Low Cost CO Detector Integrated with IoT

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***Abstract*—This article presents a low cost project focused on detecting carbon monoxide in the environment and warning the user, based on the usage of the MQ-7 sensor, a loudspeaker (active buzzer) and the integrated circuit ESP8266. By means of the mobile application Blynk, the prototype will display the carbon monoxide levels in the environment in real time on your mobile device. If the concentration of carbon monoxide exceed 25 particles per million a loudspeaker will ring and send an alert to the mobile device instructing the people to leave the room, because this level of carbon monoxide concentration can be harmful or lethal to human health. The objective is to monitor the areas where it is possible a harmful concentration of carbon monoxide and ensure that people can leave in time before their health is in danger.**

Keywords—Air quality, Carbon monoxide, ESP8266, Gas sensor, IoT, Security, Smart Home

I. Introduction

The smart home is part of the concept that is related to the networking of home automation systems, home appliances and communications and entertainment electronics [1]. Fortunately, it has become a source of solutions for the needs of the user. During the last years, a range of sensor technologies became available in the market, enabling a revolutionary shift in air pollution monitoring and assessment [2]. The application of sensors in homes shows us the limits and the possibilities to control the particles and gaseous pollutants in interiors [2]. CO is highly toxic, even in small concentrations. It acts on several levels, all leading to diminished oxygen metabolism and subsequent general ischemia [3]. Experiments with rats have been carried out and it was concluded that the necrosis and apoptosis (PCD) contribute to carbon monoxide poisoning-induced brain cell death [4]. Because of this, we must be aware of the damage that the CO (carbon monoxide) can cause in humans.

CO is a gas, which by nature is colorless, odorless and tasteless, making it an invisible threat. It arises from the incomplete burning of hydrocarbons [5]. CO intoxication severely interferes with the oxygen-transporting function of hemoglobin [6]. Once inhaled, CO leads to tissue hypoxia primarily affecting areas of high blood flow and oxygen demand [5], for example, the brain and heart. Only in the United States, CO poisoning results in approximately 40,000 visits in the Emergency Department annually [7]. It is a common cause of morbidity and mortality. Clinically, there is a rapid course that can progress from nausea and vomiting to loss of consciousness and sudden death. Nonspecific symptoms such as headache, dizziness, weakness, confusion, shortness of breath, chest pain, and visual disturbances are common in patients [8]. As a secondary consequence of the CO poisoning, the thrombotic tendency increases and the risk of deep poisonous thrombosis [9].

Present day health care applications of wireless sensor networks (WSN) aim to monitor heart troubles, breathing issues, panic response, and stress levels [10]. This IoT (Internet of Things) technology can be used to monitor the ambient in a house or an office to prevent CO poisoning. Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), and Iran Health Ministry have recommended time weighted permissible exposure limit (PEL-TWA) of 50 ppm, recommended exposure limit (REL-TWA) of 35 ppm, and occupational exposure limit (OEL–TWA) of 25 ppm for occupationally exposed workers, respectively [11].

To accomplish these standards, the implementation of a CO detector offers a feasible solution for the reduction or null termination of deaths caused by CO poisoning. Our proposal is the creation of a low cost CO detector that will prevent deadly consequences and generate safety and quality of life method, by alerting the user in case of a high concentration of CO in the air through a sound and light alarm in a mobile application.

This paper is organized as follows: Section 2 describes the project development of the CO detector and describes the software and hardware implementation of the proposed system. Section 3 summarizes the results and compares the prototype to commercial systems and Section 4 gives the conclusions of the study.

II. Project development

The hardware includes a MCU ESP2866, a MQ-7 sensor, a led, and an active buzzer. The diagram (Figure 1) shows that the pin A0 of the MCU ESP2866 is connected to the analog output of the MQ-7 and in the pin D3 are connected the active buzzer and a led.

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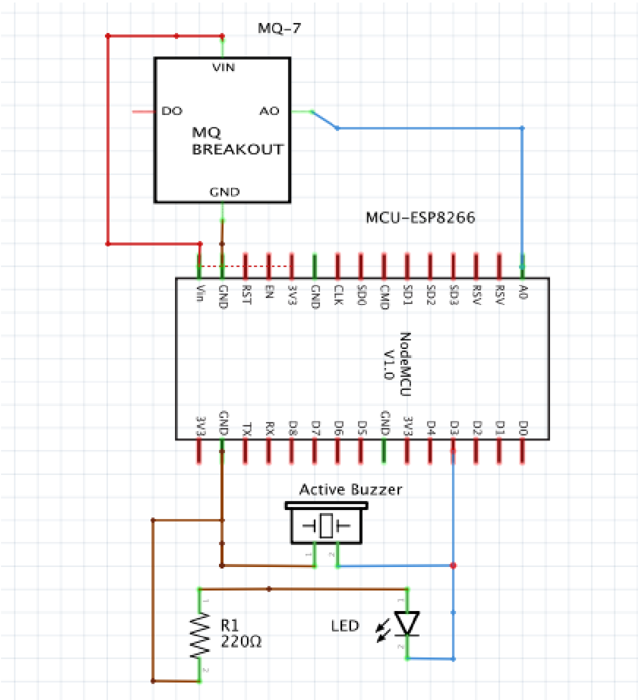

Fig. 1. Electrical connection diagram.

For the calibration of the device, we use a graph (Figure 2) that shows the exponential adjust of the sensor to read a specific concentration of CO. In this case, we used the occupational exposure limit (OEL–TWA) of 25 ppm. The graph shows that the sensor unit for this limit is approximately 110. Between the level of 0 to 25 ppm the behavior of de graph is almost a straight line, so we decide to use a simple equation:

$$y = m \cdot x + b \rightarrow y = \frac{y_1 \ \ -y_1}{x_2 \ \ -x_1} \cdot x + b \ \rightarrow \ y = \frac{110}{25} \cdot x$$

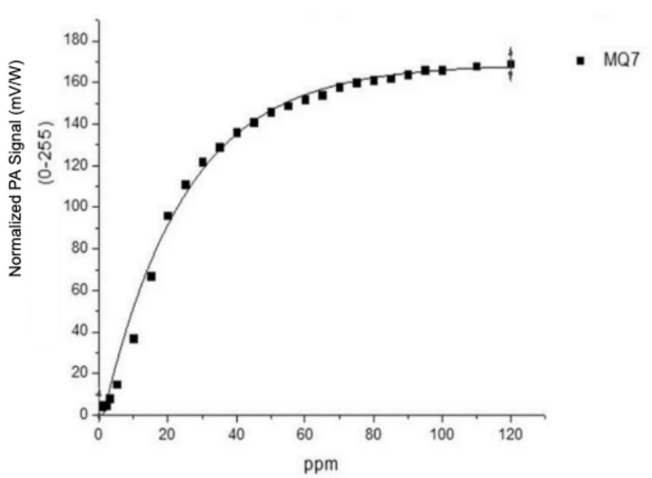

Fig. 2. Graph ppm of CO versus Output unit of the sensor [12].

For the configuration of the MCU ESP2866 we used the software IDE of Arduino. These are the most important parts of the code uploaded to the chip:

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
float sensa = A0;
float a;// Analog sensor variable
int sensd= 2;
int zu=3;
```

In this part of the code, the sensor reading starts and we change the range of the information to 255 bits max because the ESP8266 cannot read 1023 bits.

```
a=analogRead(sensa);
delay(200);
a=map(a , 0, 1023, 0, 255);
```

The V5 is a virtual pin where we send the information of the analog sensor to display it with a gauge in Blynk's application.

```
Blynk.virtualWrite(V5, a);
```

The value of 110 is equal to 25 ppm of CO in the air, this is the limit were the alarm starts to sound.

```
if (a >= 110) {
digitalWrite(zu, HIGH);
delay(200);
digitalWrite(zu, LOW);
delay(200); }
```

We measured the components and designed a case for the system (Figure 3). It's composed by 2 pieces (Figure 4).

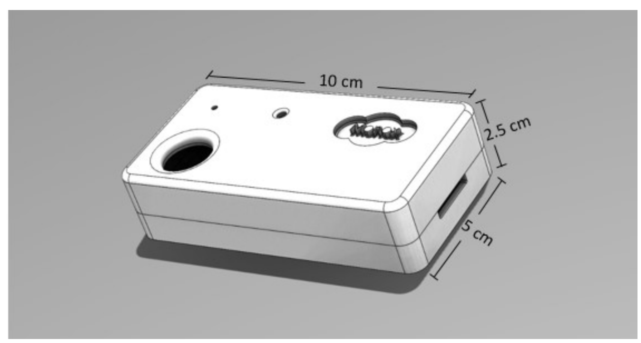

Fig. 3. Case prototype assembly.

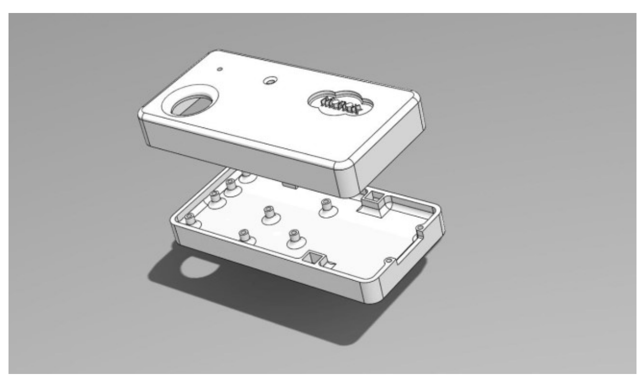

Fig. 4. Explosion view of the case prototype assembly.

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III. Results

The Blink application displays the amount of ppm of CO detected in the ambient of room (Figure 5). Two icons are also displayed. With these, you can configure the app to send a notification on the mobile phone at a determined level of ppm, it is set to 25 ppm of CO.

For the testing of the device we ran it for 22 hours and measured the level of CO in the selected room (Figure 6). We had some internet disconnections but the device found and reconnected very fast to the WiFi network. We consider that this is not a problem because the time of-line was less than 30 seconds. Figure 7 show the physical low cost CO detector prototype.

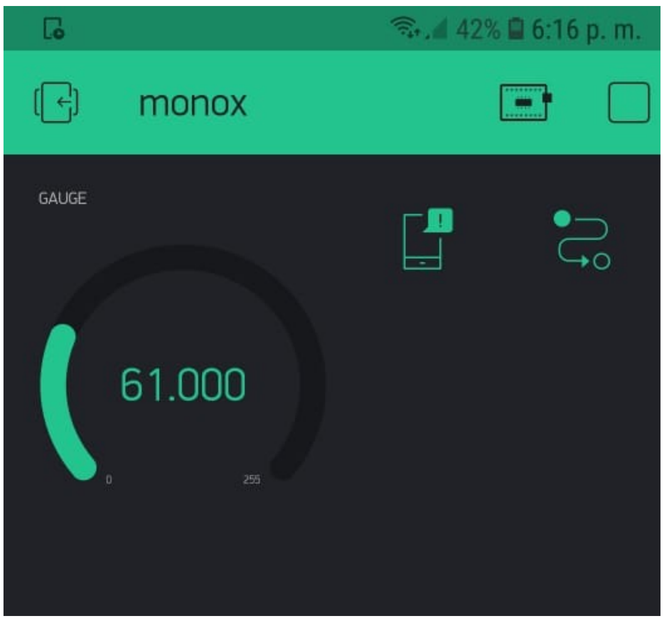

Fig. 5. Blink app.

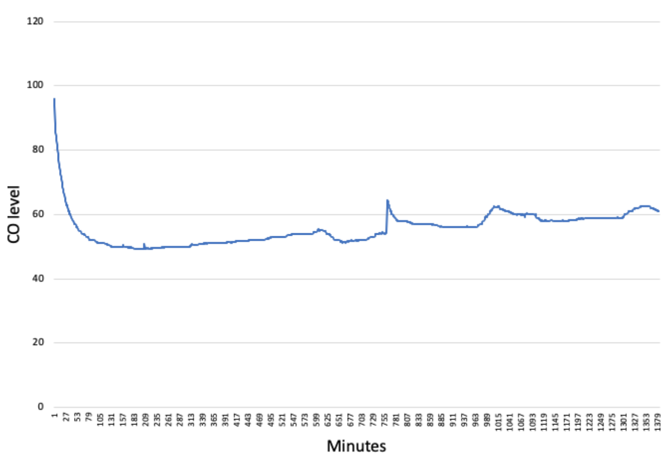

Fig. 6. Graph of 22 hours of data recording of CO with our device

Table I presents comparison of prices of different devices in the market against our device.

TABLE I. Price comparison of different devices

Device	***Cost (USD)***	***IoT***
MSA Monoxide Detector	$536.07	No
First Alert SCO2HMX	$40.75	No
Samsung SmartThings ADT Home Safety Expansion Pack	$199.99	Yes, requires a Hub
Nest Protect 2G	$105.00	Yes, no requires a Hub
Our device	**$20.00**	Yes, no requires a Hub

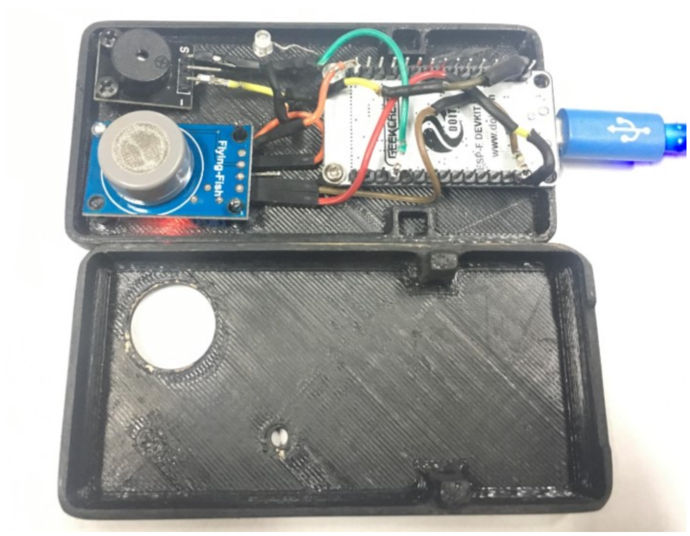

Fig. 7. Low cost CO detector prototype.

IV. Conclusions

The surging of low-cost electronics is creating a tendency right now. People everywhere are taking courses and starting to pay attention to instructables and more DIY-Tutorials. Health-focused low-cost projects are important because we learn not to depend on big corporations to take care of our health, but instead we can take creative decisions and spread knowledge to prevent risks all around the world.

It is known that the issue that is being presented, CO poisoning, can be lethal, but it can be avoided easily and in an economical way. It is true that it is not a revolutionary invention, but still, the price is accessible and devices like this can help people and motivate others to develop new technologies.

As we can see, most of the top sellers of Monox alternatives are from the USA and their prices are really high in comparison to the prototype. We strongly support the idea that the revolutionary aspect of the project is the low cost of production. As a prototype the results were satisfactory, the tests allow us to prove the correct functioning of the device and the alert system in the mobile application.

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The objective, to create a low cost CO detector that will prevent deadly consequences by alerting the user in case of a high concentration of CO in the air through a sound and light alarm and a mobile application, was accomplished.

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