not already build within Proteus, instead, a chip called the 24LC08N, which caused errors in prototyping stage of I2C not being interfaced correctly in prototyping.

Prototype Board

The final board achieved basic implantations by being able to detect VOC/CO₂. The molecular density of gas laws could not be implemented, to correct errors, thus, this device was not able to be portability used as a chance in pressure or CO₂ could affect reading dramatically.

The schematics for this project show the achievement of low power consumption and a small confirmation this was made to interlink with portability.



7.Programming

```
izc_start();           // send start condition
izc_write(0x5B);       // point to first address
for (q=0;q<7;q++)
{
    data[q]=izc_read(TRUE); // read sequential bytes with acknowledge
}
data[q]=izc_read(FALSE);  // read final byte without acknowledge
izc_stop();
```

This project has done all coding in Proteus with the assistance of CCS compiler this project was aiming to display all data from Chosen sensors on an LCD screen. Background research was done on how I2C Coding practices and using CCS compilers help files. When calling I2C there a few steps to be taken depending on the product being used datasheet may vary. First, a Start bit is sent. Second, the Device address is call. Third Read sensor data . Fourth send the last reading without Acknowledgment. Fifth send a stop bit. This combined with LCD display, Warning light and composite calculations build are a coding structure.

8.Evaluation

This project was created for initial from research in to how CO₂ can kill people premature like in London, which estimated that 9,416 premature deaths were caused by air pollution in London alone. This report chose to informed people on air quality and from this research create a detect device.

The objective set-out in this report was not full achieved but the basic outline was informing people and developing a CO₂/VOC detection device. The BME 280 was not integrated fulling having issues with its communication though I2C.

Further Development

- Implementing Bluetooth and WIFI capabilities, in order to display data on mobile devices
- Adding a fan or pump, to give more accurate indoor reading
- Creating a case of the device, in order to protect and make it more portable
- Condensing the size of the device, and its screen through ASIC to make it more portable and to lower long-term costs.
- Adding the ability for a SD card/USB giving the device the ability to save environmental data, and transfer it to a PC.
- Implementing composite calculation to correct errors created by temperature and pressure.

Topic	Discussion	Evaluation
I2C	I2C brought about the most time-consuming error, this being the fact that it was hard to program.	This was the case due to the fact that I2C data transmitting can be difficult to program. The solution used resolve this issues was to research more into the coding required.
BME280 (general)	The main issue regarding the BME280 sensor is that it has not been calibrated and a casing has not been built for it.	This is the case due to time limits as well as a lack of funding. The issue means that the device will not effectively function within an outdoor environment. This could be improve through less financial and time constrains.
BME280 (Humidity, pressure, and temperature	Another issue with regards to the BME280 was the fact that it was not reading humidity, pressure or temperature values.	This is because the BME280 was stuck in sleep mode, this could have been resolved by having more flexibility with regards to timings, in order to research this issue more.
IAQ (VOC/CO ₂)	With regards to the IAQ sensor, there were no major issues concerning CO ₂ or VOCs.	This element of the project functioned, as planned, with testing showing this to be the case.

9.Conclusion

Project Conclusion

In conclusion, the main requirement for an air quality detection device was achieved in this project. As programming for the BME280 is still an ongoing problem that needs to be resolved, apart from this, the project meet the basic specification that was planned and has worked effectively.

This report has overviewed many areas of CO₂ levels and VOCs. From the beginning of this report, one of the fundament aspects was to create a device that would be able to help people acknowledge and act on dangerous levels of CO₂ and VOC exposure. This has been set out through researching, design, simulating and prototyping. From this, the report has set out the full potential of a potable air quality device. From research, it had been easy to observer and understand the risk of CO₂ and VOC, this knowledge has been implanted in LEDs, which show hazardous air quality levels, which have been deeply investigated, and are up held by many agencies.

Learning idle air laws, and how pressure and temperature can cause errors when dealing with air quality gave this project the ability to make this device portable, without these laws this device would not be precise at reading CO₂ and VOC with fluxing pressure and temperature. The final prototype device created in this project did not fit its full role of portability, it was able to measure VOC and CO₂, but not with assistance of idle laws as the BME280 device would not seem to function after testing the device with Arduino, it was observed that this issue occurred due to a lack of knowledge with regards to imbedded C.

Reference

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