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SUMMARY
PhD thesis

RESEARCH ON THE USE OF INTERNET OF THINGS (IOT) TECHNOLOGIES IN AUTOELECTRONICS

RESEARCH ON THE USE OF THE INTERNET OF THINGS (IOT) TECHNOLOGIES IN AUTOELECTRONICS

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List of abbreviations

MEMS - microelectromechanical devices

IoT - Internet of Things

AQI - Air Quality Index

PM - Particulate Matter

ESD - Electrostatic Discharge

EMC - Electromagnetic Compatibility

TVS - Transient Voltage Suppression Diode

CO2 - Carbon Dioxide

HVAC - Ventilation, Heating and Air Conditioning

GPS - Global Positioning System

MIPS - Millions of Instructions Per Second

EEPROM - Electrically Erasable Programmable Read Only Memory

SRAM - Static Random Access Memory

PCB - Printed Circuit Board

USB - Universal Serial Bus

ADC - Analog-to-Digital Converter

VOC - Volatile Organic Compounds

NO2 - Nitrogen Dioxide

HMI - Human-Machine Interface

3D - Three-Dimensionality

LED - Light Emitting Diode

SPF - Frames Per Decond

TCP / IP - Transmission Control Protocol / Internet Protocol

GSM - Global Dystem for Mobile Communication

HTTPS - Secure Hyper Text Transfer Protocol

1. Introduction

1.1 Presentation of the doctoral area

This thesis deals with the introduction of a new technology in car electronics by equipping a vehicle with a complex sensor structure that uses the technology of the Internet of Things to provide central information about the gaseous component of the ambient air and the temperature in the passenger compartment.

In this way, the car is transformed into a mobile sensor that is connected to the internet and that helps highlight the atmospheric composition in applications such as urban air pollution management and create a new perspective.

The more sensor structures are mounted on vehicles, the higher the detection rate of possible hazards in real time is.

Air pollution and greenhouse gas measurements have a wide variety of uses, from academic research to services for individuals and businesses. In addition to some basic meteorological parameters, measurements of air composition have traditionally been carried out by specialized organizations and qualified users.

1.2 The purpose of the work

The paper presents the research and experimentation activities during the author's doctoral program. First, the exact requirements of the system for monitoring the interior of a vehicle are specified. The design and implementation of the systems follow, finally the resulting devices are detailed, the data is collected from several prototypes mounted on vehicles and how they are used.

Nowadays, people spend a lot of time in the car, especially in traffic jams that increase exposure to car emissions. Sensors based on MEMS technology are suitable for multi-sensor integration due to their small size and packaging technology.

The aim is to highlight and create a new perspective on atmospheric composition in applications such as urban air pollution management, where the data requirements of the sensor system have not yet been specified and the data collection methods are still in their infancy. The increasing combination of fossil fuels over the past century is responsible for the progressive changes in atmospheric composition.

At the same time, it is desirable to implement a way of making users aware of possible dangers that may arise when using vehicles in order to make the autonomous car aware of the circumstances.

1.3 The content of the work

Theoretical and practical aspects such as already existing methods, techniques and systems were examined in order to measure the air pollutant content, temperature measurement, gesture recognition, IoT device management and the use of MEMS sensors. At the same time, the existing challenges in measuring the pollutant content are highlighted.
Several prototypes will be developed to solve problems of interest to university and research environments. They are widely used in the automotive industry, where the focus is on lowering operating temperatures and increasing their reliability.
Two interfaces have been developed for viewing and managing data from multiple IoT devices.

2. Safety and prevention in the automotive sector

Air pollution consists of changing the balance of an ecosystem through exposure to pollutants. The air must have a certain component in order to support life of any kind. Every harmful gas or molecule that can cause death, allergies or disease and that affects the composition of the air is defined as a pollutant [1]. The effects of pollution on humans are manifold. In [2,3] it is stated that air pollution affects the blood flow to the veins and thus causes heart attacks or heart attacks by affecting the blood vessels in the brain.
Sources of pollution, according to [4]. :

Naturally:

- fires
- volcanic emanations,
- pollen etc.

The most common sources of pollution are generated by human activity:

– Fine dust from construction sites and when using vehicles
– Combustion of wood and coal to produce sulfur oxide (SO_2)
– Use of fuels in power generation, especially in the automotive industry to generate nitrogen oxides (NO_X) and carbon monoxide (CO and CO_2)
– Volatile organic compounds (VOC) are produced from coal processing or the chemical industry (paints, varnishes).
–Smog caused by the reaction of nitrogen oxides and hydrocarbons in the presence of sunlight

Calculation of the AQI (Air Quality Indicator)

AQI works like a thermometer from 0 to 500 degrees. Rather than showing changes in temperature, AQI is a way to show changes in air pollution. At the border between the AQI categories there is a discontinuous jump of an AQI unit. To convert from concentration to AQI, the following equation is used:

$$I = \frac{Ihigh - Ilow}{Chigh - Clow}(C - Clow) + Ilow$$

Symptoms and consequences of pollution

Air pollution has acute and chronic effects on human health and affects a number of different systems and organs. It ranges from irritation of the upper respiratory tract to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, a worsening of pre-existing lung diseases or asthma attacks. Up to 92% of the world's population live in regions in which the air pollutant content is above the limit values set by the World Health Organization [6].

Circuit protection for applications in automotive electronics

A major change has been the advancement of electronic devices and systems that have replaced mechanical devices. However, without adequate protection, these electronic systems can fail without warning. The design of electronic circuits for use in the automotive industry presents many challenges, such as: B. taking into account large temperature fluctuations from -40 to +85 ° C, and the humidity can range from minimum desert values to maximum values of a lake. [9].

Protective measures used in the work:

- **Protection of the devices against electrostatic discharge.** The most common method of protection against ESD is the use of varistors. A varistor is an electronic component whose resistance varies with the applied voltage [11]. Protection by varistors is insufficient to be used for all types of system peripherals, so transient voltage suppression diodes (TVS) are used in parallel.
- **Overload protection of devices.** One solution to overload protection is to use oxide-metal varistors (MOV) or transient voltage suppression diodes (TVS) for overvoltage protection, which are connected along with a positive temperature change thermistor (PTC) to limit the current. Overload.
- **Short circuit protection.** The PTC MF-RHT450-AP components will be used during the project. If a short circuit occurs, the component heats up, the internal resistance increases and the faulty current is switched off. After the short circuit has been removed, the PTC cools down and allows normal current to flow, which makes the circuit usable. TVS diodes are used to protect against electrostatic discharge in order to reduce the voltage peaks on the control lines and sensor inputs. They are used in conjunction with the short-circuit protection of the PTC components to ensure safe use of the circuits.

- **Electromagnetic compatibility.** To increase the immunity of the circuit against electromagnetic fields, but also to limit the generation of electromagnetic energy, an LC low-pass filter is used to filter high-frequency noise from outside the system, but also from the inside. For all integrated circuits used in the project, 100 nF isolating capacitors were used on the power connectors to provide enough power to the pin, it is connected to keep the voltage stable when the input voltage fluctuates.

3. IoT system for collecting air quality data

This system is based on the ATmega 2560 microcontroller and combines several sensors, most of which can measure pressure, temperature, humidity, volatile organic compounds, carbon dioxide, fuel gas, hydrogen sulfide and oxide with the help of MEMS (Micro Electromechanical Systems) technology The advantage of a quick response, low costs and easy integration into other systems. At the same time, it can warn the user of a possible dangerous pollutant content with the help of a display, so that any identified danger can be combated more quickly. Internet access is provided through the use of the ESP8266 microcontroller. The type of interaction with the system in the vehicle is achieved using a display and control system based on a gesture recognition technique using infrared sensors.

The system consists of several interconnected subsystems, modular components, in order to achieve a high degree of adaptability and increased efficiency using all resources.

Figure 3.1 shows the block diagram of the system with the following components:

- Motherboard or motherboard
- Air quality sensor module
- Expansion mode
- user interface
- Particle sensor
- Microcontroller ESP8266

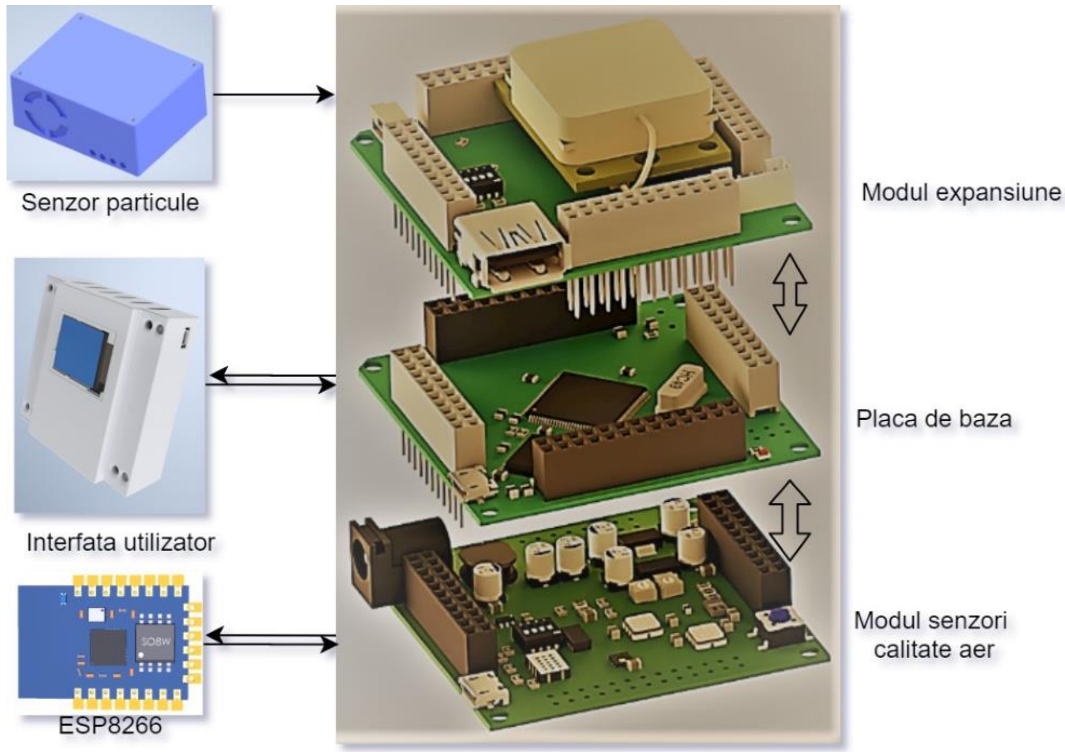


Figure. 3.1 Block diagram of the IoT system for collecting air quality information

3.1 Development platform with ATmega2560

The motherboard shown in Fig. 3.1 is designed so that it can be adapted for different functions. Within the project, it will be used to collect and process information from air quality sensors and information about the current location of the module GPS.

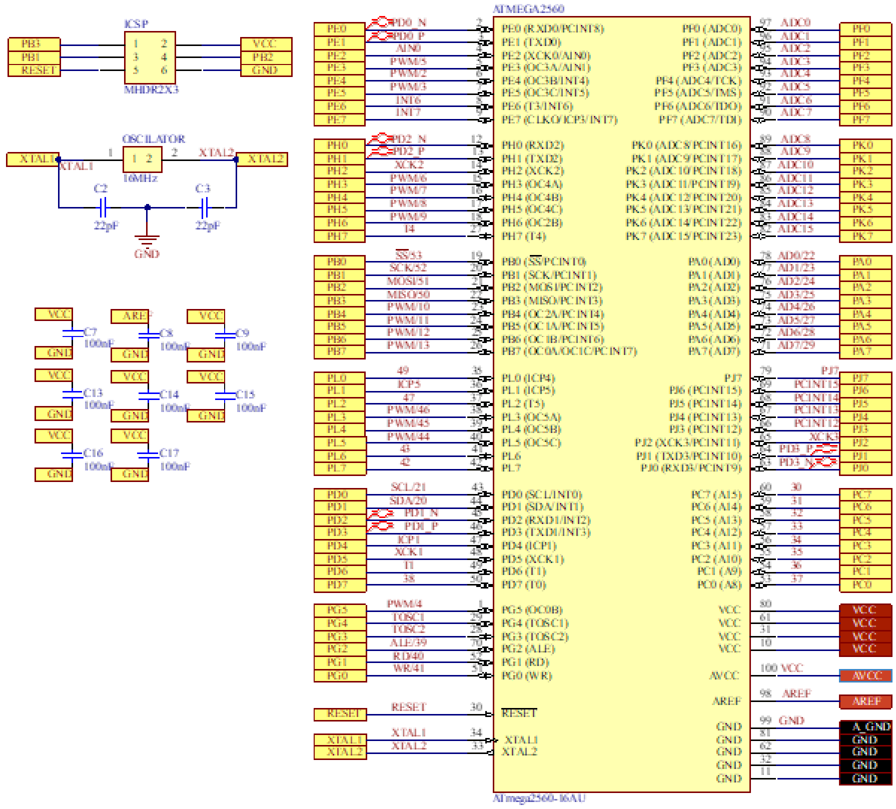


Figure. 3.2 ATmega2560 circuit diagram

The printed circuit board (PCB) is designed to improve its functionality by adding additional hardware. It uses four connectors that allow access to the input / output pins of the ATmega2560 microcontroller. Through them, the power supply of the circuit can be realized (Fig. 3.3) in order to reduce the complexity of the work in the new systems and to facilitate the achievement of immediate results. The motherboard is designed for low power consumption and a programming, communication and debugging interface via a serial interface using an integrated USB-to-serial converter (FT232RL) (Fig . 3.3) .

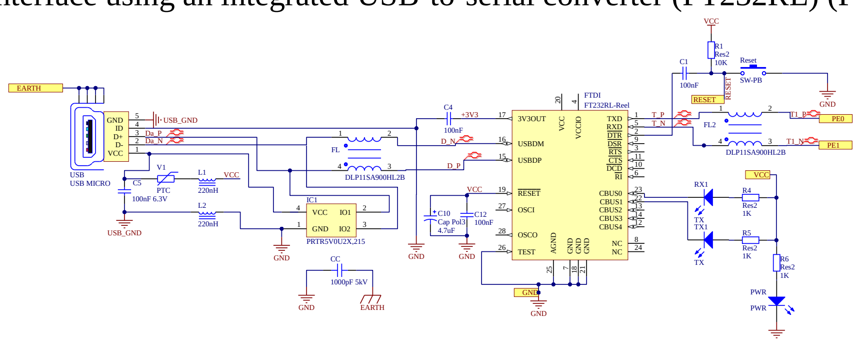
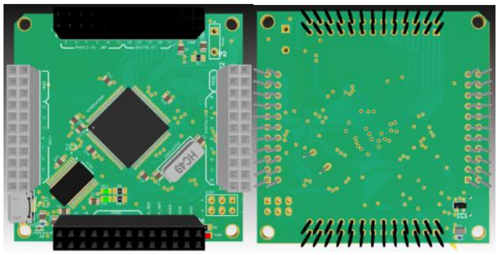


Figure. 3.3 Serial interface of the motherboard

The circuit can be powered via the existing micro-USB socket on the circuit board or via the pins on the connections. The configuration of the pins on the connectors has therefore been designed so that they can also be used by other modules.



a) b)

Figure. 3.4 Motherboard layout TOP a), BOT b)

3.2 Expansion mode

The module contains a USB connection for the interface of the display and control system, a charging module for a battery, a connection for the PMS5003 particle sensor, a connection for the GPS module NEO6MV2, the four connections for connection to the motherboard and one Connection for the ESP8266 microcontroller.

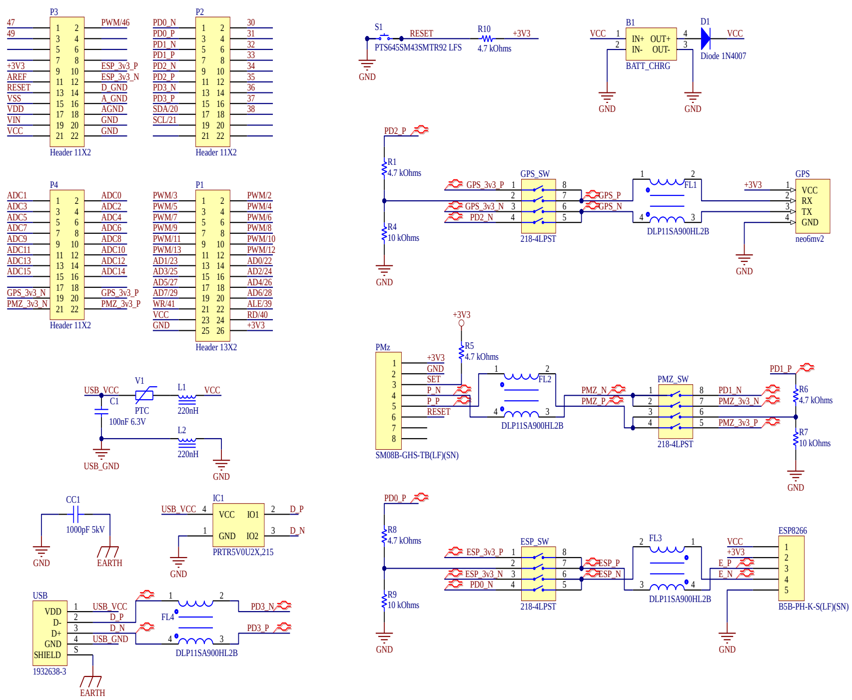
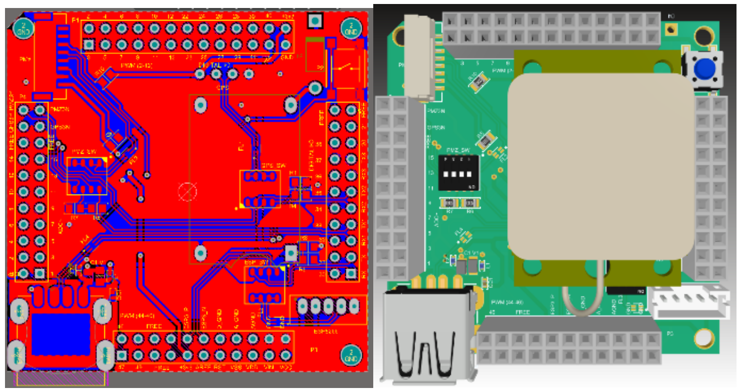


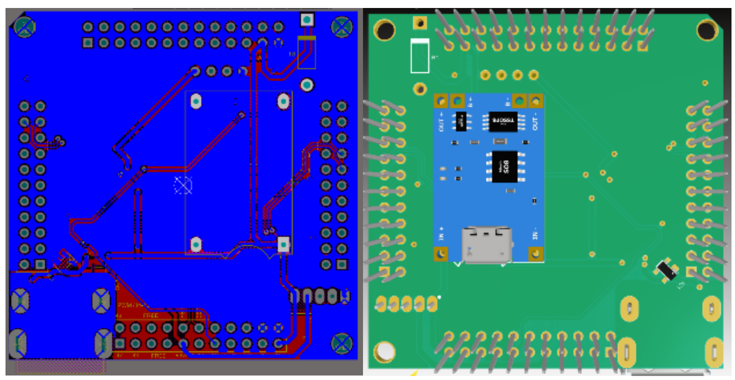
Figure. 3.5 Schematic expansion mode

The mode is powered and communicates with the motherboard via the four connectors. For the serial interface with the GPS module, the particle sensor and the ESP8266 microcontroller, switches have been provided that can toggle between the 5V logic level connection on the motherboard or a routed connection to the pins left free by the connections It can for future system -Upgrades are used, e.g. B. to use a different microprocessor or add a new module.



a) b)

Figure. 3.6 Display of the expand mode TOP a) Layout, b) 3D



a) b)

Figure. 3.7 Displays the BOT expansion mode a) layout, b) 3D

3.3 Air quality sensor module

The interface between the sensors and the microcontroller is described in Figure 3.8. Most communication takes place via the I^2C protocol. However, some of the sensors are analog. In this case, the data is converted by an ADC before it is transferred from the sensor board to the main board.

	Carbon dioxide and nitrogen oxide	Volatile organic compounds	Humidity and temperature	PM2	Combustible gas	Hydrogen sulfide	Smoke and particle
Sensor	MICS4514	CCS811	HDC1080	PMS5003	GM-402B	GM-602B	MAX30105
Interface	Two ADC channels	I²C	I²C	RS232	One ADC channel	One ADC channel	I²C
Range	CO:1 ~ 1000ppm NO2: 0.05~10ppm	VOC: 0ppb ~ 32768ppb.	%RH: 0 ~ 100 Temp: -40 ~ 125	0.3~1.0; 1.0~ 2.5; 2.5~10	Detection Range CH4, C3H8 : 1 ~ 10000ppm	Detection Range H2S: 0.5 ~ 50ppm	PM 2.5 - PM 10
Power consumption (max)	81mW	60mW	66uW	80mW	80mW	40mW	35mW
Price	£7.55	£9.25	£2.63	£16	£3.26	£5.00	£6.29

Figure. 3.8 Information on the sensors used, price, energy consumption and their interface

Realization of the experimental module

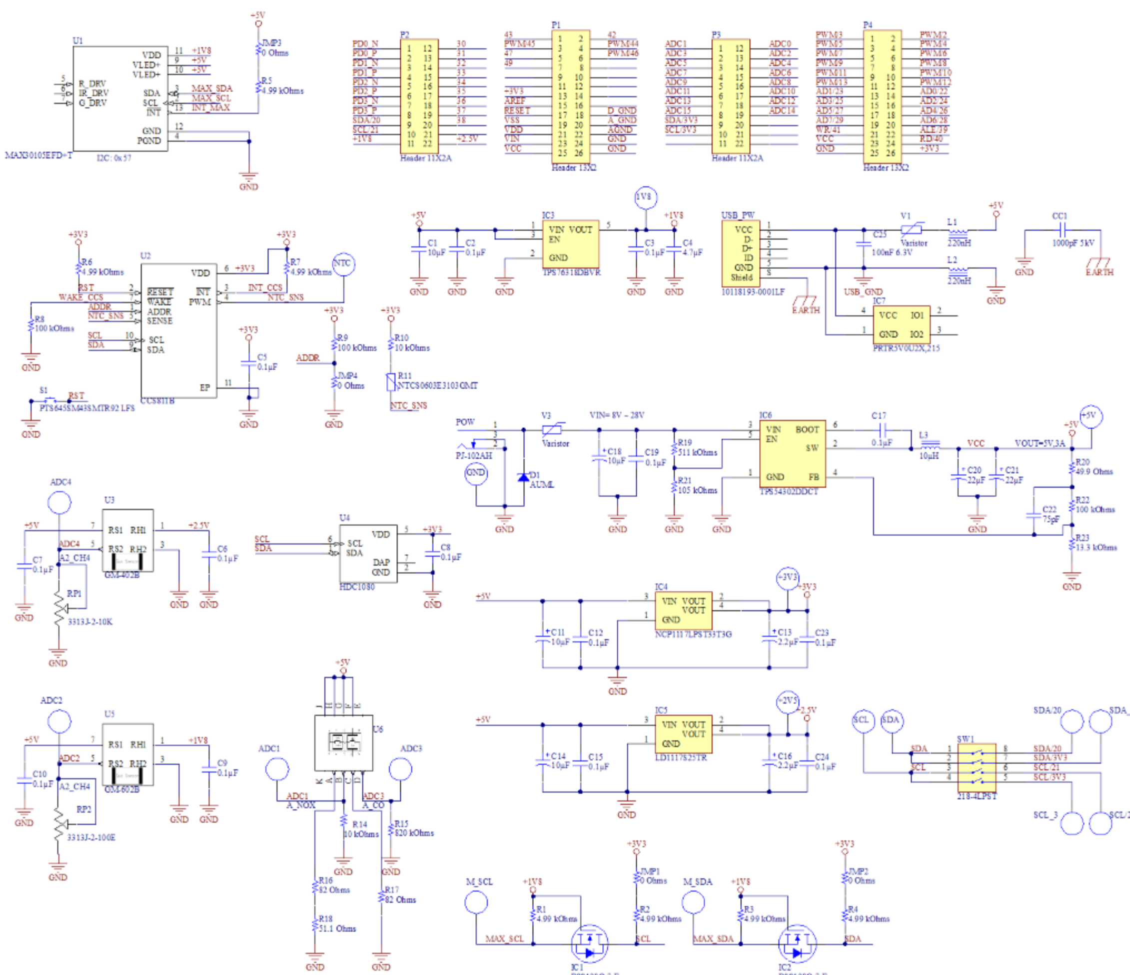
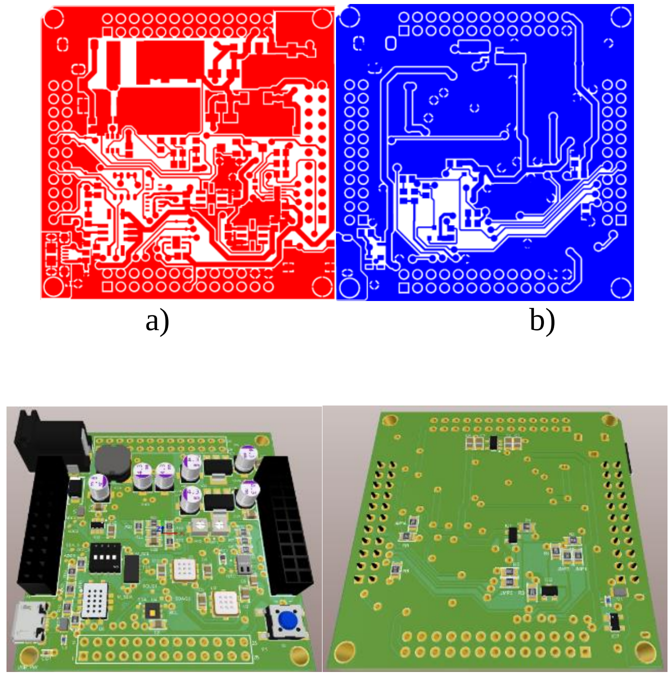


Figure. 3.9 Experimental mode wiring diagram



a) b)

c) d)

Figure. 3.10 Structure of the test module TOP a) BOT b) TOP 3D c) BOT 3D d)

Power the system

The system can be powered in two ways: via the USB plug on the module or via a plug that is supplied with power from the vehicle's 12 V socket. Since the sensors require different supply voltages, several voltage sources had to be designed:

- + 5V
- + 3.3V
- + 2.5V
- + 1.8V

The influence of the thermal regime on sensor functionality and the integrity of the power supply

The design of the data acquisition module from the sensors requires increased consideration of the thermal and also the electrical operating state. The DC simulation is used in parallel with the thermal simulation to analyze the temperature migration between sensors and to identify possible hot spots caused by the temperature.

Thermal and electrical modeling is an integral part of the manufacture of printed circuit boards. There are various applications in the market that offer analysis with varying degrees of accuracy.

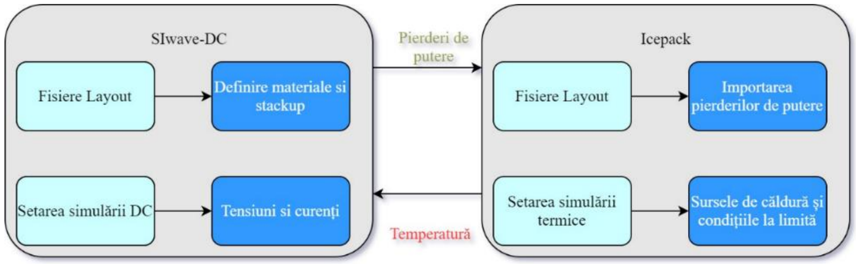


Figure. 3.11 SIwave DC connection block diagram -> Icepack

The DC simulation was carried out with the SIwave platform from ANSYS [66]. The analyzes were:

- Analysis of voltage drops for supply and earthing routes
- Analysis of the current distribution including the way back
- Power density analysis
- Communication with ICEPACK [66] for thermal analysis

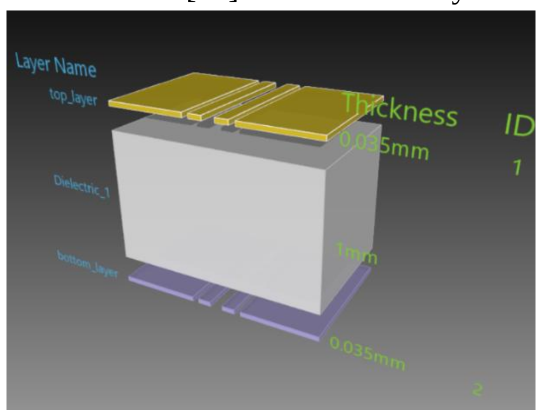


Figure. 3.12 Adjusting the Padstack Size

The thermal model is created for each capsule to be simulated (Fig. 3.13) in order to simulate its temperature only at critical points using the ICEPACK application. The information about the active area (a) and the interface (b) between the active area and the copper base are specified in detail. (c) and component pins (df), which uses less processing power.

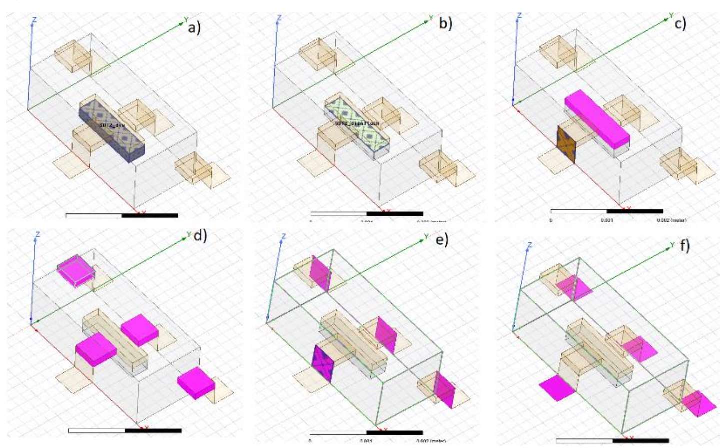


Figure. 3.13 Example of a thermal model

3.4 Display and control system based on gesture recognition technology using infrared sensors

During the development of this microsystem for gesture recognition, attempts were made to expand the number of sensors to be detected from 2 or 3, which are currently used in other microsystems of the same type, to a total of 4 sensors. Using this new approach, most existing gesture detectors use two photodiodes and can only detect a few gestures (e.g., top to bottom, bottom to top), which doubles the number of LEDs and photodiodes and increases it to four Following the same rules, we have increased the number of recognized gestures to 5 (up-> down, down-> up, left-> right, right-> left and close).

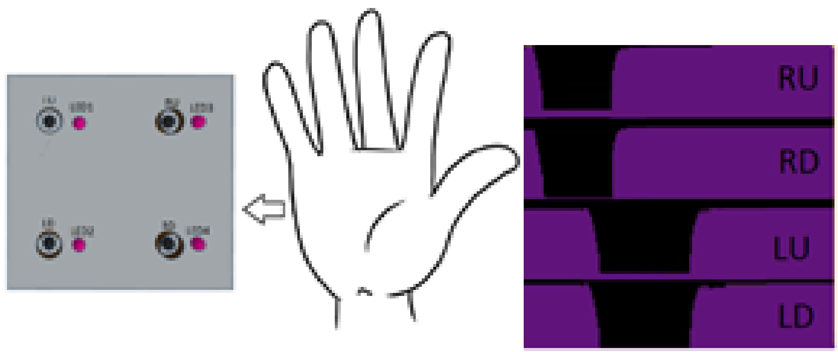


Figure. 3.14 Move your hand from right to left over the microsystem with four photodiodes (left) and read off the corresponding voltage (right).

Recognizable gestures are:

- From bottom to top (hand movement from bottom to top)
- Upside down (hand movement from top to bottom)
- Left-Right (movement from left to right)
- Right-Left (move from right to left)
- Below (hand is positioned above all sensors)

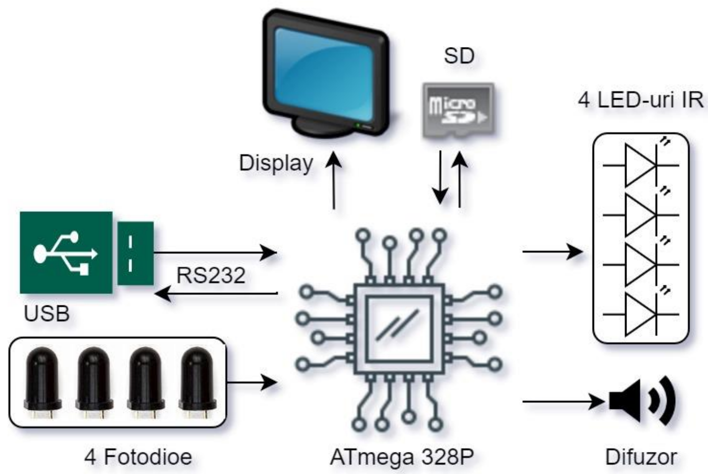


Figure. 3.15 Block diagram of the prototype

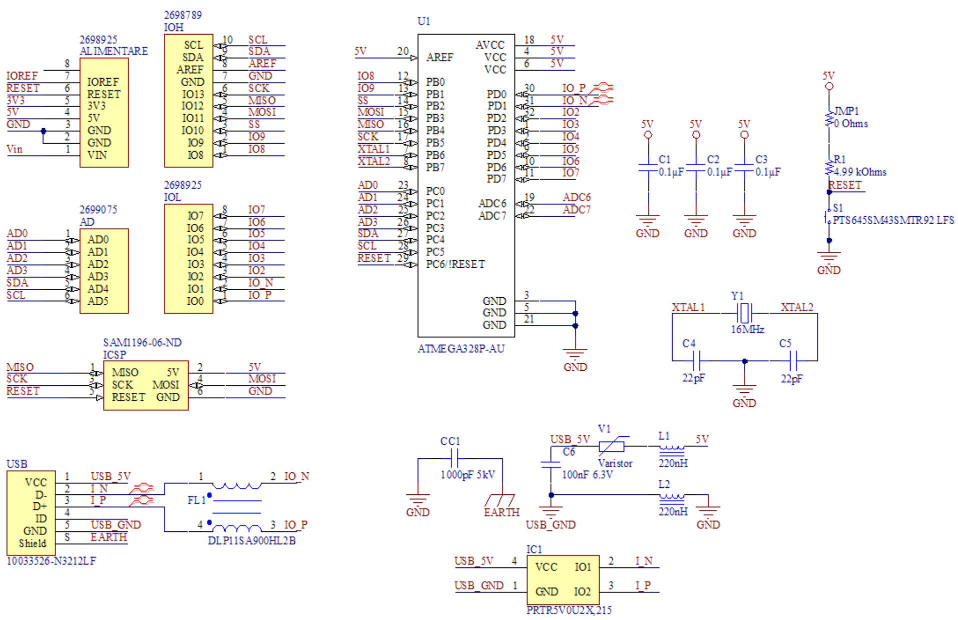
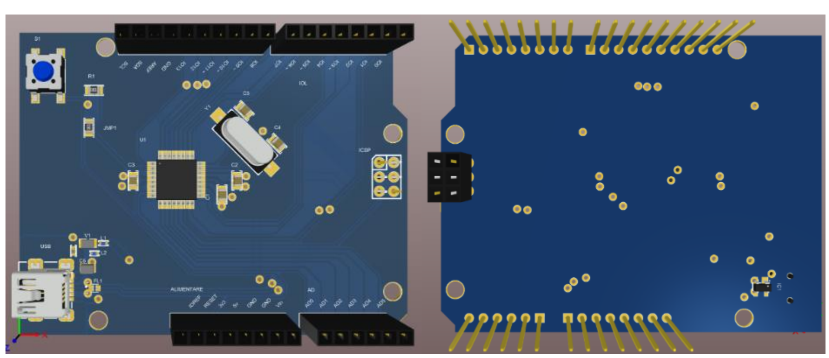


Figure. 3.16 Circuit diagram main board



a) b)

Figure. 3.17 PCB main circuit layout TOP a), BOT b)

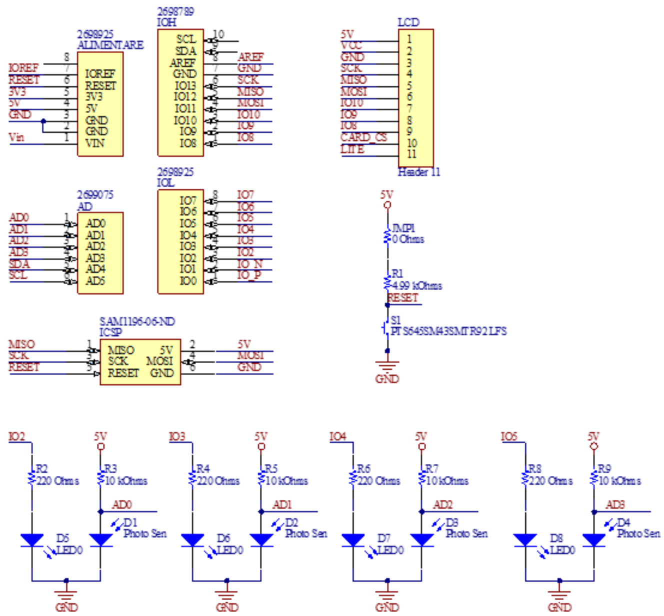


Figure. 3.18 Circuit diagram of the secondary circuit board

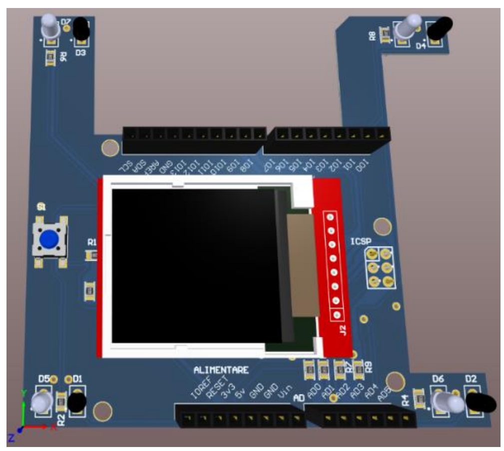


Figure. 3.19 Top view of the secondary board

3.5 System assembly

In Fig. 3.20 it is observed how the gesture recognition system is stacked, in the upper part the secondary circuit and in the lower part the main circuit of the system with the microprocessor ATmega328P.

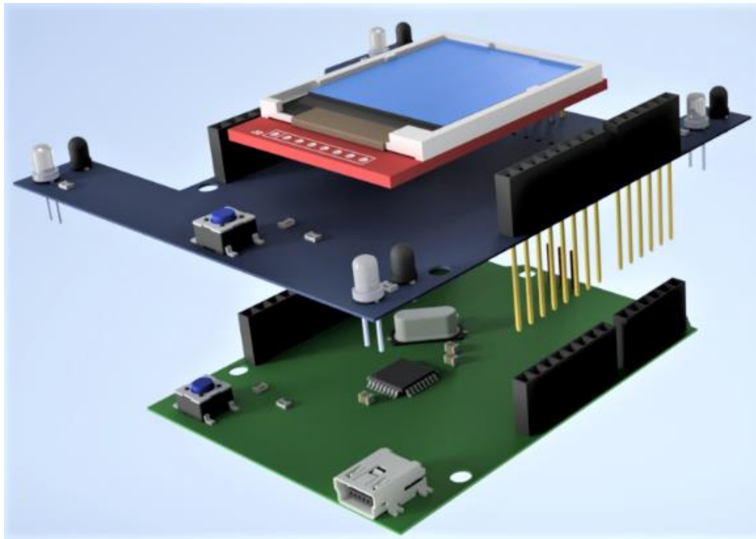


Figure. 3.20 stacking of the 2 circuits

In Fig. 3.21 it is observed the assembly of the modules of the air quality measurement system together with the PMS5003 sensor.

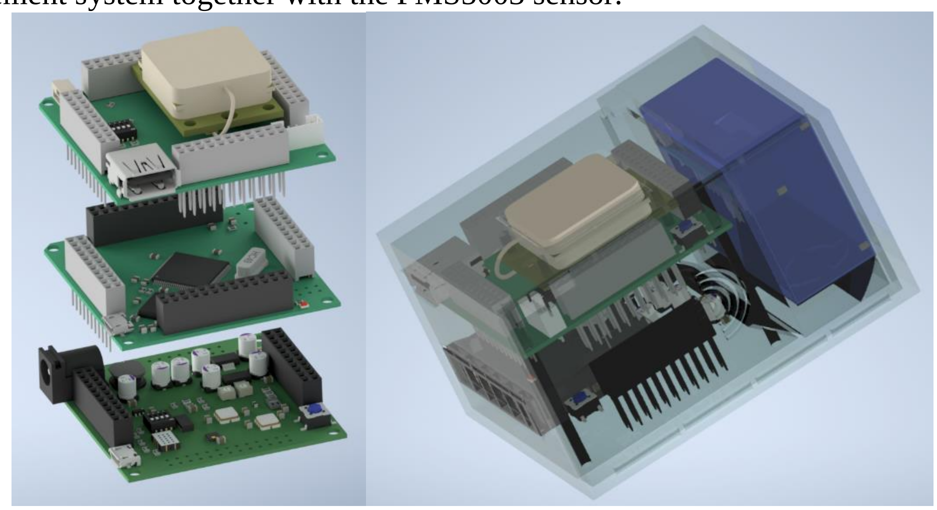


Figure. 3.21 Assembling the modules of the air quality measurement system together with the PMS5003 sensor.

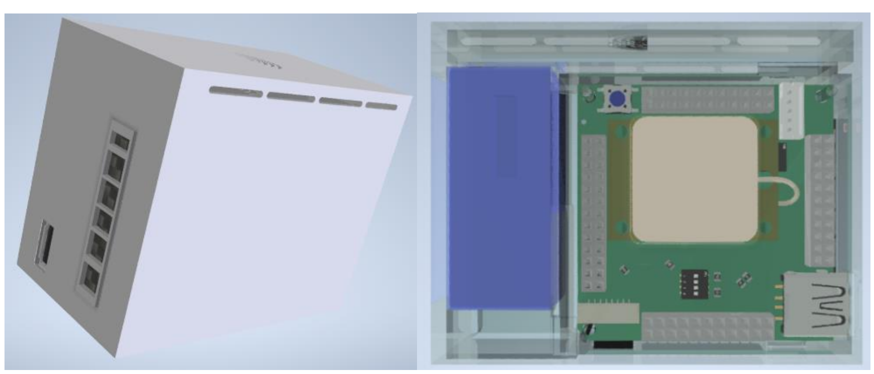


Figure. 3.22 3D model and system box compartment

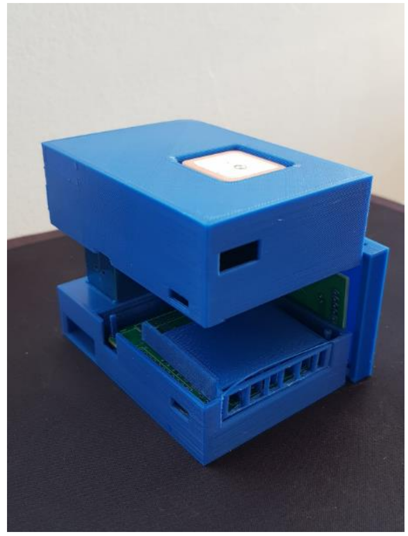


Figure. 3.23 Assembly the housing

4. IoT system for simultaneous temperature measurement at several points with one sensor based on MEMS technology

The study is based on the high-precision infrared thermal sensor AMG8834, which uses MEMS (Micro Electromechanical Systems) technology to create a map of surface heat in order to alert the user to a possible hazard and to be able to measure the temperature of a surface at several points (human body, auto parts), not the temperature of the ambient air as with existing modules on the market. It mainly aims to deploy the system in autonomous vehicles as they are becoming more and more advanced, acting as drivers, taking children from school, transporting injured people as ambulances and many other activities that tend to become common in everyday life. Since there is no person in the car who can be monitored, the need for warning messages increases in the event of danger. Vehicles usually heat up quickly, with much of the interior temperature rising in the first 15 to 30 minutes [59]; The internal temperatures rise very quickly and reach a critical temperature of 40 ° C in about 8 minutes on a summer day.

AMG8834 temperature sensor

The MEMS AMG8834 sensor is a hybrid assembly that is arranged in the form of a 14-pin SMD module in a ceramic-metal housing. It consists of a silicon lens with a field of view of 60 °, a ceramic base, an infrared detector in the form of an 8x8 MEMS sensor matrix, a thermistor and an integrated digital-analog chip (I²C interface), which is required to process signals from the Array, control and communication with the microcontroller. AMG8834 is a grid-eye infrared matrix sensor that detects the heat (infrared rays) of the human body and other objects from -20 ° C to 100 ° C with an accuracy of ± 3 ° C up to 10 times per second. Each pixel has a field of view of 7.5 ° and a range of up to 7 meters, which makes it the perfect choice for use in the car. The sensor makes it possible to generate the thermal image of the surrounding objects in the form of an 8x8 matrix, which it sends to the microcontroller. Each cell in the matrix is associated with the temperature of the object that fell in the field of view of a particular receiving cell. Grid-EYE is a very user-friendly and economical sensor that is ideal for wireless IoT (Internet of Things) applications.

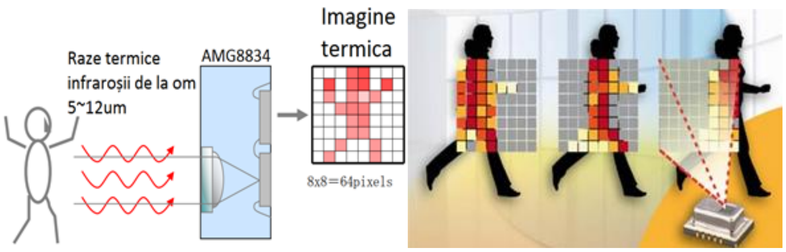


Figure. 4.1 Functional principle of the AMG8834 sensor (a-detection of human body temperature, b-motion detection) [65].

The communication mode with the sensor is implemented via the registers, which can be used to configure several settings. The most important are the operating modes (table below), the number of images per second (1: 1FPS - 1 image per second). 0: 10FPS - 10 frames per second) or generate interrupts if the temperature read on one of the pixels exceeds an initially set value.

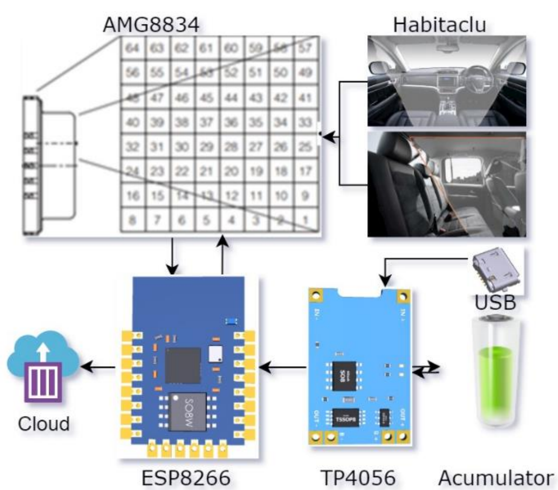


Figure. 4.2 System block diagram

4.1 Calculation of the sensor positioning

The system is conveniently placed in the vehicle. To do this, the best location for the sensor was examined to determine its optimal position so that it has the largest field of view.

Based on this information, it was chosen to place the sensor in the rear of the vehicle in order to have a wide field of view so that it can detect infrared radiation from the rear seats as well as from the front and the dashboard.

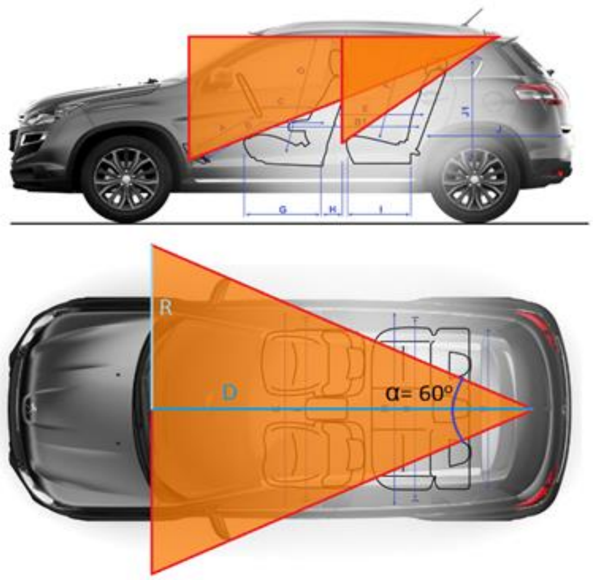


Figure. 4.3 Field of view of the sensor

4.2 Prototype production.

The prototype consists of two printed circuit boards, one of which contains the ESP8266 microcontroller, the USB port to power the microsystem, a standard 3.3V power supply, and two ports P1 and P2 for adding additional hardware. (Fig.4.5) and a secondary printed circuit board stacked on top of the main circuit, the connection between the two circuits being made using the two ports P1 and P2 and the FTDI port.

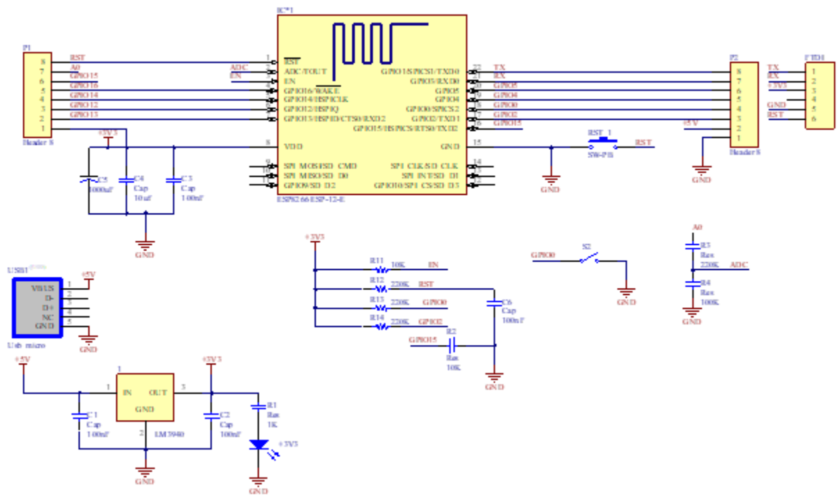


Figure. 4.4 Electronic diagram with microcontroller ESP8266

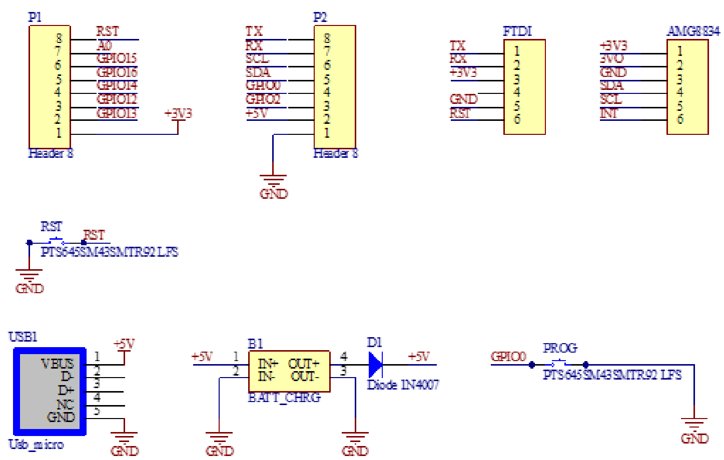
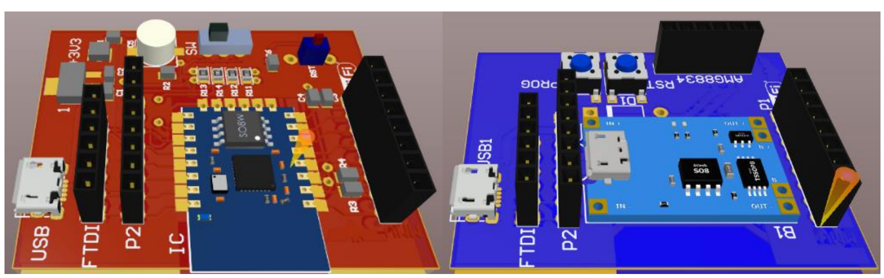


Figure. 4.5 Electronic secondary circuit diagram



a) b)

Figure. 4.6 Major (a) and minor (b) PCB layout.

4.3 System assembly

The assembly is designed so that everything is stacked on top of each other like a sandwich while still allowing access to measurements and future additions to modules.

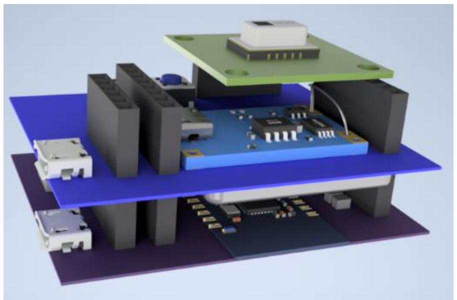


Figure. 4.7 Circuit stack mode

5. Solution for viewing and centralizing online data received from IoT devices

In order to be able to display and save the data received from the IoT sensor nodes, several existing options were examined. The problems to be solved were the visualization of the data from each sensor node on a card, the storage of data in the cloud for their analysis, the alarm signaling of possible real-time events and the visualization of information received from sensors with the cloud, while at the same time ensuring the security of the Communication is tracked.

Various options in the market that offer solutions for managing internet connected devices have been examined and some of them have been selected for a comprehensive analysis. The exclusive use of online platforms without the use of local servers was considered for better data management and security.

Some of the important information that must be displayed in real time, are the location data, the time at which the data has been sent and the information from the sensors. Solutions were also sought to send warnings on a smartphone in the event of possible dangers.

5.1 Introduction

As described above, the goal was to develop a platform to display data from mobile IoT sensors. There are many solutions for viewing data online, with their advantages and disadvantages. Therefore these have to be combined to get an optimal solution.

Small summary of the problems to be solved:

1. Sending data from air quality sensors and point temperature sensors in a cloud-based IoT environment
2. Storage and analysis of the data received in the cloud
3. Sending real-time warnings in the event of an identified hazard
4. Show air quality data on an interactive map with data stored in the cloud data, bearing in mind is, are that IoT systems that send information in the cloud not static.

5.2 Motivation

The graphical representation of data appeared long before the advent of modern technology (printers, computers) from the days of handcrafted maps and later in more detailed maps. [72]. The use of modern technologies enables a user to view data much more easily and simply, from a simple chart in Excel to real-time visualization of the ion collision [73].

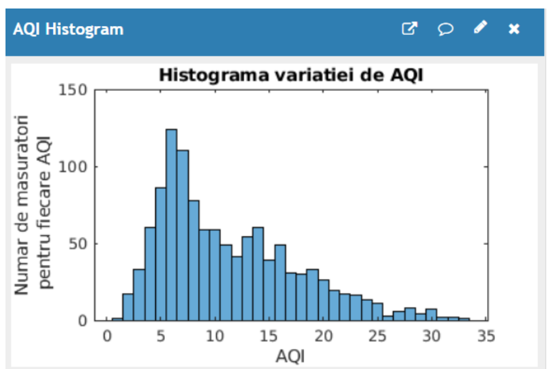


Figure. 5.1 Example for the visualization of the histogram of the variation of AQI

Highlighted Results:

1. Create a map that can display data from air quality sensors based on the coordinates received from each device's GPS module
2. Two-way communication between sensors and the IoT server
3. View results in real time

5.3 Development of an IoT system for data management and use

The IoT system developed in this project consists of several IoT devices that are connected via a server with the cloud are, and to display a possibility that received data. The project focuses on building an architecture of mobile sensors in autonomous vehicles to achieve an integrated IoT system that can be used to map areas with more polluted air, issue real-time alarms for possible hazards, and store information in a database for subsequent processing should be in order to achieve a higher level of knowledge about the gaseous composition of the environment.

5.4 IoT system design

The system has a node with two ESP8266 microcontrollers mounted in an autonomous vehicle. One of them monitors the temperature levels of surfaces or people in the passenger compartment and, using the application installed on the smartphone, alerts the user of the presence of people or people animals indoors, which may be in an alarm situation due to excessive temperatures in the passenger compartment. It can also be used as an alarm device in the event of illegal entry into the vehicle. The alarm is sent on the smartphone device. The second ESP8266 microcontroller in the passenger compartment takes over the acquisition of information from sensors and its transmission to the cloud in order to analyze and display it in real time.

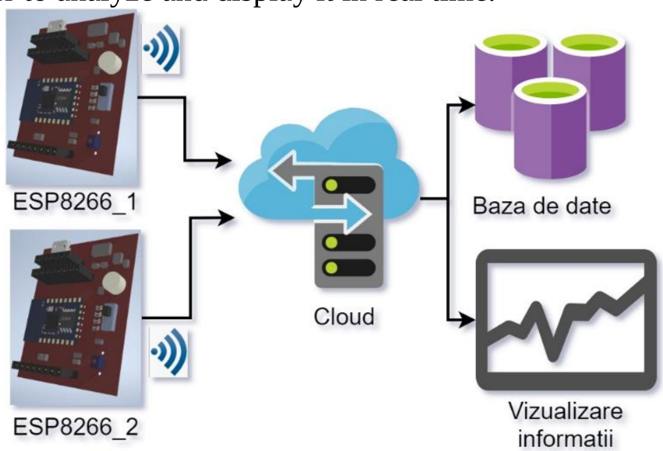


Figure. 5.2 IoT management system diagram for a sensor node

5.5 Ways to use and view data received from sensors

One way that is being developed is to use the Blynk server and an application installed on a smartphone so that the IoT node user can view the purchased data in real time and receive alerts on node generated events. It is therefore desirable to create a personal IoT system where the owner of the IoT node is the one who manages it. The second usage mode to be developed uses an online platform to manage all started IoT nodes and to store data in a cloud database for later viewing and processing in various applications. The ultimate goal is to have all devices managed by a single operator.

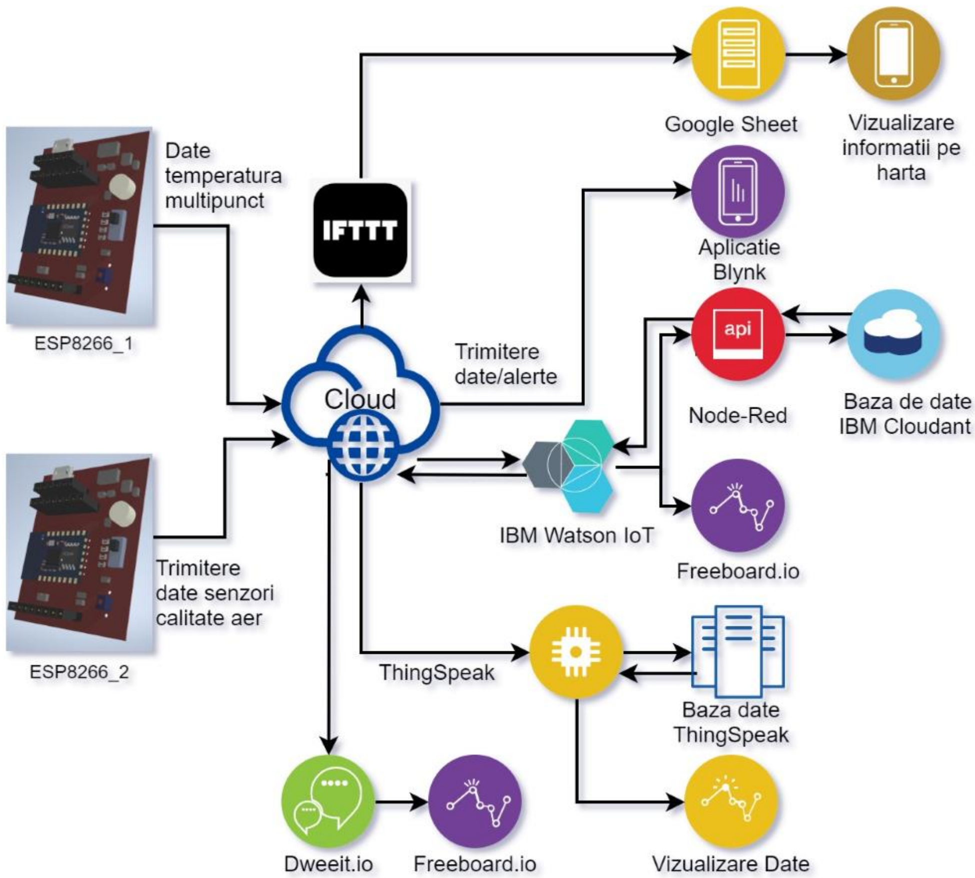


Figure. 5.3 Block diagram of the designed cloud platforms

6. Conclusions

6.1 Results obtained

Results Chapter 3. IoT system for collecting air quality data

In this chapter we have developed a prototype of a microsystem that is used to retrieve detection data from sensors (CO_2, NO_x, temperature, humidity, VOC, smoke, particles, flammable gas and H_2S), display information on a display and warn the user against an increase in pollutants.

The experimental results were obtained by incorporating the system into the vehicle's heating, ventilation and air conditioning installation to demonstrate its functionality.

The interface to the sensors is achieved through I2C communication for the CCS811, HDC1080 and MAX30105 sensors. With MICS4514, GM-402B and GM-602B, the interface is via ADC. The ADC levels of the sensors are well adjusted to get the best accuracy of the 10 bit ADC converter of the ATmega 2560 microcontroller and to be able to detect electrical errors. The interface to the sensor PMS5003, ESP8266, GPS NEO6MV2 takes place via serial communication.

The information from the HDC1080 sensor is also used to compensate for the gas readings from the CCS811 sensor due to changes in temperature and humidity. The MAX30105 has an on-chip temperature sensor to calibrate the temperature dependence of the particle detection subsystem. The temperature sensor has an inherent resolution of 0.0625 ° C.

The measurement takes place every 60 seconds. The system is slower to react to the presence of pollutants, but has a low average operating current. The system changes with the detection of pollutants with a higher frequency of the sample.

The microcontroller transmits all read information via the USB interface and serially to the ESP8266 so that the data can be read by any connected device.

The aim of this project is to achieve the hardware structure and general control functions to enable further development.

As can be seen, after implementation and some initial results obtained, it shows the efficiency of the proposed system, as well as the ability to monitor the interior of a car with less expensive devices than those currently in use that can react automatically without any natural reaction. the human operator.

The system can be small in production mode and save lives and property by detecting events such as fire or material damage in the car early on.

An attempt has been made to demonstrate that certain systems currently used to monitor air quality can be replaced by less expensive systems with a faster rate of generating alerts. This is not a single, but an optimal solution. To be able to demonstrate that, depending on the needs of each user, we can measure air pollution with a reasonable level of detection at a low cost and low energy consumption, with the data available in real time.

Access to inexpensive sensors offers exciting new weather applications, can support new weather services, and facilitate the addition of a new group of users.

The system is intended to encourage people in cities to collect environmental data in conjunction with the Global Positioning System (GPS). The data is used to map the city based on the measured air quality without a network of sensors required is to make every user can browse data on a web map or a mobile application. This is the main goal is to raise citizens' awareness of the environment.

Display and control system results based on gesture recognition techniques using infrared sensors

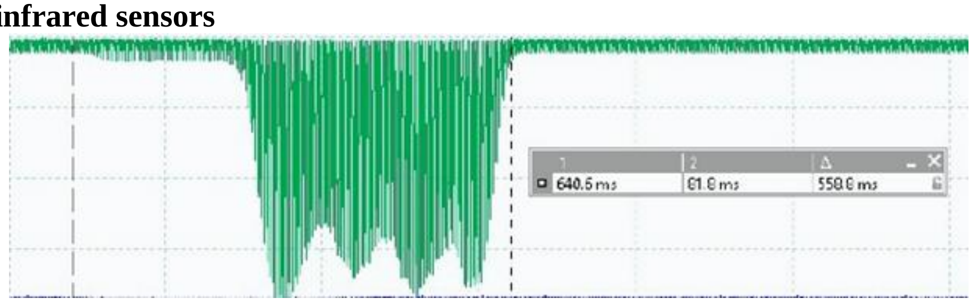


Figure. 6.1 The voltage read on the oscilloscope when the hand moves over a photodiode and the time of movement

When a "down" gesture is recognized, the ringtone beeps (every time a gesture is correctly recognized, it beeps and the system sends the information to the serial interface for interpretation

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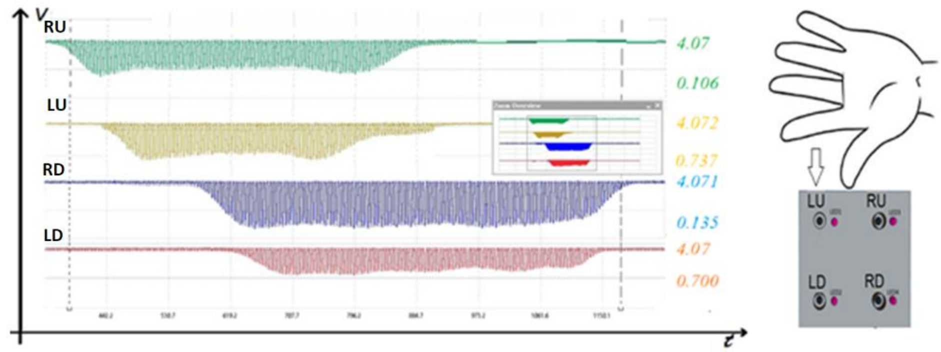


Figure. 6.2 Voltage values read with the oscilloscope for a top-down gesture

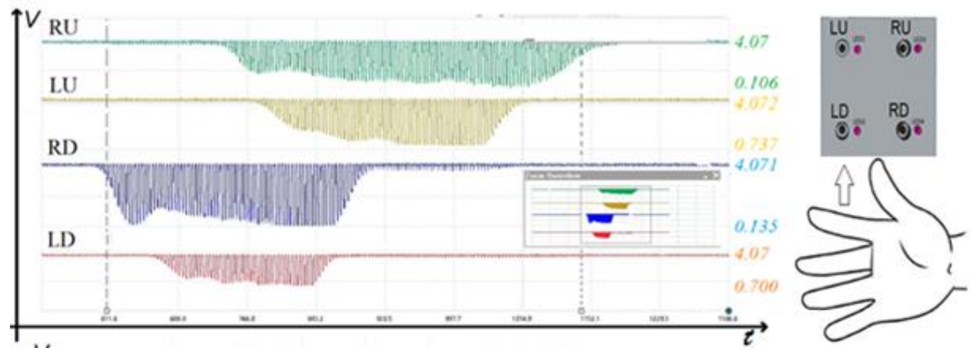


Figure. 6.3 Voltage values read with the oscilloscope for a downward movement

An additional advantage over the use of two or three sensors was observed during the tests, namely the detection of gestures in three-dimensional (3D) space with subsequent development, as can be seen in Fig. 6.4. The fingers can be recorded individually.

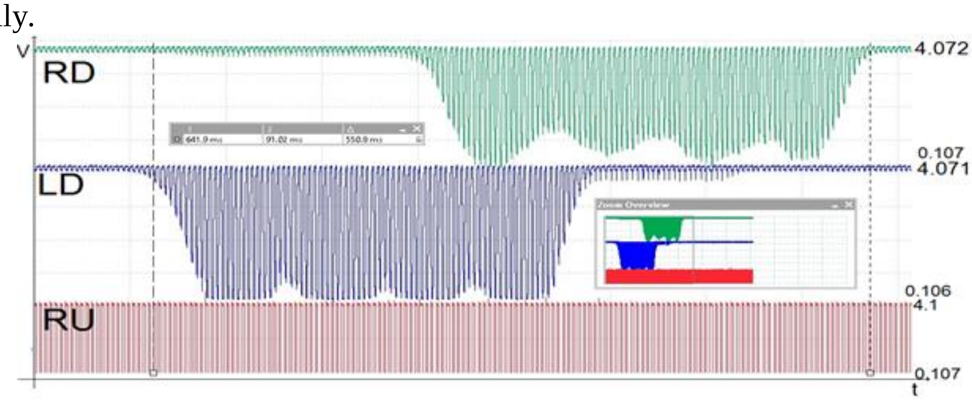


Figure. 6.4 voltage readings from 2 sensors (RD and LD) are read by the oscilloscope when the fingers are swept over them and by a fully covered sensor (RU).

When the pollutant level exceeds a certain threshold, the screen will display a temporary red color with a warning message informing the user (Fig. 6.5).

Figure. 6.5 Information shown on the display with an alarm that is triggered when a high concentration of flammable gas occurs

This implementation, which as a novelty uses the placing and reading of the four sensors in the exposed mode, makes it easier to identify a gesture made by a hand moving over the four photodiode sensors, and it can also be better captured with further development many Movements with precise hand speed and complicated gestures. The main advantage of using four photodiode sensors over two is that they offer more options for use, capture a greater number of gestures at a higher speed, and improve the ability to recognize gestures more accurately and in greater detail.

The thermal simulation leads to Icepack and SIWAVE

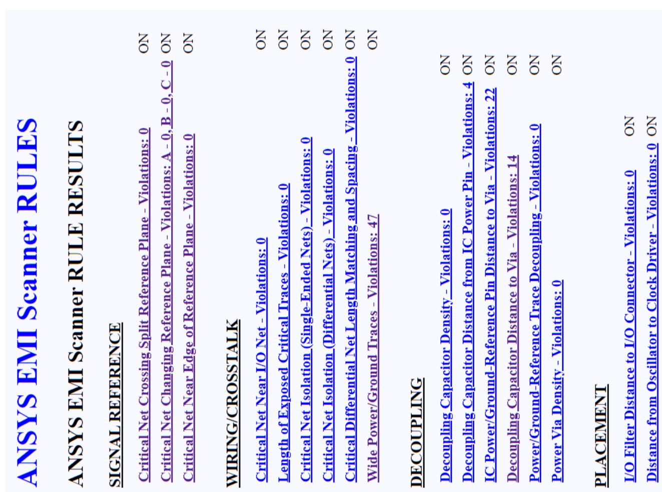


Figure. 6.6 Results of EMI Analysis

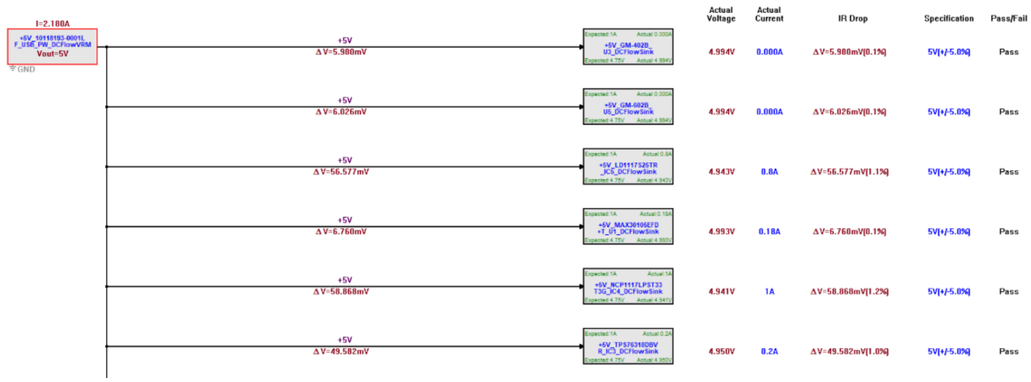
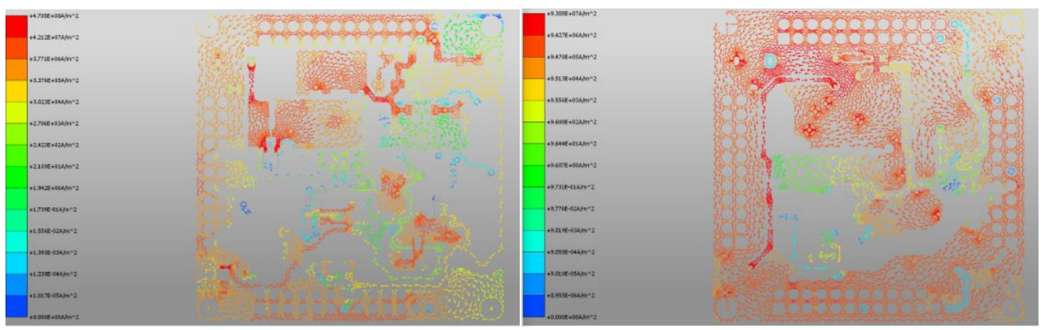
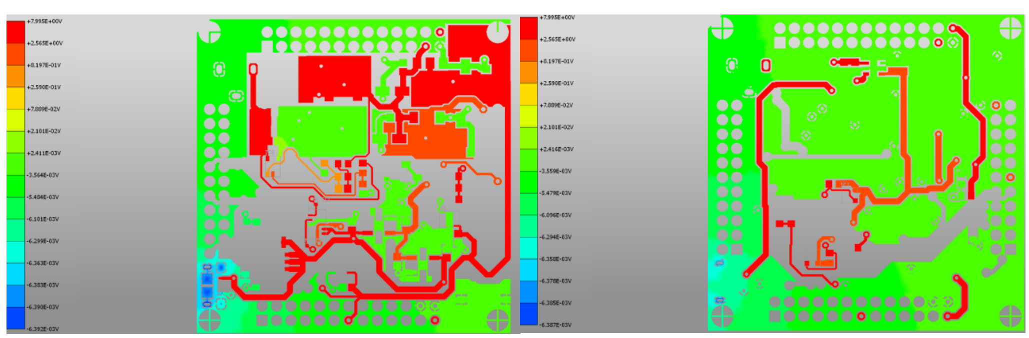


Figure. 6.7 Results of the stress analysis



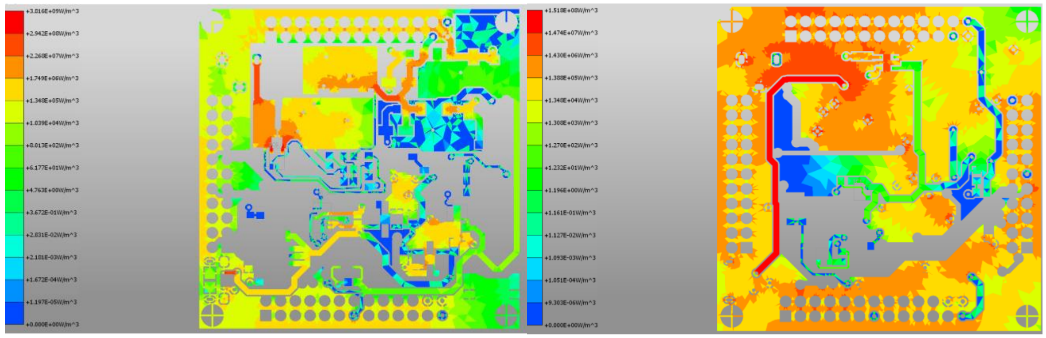
a) b)

Figure. 6.8 Current density on TOP a) and BOT b)



a) b)

Figure. 6.9 The values of the tensions on the routes on TOP a) and BOT b)



a) b)

Figure. 6.10 Power density TOP a) and BOT b)

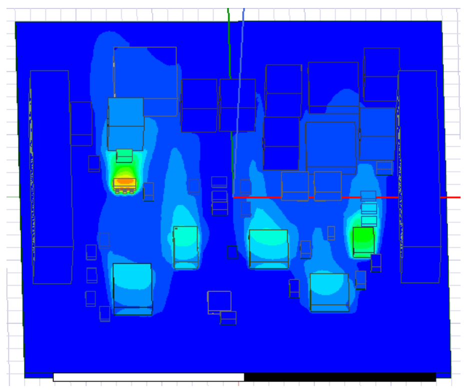


Figure. 6.11 Heat simulation with filtered air flow

Results Chapter 4. IoT system for simultaneous temperature measurement at several points with a sensor based on MEMS technology

The system was tested by creating a test in which part of the surface on board a vehicle was heated to two different temperatures and the temperature was measured at each stage. When a high temperature is detected, the microcontroller will send a warning over the internet. Flames are detected by processing the data collected by the MEMS sensor and analyzing the constant change of each pixel value in successive frames.

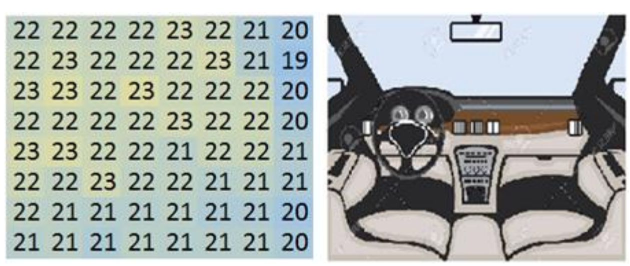


Figure. 6.12 Read off ambient temperature values

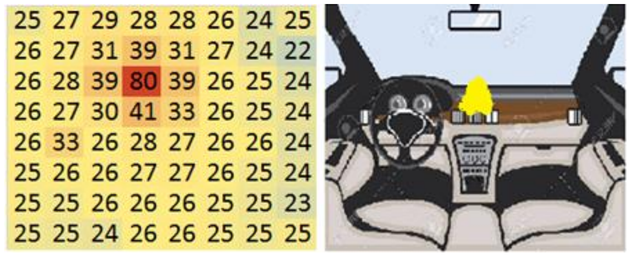


Figure. 6.13 Temperature display after an area has warmed up slightly

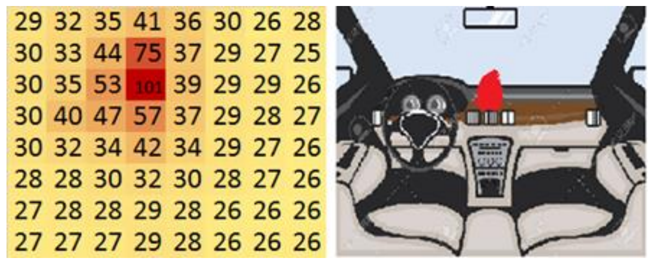


Figure. 6.14 Temperature display after applying a high temperature to an area

It has been tried and shown that certain systems currently used to monitor the interior of a car can be replaced by less expensive systems with much more efficient algorithms for data processing and alarm generation (a decision algorithm based on 64 points) The measurement is a lot more efficient than an image processing algorithm. This is not a unique solution, but an optimal solution.

The AMG8834 sensor uses infrared radiation (IR) versus heat transfer by conduction. This offers a unique solution that can achieve new levels of performance and reliability in many constrained applications. Thus, using the infrared temperature detection device, it was possible to map the temperature and the heat distribution in 64 points of a scanned surface passively without intrusion, which enables temperature thresholds to be defined depending on each scanned area. acceptable as well as alarm thresholds. At the same time, you can also set the rate of temperature change and the alarm thresholds for certain scanned surfaces. The proposed system can be the basis for the development of other subsequent applications such as alarm systems and burglar prevention. Unlike single element thermal sensors and pyroelectric sensors, the system can or cannot detect multiple people at the same time , and surface temperatures can be measured extremely accurately in real time. The designed system can be used as a platform for use and further development for other research purposes so that an unknown user can easily understand it and quickly develop an application.

Findings Chapter 5. Solutions for viewing and centralizing online data received from IoT devices

As a user, the information is processed by several mobile IoT nodes located in the passenger compartment of the vehicle using the platforms presented above. The end result is their integration into a web page that the user can access through the Blynk application, but also from any other terminal with internet access. At the same time, information is sent from an IoT node and displayed directly in the connected Blynk application so that it can receive warnings in the event of a possible real-time danger.

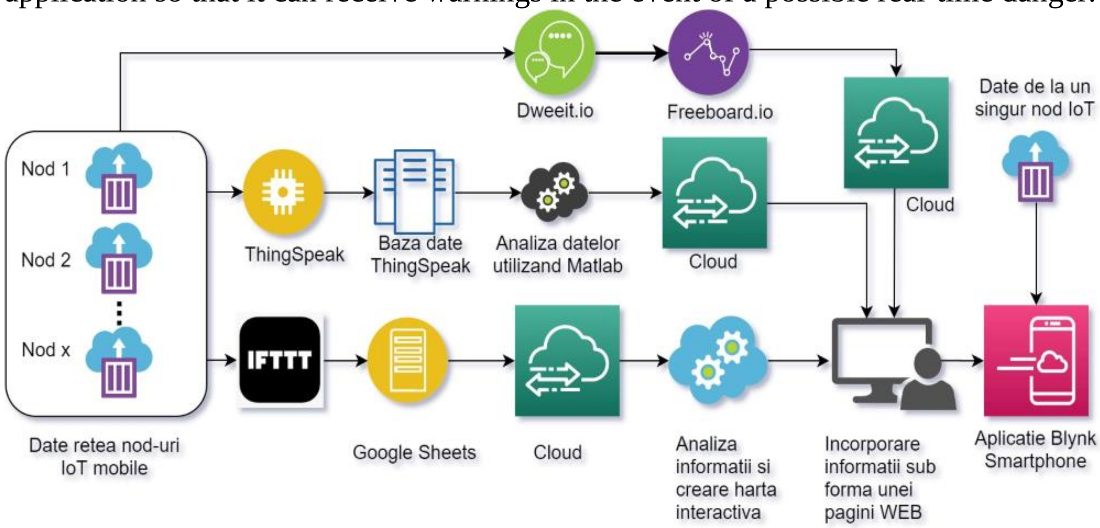


Figure. 6.15 User mode block diagram

The user mode includes several platforms from the ones presented above, namely the ThinkSpeak, Google Sheet, Blynk, IFTTT, Dweeit.ro and Freeboard.io platforms to deliver the end result, namely displaying data in real time and positioning on a map and an analysis of them over one or more days.

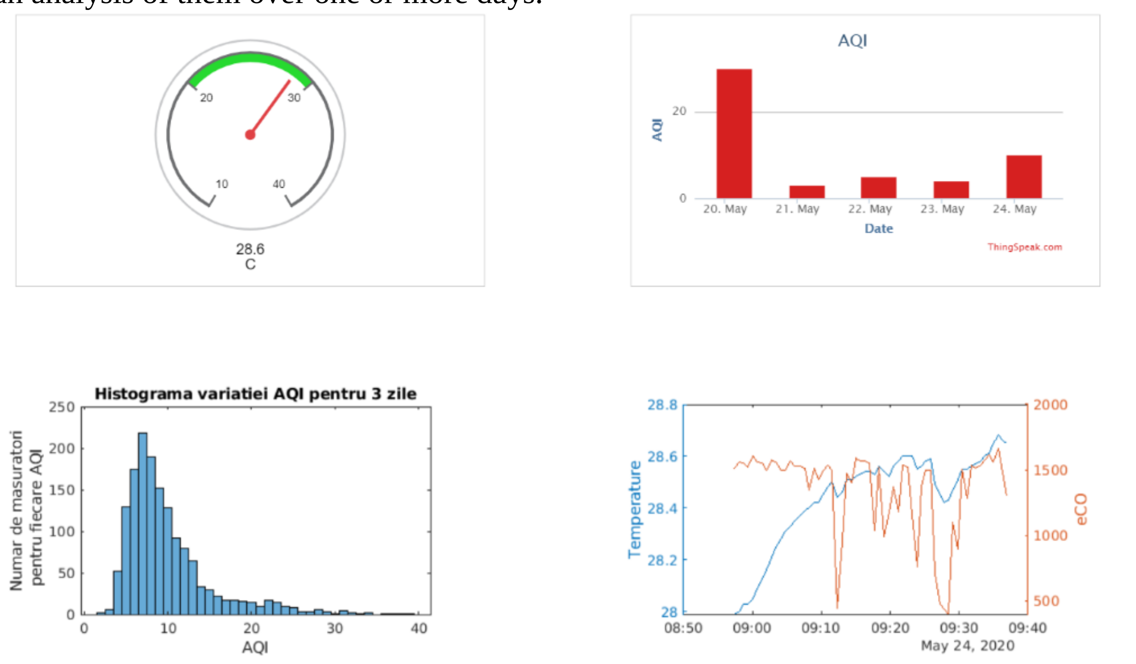


Figure. 6.16 Matlab data processing leads to ThinkSpeak

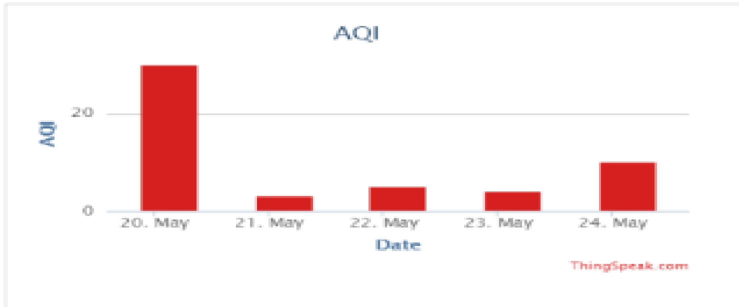


Figure. 6.17 AQI average daily view

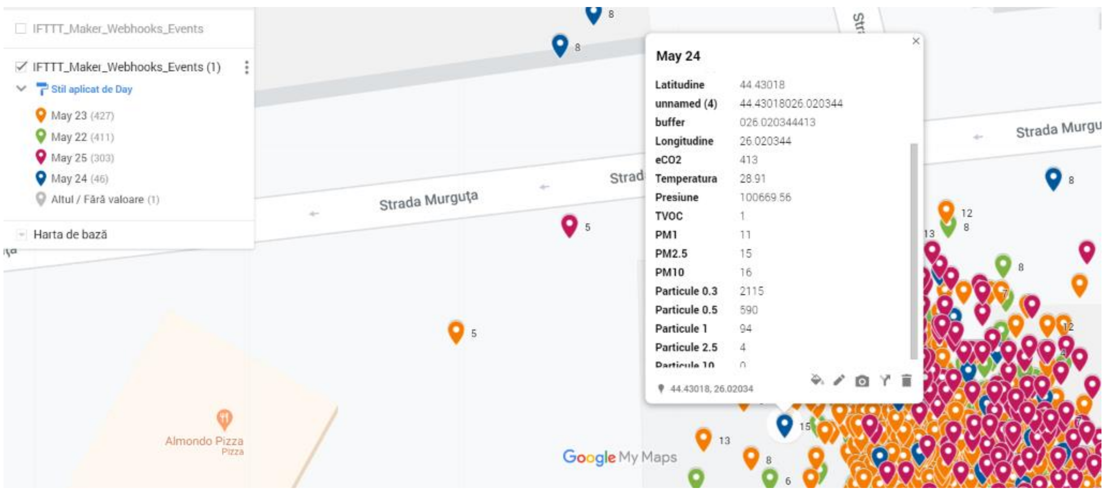


Figure. 6.18 Display of the values of the sensors sent in Google Sheets on the map

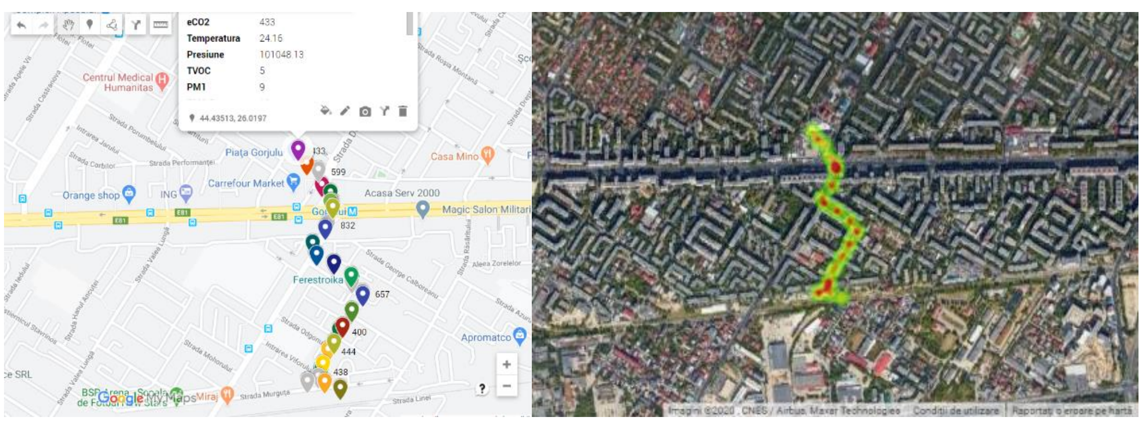


Figure. 6.19 View the heat map created for eCO2 using Google Sheets and Google Maps

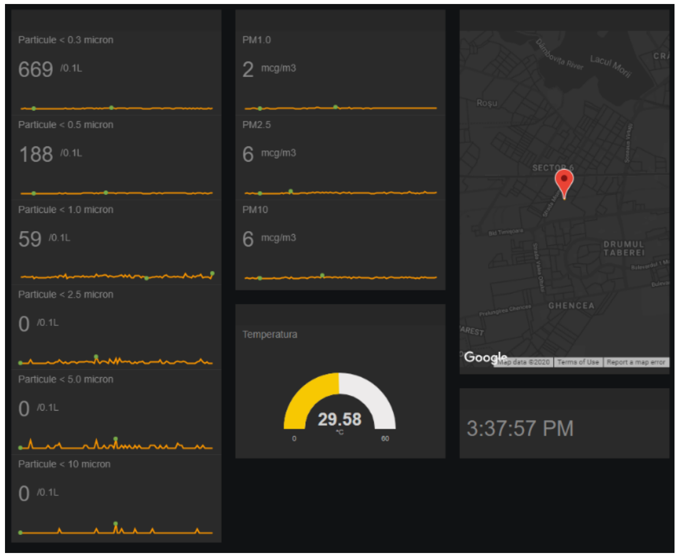


Figure. 6.20 View over the Freeboard.io platform

After implementing the work mode, the next step was to use Google Sites to develop a WEB page to make it easier to access data on the map. The website is created in HTML, CSS and JavaScript. Figure 6.21 shows some of the information available on the website, including the view of Freeboard.io in Figure 6.20:

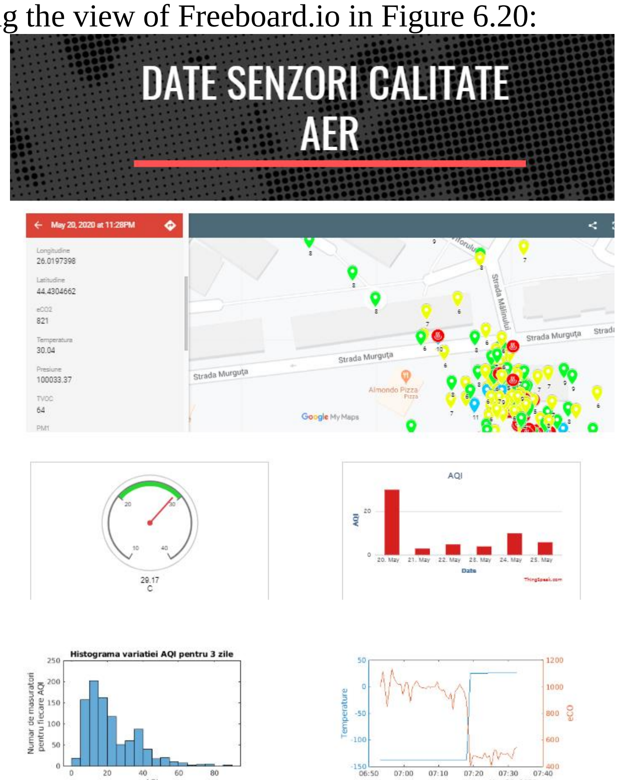


Figure. 6.21 Display the developed WEB page

The IBM Watson IoT platform was used to implement the administrator usage mode (Figure 6.25), which provides a higher level of security, easier monitoring and troubleshooting of all IoT devices, and later allows for an update distribution mode to be implemented. Software or to configure certain device settings using Over The Air (OTA) technology.

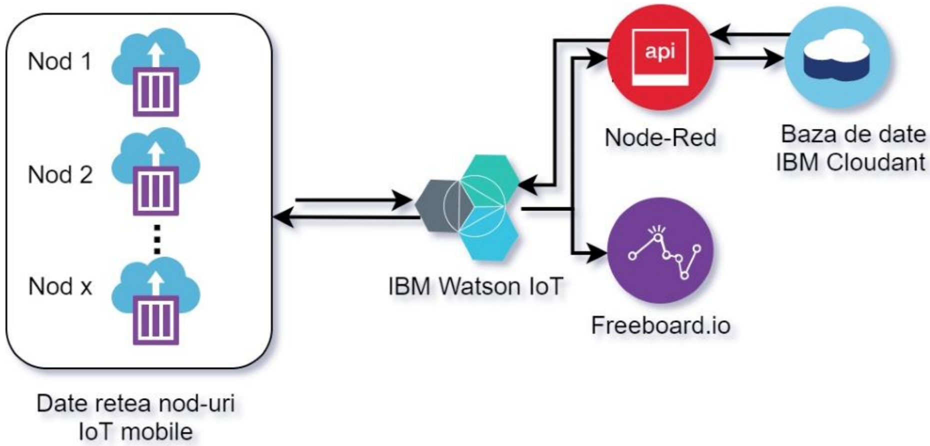


Figure. 6.22 Using the IBM Watson IoT Platform

Access to the administrator platform is via an ID and a password.

The view mode provided by the platform is used to display the data (Fig. 6.26). However, the Freeboar.io platform is also used to publish information that can be accessed by all users.

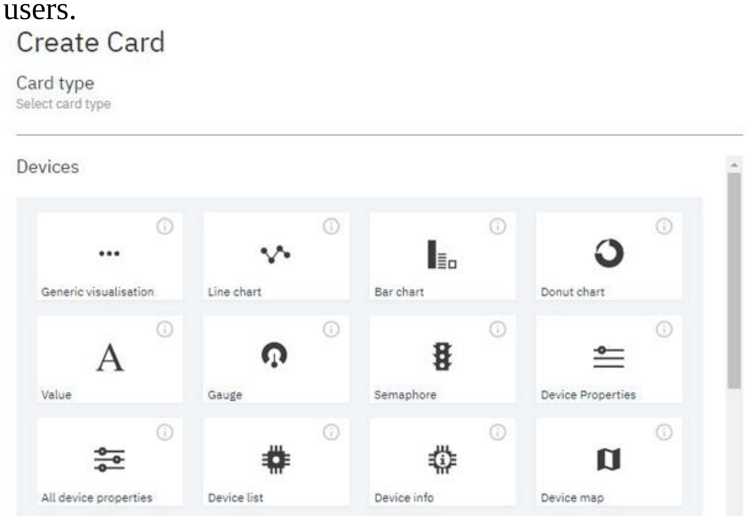


Figure. 6.23 View Modes Available on the IBM Watson IoT Platform

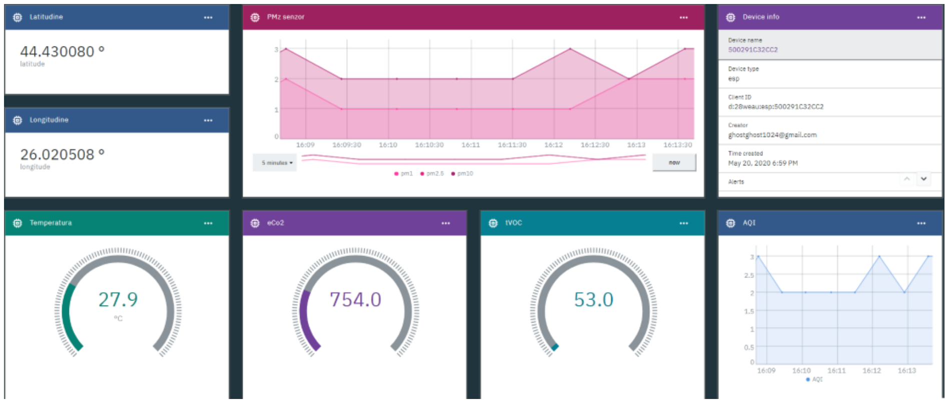


Figure. 6.24 Viewing Information from an IoT Cloud Using the IBM Watson Platform

Displaying information for mobile IoT devices that are on the go is used in many fields. Integration into car electronics is only a matter of time.

6.2 Original contributions

1. Design a device that is accessible to all groups of people to give them a new perspective on the atmospheric composition
2. In establishing the criteria for sensor selection, we looked for the latest sensors on the market that meet the goal of being cheap, yet efficient and effective at the same time
3. Design of the prototype as an integral part of a network of sensors on autonomous vehicles that help manage air pollution in a city or region
4. Realization of a command and control prototype with four infrared sensors and implementation of an algorithm for detecting gestures on the basis of the voltage information processed by the microcontroller.
5. Realization of a 3D model for thermal simulation
6. Performing the DC simulation to determine the stability of the supply lines
7. Design of the assemblies of the modules used and their 3D design
8. Realization of all printed circuit boards as development platforms , the use thereof in other subsequent enable research
9. Implementation of two modes for the management and administration of IoT devices, including storage, processing and manipulation of data in the cloud.

6.3 List of original works

1. MV Moise, AG Mazare and PM Svasta, "Implementation of a 3D Gesture Control System for Environmental Control", 7th Conference on Electronic System Integration Technology (ESTC) 2018, Dresden, 2018, pp. 1-4, doi: 10.1109 / ESTC .2018.8546342 .

2. M. Vasile Moise, L. Mihai Ionescu and P. Mugur Svasta, “Comparison between Deploying an IoT System for Online Use and One for Offline Use,” IEEE 24th International Symposium on Design and Technology in der electronic packaging 2018 (SIITME) , Iasi, 2018, pp. 161-164, doi: 10.1109 / SIITME.2018.8599279.

3. Vasile Madalin Moise; Vlad Andrei Zamfirica; "Solution for Autonomous Driving on the Autobahn" - 2017 - Journal of Electrical Engineering, Electronics, Control and Computer Science, Volume 3, No. 3 (2017), https://jeeeccs.net/index.php/journal/article/ view / 72

4. MV Moise, PM Svasta and AG Mazare, "Implementation of an embedded prototype system for multipoint temperature measurement in the car", 22nd European Conference and Exhibition for Microelectronics and Packaging (EMPC) 2019, Pisa, Italy, 2019, pp. 1- 4 , doi: 10.23919 / EMPC44848.2019.8951766.

5. MV Moise, P. Mugur Svasta and LM Ionescu, "Implementation of a prototype air quality measurement system using MEMS sensors", IEEE 25th International Symposium on Design and Technology in Electronic Packaging (SIITME) 2019, Cluj-Napoca, Romania , 2019, pp. 106-109, doi: 10.1109 / SIITME47687.2019.8990695.

Articles accepted for publication:

6. Madalin Vasile Moise, Paul Mugur Svasta and Alin Gheorghita Mazare, “PROGRAMMABLE IOT PILL DISPENSER ” - 2020- 43rd International Spring Seminar on Electrical Engineering, Demanovska Valley - Slovakia

7. MV Moise, P. Mugur Svasta and LM Ionescu, "Implementation of a prototype of a network system for the detection of air quality with geolocation", 2020, 8th Conference on technology for integrating electronic systems 15 bis 18 September 2020

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