Innovative: International Multi-disciplinary Journal of Applied Technology
(ISSN 2995-486X) VOLUME 02 ISSUE 03, 2024

Automatic oxygen controller for Covid-19 patient

Miqdam Muhanad Ahmed
Department of Medical Instruments Engineering Techniques, Bilad Alrafidain University College
Ali Shaaban Hasson
Department of Medical Instruments Engineering Techniques, Bilad Alrafidain University College

Abstract:

In early December 2019, a disease known as Corona spread in Wuhan, China. On January 30, the World Health Organization officially declared that the virus outbreak constitutes a public health emergency of international concern, and confirmed the transformation of the outbreak into a pandemic on March 11. More than 668 million cases of Covid-19 were reported. 19 in more than 188 countries and regions as of January 22, 2023, Common symptoms of the disease include fever, cough, fatigue, shortness of breath, and loss of sense of smell and taste. The list of complications may include both pneumonia and acute respiratory distress syndrome. Corona greatly affected the respiratory system, especially in the elderly, Where the urgent need for medical oxygen appeared due to the lack of Spo2 in the patient's blood.
This device helps workers in the health sector in general and patients in particular, they can buy the device for a cheap amount, the work of the device depends on the oximeter piece attached to the patient's finger, and when the level of SpO2 in the blood drops below 95%, the piece sends signals to the motor attached to the cylinder, and then it rotates to open the oxygen cylinder When the patient is stable, it sends opposite signals and closes the cylinder. However, the device is designed based om the Internet of Things system, where I connected all the pieces with the blynk program.

Keywords: oxygen controller, covid-19, world health organization

Introduction

Internet of Things (IoT) technology has brought a revolution in several ways to a common person's life by making everything smart and intelligent. During the Covid-19 crisis, health workers around the world needed to monitor patients' health and needed to provide sufficient oxygen, when necessary, as Covid-19 was responsible for many respiratory cases Health workers were at high risk of being contaminated while treating Covid-19 patients. The study of this paper is to propose an IoT-based automatic oxygen flow control in response to the Covid-19 crisis. The proposed approach helped to real-time monitoring of SpO2, heartbeat, oxygen quantity of oxygen cylinder, and control of the flow of oxygen based on SpO2 value. A health worker can monitor a patient's health-related parameters and control the flow of oxygen without any physical contact with it. Also, provides an alarm to the health worker when SpO2 is below the threshold and re-measuring oxygen quantity of oxygen cylinder with the help of our developed android app. Implementation of IoT-based low-cost pulse oximeter and IoT-based pressure gauge helps to monitor and control different health parameters. The IoT-based system may potentially be valuable during the Covid-19 pandemic for accurate oxygen flow distribution and for saving people's lives .

This device works with a system called the iot system, where all the components of the device are connected to each other via the Internet as in the Fig 1.

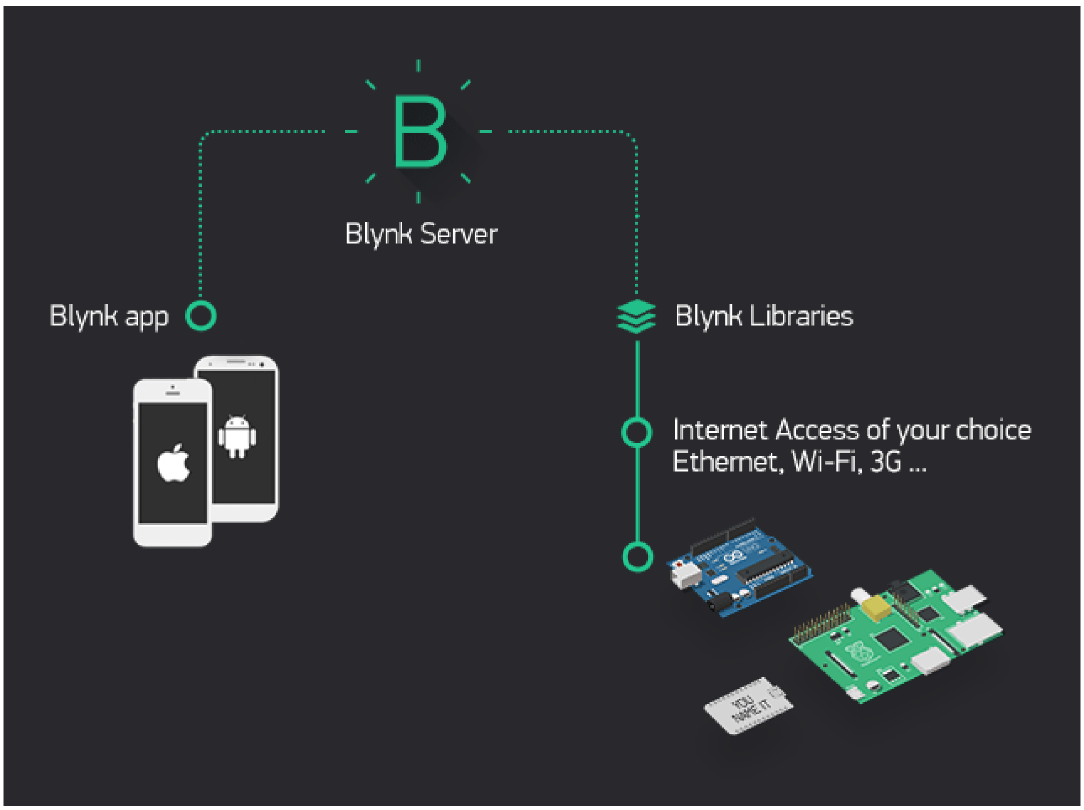

Fig.1 Iot system

The oximeter is connected to the patient's finger and sends a signal to the NodeMCU (ESP8266). These signals contain the following readings (SpO2, number of heartbeats, temperature), then they are translated and sent in two directions, the first to the phone to display the readings on the phone screen, and the second to the Arduino nano .

When the signal reaches the Arduino Nano, it moves the motor through the driver
If its spo2 reading is 95% and above, the stepper motor will not move, but if the reading is less, the stepper motor will move and open the oxygen As the fig 2

Fig.2 Oximeter

Fig. 3 Stepper motor

This device was designed for two reasons :

The first is to reduce the burden on the health staff and the patient's facilities, as the process of opening and closing the cylinder can be controlled automatically or manually by stepper motor as in the fig 3. The price of this device is very cheap and any patient can buy it.

The second goal is to reduce the waste of oxygen that occurs because of forgetting an open oxygen cylinder...

Many countries suffered from a severe lack of oxygen, including Iraq, where the hospitals were full of Covid 19 patients, and there was a great shortage of medical oxygen.

The lack of oxygen is due to the lack of laboratories and the sudden increase in demand for oxygen, with the presence of wasting oxygen.

2.3 Covid 19 with Oxgyen

Reports all over the world show the severity of the situation: There is a shortage of homeopathic medicine, a bio-material vital to supplying COVID-19, in India. Although it is vital to provide effective treatment for COVID-19 patients who are hospitalized or at home, access to oxygen, which is relatively easy in Europe and North America, is limited in these countries due to cost, limited infrastructure and logistical hurdles, as explained by the International Procurement Facility. Medicines (United), an international organization. According to the World Health Organization, one in five patients with COVID-19 requires oxygen.

Fig.4 patients of covid 19

The World Health Organization has estimated that more than half a million people need 1.2 million vials of oxygen per day in these countries. United stimates it will need about $1.6 billion to buy bottles for the poorest countries this year during what it describes as a "global emergency requiring a global response." According to the organization, the main challenges are present in 20 countries, including Malawi, Nigeria and Afghanistan . The aim of the study is to help poor countries that do not have abundant medical oxygen to reduce the waste of oxygen, as many countries, such as Kenya and India, suffered from severe oxygen deficiency, especially during the Corona period. Reducing the burden on health sector employees and reducing the pathogen's contact with the disease, thus reducing the process of spreading the virus. Monitoring (temperature, spo2, and heartbeat) of the patient remotely, by phone or computer, and immediate intervention if necessary.

2. Methods and Materials

In this chapter, we will address what are the parts used in the manufacture of this device, what materials were placed in the device, and how the device was connected and collected in details with the conclusion with mentioning the programming code to clarify how the Arduino and how was programmed so that this chapter is complete from all its merits.

Research methods and material

In this section, we will discuss what materials we used to build the device and how to connected them as displayed in fig. 5.

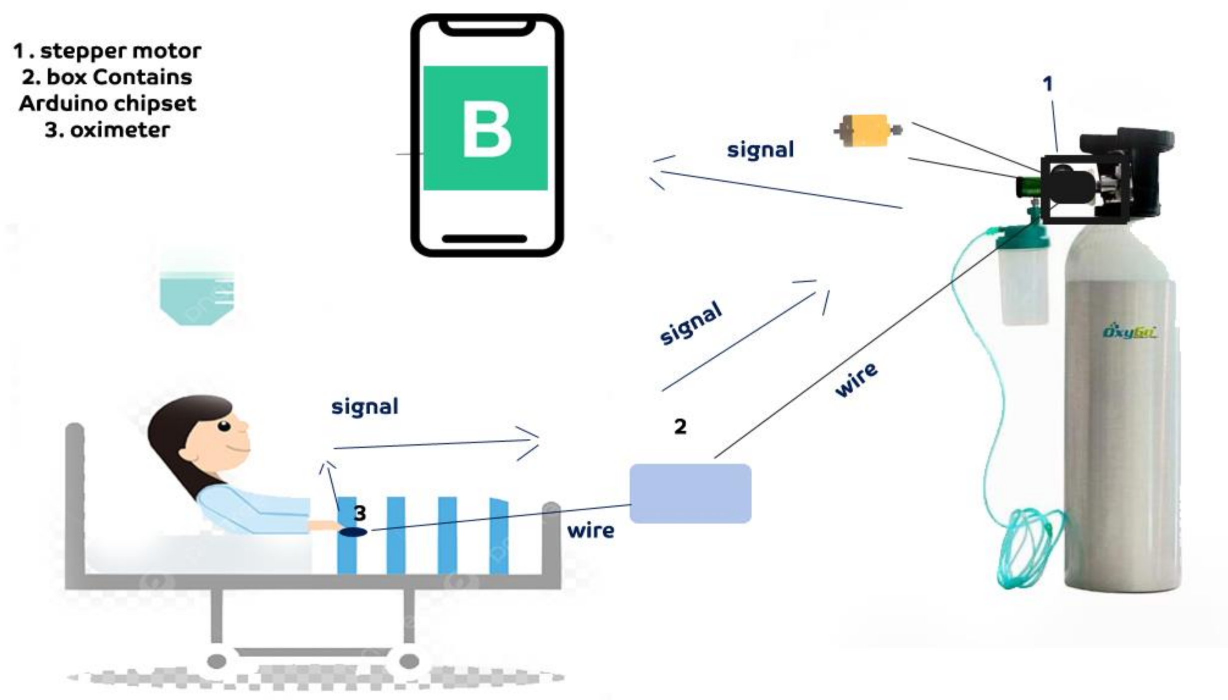

Fig. 5 Research methods and material

However, the design of the devise is consists of two main part ; Hardware and software:

The Hardware parts: contain (Stepper motor, Arduino Nano, driver a4988, nod mcu wife, Relay, oximeter).

The software parts: contain code written in a programming language called (c Arduino) and linked to the internet of things (iot system).

It is also controlled manually via the blynk program installed in the phone.

The device is connected to an electricity source, the mechanism of this device depends on the (oximeter) where it is attached to the patient's finger and reads the three vital indicators (Respiratory rate, Heart Rate or Pulse, Body temperature) [5].

And it sends all the details to the phone via Wi-Fi. Furthermore, there are two mechanisms for the operation of this device:

The first is automatic: when the respiratory rate drops below 95%, the device sends an electrical signal to open the oxygen cylinder and send oxygen to the patient in different degrees, according to the rate of decline of the respiratory rate in the patient's body.

The second method is manually : Where the health staff remotely controls the amount of oxygen emitted to the patient through the blynk program installed on the phone.

Device Components

stepper motor:

It is an electric motor used in small machines that need precision in controlling their motors, such as printers, laser cutters, etc. One of the most important features of this type of engine is that the number and speed of its cycles and the stopping angle can be controlled accurately. It needs approximately 0.5 amps to operate, this motor is also used in robotic applications, since it can be controlled to stop at a specific angle as in the fig6

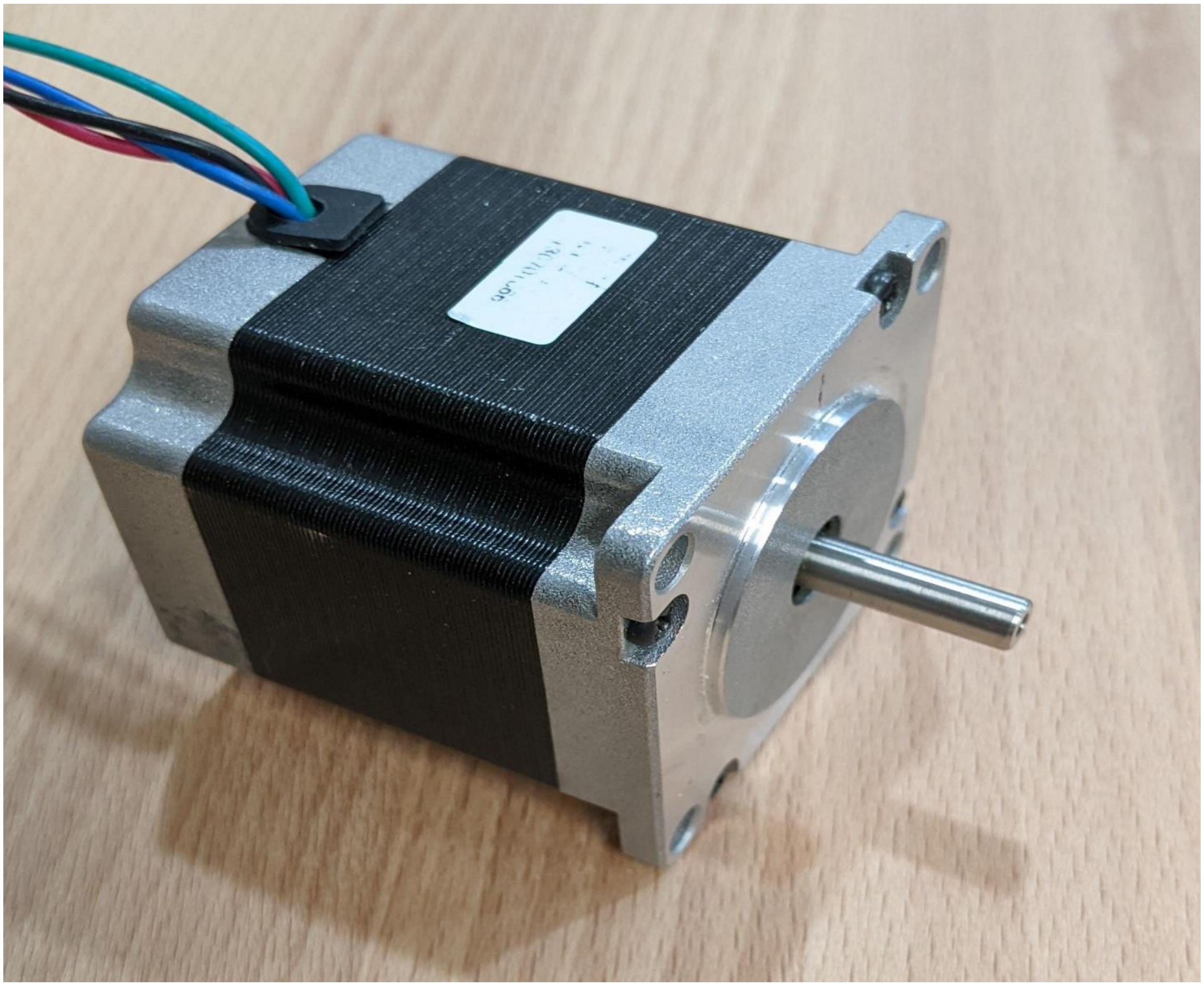
Fig. 6 Stepper motor

Box contains Arduino chips :

This box contains all the Arduino chips that I needed to make this device ,connected to each other as shown in the picture Fig.7. The box is connected to an external wire that connected with the motor, used for send and receive signal when closing and open. In the following, we will discuss in detail the contents of the box:

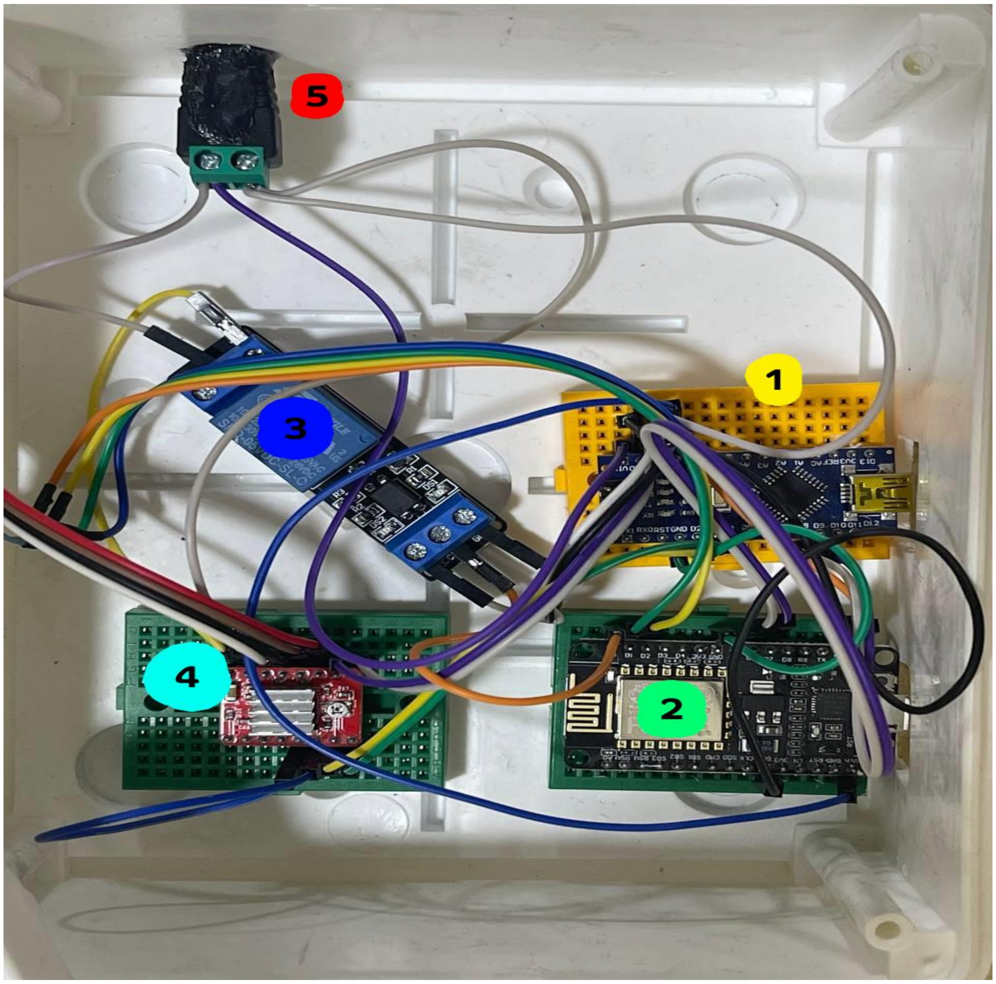

Fig.7 Box contains Arduino chips

Arduino Nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor [1]. The Arduino Nano is equipped with 30 male I/O headers, in a DIP-30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-B mini-USB cable or from a 9 V battery. The function of the Arduino Nano in the circuit is to receive the signal and data from the ESP8266 and send it to the stepper motor driver. The shape of the Arduino Nano is as shown in the picture Fig 8.

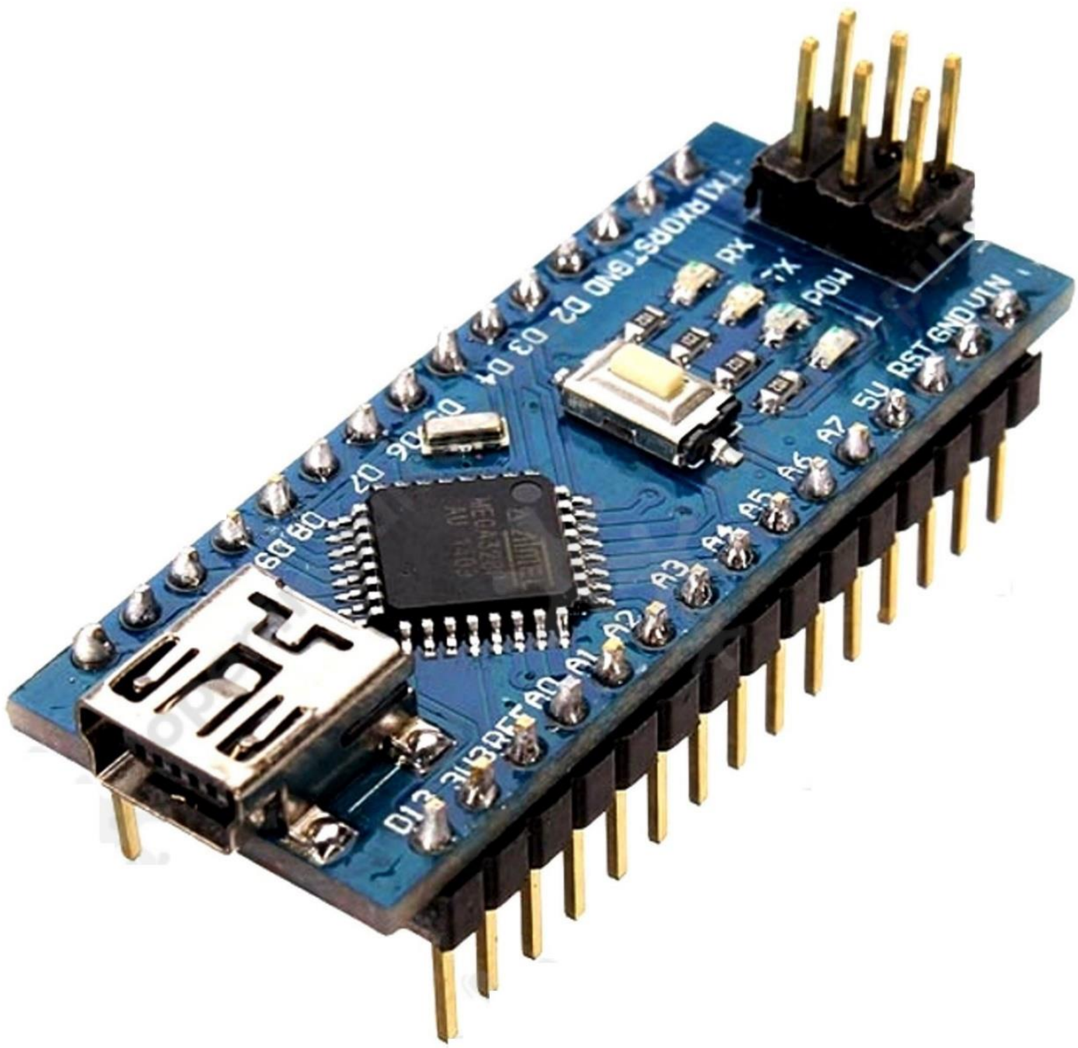

Fig. 8 Arduino nano [4]

NodeMCU (ESP8266)

The ESP8266 board is a low-cost microcontroller that fully supports TCP/IP protocols with microcontroller characteristics at the same time, produced by Espressif Systems in Shanghai, China. This microcontroller gained great attention in Western countries with the ESP-01 version, which was manufactured by a third party company, Ai-Thinker, as that version allowed the microcontroller to connect to a WiFi network and establish a TCP/IP connection using simpler (Hayes-style) commands. However, when the initial versions were sent to the market, there was no documentation in English about the orders it accepts, however, due to its low price and few external plug-ins associated with it, However the advantages are summarized as the following:

3.2.2.3 Relay

It is an electric switch that opens and closes a circuit called the power circuit under he control of another circuit called the control circuit, so it performs the function of electrical isolation or what is known as galvanic isolation between the two circuits as the fig 10.

Fig.10 Relay

Driver a4988

The A4988 driver Stepper Motor Driver is a complete micro-stepping motor driver with built-in converter, easy to operate. It operates from 8 V to 35 V and can deliver up to approximately 1 A per phase without a heat sink or forced air flow (it is rated for 2 A per coil with sufficient additional cooling). The function of the driver in the circuit is to take the voltage from the voltage input and take the signals from the Arduino Nano (each stebr motor contains a driver) as the fig 11

Fig. 11 Driver a4988

3.2.2.5 Plug-in charger 12 volt

A 12-volt outlet is any electrical outlet that outputs 12 volts and may refer to: Cigar lighter receptacle, the most famous example. Molex connector, used for connecting hard drives and optical drives, and sometimes for powering flash memory surrogate hard drive modules. A plug-in charger 12 volt is used to deliver electrical power to the device .

4.Result and discussion

In the fourth chapter, we will discuss the device in terms of discussing the results and statistics to show the efficiency of Automatic oxygen controller and we will perform calculations on a different range, in order to know the accuracy of this device and its impact on the patient

4Experimental Results

We tested the operation of this device practically and connected it with the phone via Wi-Fi, and we saw the three vital indicators on the phone screen through the application (blynk), the spo2 reading was high (99%), and in this case the device did not do anything,

We started by raising the finger from the oximeter slightly and gradually (in order for the spo2 reading to decrease), the readings began to decrease gradually until the spo2 percentage reached 90%
And the motor installed on the Oxygen Regulator began to move to open the regulator so that the oxygen could flow, but not quickly.
When the oxygen level reached 80%, the developer moved quickly and opened the oxygen regulator At full speed

The price of this device is very cheap compared to the benefits it provides, it cost us almost $100 It will be much cheaper in bulk

An experience

This device is very useful for premature babies, as there was a study at Leiden University in which infants less than 30 weeks of gestation were compared in the medical center before and after the implementation of automatic oxygen control. The percentage of time spent with SpO2 within and outside the target range (90-95%) was calculated. SpO2 values were collected every minute and included for analysis when infants received supplemental oxygen.

Fig16 Baby with oxygen

In a period of 9 months, 42 preterm infants (21 manual, 21 automated) were studied. In the automated period, the median (IQR) time spent with SpO_2 within target range increased (manual vs automated

During oxygen therapy, preterm infants spent more time within the SpO_2 target range after implementation of automated oxygen control, with a significant reduction in hyperoxaemia, but not hypoxaemia.

5. Conclusion

A pilot clinical study was conducted that compared the peripheral oxygen saturation (SpO_2) targeting performance of an automatic oxygen control system with manual oxygen control, which is the standard of care for preterm and low birth weight infants on high-flow nasal cannula (HFNC). The new oxygen control device studied was used to automatically adjust the fraction of inspired oxygen (FiO_2) according to a desired SpO_2 target setpoint and measured feedback signals including the SpO_2 and other signals.

A crossover study was designed with several endpoints including the comparison of the percentage of time that the SpO_2 was within the target range with the automatic oxygen control device versus manual oxygen control. Other metrics were also compared to assess the performance of the system including the number of bradycardia events. The pilot study included six patients that fit the inclusion criteria. The results showed that there were improvements in all of the measured outcomes considered including statistically significant improvements in the number of bradycardia events during the period when the automatic oxygen control device was used.

The idea of this device came to me because of my work in the oxygen sector, and I see daily what happens in hospitals, especially during the Corona period when the health staff was very tired, The government was trying hard to provide oxygen to the patients

References

1. Hallenberger, Antonietta, et al. "Closed-loop automatic oxygen control (CLAC) in preterm infants: a randomized controlled trial." Pediatrics 133.2 (2014): e379-e385.
2. Nair, Vrinda, et al. "Automatic oxygen control for reducing extremes of oxygen saturation: a randomised controlled trial." Archives of Disease in Childhood-Fetal and Neonatal Edition 108.2 (2023): 136-141.
3. NAIR, Vrinda, et al. Automatic oxygen control for reducing extremes of oxygen saturation: a randomised controlled trial. Archives of Disease in Childhood-Fetal and Neonatal Edition, 2023, 108.2: 136-141.
4. Yilmaz, Murat, and Philip T. Krein. "Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles." IEEE transactions on Power Electronics 28.5 (2012): 2151-2169.
5. O'Donnell, Jane, et al. "Role of L-carnitine in apnea of prematurity: a randomized, controlled trial." Pediatrics 109.4 (2002): 622-626.
6. Wang, Bin, et al. "Risk factors associated with deep vein thrombosis in COVID-19 patients." MedComm 2.2 (2021): 288.
7. McCarthy, Mary C., et al. "Neurologic outcomes with cerebral oxygen monitoring in traumatic brain injury." Surgery 146.4 (2009): 585-591..