

ElectroCap Project Proposal

Monitoring Air Quality in AC units

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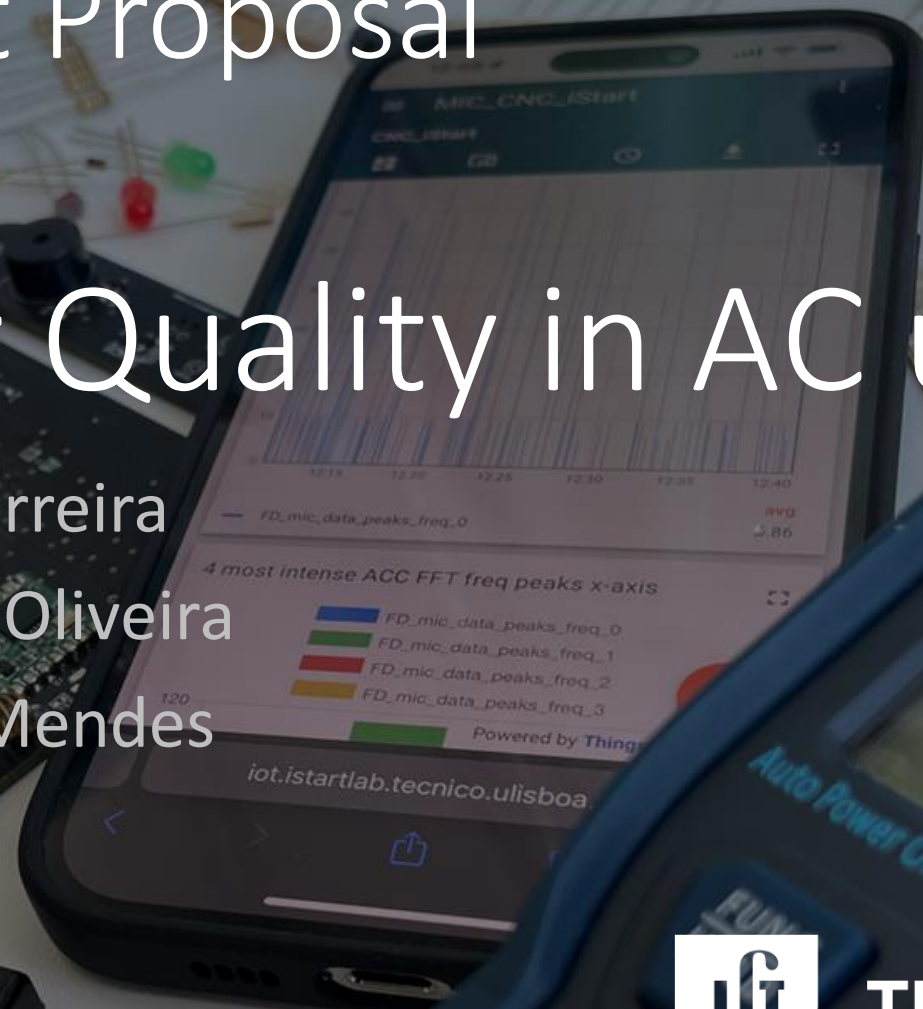
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TÉCNICO LISBOA

1. Advisors and Mentor

- Scientific advisor: Prof. Luís M. Correia;
- Coordinator: Prof. Luís M. Correia;
- Co-coordinator: Prof. João Felício

2. Problem definition

Air quality monitoring is crucial and increasing in importance every day, as pollution also increases. There are several air quality monitoring devices, but none that monitor air that comes out of Air Conditioning Units. This monitoring would be very important, to ensure that the air being circulated is clean and free from pollutants, allergens, and harmful particles that can, often, be caused by poor maintenance of these equipment's, allowing for timely fixing. To evaluate air quality, we will use an air quality scale and different scales of other particles.

The air quality scale that we will use is based on the Portuguese Air Quality Index, that uses the concentrations of 5 different pollutants to give a grade to the air.

Portuguese Air Quality Index - <https://rea.apambiente.pt/content/índice-de-qualidade-do-ar>

Our air quality index will work the same way as the Portuguese Air Quality Index , but we chose to use 3 pollutants: CO₂, NO₂ and PM_{2.5}.

We will measure the concentrations in the air of these 3 pollutants, then we will use a scale that shows which of the 3 pollutants has the worst index in the air, and that one will give a grade to the air quality.

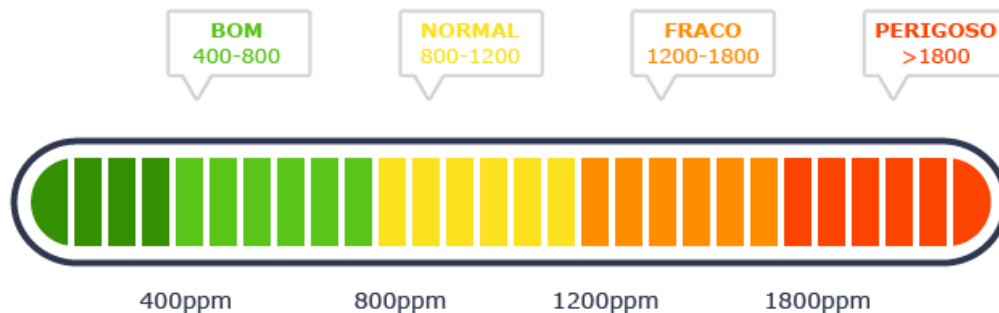
2. Problem definition

Scales of different pollutants

Classificação	PM10	PM2.5	NO2	O3	SO2
Muito Bom	0-20	0-10	0-40	0-80	0-100
Bom	21-35	11-20	41-100	81-100	101-200
Médio	36-50	21-25	101-200	101-180	201-350
Fraco	51-100	26-50	201-400	181-240	351-500
Mau	101-1200	51-800	401-1000	241-600	501-1250

Level	Recommendation	TVOC [$\mu\text{g}/\text{m}^3$]
Outside quality classes	Greatly increased (not acceptable)	>3'000
4	Significantly increased (only temporary exposure)	1'000–3'000
3	Slightly increased (harmless)	500–1'000
2	Average (harmless)	250–500
1	Target value	<250

IAQ levels for Europe according to WHO



Formaldeído - efeito dependente da concentração

0,05 - 0,125 ppm	Limiar olfativo
0,01 - 1,6 ppm	Irritação das membranas mucosas (nariz, garganta) e os olhos
2 - 3 ppm	Ardor no nariz, olhos, garganta
4 - 5 ppm	30 minutos suportável, desconforto cada vez maior, lacrimejamento
10 - 20 ppm	Já depois de alguns minutos de exposição, forte lacrimejamento (até 1 hora após a exposição continuada) dispneia imediata, tosse, forte ardor no nariz, na garganta e nos olhos
30 ppm	Edema pulmonar tóxico, pneumonia, perigo mortal!

3. Solution beneficiaries

Industrial workers will be the main beneficiaries of our solution, as through our product, they could monitor air pollutant levels, thereby helping to create a healthier and safer work environment. Companies themselves would benefit from our solution, as they could optimize their processes by monitoring air pollutants, avoiding regulatory penalties, and improving worker safety conditions.

4. Technological solution

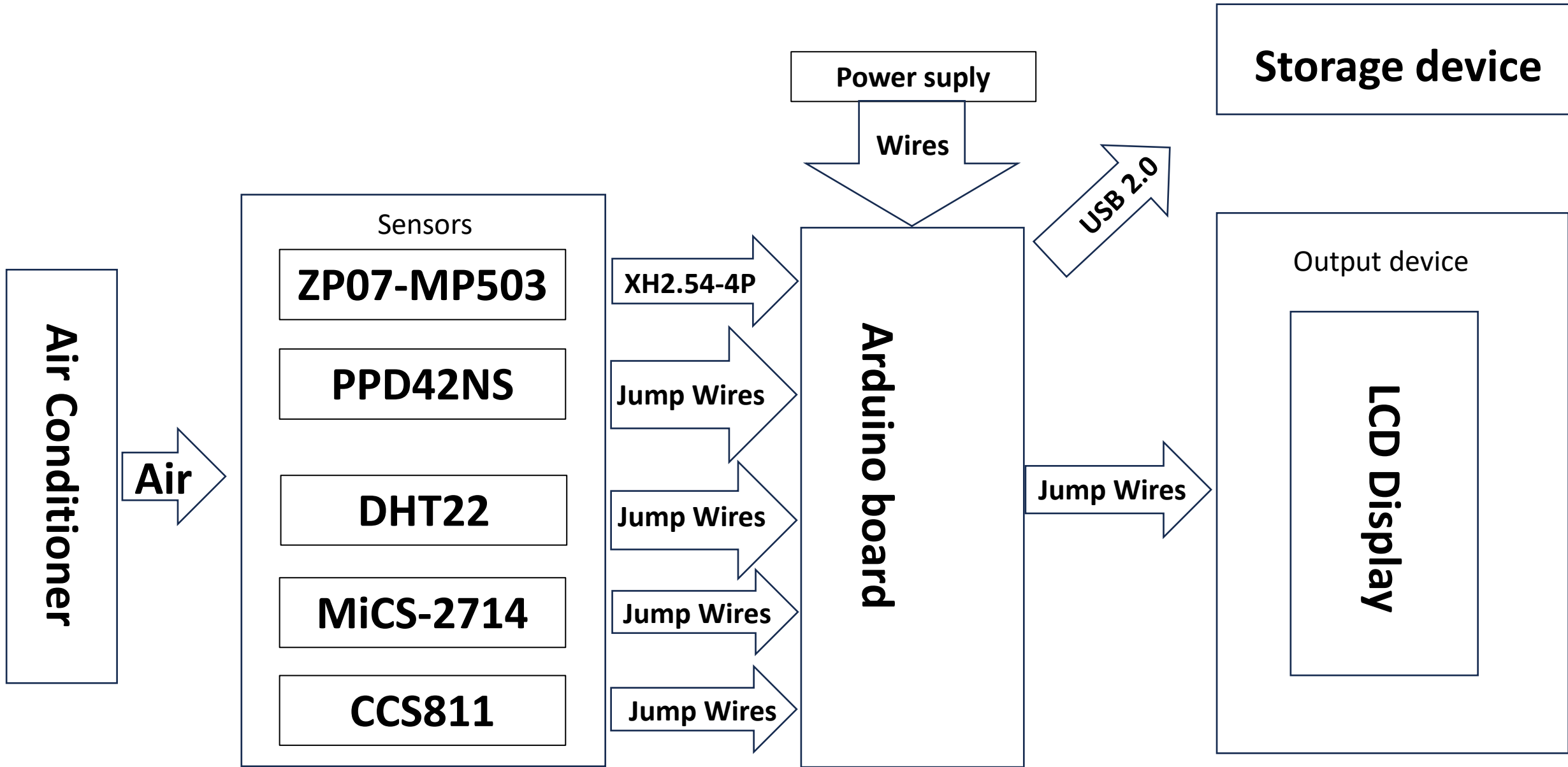
In our technological solution, we intend to use an Arduino to program and control the circuit, a set of sensors to measure airborne concentrations of particles and bacteria, and a panel with an interface to access the information. We also aim to make it possible to somehow attach our product to the Air Conditioning Unit outlet for easier use. We want to attach our product to the AC unit for it to be easier to use and to be placed in the best possible position in the AC unit to measure the air quality.

Sensors:

- **Zp07-mp503** – <https://www.winsen-sensor.com/d/files/ZP07-MP503-4.pdf>
- **PPD42NS** - https://www.mouser.com/datasheet/2/744/Seeed_101020012-1217636.pdf
- **DHT22** - <https://www.sparkfun.com/datasheets/Sensors/Temperature/DHT22.pdf>
- **MiCS-2714** - https://www.sgxsensortech.com/content/uploads/2014/08/1107_Datasheet-MiCS-2714.pdf
- **CCS811** - https://cdn.sparkfun.com/assets/learn_tutorials/1/4/3/CCS811_Datasheet-DS000459.pdf

4. Technological solution

Equipamento	Loja	Preço
Zp07-mp503	https://solectroshop.com/pt/sensores-de-qualidade-do-ar/5415-sensor-de-qualidade-do-ar-zp07-mp503-deteccao-de-gas.html	9,40 €
PPD42NS	https://solectroshop.com/pt/sensores-de-qualidade-do-ar/1175-modulo-de-sensor-de-poeira-ppd42ns-pm25.html	13,84 €
DHT22	https://www.ptrobotics.com/atmosfericos/2332-dht22-temperature-humidity-sensor.html	16,18 €
MICS-2714	https://www.botnroll.com/pt/biometricos/4896-m-dulo-sensor-g-s-mems-mics-2714.html	14,40 €
CCS811	https://satkit.pt/pt-pt/ccs811-sensor-de-dixido-de-carbono-co2-temperatura-e-umidade-vocs-monitor-de-qualidade-do-ar-mdulo-sensor-enrolador	14,52 €
LCD1602	https://www.ptrobotics.com/lcd-alfanumerico/6778-16x2-lcd-module-verde.html	11,44 €
Kit Desenvolvimento + Arduino UNO	Equipamento disponivel_v20240228	
Cabos XH2.54-4P (5x)	https://mauser.pt/catalog/product_info.php?products_id=096-6576	2,10 €
Conjunto Breadboard + 140 Jump Wires	https://mauser.pt/catalog/product_info.php?products_id=096-4918	12,10 €
Cabo USB tipo A/B	https://mauser.pt/catalog/product_info.php?products_id=047-1848	1,51 €
Pilha Alcalina 9V	https://mauser.pt/catalog/product_info.php?products_id=110-0108	2,45 €
Suporte Pilha 9V com interruptor	https://mauser.pt/catalog/product_info.php?products_id=035-1101	1,86 €
Transistor 2N3904	https://mauser.pt/catalog/product_info.php?products_id=002-0323	0,10 €
Botão ON/OFF	https://mauser.pt/catalog/product_info.php?products_id=010-0951	0,74 €
Conjunto de Resistências	https://mauser.pt/catalog/product_info.php?products_id=104-0213	4,00 €
Módulo Bluetooth HC06	https://www.botnroll.com/pt/bluetooth/2583-m-dulo-bluetooth-hc06.html	11,90 €
LED Vermelho	https://mauser.pt/catalog/product_info.php?products_id=017-0210	0,16 €
LED Amarelo	https://mauser.pt/catalog/product_info.php?products_id=017-0319	0,0344 €
LED Verde	https://mauser.pt/catalog/product_info.php?products_id=017-0982	0,11 €
PCB		
Filamentos 3D		
TOTAL:		116,84 €



5. Competitors and previous work

- Competitors: Companies such as "Kaiterra", "Elpro" or "Vaisala", offer a similar service to what we want to implement, but it is only available for businesses and requires installation by technicians in the building. We aim for our product to be usable by anyone and to be user-friendly, meaning that a professional installation on the Air Conditioning Unit is not necessary. Besides this, we strive to deliver a cheaper and simpler product that can be used by smaller companies that search for better conditions for their workers.
- Websites of competitors: <https://www.kaiterra.com/sensedge>, <https://www.elpro.com/en/on-site-monitoring>, <https://www.vaisala.com/en/industries-applications/hvac-measurement/indoor-air-quality>
- Previous work: https://www.youtube.com/watch?v=esY_OtDLv7g&t=320s. The biggest difference between previous work and our project is that we will do a product that is specifically designed for industrial AC units.

6. Solution requirements

To solve our problem, we need to make sure that the sensor is capable of measuring key air quality parameters. It should be capable of detecting pollutants, allergens, and harmful particles and differentiate between normal variations in air quality and potential issues related to air conditioner performance or maintenance. All this should be provided to the user in real-time and, the sensor, should have a high level of sensitivity to ensure accurate detection of even minor changes in air quality. Besides this being user friendly is, also, a priority and it should operate reliably over extended periods without significant drift in accuracy.

Some parameters that we pretend to measure: Temperature, Relative Humidity, CO₂, CH₂O, PM₁₀, NO₂, TVOC.

7. Technical challenges (I)

During the creation of this gadget, we may encounter some technical challenges, such as ensuring the accuracy of sensors for measuring components present in the air, such as particulate matter, humidity, and the percentage of bacteria. Some sensors could interfere with each other, leading to inaccurate readings. Additionally, we need to design an intuitive and user-friendly interface to ensure that every user can easily understand how to interpret the provided air quality information. Another challenge is to choose how we will power our product. The durability of the enclosure can be another problem; we must design an enclosure that protects the gadget from environmental factors while allowing proper ventilation for sensors. The last challenge is cost constraints; balancing the cost of components and sensors can be challenging, and budget constraints may impact the selection of sensors and other components.

7. Technical challenges (II)

Each type of industry has different specifications and pollutants that must be considered in the product's development and sensor selection. The way to attach the product to the industrial AC unit also varies depending on the type of industrial AC unit, as different AC units have different structures and outlets.

Due to financial constraints and limitations in the sensors that can be utilized in our solution, it is not possible to create a product that measures air quality in all industries. Therefore, we must restrict our product to only measure pollutants present in certain industries. Even in a specific industry, it will not be possible to measure all pollutants due to limitations in the sensors we will use.

Another limitation of our product is the fact that we will use inexpensive sensors with low precision, which will not yield the best results.

Finally, another factor to consider is in which type of industrial air conditioning (AC) our product should be applied, as there are different types of AC units for industries.

8. Partners

Throughout the project we will research and gather information about possible partners that have the knowledge and resources to contribute to the development of the project.

Some of the possible partners:

- Agência Portuguesa do Ambiente;
- IPMA.
- <https://aqicn.org/gaia/pt/>
- <https://www.envea.global/pt/>
- <https://www.megaclima.pt/>
- <https://www.cigala.pt>
- <https://www.caima.pt/pt>
- <https://www.hisensehvac.com/>

9. Testing and validation metrics

To assure the quality of the system, we are going to test it in a controlled environment to ensure the output is correct, checking if there is any abnormality. After that we will put it to test in different conditions to see if it corresponds to the expected results and act accordingly. For example, we will use a fan with dirty filters, a lighter to test the CO₂ sensor, a formaldehyde solution to test the HCHO sensor.

10. Division of labor (I)

Afonso Oliveira	Tomás Oliveira	Francisco Oliveira
Project Manager	Programmer	Design
Solution demonstration video	Programming	Product design
Research	Research	Prototype planning
Website creation	Arduino configuration	PCB design

11. Division of labor (II)

João Santos	Miguel Parreira	Gonçalo Mendes
Programmer	Circuit Planner	Test Engineer
Sensor calibration and testing	Sensor research	Arduino configuration
Presentation planning	Prototype planning	Poster preparation
Arduino programming	PCB design	Develop test protocols

