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# An intelligent Health Monitoring System for Patients with Chronic Obstructive Pulmonary Disease based on Internet of Things

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***Abstract: Chronic obstructive pulmonary disease is an important cause of global mortality. These patients are in dire need of treatments to maintain lung function and reduce consecutive visits and hospital stays. IoT acts as a specialized assistant in healthcare, providing a wide range of potential applications such as remote monitoring. Therefore, this study has been compiled with the aim of designing a care system based on the Internet of Things for patients with chronic obstructive pulmonary disease. In this project, we designed a system for monitoring chronic obstructive pulmonary disease patients using an Arduino board and embedding three air quality sensors, heart rate and pulse oximetry, temperature sensor and Bluetooth module, and then implemented it on a patient with obstructive pulmonary disease. . The information obtained from the sensors is sent via Bluetooth to the mobile application that has the ability to share and store information and informs the doctor and the person about the changes. By using the pulse oximetry sensor, the patient increases the monitoring and part of his pulmonary rehabilitation, and by using the temperature and air quality sensor, he identifies the undesirable and harmful air and by informing the doctor and the person, he prevents the exacerbation of the symptoms of chronic obstructive pulmonary disease. This system increases the rehabilitation and self-care of patients, and by providing suitable environmental conditions, prevents unnecessary medical interventions and consecutive visits, and increases the quality of life of patients and reduces costs.***
***Keywords: Internet of Things, Chronic Obstructive Pulmonary Disease, wearable technology, Arduino board, health care, sensor***

## I. INTRODUCTION

Multiple sclerosis is a chronic, progressive and common demyelination disease of the central nervous system in young adults. According to the available evidence, currently more than 2.3 million people worldwide are suffering from this disease (1, 2). In the United States, approximately 500,000 people are suffering from multiple sclerosis, and every year about 8,000 new cases are diagnosed. This disease mostly affects people aged 20-40 and is the third leading cause of disability in the United States (3, 4).

In Iran, according to the information of the Multiple Sclerosis Association, there are nearly 50,000 patients with multiple sclerosis and the number is increasing (5). The increasing trend of MS patients increases the need to pay attention to patients' treatment issues and problems (1). The Internet of Things (IoT) is one of the latest applications of information technology in healthcare. The Internet of Things can be defined as a network of smart measuring devices and physical objects that are digitally connected to collect, monitor and control healthcare data (6, 7). The Internet of Things in the health care sector can reduce the unnecessary hospitalization of patients in the hospital while reducing treatment costs and increase the well-being of patients (8, 9). In this project, a portable system was designed with the help of IOT tools, which can continuously measure movement, heart rate, pulse oximetry and body temperature by connecting to the patient's body. This tool displays information on an LCD board without any interruption of time by connecting to the patient's body, and if the information is transferred to a mobile phone, this information can be used in various ways. In this connection, authorized people can connect to the board with a personalized password, which prevents data security from being compromised.

## II. LITERATURE REVIEW

Chronic Obstructive Pulmonary Disease (COPD) is a serious disease that leads to progressive airflow obstruction followed by airway damage [1].

According to the World Health Organization, chronic obstructive pulmonary disease is an important cause of global mortality, and Venice is considered the fifth and third cause of death in 2002 and 2020, respectively [2]. According to the report of the World Health Organization, about 450 million people on the planet suffer from chronic obstructive pulmonary disease, and this disease was the fifth debilitating disease in 2020 [3].

Since COPD is a progressive chronic disease and there is no definitive treatment for it, this condition worsens over time. However, hospitalizations are increasing, resulting in increased direct and indirect costs to health care systems worldwide. According to several reports, in the United States, direct costs increased from $18 billion in 2002 to $29.5 billion in 2010 [4]. A study conducted in the United States found that rural residents were less likely to receive and complete pulmonary rehabilitation. Only about 30% of rural residents have access to lung services within a radius of 16 kilometers [5].

Lack of time or economic problems prevent patients from communicating regularly with their doctors, and as a result, aggravate chronic conditions and hospitalization; therefore, preventing exacerbation of chronic obstructive pulmonary disease patients in order to improve the quality of life of chronic patients and reduce costs is the main concern of the medical community [6].

Tools to prevent or shorten hospital admissions are necessary to slow COPD progression and limit health care costs [7]. The Internet of Things (IoT) is one of the latest applications of information technology in healthcare. The Internet of Things can be defined as a network of intelligent measuring devices and physical objects that are digitally connected to collect, monitor and control healthcare data [8]. It can improve patient well-being and reduce service costs, for example by avoiding unnecessary hospital admissions and ensuring better care for people in critical conditions.[9]

In this project, we designed a portable system with the help of IOT tools that can continuously measure temperature, heart rate and pulse oximetry, air pollution by connecting to the patient's body. This tool displays information on the LCD board without any interruption of time when connected to the body, and if cheap and available Bluetooth is connected to the mobile phone, the information can be displayed and saved, shared and transferred if needed. In this connection, authorized people can connect to the board with a personalized password. This prevents data security from being compromised.

## III. COMPONENTS SPECIFICATIONS

### A. *MQ 135 air pollution detection sensor*

Air pollution detection sensor. MQ series gas sensors use a small internal heater along with an electrochemical sensor. These sensors are sensitive to a wide range of gases and are used at home and at room temperature. MQ sensors have internal heater and electrochemical sensor. MQ135 module has analog and digital output. MQ-135 sensor is a sensor for detecting air quality. This sensor has the ability to detect smoke, alcohol and Petrol in the air and also detects all gases that affect the quality of human breathing. The heater of this sensor uses 5V voltage.


Fig1. MQ 135 air pollution detection sensor

### B. *LM35 temperature sensor*

LM35 is a temperature measuring device and has an analog output voltage proportional to temperature. This sensor provides the output voltage in Celsius (Celsius). It does not require any external calibration circuit. Its sensitivity is LM35 10mV/°C. As the temperature increases, its output voltage increases. It is a 3-terminal sensor used to measure temperatures from -55°C to 150°C.

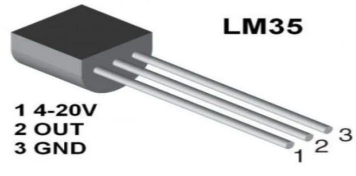


Fig2 LM35 temperature sensor

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### *C. MAX30100 oximeter*

The MAX30100 is an integrated pulse oximetry instrument and heart rate monitor sensor. This instrument contains two LEDs, an optical detector, optimized optics and signal processing. It is a heart rate monitoring sensor along with a pulse oximeter. This sensor includes two light-emitting diodes, an optical detector and a series of low-noise signal processing devices for heart rate detection and pulse oximetry. Low noise log combines pulse oximetry and heart rate signals for diagnosis. This sensor device is placed on a thin part of the patient's body, usually the fingertips and the earlobe, which have a higher blood flow rate than other tissues and facilitate heat transfer.

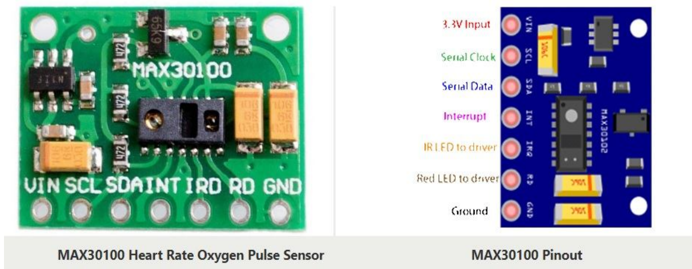


Fig3. MAX30100 Oximeter

### *D. Bluetooth module HC-05*

The HC-06 Bluetooth module is an easy and inexpensive tool designed for wireless serial communication. It is a slave module, which means that it can receive serial data when serial data is sent from a master Bluetooth device (such as a smartphone or PC). When the module receives wireless data, information is sent. No special source code for Bluetooth module is needed in Arduino chip. An app on the phone is used to send input to the module, which receives and then transmits it to the Arduino. The Arduino and the actuators in turn respond according to the specified source code. When the module is not in pairing mode, the LED on the module will flash quickly, and when it is paired with the mobile app, the LED on the module will remain steady red.

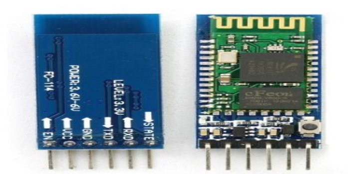

Fig4. Bluetooth module HC-05

### *E. Arduino UNO*

Arduino Uno is a microcontroller board based on ATmega328 (datasheet). It has 14 digital I/O pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connector, a power jack, an ICSP header, and a reset button. . It can be powered by a USB cable connected to a computer or by an AC-to-DC adapter or battery. The Uno differs from all previous boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it has an Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.


Fig5. Arduino UNO

### *F. Description of Serial Bluetooth*

Terminal application 'Serial Bluetooth Terminal' is a line-oriented terminal / console application for microcontrollers, Arduinos and other devices with a serial / UART interface that connects to your Android device via Bluetooth to serial conversion. This application supports different versions and different Bluetooth devices, this application also has the ability to share, transfer and store data. Also, the ability to display the date and time next to each data provides the ability to have a detailed medical history.

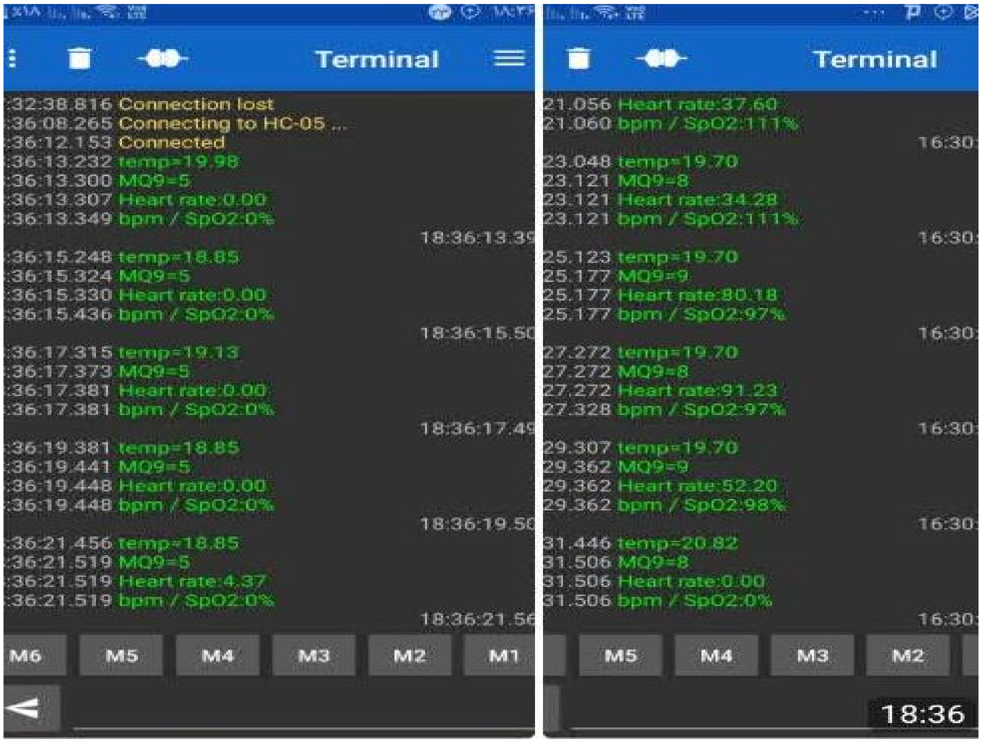

Fig6. Display of heartbeat and blood oxygen and temperature and mobility reading on the Serial Bluetooth Terminal

## IV. BLOCK DIAGRAM

MQ135 air quality sensor and LM35 temperature sensor, Max 30100 heart rate and pulse oximetry sensor, HC05 Bluetooth and power supply are connected to Arduino Uno. The temperature sensor measures the body temperature. When the oximetry sensor is in contact with the patient's hand, it measures the pulse, and the oximeter measures the oxygen level, and the air quality sensor measures the air quality. Arduino processes the code and displays the patient data on the LCD screen. The HC05 Bluetooth module provides connectivity through which data is recorded on the mobile phone application. Therefore, the patient can access the data using the application and provide it to his doctor or health care providers periodically or online. Therefore, the patient's health data is recorded and remotely controlled and processed, and the necessary measures are taken accordingly.

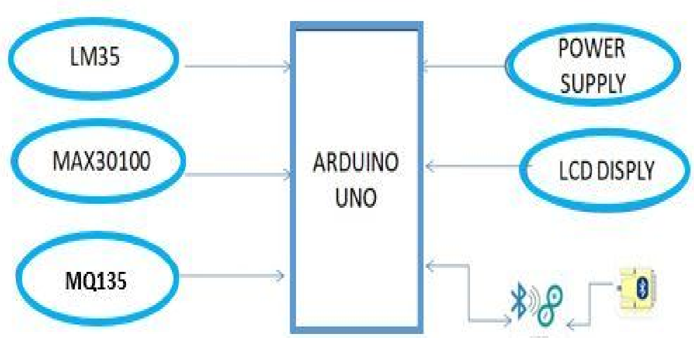

Fig 7. Block diagram

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## V. HARDWARE DESIGN

A remote health monitoring system using IOT is proposed where one can receive, store and send data. The motion sensor can measure the patient's movement, the LM35 temperature sensor is a precision integrated circuit temperature device with a linear output voltage proportional to the temperature in Celsius, and has an advantage over linear temperature sensors calibrated in Kelvin. MAX30100 is a multipurpose sensor that displays heart rate along with pulse oximeter. . Bluetooth HC05 is commonly used to connect small devices such as mobile phones using a short-range wireless connection for file exchange. Arduino UNO board is based on ATMega328P (receive datasheet). This board has 14 digital input and output (I/O) pins, the data transfer speed can vary up to 1 megabit per second and it is within the range of 10 meters. It uses the 2.45 GHz frequency band. The Arduino processes the code and displays the patient data on the LCD screen. The HC05 Bluetooth module provides the connection through which communication is established with the mobile application and the data is monitored on the mobile screen. By storing, sharing and transferring information, any disturbance in vital parameters and changes in life status can be diagnosed by remote doctors

## VI. METHOD

By connecting the MQ135 air pollution detection sensor, Max 30100 heart rate and blood oxygen detection sensor, LM35 temperature sensor, HC05 Bluetooth module to the Arduino board, we designed a device to be connected to the patient's body, which collects the patient's condition and through Bluetooth sends to the Bluetooth serial application of the terminal on the mobile. By connecting the patient's finger to the Max 30100 heart rate and blood oxygen detection sensor and body temperature, it is measured and displayed in the available application. Also, by placing the device in any environment, it can show the air quality index of that environment. The Arduino processes the code and displays the patient data on the LCD screen. The HC05 Bluetooth module provides the connection through which data is displayed and monitored on the application. Therefore, the patient and other relatives can connect to the board through the application, and the doctors and relatives of the patient can access the data, which causes more self-care and control of the patient's health.

## VII. EXPERIMENTAL RESULTS RELATED TO HARDWARE

The images below show the blood oxygen values, heart rate and temperature measured and the acceleration measured by the respective sensors on the LCD screen and the mobile app when the finger tip is placed on it.

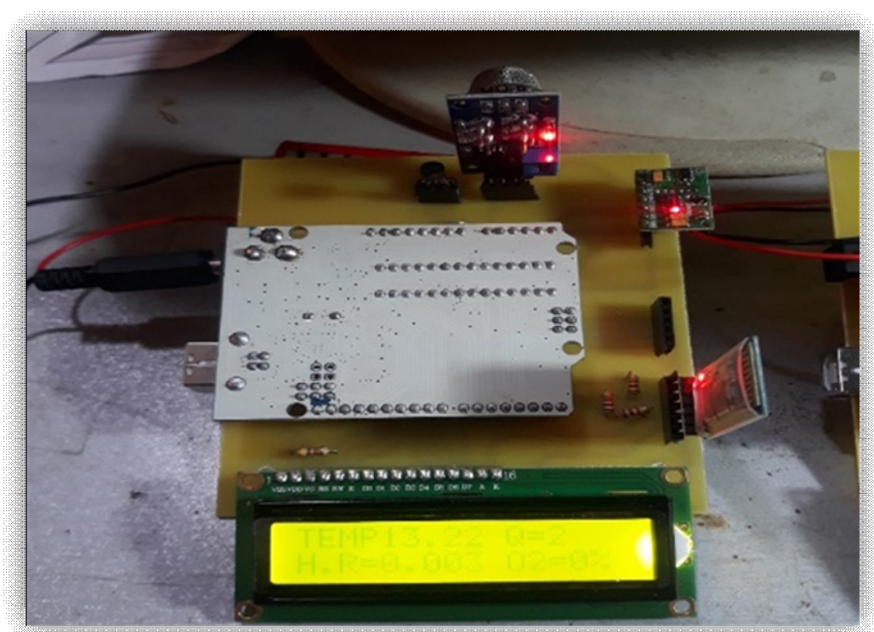


Fig 8. Hardware Display of heartbeat and blood oxygen and temperature and mobility

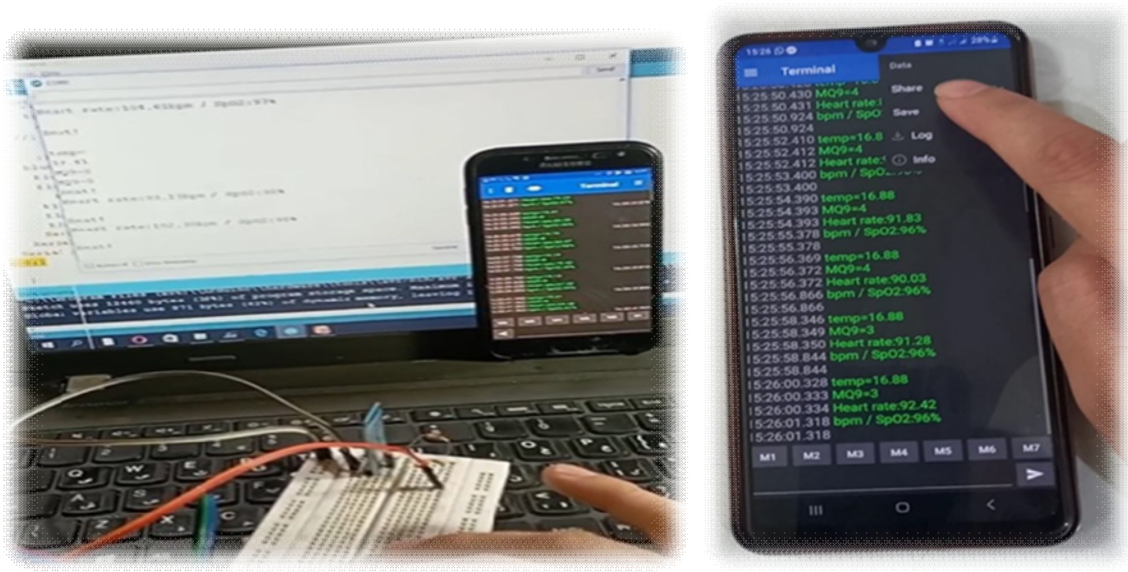


Fig9. Fig6. Display of heartbeat and blood oxygen and temperature and mobility reading on the Serial Bluetooth Terminal

## VIII. CONCLUSION

In this research, a device has been designed to monitor the health of chronic obstructive pulmonary disease patients. This device is user-friendly and effective in the self-care of these patients. This cost-effective and practical device can be the basis of other projects for self-care and remote monitoring of MS patients, and by expanding it, we can take a big step in the treatment and care of these patients.

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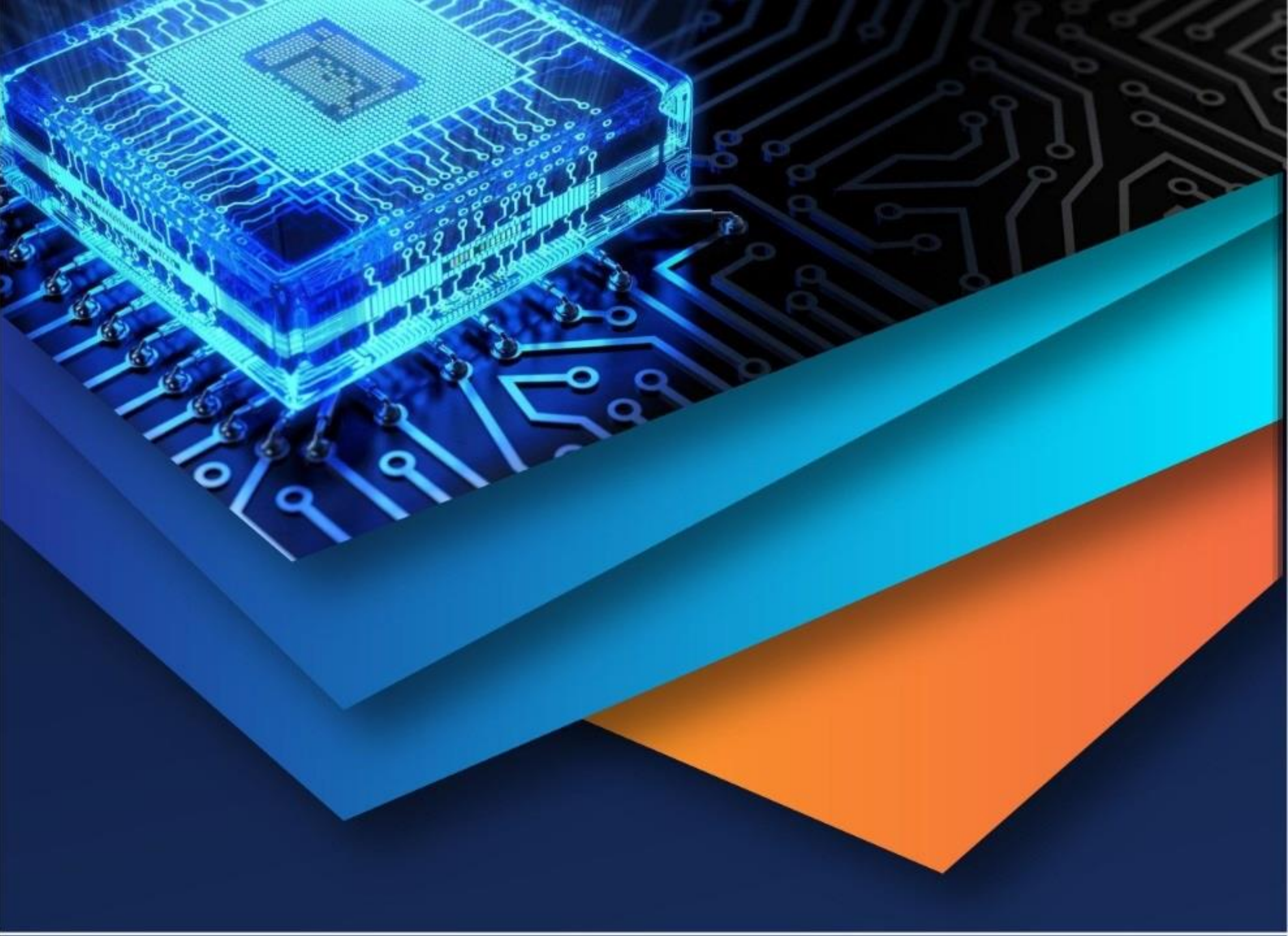


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