# PORTABLE PROTOTYPE OF A CO2 LEVEL METER WITH SET POINT APPLYING IOT FOR HYDROCARBON COLLECTION AND TREATMENT STATIONS

Jesús D. Quintero-Polanco, Andrés C. Aquite-Parra and Juan D. Polo-Méndez
Department of Electronic Engineering, Faculty of Engineering, Surcolombiana University, Neiva, Huila, Colombia
E-Mail: jdavid@usco.edu.co

**ABSTRACT**

This work describes the development of a portable prototype of a CO2 level meter with set point applying IoT for hydrocarbon collection and treatment stations, developed to monitor the amount of CO2 that is present around its environment, through the use of any device that has internet connection. The following describes the development process at hardware and software level and the tests carried out to verify the correct equipment operation. Mention is also made of some technical details for the end user, which will facilitate the use of the equipment at the time of use.

**Keywords:** $CO_2$, web application, design, interface, internet of things.

## 1. INTRODUCTION

IoT (Internet of Things) is part of the new technological advance led by the development of 5G communications, it is made up of complex networks with miles of millions of interconnected devices within the framework of multiple conventions, technologies and stages. With the help of hardware devices and Internet connection, the condition of an intelligent environment can be built to make cities, industry, health, energy, transportation, etc., intelligent for our daily lives (Pallavi, *et al*., 2017). This project sought to carry out a basic development and implementation of IoT in a CO2 measurement equipment, which is recognized as the main greenhouse gas that is produced in the form of waste in certain industries. as the case of oil industry, which is the focus of this project.

Currently, there are many commercial meters of CO2 levels, which must be manipulated by an operator at the place where the measurement is made or simple equipment that shows the concentration on a display. The objective of this project was the development of a prototype that fulfills the function of measuring the concentration of CO2 through the use of IoT, that does not depend on the manipulation of an operator and allows the equipment connection to the internet, so that the information that gets monitored from any electronic device that allows an internet connection (Laptop, Smart phone, smart tablet, etc).

The website has been made on the free Netbeans integrated development environment, who's coding was carried out using the PHP language (Hypertext Processor), so that it is interpreted through the use of a paid web server that also provides hosting services. The programming of sensors and modules was done through the Arduino development platform, which is based on a board that incorporates a re-programmable microcontroller, this allows establishing connections between the microcontroller and the different sensors, later in order to transfer the information to a GPRS module for the connection and sending the data through the cellular network.

This prototype provides the benefit to users who are in an oil zone, specifically in hydrocarbon collection and treatment stations, to monitor the concentration of CO2 measured in PPM (parts per million) that are around it, it is also worth noting that Measurements can also be made anywhere in the world, due to its portability and battery autonomy, making it easy to move and handle.

The life forms of all hierarchy's request air of unequaled quality to have a healthy stay on the planet. Increasing population, urbanization, and all the other implications of population growth have increased the number of ways the air can be subject to pollution. Coal and oil currently have no green substitutes that can be implemented on a large scale (Kodali, Rajanarayanan, 2019).

In Colombia, the monitoring and control of air pollution has taken on greater relevance day by day, because, according to figures from the World Health Organization, one out of every eight deaths worldwide are caused by air pollution (IDEAM, 2017).

The main source indoors is human respiration. Other possible sources due to combustion should be considered in cases of high concentration levels. The main effect of CO2 is asphyxia by displacement of oxygen, but this is produced by very high concentrations capable of displacing oxygen and reducing its concentration below 20%. At high concentrations, close to 30,000 ppm, it can cause headaches, poor concentration, drowsiness, dizziness, and breathing problems. In work environments, such as offices, odor complaints begin to begin at 800-1000 ppm. It is important to note that people with asthma problems or multiple chemical sensitivity syndrome (MCS) must provide themselves with air with low concentrations of CO2 (Institute for geo environmental health, 2018).

Knowing that this problem costs the country both monetary and life losses, a way must be found in which the problem can be controlled and treated. This confirmed by a report from the DNP (National Planning Department) of this 2018 associates them that only urban air pollution contributed 75% of the health sector expenses, about 15.4

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billion pesos. These expenses are associated with some 10,527 deaths and 67.8 million related to diseases and their symptoms. The National Planning report embraced a World Bank methodology for the number of deaths and illnesses caused by these factors, but it does not correspond to exact crossovers between the health system and the country's environmental indicators (El Tiempo, 2017). With this information we can ensure that the workers who are in charge of the hydrocarbon extraction process are subject to the dangers that excess CO2 can cause, being more specific those people who are in the hydrocarbon collection and treatment stations where they are The product is processed and the different gases extracted from the well are separated, according to the Consultative Group of Experts (GCE), the main sources of fugitive emissions from oil facilities are those from equipment (many of which are combustion engines) and venting, evaporative losses (as a consequence of the storage and product handlin, in particular when instantaneous losses occur) and accidental discharges or equipment failures (Consultative Group of Experts, 2018). The result is increasing the gas level in the environment, which in high concentrations is harmful to the operators and personnel in the area.

## 2. METHODOLGY

The first step carried out was the preliminary investigation, which consisted of searching for the necessary information for the equipment feasibility. In the first place, the justification for carrying out this project is based on the need to monitor CO2 in the hydrocarbon collection and treatment stations, as a consequence of the high concentrations of CO2 that occur in the area for combustion engines uses, gas leaks by evaporation and the generation of CO2 as a residue from the entire process carried out. Although there are different types of commercial meters as shown on the PCE site where they describe the characteristics of these "the models have the function of self-calibration, alarm setting and data recording to be exported to a computer" (PCE, 2018), it was not possible to find one that would satisfy the needs raised, which is that the equipment is capable of making measurements at CO2 concentrations, transmitting them to a database hosted on a web server, and also being portable. Therefore, the prototype must perform measurements of CO2 levels, in order to monitor, transmit and process this information so that it can be viewed anywhere in the world through the use of email, having access to the internet through A user kit to keep the monitored area safe from dangerous concentrations of CO2.

The initial prototype construction was carried out in two parts, a part corresponding to the design and implementation of the hardware and another part for the software design and implementation. In hardware, the decision was made to use a reference CO2 sensor MG-811 in a sen0159 module as the main sensor shown in Figure-1, "this analog CO2 gas sensor works with Arduino, it detects the concentration of Carbon Dioxide (CO2). Among its main applications are: Control of air quality, control of fermentation processes and detection of CO2 concentration at room temperature" (Didacticas electronicas, 2019) also, it has a wide measurement range of 350-10000ppm. In addition, to carry out a more complete monitoring, the MQ-135 sensor was used, this sensor has a detection range of 10-1000ppm. The choice was based on the response curve that the sensors have, like a straight line, which facilitates their calibration and subsequent use.

The system application was created using the view controller model (MVC), which is an architecture pattern that separates the application data, the user interface, and the control logic into three different components (model, view and controller).

**Figure-1.** MG811 sensor with sen0159 module (Didacticas electronicas, 2019).

The GPS chosen was the NEO-6, it corresponds to the family of receivers manufactured by U-Blox, they can be easily connected to a controller. It was chosen for its precision in the position of 2.5m, in speed of 0.1m / s and in orientation of 0.5 degree. To control and manage the information coming from the sensors and the GPS, the Atmega2560 microcontroller is used on the arduino board, initially it was tested with the Atmega 328P board, but it was not possible to use this board, since it only has a serial port and two were required. In addition, the Atmega2560 has three serial ports, one for the gas measurement sensors and the other for the GPS data, and finally an analog input was used to report the charge value of the batteries.

The information will be transmitted through a GPRS module, reference sim900 GSM, GPRS, whose main applications are M2M (machine-to-machine) communication and remote monitoring station, as in this case. Likewise, this module allows the sending of data to a web server as used for this project. On the other hand, the module only requires a 5v power supply to work with a low consumption of 1.5mA and the use of a SIM card to allow connection to the cellular network. Its transmission

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frequencies are quad-band 850/900/1800 / 1900MHz, which means that this module has a great versatility to transmit practically regardless of the frequency used in the country cellular network where it is located.

To make the link between the device and the server where the databases are hosted, the transmission is made by using the AT commands, whose function is to open a connection to the cellular network of the SIM card operator, enter the URL scheduled in advance to store the data, and finally close the connection. This process is carried out every time the microcontroller takes the reading data, and immediately orders the module to send them, thus achieving a constant sending of information that communicates the device with the database. To add, the URL sends the data to a web page, which only the module has access to avoid external data manipulation. The web application programming was made using PHP language (Hypertext Preprocessor) and to pass the data to the page the GET method is used, which sends the information through an HTTP (Hypertext Transfer Protocol) request directly in the URL.

A battery bank is used as the power source. Each individual battery has a capacity of 4200mA / h at 3.7v, the batteries have an anti-discharge circuit to prevent the voltage from reaching zero. The batteries were configured in 3 groups of two batteries connected in parallel and in turn these groups were connected in series between them. It was tested with other configurations for the batteries considering the consumption of the equipment, but it was decided on this arrangement since it is causes fewer problems.

Between the batteries and the hardware system, a mini adjustable voltage regulator from 12-24v to 5v was used, since the elements used work at 5V, and it is required to meet the requirement of current consumption especially with the MG-811 sensor.

The system application was created using the view controller model (MVC), which is an architecture pattern that separates the application data, the user interface, and the control logic into three different components (model, view and controller. ) as shown in Figure-2.

**Model:** It is the specific representation of the information with which the system operates. Data logic ensures data integrity and allows new data to be derived; for example, not allowing to buy a negative number of units, or calculating the totals and shopping cart taxes. This means that the data and the business rules associated with the system are operated here, including the parsing and processing of the input data and the output data.

**View:** The model is presented, usually the graphical user interface. It is the application layer that the user sees in a suitable format to interact, in short, the graphical interface.

**Controller:** The Controller is the layer that controls everything that our application can do. It responds to events, usually user actions, and invokes changes to the model and probably the view. It is made up of actions that are represented with functions in a class.

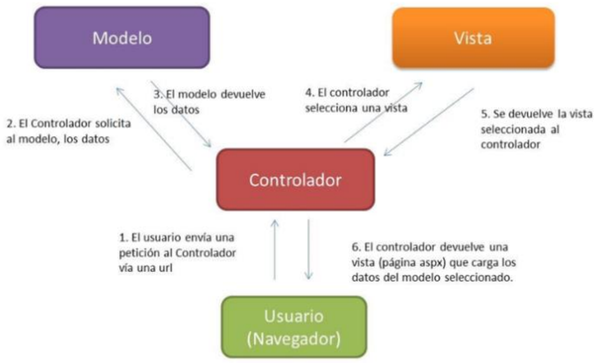


**Figure-2.** Model View Vontroller (MVC) diagram (QualityDev, 2015).

## 3. RESULTS

The equipment which can be seen in figure 3 is the device that the user takes with him wherever he wants to carry out CO2 measurements and can work remotely, this device consists of a SIM 900 module which allows us to send CO2 measurements Through GPRS to a database which is linked to a web page that is for the user to view the measurements obtained, in addition to sending the geographic location of the prototype, this being possible with the GPS module that has the prototype incorporated for to be observed in the web application.

**Figure-3.** Portable CO2 measurement prototype.

The The web interface of our website is an easy-to-use interface showing two boxes, which indicate the levels of CO2 that our prototype produces and the prototype geographical location, in Figures 4, 5, 6 and 7 different views of the interface can be seen.

VOL. 16, NO. 7, APRIL 2021 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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**Figure-4.** Web application Home page for data visualization.

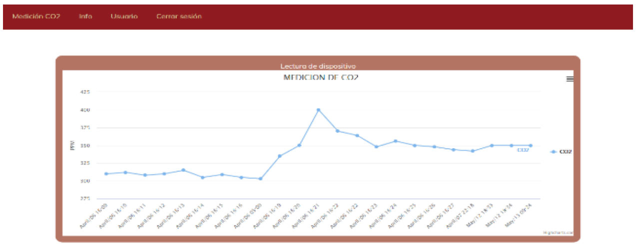



**Figure-5.** View of the web application with the data obtained from the device remotely.

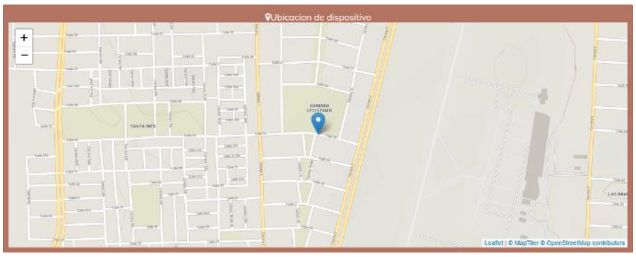
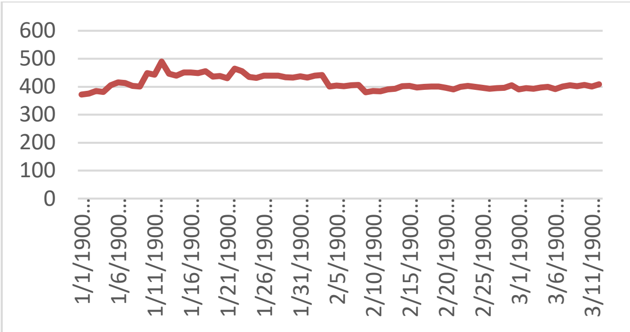


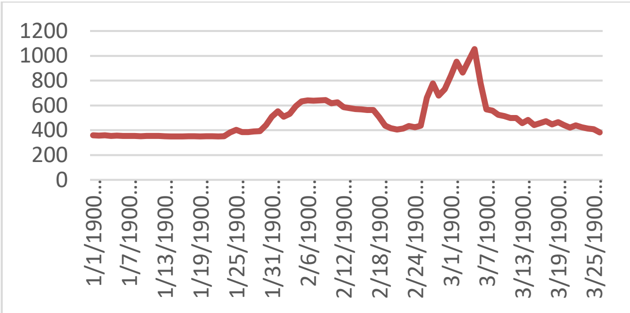
**Figure-6.** Device location in the web application.


**Figure-7.** Percentage of charge of the prototype battery.

The device has been tested in an indoor room as a controlled environment where the air flow is practically zero, showing a reading that remains in a constant range without many variations as shown in Figure-5 (a), It is observed in the Web application that from the beginning of the test the concentration maintains a value around 400 ppm of CO2 where the measurements oscillations are attributed to the little air that manages to circulate and to the CO2 produced by the two people in charge of carrying out the test. The readings obtained in this test are considered within the normal range considering the circumstances given for the test. A test was also carried out exposing the sensor to the exhaust gases of a car in an indirect way and it shows a corresponding behavior, consequently to the increase of the CO2 concentration and returning to a concentration similar to the previous one in approximately 450 ppm after the exposure as shown in graphic 1 and 2 since the place had good ventilation that allowed the rapid dispersion of the gases produced by the combustion engine. The results obtained are described as expected and conclusive based on (Instituto para la salud geoambiental) where it mentions that CO2 concentrations range between 300ppm and 500ppm depending on whether it is in a rural or urban place, demonstrating that the levels are within normal values and that the spikes induced by using the combustion engine behave as expected.




**Graphic-1.** Test performed in controlled environment.




**Graphic-2.** Test performed by exposing the equipment to exhaust gases from a combustion engine.

Although the prototype is only in charge of monitoring CO2, it has been shown that it can be scaled to more equipment's thanks to the web architecture web application and as it is expressed (Ming, *et al.*, 2019) "it is possible to make an extension to the device by implementing additional sensors, either of the same nature, or those used for temperature, humidity and other environmental perspectives. The integration of additional components can further improve the capacity of this system, in order to achieve the development of a more complete and robust system". The battery has an autonomy of 21 hours, which in some cases may not be enough to operate the equipment autonomously depending on the place where it is decided to carry out the operation, an option for the power system improvement, ideally obtaining energy irradiated by the sun, since it is demonstrated as it says (Ngi Ing Hong, *et al.*, 2014) that "the use of a solar energy collector has the promising potential to guarantee a sustainable and perpetual operation of the WSN (Wireless Sensor Network) "as is the case with this application and it would be a very efficient system.

## 4. CONCLUSIONS

A prototype and a web application were designed, which meets the previously defined requirements. That is, to measure the CO2 concentration, where the equipment is located and transmit the data read, record them together with the location, to allow them to be viewed by the user through the web application, as well as the use Alert notifications, via email when the CO2 concentration in the area where the device is located exceeds the concentrations considered safe.

The project was mainly focused on the measurement of CO2 concentration for hydrocarbon collection and treatment stations. However, the device can be used for different types of applications, where CO2 measurement is critical, such as, for example, air quality monitoring in urban areas, closed environments such as laboratories or even in greenhouses.

At the technological level, there were several difficulties, one of them was initial ignorance of the programming languages used for the web application creation, the management of databases and information from them and the integration with hardware technologies such as sensors. , and modules used in the equipment.

Although the 3D printing technique using high-density plastics is proven and growing, this did not turn out to be the best way to build the housing for the equipment thinking about a mass production of this device, the reasons for this, is Due to the printing phase, this is a critical phase where any error can completely damage the printing that is made and consequently, this failure would produce an increase in costs in the final equipment. Because this printing technique is not yet economically viable. The other reason is the time required to print such a model, which, although relatively simple, took 4 days to complete. Ideally, opt for materials such as acrylic that is easier to handle although it is not as resistant as high-density plastic, another alternative that can be considered is the use of aluminum for this part of the equipment.

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