

BUILDING A LOW-COST ELECTRIC DEVICE FOR AMBIENTAL MONITORING

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Abstract. *Considering the poor quality of the air, devices for monitoring the environment have become more and more sought after, they not only offer precise measurements, but also provide added comfort to users. This article presents the components needed to build an electrical device used for ambiental monitoring, a cost analysis, and a study on the acquisition costs of commercial devices that have similar monitoring capabilities.*

Keywords: electrical device, ambient monitoring, low-cost, sensors, air quality.

1. INTRODUCTION

Air pollution causes harmful effects both on the environment and on human health. Mainly, air pollution is determined by industrial activities and intensive road transport, which cause various types of diseases [1]. There are many factors that control air quality and there are many contributing sources such as natural, industrial and anthropogenic. Climatic conditions continue to degrade annually due to the growth of civilization, intense traffic and industrial activities. Even though air is at the top in terms of the importance of resources for life, there is currently a large part of the population that is not well informed about this significant issue and/or is indifferent when it comes to the demands of air pollution [2]. Considering the modern activity conditions of the industrial field of large enterprises and the urbanization of territories, the harmful impact of pollution on the environment is continuously increasing [3]. Road transport is currently one of the most harmful sources of air pollution in urban areas and has a significant effect on human health [4].

It is necessary for the authorities to whom these attributions have been assigned to realize a set of effective traffic management strategies to reduce the large volume of emissions [5].

In order to ensure the awareness and implementation of the basic principles of the effective operation of an environmental pollution monitoring system, it is necessary to constantly involve the existing potential of all professionals in this field, based primarily on competences regarding the technical, legal and not in lastly, the methodological support of monitoring networks [6].

2. THE PRACTICAL REALIZATION OF THE DEVICE

It is about an electrical device built for environmental monitoring, it being made up of the following components:

NANO V3 - It is a small size development board based on the high-performance ATMEGA328P microcontroller. It contains a CH340 USB serial converter, a bootloader and offers the possibility to be programmed through a cable with a mini USB plug [7].

WeMos D1 - It is a development board equipped with a wireless ESP8266 microcontroller with Wi-Fi 802.11, it includes a CH340 USB interface and it can be programmed via a cable with a micro USB plug [8].

DHT22 AM2302 - It is a sensor that has the ability to measure temperature and humidity with DHT22 calibrated digital signal. It uses the exclusive digital signal collection technique and moisture detection technology, ensuring its reliability and stability. Each sensor of this model is temperature compensated and calibrated [9].

GP2Y1010AU0F - A sensor for dust particles that works with the help of an optical detection system. In the composition of this sensor, an infrared emitting diode and a phototransistor are arranged diagonally, this having the ability to detect the light reflected by the dust in the air [10].

BMP280 - It is an atmospheric pressure and temperature module with Bosch BMP280 sensor, either of the two sensors can be disabled independently. The mode works at a logic voltage of 5V and can also be used as an altimeter when using the pressure sensor, which has an approximate accuracy of 1m [11].

MQ-135 - A sensor that has the ability to detect gases such as ammonia, sulphur, benzene, CO₂, other harmful gases and smoke. As with other sensors in the MQ range, it has a digital and analog output pin. When the level of these gases exceeds the threshold limit in the air, the digital pin goes high, this threshold value can be set using the on-board potentiometer [12].

MQ-7 - A carbon monoxide sensor that has the ability to detect CO concentrations in the air and transmit its reading as an analog voltage. The sensor can measure concentrations from 10 to 10,000 ppm. The sensor has both digital and analog outputs, the threshold level for the digital ones can be set using the on-board preset [13].

s-Sense CCS811 - A sensor with I2C interface, for measuring air quality by determining the values of carbon dioxide and volatile organic compounds [14].

HC-SR501 - An infrared sensor based on IR technology, it provides reliability and has the ability to detect

movement in a room, and depending on the position of the jumper, it enters the position of High or Low [15].

DS3231 RTC - It is a precise real-time clock module that has in its composition 32 Kbit EEPROM and a built-in 10-bit temperature sensor with a resolution of 0.25C. This module contains a battery input and has the ability to maintain accurate timing when the power supply is interrupted [16].

DFR0034 - This sensor is used to detect the intensity of ambient sounds, the controller can collect the output signal and act accordingly [17].

LM386 Audio Amplifier - This module can benefit from a sound amplification of up to 200 times. The chip also has a potentiometer to control the volume [18].

CJMCU-219 - A module that has an I2C interface with low-power, bidirectional current and power monitoring integrated circuits. The INA219 with the highest accuracy and smallest size, is used to monitor the voltage drop. The device is available in a SOT23 package [19].

Relay - Built to work with the WeMos mini and mini Pro ESP8266 development boards, this component provides the ability to switch high voltage or high power devices from a single digital pin [20].

SG90 - Servo motor used for power applications [21].

Fan - 12V 25x25x7mm, 2507S, 2 wires, 2 Pin connector for convenient power supply connection.

Fan - 12V 40mm, 2 wires, 2 Pin connector for convenient power supply connection [22].

OLED 0.96" - A display with I2C and IIC communication interface that does not require backlighting, this is given by the pixels. It has a low energy consumption of only 0.08W. Brightness and very high contrast are adjustable. Has a built-in controller and the interface type is IIC [23].

Led matrix module - Has 16 LEDs and uses the integrated MAX7219 and is composed of matrix plus control board, has both Input and Output and can be used alone or cascaded with other modules [24].

Audio speaker - 40mm 3W - 3w, 40ohms, 40mm [25].

Three Key Board - Independent Touch Button Module with LED Power Indicator [26].

Case - Designed and printed using 3D technology [27].

DuPont Jumper wire - Male-Female, 30 pieces with a 20 cm length.

Table 1. Technical specifications of the components

Name	Scope	Supply voltage
NANO V3	Development Board	5V
WeMos D1	Microcontroller	3V~5.5V
DHT22 AM2302	Temperature and humidity sensor	5V
GP2Y1010AU0F	Dust particle sensor	4.5V~5.5V
BMP280	Atmospheric pressure sensor	3V~5V
MQ-135	Air quality sensor	5V
MQ-7	Carbon monoxide sensor	5V
CCS811	TVOC and CO ² sensor	3.3V~5V
HC-SR501	PIR motion sensor	4.5V~20V
RTC DS3231	Real Time Clock	3.3V ~5V

DFR0034	Sound sensor	3.3V~5V
LM386	Audio amplifier	5V~12V
CJMCU-219	Current sensor	3V~5V
Relay	Command	5V
SG90	Servomotor	4.8V
Fan	Cooling	5V
Fan	Ventilation	5V
Display	OLED	3.3V~5V
Matrix	Led	4V~5.5V
Speaker	Audio	5V
Board	Buttons	3V~6V

Table 1 shows the technical specifications of the components that make up the device made for ambient monitoring.

Figure 1 shows the circuit diagram of the electrical device made for ambient monitoring.

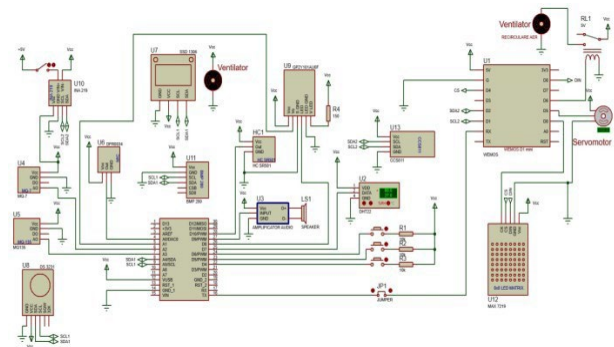


Figure 1. Circuit diagram

3. ANALYSIS OF PURCHASING COSTS OF THE AMBIENTAL MONITORING DEVICES

A. Estimated costs of device manufacturing

Table 2. Estimated costs of device manufacturing

Name	Scope	Price (€)
NANO V3	Development Board	10.2
WeMos D1	Microcontroller	10.1
DHT22 AM2302	Temperature and humidity sensor	3.92
GP2Y1010AU0F	Dust particle sensor	9.15
BMP280	Atmospheric pressure sensor	3.76
MQ-135	Air quality sensor	5.92
MQ-7	Carbon monoxide sensor	5.95
CCS811	TVOC and CO ² sensor	31.2
HC-SR501	PIR motion sensor	1.92
RTC DS3231	Real Time Clock	4.15
DFR0034	Sound sensor	11.6
LM386	Audio amplifier	2.25
CJMCU-219	Current sensor	6.04
Relay	Command	6.69
SG90	Servomotor	3.25
Fan	Cooling	2.42
Fan	Ventilation	2.66

Display	OLED	5.46
Matrix	Led	3.62
Speaker	Audio	1.69
3 Key Board	Buttons	1.71
Case	3D Print	29,5
DuPont	Wire	1,15
Total		164.31

Table 2 shows the purchase costs of the components that make up the device made for ambient monitoring.

B. Estimated purchase costs of similar devices.

To carry out the analysis, we chose to compare several devices that have similar monitoring capabilities.

Table 3. Popular devices used for ambient monitoring

Device	Air quality sensor for PM	Other sensors	Real-time readings	Mobile application	Alternative communications	Price (€)
AirLink	PM 1, PM 2.5, PM 10	No	Yes	Yes	No	201
Prana Air	PM 2.5, PM 10	CO, O3, NO, NO2, UV, temperature, humidity, noise	Yes	Cloud storage	GSM, Wi-Fi	791
Ecomsmart	PM 1, PM 2.5, PM 4, PM 10	TSP, O3, NO, NO2, SO2, H2S, NH3, HCl, Cl2, CH2O, temperature, humidity, atmospheric pressure	Yes	Realtime transfer to a web platform	Wi-Fi, 3G/4G, LORA, Zigbee	4150
Polludrone PRO	PM 1, PM 2.5, PM 10, PM 100	CO, CO2, NO2, O3, H2S, UV, temperature, humidity, light, noise	Yes	Only Cloud data	GSM, Wi-Fi, LORA	5641

Table 3 shows several popular devices for ambient monitoring that are made by well-known companies.

AirLink - An air quality monitor that has the ability to take effective measures to deal with poor air quality, especially for sensitive users. The AirLink professional monitor can be used both indoors and outdoors. Provides real-time air quality index readings and can easily send them to your phone/laptop. The air quality sensor measures particulate matter in the air of several sizes,

PM1, PM2.5 and PM10. The air quality meter supplies information both as data and as color-coded graphs [28]. *Prana Air* - It has the ability to use the continuous ambient air quality management system that helps to assess the degree of pollution and provides prompt data on air quality monitoring and emission control strategies. Meteorological factors significantly influence the air quality, a constant air monitoring can significantly prevent the population from getting sick [29].

Ecomsmart - It is a device capable of measuring a wide range of parameters such as concentrations of air pollutants, PM1, PM2.5, PM4, PM10, TSP, O3, NO, NO2, SO2, H2S, NH3, HCl, Cl2, CH2O, meteorological parameters, air temperature, air pressure and relative humidity. Ecomsmart can collect real-time data and transmit it wirelessly to the advanced Dedicated web platform, can be studied, managed and uploaded to smart platforms and imported into software programs [30].

Polludrone PRO - A device built for monitoring air quality that supplies accurate measurements that can be used for various purposes, such as optimizing the pollution process and detecting false alarms. Polludrone Pro has been built to measure most critical ambient air quality parameters such as PM1, PM2.5, PM10, PM100, carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen dioxide, ozone, hydrogen sulphide, noise, light, UV, temperature and humidity [31].

4. CONCLUSIONS

Considering the low level of air quality, it is important that in every space, whether it is a personal or a professional one, there is a functional device for ambient monitoring. Considering the components of which it is composed, a web application can be created for this system that can be used and accessed easily from anywhere with the help of the Internet, in order to be able to effectively monitor the air quality. Since the devices currently present on the market have excessive costs and not every person can afford to buy them, this work presented a solution to build an ambient monitoring device with a low cost.

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